An investigation into the feasibility of utilizing phytoliths to identify domesticated plants frequently used at southern African archaeological sites.

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I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

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ABSTRACT

A lack of macro-botanical remains often hampers investigations into the agricultural practices of precolonial farming communities in southern Africa. It has been suggested (see e.g. Pearsall 1982; Piperno 1984; Logan 2012) that phytoliths could be used to establish which plants were cultivated and used at archaeological sites, but few studies have explored the diagnostic value of the phytoliths produced by plants domesticated in Africa.

This PhD will help to address this lacuna. Consequently, the aim of this research was to establish the diagnostic potential of African domesticates, including *Eleusine coracana* subsp. *coracana*, *Pennisetum glaucum*, *Sorghum bicolor* subsp. *bicolor*, *Vigna subterranea* and *Vigna unguiculata* subsp. *unguiculata*, as well as two naturalized plants, namely *Zea mays* and *Arachis hypogaea*.

The phytoliths from different varieties of each crop were analysed to determine if there are significant differences between the phytoliths produced by them. During this study the phytoliths of mature and juvenile specimens of each domesticate were also evaluated in order to establish whether phytolith morphology changed with age. Lastly, a comparison between the morphology, length and width of the phytoliths from domesticated plants and selected wild taxa were compared to determine the diagnostic value of the phytoliths from each crop.

My analysis showed that, based on the morphotypes and measurements that I considered, *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata* phytoliths cannot be used to determine the presence of crops at archaeological sites. *E. coracana* subsp. *coracana*, *P. glaucum* and *S. bicolor* subsp. *bicolor* phytoliths have limited diagnostic potential, while *Z. mays* creates unique phytoliths that can be used as a proxy for crop usage at archaeological sites in southern Africa. Lastly, while there are no significant differences between the phytoliths from the juvenile and mature Fabaceae specimens that were analysed, there are some noteworthy variances between phytoliths from the juvenile and mature Poaceae samples.

In memory of all the people I have lost along the way

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CHAPTER 1: GENERAL INTRODUCTION

The diagnostic potential of phytoliths for the identification of African domesticates in an archaeological contexts has not been ascertained for many crops indigenous to Africa, including *Eleusine coracana* subsp. *coracana*, *Pennisetum glaucum*, *Sorghum bicolor* subsp. *bicolor*, *Vigna subterranea* and *Vigna unguiculata* subsp. *unguiculata*. This thesis endeavours to do so by analysing the morphology, as well as length and width measurements of the phytoliths produced in the above mentioned crops.

This is an important undertaking because agriculture played a vital role in the lives of precolonial southern African farming communities. It not only influenced settlement layout and location, but also had an impact on local economies, politics and social structures. In addition, agriculture and the practices associated with it had an effect on various aspects of farmers' daily lives, including the division of labour and diet (Hall 1987; Greenfields *et al*. 2005; Delius & Schoeman 2008). Needless to say, it is impossible to reconstruct the lives of past agriculturalists without a good understanding of how they produced food and which crops they used.

Researchers have been trying to answer questions related to the origins and spread of agriculture since the 1950s (Neumann 2005:250), and numerous studies have been done on major crops and the areas in which they were domesticated, namely Mesoamerica, Mesopotamia and Asia (e.g. Smith 1998; Piperno 2001; 2011; Fuller *et al.* 2007). Few studies have, however, focussed on the crops domesticated in Africa, which has resulted in controversy over their exact origins and how they spread to other regions (Marshall & Hildebrand 2002:125).

Several plants, among others *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor*, as well as *V. subterranea* and *V. unguiculata* subsp. *unguiculata*, were domesticated in eastern and western Africa. Macro-botanical remains suggest that *S. bicolor* subsp. *bicolor* was first cultivated around 5000 B.P. (De Wet & Harlan 1971:133; Marshall & Hildebrand 2002:126-127). Similar dates were determined for *E. coracana* subsp. *coracana*, which originated from the eastern part of Africa (Hilu & De Wet 1976:207; Hilu *et al*. 1979:333). Evidence of other domesticated plants from western Africa, such as *P. glaucum* and *V. unguiculata* subsp. *unguiculata* date to approximately 3500 B.P (Marshall & Hildebrand 2002:124-125; Zach & Klee 2003:189; D'Andrea *et al.* 2007:692), but it is still unclear when *V. subterranea* was first cultivated (Howell *et al*. 1994:217).

After each of the above mentioned crops were domesticated, they rapidly spread to other regions of the continent and evidence of them appear in southern Africa around AD 200 (Davies 1975:657-658; Maggs 1980:5). While several archaeological sites in southern Africa have yielded macro-botanical remains of crops (see e.g. Huffman 1971; Maggs 1980; Boeyens 2003), it is still difficult to trace how they spread into the region. It has been suggested that migrating Bantu-speaking farmers brought domesticated plants, as well as the knowledge of agriculture, to southern Africa when they moved into the area at the start of the first millennium A.D. (Hall 1987). This theory has not, however, been sufficiently tested.

Another process which can account for the movement of crops and agriculture is diffusion. Sadr (2003), for example, suggested the possibility of forager communities adopting farmer's livestock lifestyles, rather than being replaced by them. Sources of evidence of livestock and material culture linked to farmers are often found at sites associated with hunter-gatherers and researchers have suggested that the presence of these artefacts is due to trade. They, however, could also be indicators of a change in forager's economies (Sadr 2003). Since there is a possibility of hunter-gatherers adopting pastoralism (Sadr 2003), it can be inferred that some members of these communities could have adopted agriculture in areas suitable for farming.

Testing theories about how agriculture was introduced into the region is difficult, because of our fragmented knowledge on crops and agricultural systems. Establishing which crops were cultivated at specific sites could facilitate a more nuanced understanding of agricultural practises, but a lack of direct evidence of domesticated plants hampers investigations. Until recently, many research projects relied on macro-botanical remains, for example carbonized seeds, in order to determine plant usage at archaeological sites in southern Africa (see e.g. Maggs 1980, 2008; Eubanks 2001). These types of remains, however, only preserve under specific environmental conditions and thus do not often survive (Brinkkemper 2006). Evidence of domesticated plants at farming community sites is exceptionally rare, but in some instances the remains of African domesticates such as *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*, as well as non-indigenous crops, for example *Z. mays*, have been identified at southern African sites (Maggs 1980:5-6; Schoeman 1998:77; Schoeman 2006a:158-159).

Since direct evidence of domesticated plants is frequently absent from archaeological sites, indirect evidence, for instance missionary accounts and the remains of lower grindstones, are

regularly used as proxies for the types of crops that precolonial farming communities used and cultivated (Hall *et al.* 2008; Maggs 2008). The evidence from these types of sources is, unfortunately, circumstantial at best and many researchers question the reliability of the information gleaned in this manner (see e.g. Boeyens 2003).

In the absence of macro-botanical remains micro-botanical evidence, such as pollen and phytoliths can be used to establish plant usage at sites (see e.g. Pearsall 1978; Piperno 1984). Phytoliths are microscopic hydrated silica units, which form in cellular and intercellular spaces of living plants (Piperno 2006:1). They resist decay better than various organic materials, for example wood and seeds, which is why they, along with pollen and starch grains, are frequently used to reconstruct palaeoenvironmental and palaeoclimatic conditions (see e.g. Fredlund *et al*. 1998; Thorn 2004; Sjöström 2013), determine regional plant growth (see e.g. Sjöström 2013; Hattingh 2014), and establish plant usage at archaeological sites (see e.g. Piperno 1984; Pearsall *et al*.1995).

Research conducted on the phytoliths of major crops, such as *Zea mays* (Maize), *Hordeum vulgare* (Barley), *Triticum spp*. (Wheat) and *Oryza sativa* (Asian rice) (see e.g. Pearsall 1978; Pearsall & Piperno 1990; Rosen 1992; Ball *et al.* 1993; Pearsall *et al.* 1995; Zhao *et al.* 1998; Pohl *et al.* 2007) has shown that it is possible to distinguish between domesticated plants and their wild ancestors. Phytoliths, therefore, can be used to establish the presence of crops at archaeological sites. Reference collections which incorporate phytolith morphology and morphometrics are, however, essential in order to correctly identify them.

Unlike major crops, few studies have exclusively focused on the phytoliths created by plants domesticated in Africa (Piperno 2006:79), and this limits the extent to which they can be used in an archaeological context. The research conducted by Radomski and Neumann (2011), Logan (2012) and Out and Madella (2015) has focussed on providing more information on the diagnostic value of the phytoliths produced by African domesticates such as *S. bicolor* subsp. *bicolor* and *P. glaucum*. Their research suggests that diagnostic phytoliths may be present in domesticated African plants (Radomski & Neumann 2011; Logan 2012). However, further research is required in order to determine whether the morphological and morphometric attributes of the phytoliths of African domesticates are unique.

In this thesis I access the viability of using phytoliths as an alternative to macro-botanical remains to establish the presence or absence, of domesticated plants at archaeological sites. I do this by establishing the morphological attributes, as well as the length and width

measurements of the phytoliths from *E. coracana* subsp. *coracana*, *S. bicolor* subsp. *bicolor*, *P. glaucum, Vigna subterranea* and *V. unguiculata* subsp. *unguiculata,* and comparing them to wild taxa which occur in southern Africa. I also analyse the phytoliths created by exotic domesticates, including *Z. mays* and *Arachis hypogaea*, to establish whether their phytoliths can be separated from those produced by African plants related to them.

In addition, I assess the differences between the phytoliths of mature plant specimens and samples of domesticates harvested at two other growth stages. This is done to gain insight into whether the phytoliths of crops changes throughout each plant's life cycle and it will broaden our understanding of phytolith production. I also examine the phytoliths formed by different varieties of domesticates, in order to establish whether their phytoliths are morphologically different. The data gathered during this study will supplement the information available from previous works (for example Radomski & Neumann 2011; Logan 2012; Out & Madella 2015) and will contribute towards the creation of an identification key for each domesticate.

I discuss the studies consulted for this thesis in a literature review that spans chapters two and three. In chapter two I discuss the origins of domesticated plants farmed by pre-colonial farmers in southern Africa. I also discuss the macro-botanical evidence available for each of the crops in southern Africa and I review evidence for food production in southern Africa. Next, I reflect on changing environmental conditions, before briefly discussing factors that influenced crop selection.

In chapter three I explore the history of phytolith research and the processes that govern phytolith production. I also discuss the correlation between plant families and phytolith morphology, as well as the advantages and disadvantages of using phytoliths as a proxy for crop usage at a site. Lastly, I scrutinize the research available on the morphology and morphometrics of the phytoliths of each crop chosen for this study.

I discuss the methods used to collect and cultivate domesticated plants for this project in chapter four. I also provide information on the techniques used to process and analyse the phytolith samples.

In chapter five I present the results of my analysis, which I then place into context and discuss in chapter seven. Key interpretations are also highlighted in this section with the emphasis being on the diagnostic value of the phytoliths of each crop type. Lastly, in chapter

seven I conclude my study with a summary of the main achievements and challenges that I encountered during this project.

CHAPTER 2: BACKGROUND OF DOMESTICATED PLANTS

Introduction

Archaeological evidence suggests that Early, Middle and Later Farming Communities in southern Africa had access to a number of plants, which they cultivated in order to sustain themselves (Parkington & Hall 2012:80). These included African domesticates, such as *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor*, *V. subterranea*, *V. unguiculata* subsp. *unguiculata*, *Lagenaria siceraria* and *Citrullus lanatus*, as well as South American crops such as *Z. mays* and *A. hypogaea* (Maggs 1980:7).

Dozens of varieties of each of these crops exist and many have been adapted to grow in specific ecological conditions. While not all of these varieties are morphologically distinct from one another, some exhibit physical differences, such as dissimilar crop height or seed colour. Some of these unique physical attributes, as well as adaptations to specific ecological conditions, might have influenced which crops were selected by precolonial farmers for cultivation.

For my study I chose to examine the phytoliths of the Poaceae and Fabaceae domesticates that are most commonly found at archaeological sites in southern Africa. In this chapter, I give a short overview of each crop's history and briefly discuss the evidence for the presence of these crops in southern Africa. I also discuss the wild taxa related to each domesticated plant, and review the environmental conditions experienced in southern Africa during the late Holocene. Lastly, I provide information on the general environmental requirements of each domesticated plants, and list some of the varieties of these taxa available for cultivation.

The origins of the domesticated plants used at precolonial southern African sites

At present our understanding of the origins of plants domesticated in Africa is incomplete. This is partly due to the limited amount of crop remains found at archaeological sites, but the limited number of research projects on agriculture in Africa also plays a role. As a result, the origins of many African domesticates are still disputed (Neumann 2005), and little is known about how they spread to other regions of the world, for example southern Africa.

Plant domestication in Africa took place much later than in many other regions, for example Mesopotamia and the Fertile Crescent, and the domestication of many African plants only took place after the spread of winter crops from the Near East into the northern parts of the

continent (Neumann 2005:252). This has resulted in theories that suggest that diffusion is responsible for the start of plant domestication in Africa. Domestication of African crops as an independent invention is also possible, but more evidence is needed to prove the theory (Neumann 2005:252-253).

While direct evidence of domesticated plants are rare at sites in Africa, several researchers have used indirect evidence, for example the distribution of the wild progenitors of crops, to theorize possible locations of crop domestication (Hilu *et al.* 1979; Neumann 2005:250-251). Currently, it is believed that the majority of African crops were domesticated in one of two locales, namely the sub-Saharan savannah belt and the East African highlands (Neumann 2003).

The sub-Saharan savannah belt, which runs from Senegal in western Africa to the Red sea on the eastern side of the continent, is posited as the point of origin for domesticates such as *Digitaria exilis* and *Digitaria iburua* (Fonio), *Oryza glaberrima* (African rice), *P. glaucum*, *S. bicolor* subsp. *bicolor*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*. The East African highlands, on the other hand, is the area where *E. coracana* subsp. *coracana*, *Eragrostis tef* (tef) and *Musa ensete* were possibly domesticated (Marshall & Hildebrand 2002:125; Neumann 2003:72). While these broad domestication areas can be used as indicators of where crops originated, more evidence is still needed to narrow down the areas where specific domesticated plants were first cultivated (Neumann 2005).

Tracing the origins of *E. coracana* subsp. *coracana*, for instance, is difficult because of a lack of archaeobotanical remains. At present it is believed that the highlands of Uganda and Ethiopia, in eastern Africa, are some of the areas where it originated from (National Research Council 1996:39; Neumann 2005:253), because the crop's wild progenitor, *Eleusine coracana* subsp. *africana*, commonly occurs in the area. Early evidence of *E. coracana* subsp. *coracana* also appears at sites in Ethiopia, such as Axum (Aksum), which dates to 2500 B.P. (Hilu & De Wet 1976:207; Hilu *et al.* 1979:333; De Wet *et al.* 1984:551; Mehra 1991:162; Neumann 2005:253). An early theory suggests that this crop could have been domesticated as early as 5000 B.P. This theory, along with suggestions that India is *E. coracana* subsp. *coracana*'s point of origin is not, however, supported by evidence (Hilu & De Wet 1976:207; Hilu *et al.* 1979:333; De Wet *et al.* 1984:551; Mehra 1991:162).

While limited archaeobotanical remains are available for *E. coracana* subsp. *coracana*, evidence of *P. glaucum* is widespread in the African archaeological record. Some of the

oldest evidence of the crop is from sites in Mauritania, for example Dhars Tichitt and Oualata (±3500 B.P.), as well as sites from northern Ghana, such as Birimi (±3500 B.P.) (Zach & Klee 2003:189; Marshall & Hildebrand 2002:122). *Pennisetum glaucum* subsp. *monodii*, the wild progenitor of *P. glaucum*, is commonly found in dry, hot areas west of Sudan. Its distribution, along with the oldest evidence of *P. glaucum*, occurs in the dry Savannah areas of western Africa. This suggests that this crop was domesticated in West Africa rather than Ethiopia (Brunken *et al.* 1977:172; Marshall & Hildebrand 2002:124-125), as some scholars (Vavilov 1949/1950) have suggested.

Unlike P. glaucum, the point of origin for *S. bicolor* subsp. *bicolor* is less well understood and evidence of the crop has been documented at numerous sites in Sudan and the eastern Sahara. Wild forms of this domesticate are abundant throughout Africa, but are absent from other continents such as Asia. This strengthens the argument that *S. bicolor* subsp. *bicolor* was first cultivated in Africa (De Wet & Harlan 1971:132).

Dates from sites such as Jenné Jenno suggest that domesticated *S. bicolor* subsp. *bicolor* was cultivated around 2060 B.P., but evidence from multiple sites in eastern Africa, including Nabta, Zakiab and Um Direiwa, shows that communities may have utilized its wild forms as early as 8000 B.P. (De Wet & Harlan 1971:133; Marshall & Hildebrand 2002: 126-127). While conclusive dates for the domestication for this crop are not available, it is possible that it was domesticated as early as 5000 B.P. (Marshall & Hildebrand 2002: 126-127).

In contrast to *S. bicolor* subsp. *bicolor* and many other African grain crops, which have received little attention, extensive research has been done on *Z. mays*. Genetic evidence suggests that *Z. mays* was domesticated from *Zea mays* subsp. *parviglumis*, a grass indigenous to South America. Research done at various archaeological sites in Mexico have yielded macro- and micro-botanical remains of *Z. mays*, and based on this it has been suggested that the crop was domesticated in the Balsas River Valley, Mexico, around 9100 B.P. (Pohl *et al*. 2007:6870).

While numerous South American sites in the Tehuacán and Oaxaca valleys have yielded *Z. mays* remains (Piperno 2001:2260), little direct evidence attesting to its arrival and its spread to other continents, especially Africa, has been found. It is probable that Portuguese traders were responsible for the distribution of *Z. mays* beyond the Americas (Maggs 2008:180), but more research is required to prove this.

Despite the extensive research done on *Z. mays* and other domesticated plants from Mesoamerica and South America, little information is available on the origins of *A. hypogaea*. *A. hypogaea* is adapted to tropical and subtropical climates (Seijo *et al.* 2007:1963), and western Brazil, Bolivia, Paraguay and northern Argentina have been proposed as possible areas where it might have originated from (Kochert *et al*. 1996:1982; Gericke 2005:121).

A. hypogaea has been found at various archaeological sites in South America. Excavations in the Huarmey Valley yielded remains of the crop that dates to 5000 B.P. and evidence from the Chicama Valley dates to approximately 3500 B.P. Both these areas are near the Peruvian coast where the wild progenitor of the crop is absent. This suggests that the crop was domesticated prior to 5000 B.P. and that it spread to other areas of the continent before the arrival of European explorers (Kochert *et a*l. 1996:1982; Seijo *et al.* 2007:1963).

At present *A. hypogaea* is a popular crop throughout Africa, however, it is still unclear where and when it was first cultivated. It is possible that Portuguese traders introduced *A. hypogaea* to African communities around the same time that *Z. mays* was brought to the continent (Kochert *et al*. 1996:1982; Gericke 2005:121).

Some of the oldest records of *A. hypogaea* suggest that the crop may have been used at the Gold Coast, Angola and the Congo as early as the mid to late 17th century (Logan 2012:197; Alpern 1992:26). Alpern (1992:26), however, notes that because other types of groundnuts, for example *V. subterranea*, were common in these areas, historical accounts of *A. hypogaea* should be treated with care, and should not be regarded as conclusive evidence of the presence of the crop (Alpern 1992:26). Direct evidence of *A. hypogaea* at West African archaeological sites, however, is limited, and thus when the crop was first used in Africa requires further investigation.

Similarly, limited evidence of *V. subterranea* in the archaeological record has prevented researchers from establishing where and when it was domesticated, and how it spread to other regions. *V. subterranea* was first recorded at farming community sites in West Africa (Marshall & Hildebrand 2002:127). Consequently, it has been suggested that Cameroon or Nigeria is the probable point of origin (Howell *et al.* 1994:217). The theory that *V. subterranea* was first cultivated in West Africa is supported by the wide distribution of its wild progenitors, *V. subterranea* var. *spontanea*, in that area (Purseglove 1976:291-309; Mackinder *et al.* 2001).

It is believed that *V. unguiculata* subsp. *unguiculata* was also domesticated in West Africa (Logan 2012:38), but because of its diversity and the wide distribution of its wild progenitors it is difficult to pinpoint the exact area where it was first cultivated (Vaillancourt & Weeden 1992: 1194; D'Andrea *et al.* 2007:692). Archaeological studies conducted in central Ghana yielded some of the earliest evidence of *V. unguiculata* subsp. *unguiculata* that dates to approximately 3500 B.P. (D'Andrea *et al*. 2007:693). While this could indicate West Africa as the crops point of origin, it is not conclusive proof. Several researchers (e.g. Coulibaly *et al.* 2002:365) have proposed northern-east Africa, or Botswana (Panella *et al.* 1993:383-4) as areas where *V. unguiculata* subsp. *unguiculata* could have originated from. These possible locales for domestication were suggested based on data gathered during phylogenetic studies, amplified fragment length polymorphism analysis (AFLP), as well as linguistic studies. There are, however, concerns about the accuracy of these results and more research is needed to conclusively establish the true origin of the crop (D'Andrea *et al.* 2007:692).

V. unguiculata subsp. *unguiculata* spread from its point of origin early on, and reached Europe and India between 2300 and 2200 B.P. It has been suggested that Spanish traders were responsible for the crop's arrival in the America's in the 17th century (Global Crop Diversity Trust 2013), where it is more commonly known as black-eyed peas, and is still widely cultivated for its seeds. *V. unguiculata* subsp. *unguiculata* is also popular in parts of Asia, the Caribbean and Brazil. It is also cultivated throughout Africa (National Research Council 2006:108).

Food production in southern Africa

Similar to other regions in Africa, few researchers have done a systematic study of food production in southern Africa. Thus, there are still many unanswered questions about the spread of agriculture and domesticated crops. The earliest evidence of agriculturalist communities in southern Africa dates to approximately AD 200 (Hall 1987:1). This coincides with the dates of the oldest dated remains of domesticated plants in the area (Davies 1975: 657-658; Maggs 1980:5), and it has, therefore, been suggested that the knowledge of agriculture was bought into the region from the north by these communities (Hall 1987).

Early farming communities (EFCs) occupied areas in southern Africa from approximately A.D. 200 (Huffman 2007). The majority of these communities settled in coastal forests, savannah woodland areas and in river valleys along the eastern coast of southern Africa.

These areas were not only in close proximity to water sources, but had adequate grazing for livestock, an abundance of wood for fuel and building, as well as arable land and enough rainfall (400-1000 mm per annum) for crop cultivation (Maggs 1984: 73; Greenfields *et al.* 2005:308).

EFCs had access to a number of African domesticates including *E. coracana* subsp. *coracana, P. glaucum*, S. *bicolor* subsp. *bicolor, V. subterranea* and *V. unguiculata* subsp. *unguiculata* (Maggs 1980). While it has been suggested that a combination of these crops were grown by EFCs, little is known about the agricultural methods that they employed. Researchers (e.g. Van Zinderen Bakker 1980; Hall 1987; Smith 2005) have suggested that a lack of irrigation systems at EFC sites indicates that dry-land cultivation was practiced. They also proposed that slash-and-burn, or swidden techniques, as well as various inter-cropping strategies might have been used by these farmers (Hall 1987:11; Van Zinderen Bakker 1980:71). Testing these theories, however, is difficult because of a lack of evidence of agriculture and limited evidence domesticated plants.

E. coracana subsp. *coracana* and *P. glaucum* might have been amongst the first crops cultivated in southern Africa by Early Farming Communities (EFCs) (Maggs 1980:6) (see Table 2.1). Evidence of *E. coracana* subsp. *coracana* was identified at various EFC sites and it was, for example, found in excavation units at Shongweni dry rock shelter (KwaZulu-Natal), which dated to the late second century A.D. and the 8th century A.D. (Davies 1975:657-658; Maggs 1980:5). It was also identified at other first millennium sites such as Kadzi, northern Zimbabwe (Pwiti 1996) and Magogo, South Africa (Maggs & Ward 1984).

Similar to *E. coracana* subsp. *coracana*, evidence of *P. glaucum* is widespread at first millennium archaeological sites and has been found at Kgaswe, Nqoma and Matlapaneng in Botswana, as well as Magogo and Ndondonwane in South Africa. Casts of *P. glaucum* at Silver Leaves have been dated to A.D. 300, and excavation units dating to the second century A.D. have yielded evidence of *P. glaucum* (Klapwijk 1974; Maggs 1980; Maggs 1984; Maggs & Ward 1984; Denbow 1986; Kiyaga-Mulindwa 1993). *S. bicolor* subsp. *bicolor* remains have also been found at Kgaswe and Matlapaneng, as well as EFC sites, such as Leopard's Kopje, Nqoma and Schroda in South Africa (Huffman 1974; Hanisch 1981; Denbow 1986; Kiyaga-Mulindwa 1993).

Table 2.1. A list of published archaeological sites in southern Africa, mentioned in text,that have yielded evidence of domesticated plants.

Domesticated plant types	Site Name	Site location	Date/Time period	Reference
Poaceae				
Eleusine coracana subsp. *coracana*	Shongweni dry rock shelter	South Africa	A.D. 200 and A.D. 800	Davies 1975; Maggs 1980
	Kadzi	Zimbabwe	1st millennium A.D.	Pwiti 1996
	Magogo	South Africa	1st millennium A.D.	Maggs & Ward 1984
Pennisetum glaucum	Kgaswe, Nqoma and Matlapaneng	Botswana	1st millennium A.D.	Maggs 1984; Denbow 1986; Kiyaga-Mulindwa 1993
	Magogo and Ndondonwane	South Africa	1st millennium A.D.	Maggs & Ward 1984
	Silver leaves	South Africa	A.D. 200 and 300	Maggs 1980; Klapwijk 1974
Sorghum bicolor subsp. *bicolor*	Kgaswe and Matlapaneng	Botswana	1st millennium A.D.	Denbow 1986; Kiyaga-Mulindwa 1993
	Leopard's Kopje and Nqoma	South Africa	1st millennium A.D.	Huffman 1974; Hanisch 1981; Denbow 1986
	Schroda	South Africa	8th/9th century A.D.	Voigt 1981
	M3S (site 2229 AD30)	South Africa	A.D. 1256-1285	Schoeman 2006
	EH Hill (site 2229 AD 35)	South Africa	A.D. 1266-1277	Schoeman 2006
	Mapungubwe	South Africa	A.D. 900 to 1250	Seddon 1968; Denbow 1986; Schoeman 2006
	Magozastad 248 JP	South Africa	A.D. 1600	Boeyens 2003
	2530AD 10	South Africa	Later Farming Community site/2nd millennium A.D.	Colette 1982
Zea Mays	Mgoduyanuka	South Africa	17th /18th century	Maggs 1982
	Esikhunjini	South Africa	19th century	Schoeman 1998
Fabaceae				
Arachis hypogaea	Bambata cave	Zimbabwe	Possibly 19th century	Walker 1995
	Pomongwe Cave	Zimbabwe	Possibly 19th century	Walker 1995
Vigna subterranea	Leopard's Kopje	South Africa	A.D. 900	Huffman 1974
Vigna unguiculata subsp. *unguiculata*	Leopard's Kopje	South Africa	A.D. 900	Huffman 1974
	Lanlory	Zimbabwe	A.D. 700	
	Mapungubwe	South Africa	A.D. 900 and 1250	Seddon 1968; Denbow 1986; Schoeman 2006

Despite the abundance of evidence of grain crops at EFC sites, few macro-botanical remains of Fabaceae have been found. Evidence of *V. subterranea* and *V. unguiculata* subsp. *unguiculata* is scarce, but both were identified at Leopard's Kopje (9th century A.D.). In addition, *V. unguiculata* subsp. *unguiculata* was found at Lanlory (Zimbabwe), a 7th century site (Huffman 1971:87; Maggs 1980:6).

Middle Farming Community (MFC) sites, which have a more limited geographic distribution, have also yielded remains of African domesticates. MFCs occupied southern Africa from

approximately A.D. 900 to A.D. 1300 (Huffman 2007) and sites associated with these communities are often located in similar open areas as those of EFCs, namely floodplains, riverbanks and regions near wetlands (Schoeman 2006:161; Smith *et al.* 2007:123).

It is thought that an increase in population size triggered the beginning of intensive agriculture during the MFC period (Huffman 2000; Smith 2005). While it is possible that MFCs employed the same agricultural techniques as EFCs, new methods such as flood plain agriculture might have been utilized by these farmers (Smith & Hall 1999; Smith 2005:189). The same crops that were cultivated by EFCs were used by MFCs (see Table 2.1), and direct evidence of *S. bicolor* subsp. *bicolor* was found at M3S (site 2229 AD30) and EH Hill (site 2229 AD 35). Excavations at Mapungubwe hill in the Shashe-Limpopo Confluence Area have also provided *S. bicolor* subsp. *bicolor* and *V. unguiculata* subsp. *unguiculata* remains (Seddon 1968:493; Schoeman 2006b:158 & 159).

Similar to MFC sites, direct evidence of African domesticated plants are not abundant at the sites once inhabited by Later Farming Communities (LFCs). LFCs occupied some areas of southern Africa as early as the 12th century A.D. (Evers 1974:x) and while EFCs and MFCs mainly occupied river valleys and coastal plains, LFCs expanded into grassland and thorn scrub areas. Although proximity to water still played an important role in where settlements were located (Coetzee 2008), a shift in settlement location from valley floors to hillsides can be noted in some regions (Maggs 1994/1995).

Little is known about the farming methods employed by these communities, but terraced agricultural areas in Mpumalanga could be indicative of intensive agriculture (Maggs 2008). Maggs (2008) suggested that several other farming techniques, for example mulching and fertilizing of fields with manure and crop rotation could have been used by LFCs, but at this point few research projects have focussed on answering questions about agriculture (Maggs 2008) and most theories about agricultural practices is conjecture.

Few sites have yielded macro-botanical remains of domesticated plants, but *S. bicolor* subsp. *bicolor* remains have been found at Magozastad 248 JP, which dated to approximately 350 B.P. (Boeyens 2003:78), and at 2530AD 10, a LFC site associated with the people of Bokoni (Collett 1982). In addition, indirect evidence of crop cultivation in the form of missionary accounts are available. These suggest that domesticated plants such as *S. bicolor* subsp. *bicolor*, *V. subterranea* and possibly *E. coracana* subsp. *coracana* and *P. glaucum* were

cultivated (e.g. Smith 1836; Elton 1873). African domesticates were, however, not the only crops used by LFCs.

Z. mays remains were found at Mgoduyanuka (KwaZulu-Natal), a 17th /18th century site (Maggs 1982), as well as Esikhunjini, a 19th century site (Schoeman 1998:77). Despite this evidence, it is still unclear when and where *Z. mays* was first used in southern Africa (Boeyens 2003:75). At present, it is believed that the crop was brought to the area during the 16th century A.D. by Portuguese traders and that Maputo was its main entry point (Maggs 2008:180).

Direct archaeobotanical evidence for this introduction via Mozambique is still lacking, but Ekblom *et al.*'s (2011) research on pollen sequences suggests that *Z. mays* was one of the main crops cultivated in the Lower Limpopo valley (adjacent to Mozambique) by the mid-16th century.

It, however, is also unclear how *Z. mays* spread to other regions in the interior of southern Africa after its introduction into the region. Some researchers have proposed that the spread of *Z. mays* in southern Africa was rapid. Huffman (2004:104), for example, proposed that a change in grindstone technology at LFC sites in the Northern part of the Limpopo province is linked to the adoption of a new crop, namely *Z. mays*. In contrast, Boeyens (2003) pointed out that historical sources indicate that *Z. mays* was not cultivated on a large scale until the end of the 18th century at KwaZulu-Natal sites, and not until the early 19th century at Limpopo, Gauteng, Mpumalanga and North-West (Transvaal) sites (Boeyens 2003:74; Hall *et al.* 2008:74; Maggs 2008:180).

These conflicting opinions may be the result of the use of indirect evidence to trace *Z. mays*' diffusion. Boeyens (2003) and Hall *et al*. (2008) employed oral traditions, historic accounts and lower grindstones to determine crop usage at LFC sites, while Ekblom *et al.* (2011) used pollen. While pollen data can give reliable results, it should be noted that downward transport of pollen could contaminate samples and result in erroneous early dates or *Z. mays* cultivation (Ekblom *et al*. 2011:16). Similarly oral traditions and historic accounts should be treated with caution, because differences in terminology can lead to misunderstandings concerning the presence or absence of certain domesticated plants (Ekblom *et al.* 2011:15).

Similar to *Z. mays*, there are various missionary accounts that attest to the use and cultivation of *A. hypogaea* by precolonial in southern Africa during the 1800s (Jonnson 1998:44). Macro-botanical evidence of the crop at archaeological sites is, however, incredibly rare

(Walker 1995). It was only identified at two sites in Zimbabwe, namely Bambata cave and Pomongwe cave, and Walker (1995) suggested that this evidence is linked to site occupations during the 19th century.

While there is no consensus on when exotic crops, such as *A. hypogaea* and *Z. mays*, reached the interior of southern Africa, it is possible that it spread to areas connected to long-distance trade networks first (Antonites & Antonites 2014:228). Several other factors, for example climate and topography, could also have facilitated or hampered the spread of exotic crops.

Past environmental conditions

Based on archaeological evidence precolonial farmers, mainly, settled in the central and eastern sections of southern Africa (Maggs 1980:8). These areas form part of the summer rainfall zone which, currently, receives between 431 mm and 985 mm mean annual rainfall and has average temperatures that range between 14,7℃ and 20℃ (Mucina & Rutherford 2006:40). While these conditions are conducive to crop cultivation, past climatic conditions might not have been.

Frequent climatic fluctuations occurred in southern Africa during the late Holocene, when precolonial farmers occupied the area. In general, during the last 2000 years southern Africa experienced warm, wet climatic conditions punctuated by periods of cooling that caused severe droughts (Norström *et al.* 2009; Finné *et al.* 2010; Sjöström 2013). Holmgren *et al.* (2003) and Woodborne *et al.* (2015) showed that the highest moisture levels in southern Africa were experienced during the Medieval Warming Period (MWP) which started at approximately A.D. 950 and ended around A.D. 1250 (Sjöström 2013:17). These dates coincide with MFC occupation of southern Africa and the highest amounts of precipitation, fell during the occupation of Mapungubwe (at c A.D. 1075).

Ekblom *et al.* (2012) and Holmgren *et al.* (2003) found that after the MWP drier, cooler climatic conditions were the norm. These conditions were the result of the Little Ice Age (LIA) that occurred from approximately A.D. 1400 to A.D. 1800 (Holmgren *et al.* 2003; Norström *et al.* 2005; Ekblom *et al.* 2012).

Several periods of extreme aridity were recorded in southern Africa during the LIA (Norström *et al*. 2005; Sjöström 2013; Woodborne *et al.* 2015) and Woodborne *et al.* (2015) noted that precipitation was lowest during A.D. 1635, A.D. 1695 and A.D. 1805. Despite

these arid conditions, periods of high rainfall also occurred between the 1600's and the 1700's, as well as the 1800's (Norström *et al.* 2005:166-167).

The fluctuation of climatic conditions would have had a large impact on regional plant growth in the areas of southern Africa where farming communities settled. C_4 grasses commonly grow in warmer, drier regions, while C_3 grasses occur in areas with cool and wet climates. Thus, Vogel *et al.* (1978) showed that C_4 grasses are, often dominant in the summer rainfall areas of southern Africa, while C_3 grasses mainly occur in winter rainfall areas, for example the western Cape, or the summits of mountain ranges. In some cases C_4 and C_3 occur in the same areas, as a result of seasonal fluctuations of moisture and temperatures or differences in topography. Thus, it is essential to analyse the ratios of C_3 and C_4 grasses to fully understand regional plant growth (e.g. Breman 2010; Sjöström 2013; Hattingh 2014).

During her investigation of Lydenburg fen (Mpumalanga) Sjöström's (2013) used the ratios of C_3 and C_4 grasses in order to determine past climatic conditions during the late Holocene. Her study showed that C_4 grasses were dominant in all samples, but C_3 taxa were also present. The ratios of C_3 and C_4 grasses were influenced by precipitation and fluctuations in C_3 taxa indicated shifts between mesic and arid conditions (Sjöström's 2013:72-75). Apart from, Sjöström's (2013) study, Breman (2010) also provided information on past plant growth in the Mpumalanga region. Her study showed that in Verloren Valei (Mpumalanga), for example, the vegetation has remained an open grassland since 8000 B.C., but that the proportion of C_3 and C_4 grasses fluctuated as moisture levels increased or decreased. Similarly, Grasskop (Mpumalanga) comprised a mosaic of grassland and forest from 4500 B.C. until A.D. 1400 when the environment changed to a mesic grassland. In both these regions C_4 grasses were dominant, but C_3 taxa were present in varying numbers depending on the temperature and moisture levels at the time (Breman 2010).

C_4 grasses also dominated all the archaeological samples taken from the two LFC sites analysed by Hattingh (2014). The ratios of C_3 and C_4 grasses at Komati Gorge, an open air site, indicated a shift from mesic to arid conditions during the occupation of the site, while warm, wet conditions were recorded for the period that the Buffelskloof site was occupied (Hattingh 2014).

The majority of the domesticated Fabaceae and Poaceae chosen for this study follow the C_4 photosynthetic pathway. As discussed earlier these plants were first cultivated in eastern and

western Africa or South America. Thus, it is important to note that the majority of the taxa related to them do not occur in southern Africa (see Table 2.2).

I chose to analyse the phytoliths from eleven wild Poaceae linked to the domesticated plants selected for this study (see Table 2.2). All of these wild grasses follow the C_4 photosynthetic pathway and at present they occur in the summer rainfall zones of southern Africa (Gibbs Russel *et al.* 1990; Nkonki & Swelankomo 2003; Van Oudsthoorn 2012; Fish *et al.* 2015) (see Table 2.3.). Several of the areas where precolonial farmers settled were dominated by C_4 grasses during the Holocene (Breman 2010; Sjöström's 2013; Hattingh 2014). Therefore, it is possible that some of the wild Poaceae chosen for analysis occurred in the regions where these farmers cultivated their crops.

It should be noted that some of the taxa, for example *E. tristachya, S. bicolor subsp. drummondii, S. halepense* are not indigenous to southern Africa, but are naturalized. Maroyi (2006) and Milton (2004) suggested that the intentional introduction of alien plant species by European settlers, for aesthetic or agricultural purposes, caused the spread of many non-indigenous taxa in southern Africa. However, it is also likely that migrating livestock and wild animals are responsible for the spread non-indigenous wild grasses. Since it is difficult to determine when wild taxa, such as *E. tristachya, S. bicolor subsp. drummondii, S. halepense*, were introduced into southern Africa, it is impossible to determine whether they were presence or absence from the region while precolonial farmers occupied it.

Despite the decision to include both indigenous and introduced wild Poaceae species in this study, I chose not to collect any of the wild Fabaceae taxa. The reasons for this is explained in full in Chapters 5 to 7.

Table 2.2. Wild taxa related to the domesticated plants chosen for this project (after Dunn 1983:289; Nkonki & Swelankomo 2003; Holst *et al*. 2007:17609; Global Crop Diversity Trust 2013).

Domesticated plants	Taxa related to domesticated plants	Taxa related to domesticated plants present in southern Africa
Eleusine coracana subsp. *coracana*	*E. coracana subsp. africana* *E. indica* *E. kigeziensis* *E. floccifolia* *E. intermedia* *E. tristachya* *E. jaegeri* *E. multiflora* *Ochthochloa compressa*	*E. coracana subsp. africana* *E. indica* *E. tristachya* *E. multiflora*
Pennisetum glaucum	*P. glaucum subsp. monodii* *P. sieberianum* *P. purpureum* *P. squamulatum*	*P. purpureum* *C. ciliaris** *D. ciliaris**
Sorghum bicolor subsp. *bicolor* *Sorghum bicolor* subsp. *bicolor*	*S. bicolor* subsp. *drummondii* *S. bicolor* subsp. *arundinaceum* *S. propinquum* *S. halepense* *S. amplum* *S. angustum* *S. brachypodum* *S. bulbosum* *S. ecarinatum* *S. exstans* *S. grande* *S. interjectum* *S. intrans* *S. laxiflorum* *S. leiocladum* *S. macrospermum* *S. matarankense* *S. nitidum* *S. plumosum* *S. purpureosericeum* *S. stipoideum* *S. timorense* *S. versicolor*	*S. bicolor* subsp. *drummondii* *S. bicolor* subsp. *arundinaceum* *S. halepense* *S. versicolor* *C. ciliaris** *D. ciliaris**
Zea Mays	*Z. mays* subsp. *parviglumis* *Z. mays* subsp. *huehuetenangenis* *Z. mays* subsp. *mexicana*, *Tripsacum dactyloides* *S. halepense* *T. lanceolatum*, *T. latifolium*, *T. maizar* *T. pilosum*	*S. halepense* *C. ciliaris** *D. ciliaris**
Arachis hypogaea	*V. monticola* *A. batizocoi* *V. cardenasii* *V. correntina* *V. diogoi* *V. duranensis* *V. helodes* *V. herzogii* *V. hoehnei* *V. ipaensis* *V. linearifolia* *V. magna* *A. villosa*	None
Vigna subterranea	*V. subterranea* var. *spontanea* *V. hosei*	None

Domesticated plants	Taxa related to domesticated plants	Taxa related to domesticated plants present in southern Africa
Vigna unguiculata subsp. *unguiculata*	*Vigna unguiculata* subsp. *aduensis* *V. unguiculata* subsp. *alba* *V. unguiculata* subsp. *baoulensis* *V. unguiculata* subsp. *burundiensis* *V. unguiculata* subsp. *dekindtiana* *V. unguiculata* subsp. *letouzeyi* *V. unguiculata* subsp. *pawekiae* *V. unguiculata* subsp. *pubescens* *V. unguiculata* subsp. *stenophylla* *V. unguiculata* subsp. *tenuis* *V. unguiculata* subsp. *unguiculata* var. *spontanea* *V. keraudrenii* *V. monantha* *V. schlecteri* *V. radiata* *V. vexillata*	*V. unguiculata* subsp. *tenuis* *V. unguiculata* subsp. *dekindtiana* *V. unguiculata* subsp. *stenophylla* *V. radiata* *V. vexillata*

Table 2.3. Additional information on the wild grasses chosen for this study (Gibbs Russel *et al.* 1990; Van Oudsthoorn 2012*;* Fish *et al.* 2015; Clayton *et al.* 2006).

Species	**Distribution in southern Africa**	**Flowering**	**Environmental conditions**	**Examples of where taxa occur**	**Additional information**
C. ciliaris	Savannah, Grassland and Nama-Karoo biomes	August to April	Grows well in sandy soils. Is common in dry, hot regions.	Common pasture grass.	
D. ciliaris	Savannah, Nama-Karoo and Grassland biomes	February	Grows in disturbed, sandy soils.	Often occurs on agricultural fields.	
E. coracana subsp. africana	Savanna, Grassland and Fynbos biomes	October to May	Grows in various soil types.	Common weed in cultivated land.	
E. indica	Grassland and Savanna biomes	November to February	Grows in rocky or turf soils.	Occurs in cultivated areas as a weed.	Common in tropical and subtropical regions.
E. multiflora	Grassland and Fynbos biomes	February to April	Grows well in disturbed soils/areas.	Commonly found on cultivated lands.	
E. tristachya	Fynbos and Grassland biomes	February to April	Grows well in disturbed soils/areas.	Occurs as a weed in cultivated areas.	Indigenous to tropical America and Africa.
P. purpureum	Savannah and Grassland biomes	January to June	Grows well in rich fertile soils.	Occurs in valleys, riverbeds and forest margins.	
S. bicolor subsp. arundinaceum	Savannah, Nama-Karoo and Grassland biomes	January to June	Grows well in disturbed soils/areas.	Common in agricultural fields.	
S. bicolor subsp. drummondii	Grassland biomes	January to June	Grows well in disturbed soils/areas.	Common in agricultural fields.	Indigenous to North Africa.
S. halepense	Savannah, Nama-Karoo, Grassland, Fynbos biomes	December to May	Grows best in moist, disturbed soils.	Occurs as a weed in cultivated land. Also common along roadsides and waterways.	Indigenous to Mediterranean areas.
S. versicolor	Savannah and Grassland biomes	December to May	Adapted to grow in turf sediments and disturbed soils.	Common in agricultural fields and along roadsides.	Indigenous to north Africa

Factors that influenced crop selection

Climate and topography not only influenced the distribution of wild Poaceae, but it also had an impact on how crops spread across southern Africa. Each of the domesticated plants that were available to precolonial agriculturalists are adapted to different environmental conditions. Altitude, as well as the chemical compositions of soils, for example, influence the development of crops and the size of the yields. Some crops are highly adaptable and are more tolerant of environmental stresses than others and this would have affected which crops were cultivated (National Research Council 1996).

E. coracana subsp. *coracana*, for example, can be grown under a variety of environmental conditions. This annual grass, which takes 2,5-6 months to mature (National Research Council 1996:55), fares well in areas with moderate rainfall ranging between 500 mm to 1000 mm per annum. It requires approximately 12 hours daylight for optimum growth and since it is not negatively affected by heat, it can be grown at temperatures as high as 35℃. *E. coracana* subsp. *coracana* fares better at cooler temperatures than other African domesticates and can be cultivated in temperate zones, however, temperatures below 18℃ can have a negative impact on crop growth. It tolerates a wide variety of altitudes and soil types (National Research Council 1996:56-57; Van Wyk & Gericke 2000:10), which is why precolonial farmers might have chosen it.

Similar to *E. coracana* subsp. *coracana*, *P. glaucum* requires approximately 12 hours of direct sunlight for optimum growth. It can be grown in aluminium rich and acidic soils, but yields may be affected by the nature of the substrate. It is unclear how tolerant *P. glaucum* is of high altitudes, but it fares well in areas below 1200 m above sea level (National Research Council 1996:90-91).

P. glaucum grows well in areas where temperatures exceed 30℃. It is, however, sensitive to low temperatures, especially during its seedling and flowering stages. It is incredibly drought tolerant and is commonly cultivated in areas where rainfall is as low as 200 mm per annum. *P. glaucum* can also be grown in areas with high rainfall of up to 1500 mm per annum, but it does not tolerate waterlogging, and thus it should only be grown in well-drained soils. *P. glaucum*'s ability to withstand arid conditions might have led to it being chosen for cultivation above other crops. It should, however be noted that this crop's yields are optimum when the rainfall it receives is evenly distributed throughout its growth cycle (National Research Council 1996:90-91; Van Wyk & Gericke 2000:12).

While *S. bicolor* subsp. *bicolor* is not as well adapted to arid conditions as *P. glaucum*, it fares well in dry, hot climates, as well as in cool temperatures and optimum growth occurs at 27℃ -30℃. It is very drought tolerant and is able to limit its water usage by becoming dormant when water is scarce. Between 400 and 800 mm of rainfall is needed in order to ensure a good yield (National Research Council 1996:143; Du Plessis 2008:8).

S. bicolor subsp. *bicolor* is well adapted to grow in a wide variety of soils, especially clay rich sediments. It tolerates alkaline soils and is often cultivated in areas where the pH fluctuates between 5,5 and 8,5. *S. bicolor* subsp. *bicolor* is a short-day crop and needs between 10 and 12 hours of daylight for optimum yields. It grows well at moderate altitudes and can survive short periods of waterlogging, because of its adaptability to clay soils (National Research Council 1996:142-143; Du Plessis 2008:6-8). Numerous archaeological sites in southern Africa (see Table 2.1) have yielded remains of this crop and its versatility could have been the key reason why it was cultivated.

Z. mays is less drought resistant than any of the other grain crops cultivated by precolonial farming communities in southern Africa, but fares better at cooler conditions. It requires soil temperatures of at least 10℃ to germinate and temperatures of between 16℃ and 30℃ for optimum growth (Du Plessis 2003:11). It does not tolerate frost and yields decrease substantially at temperatures above 30℃ (Lobell 2011:43). *Z. mays* can grow with as little as 350 mm of rainfall a year in temperate areas (Thobatsi 2009:2), however in warm arid areas a minimum of 900 mm of rainfall is required to produce good yields (Nafziger, n.d:7).

Z. mays does not tolerate waterlogging, thus it fares best in well-drained soils with a low clay content (Du Plessis 2003:11; Nafziger 2009:24). The amounts of nitrogen, potassium and other minerals available in sediments also has a great effect on plant growth and development. *Z. mays* requires high quantities of various minerals, including phosphorus, zinc and nitrogen to prevent crop failure (Bänziger *et al.* 2000:20). Though *Z. mays* requires more water and doesn't fare well in leached soils, it provides larger yields in favourable conditions than many African domesticates (Van Wyk & Gericke 2000:16). This could have been one of the reasons why it was adopted by southern African farmers.

Similar to *Z. mays*, *A. hypogaea* is not well adapted to arid conditions. In order to obtain good yields, it requires between 500 mm and 1000 mm of rainfall per annum. One of the reasons LFC's might have chosen this crop for cultivation is its tolerance of shade. Unlike the majority of the grain crops investigated for this project, *A. hypogaea* can be intercropped

with trees without a negative impact on the amount of seeds produced. *A. hypogaea* seeds germinate at 30-34℃ and optimum growth is achieved at 25-30℃. Cold temperatures affect it negatively and frost can kill the plant. *A. hypogaea* grows best in sandy-loam soils with a pH of between 6 and 6,5, but it does not fare well in sediments with a high salt content (Naturland Association for Organic Agriculture 2000:3-4).

V. subterranea also requires moderate to high amounts of water and during its growing season the crop needs 600-1000 mm of rainfall per annum to obtain good yields. It develops best in areas where the daily temperatures range between 20℃ and 28℃, provides good yields when planted in well-drained soils with a pH of 5 to 6,5 and tolerates soils with low fertility. It does not grow well in calcareous sediments and a great quantity of nitrogen causes abundant vegetative growth. *V. subterranea* can be cultivated at altitudes below 1600 m above sea level and it is a short day crop (Svanevelder 1998:10; National Research Council 2006:71-72).

V. unguiculata subsp. *unguiculata* fares better in dry, hot climates than the other Fabaceae taxa studied during this project, and it can grow on as little as 300 mm of rainfall per annum. It needs temperatures of above 8℃ to germinate, at least 21℃ to ensure adequate vegetative growth and temperatures of above 33℃ to advance flowering. *V. unguiculata* subsp. *unguiculata* can be cultivated in infertile soils, it is, however, vulnerable to waterlogging and thus well-drained soils ensures the best yields (Coetzee & Venter 1996:2; National Research Council 2006:107-108). *V. unguiculata* subsp. *unguiculata'*s adaptability to arid conditions and its large, reliable yields may have been the main reasons why the crop was cultivated by precolonial farmers.

Despite the importance of climate and topography and the roles it played in the selection of crops for cultivation, it should be noted that personal preference and availability also determined which domesticated plants were chosen (Hattingh 2014:77). These two factors not only influenced the decisions to use one crop instead of another, but it also determined which variety of a specific domesticated plants was used. Numerous varieties of each of the domesticated taxa exist. Some of these exhibit distinct morphological differences which can aid in their identification, while others are adapted to grow better in certain environmental conditions. Certain varieties may have been preferred to others, by precolonial farmers, because of these adaptations.

Noteworthy varieties of *E. coracana* subsp. *coracana*, for example, includes those adapted to high humidity, drought, heat and high altitudes. There are also early-maturing types which allow for multiple harvests a year (National Research Council 1996:40, 46). Some varieties can be used for porridge or bread, while others are best suited for beer brewing (Quin 1954; Van Wyk 2005:187). In many cases it is possible to distinguish between different variations of *E. coracana* subsp. *coracana* based on physical attributes, such as, plant dimensions and shape as well as seed size and colour. This is not always the case, however, and many varieties can only be differentiated from one another by monitoring their development in certain environments. The types of *E. coracana* subsp. *coracana* chosen for cultivation would have been dependant on the needs of the communities.

Similar to *E. coracana* subsp. *coracana*, each *P. glaucum* variety is adapted to a specific set of environmental conditions. Some types are adapted to be day length neutral, while other varieties are fast or slow maturing depending on the amount of available rainfall (National Research Council 1996:90-91,118). *P. glaucum* is cultivated as both a grain crop and as a forage crop, depending on whether it is a high or low grain yielding type (Van Oudsthoorn 2012:12). Popping varieties are also common (National Research Council 1996:118). Plant height, seed colour and seed size can be used to differentiate between varieties.

Different types of *S. bicolor* subsp. *bicolor* also have different physical characteristics which aid in the identification of each variety. There are several varieties of *S. bicolor* subsp. *bicolor*, some of which are specifically adapted to withstand disease, insect and bird damage, as well as environmental conditions, such as drought, low temperatures and high rainfalls (National Research Council 1996:153-157). Many types of *S. bicolor* subsp. *bicolor* produce small amounts of grain and could have been cultivated for fodder by precolonial farmers (Du Plessis 2008:14-15). Sweet-stemmed kinds which are used in a similar fashion to sugar cane (Van Wyk & Gericke 2000:14), as well as popping varieties (National Research Council 1996:177) also exist.

Similar to the grain crops domesticated in Africa, several varieties of *Z. mays* are available for cultivation, however a large number of these are GM (Genetically Modified) types which would not have been available to precolonial farming communities. Despite the wide distribution of GM *Z. mays*, unmodified versions of the crop are still widely used (Nafziger 2009:25-26). Different types of *Z. mays* can be distinguished from one another by grain size, colour and the soft tissue near the centre of the kernel (Van Wyk & Gericke 2000:16).

The different types of *Z. mays* cultivated include varieties adapted to specific environmental conditions, for example extreme heat or low rainfall and varieties adapted for special uses, for example the brewing of beer. Certain types of *Z. mays* can be eaten raw or popped, while others have large foliage to seed ratios and are used as a fuel source (Van Wyk & Gericke 2000:16). Several varieties, which have red or purple seeds, are cultivated solely for decorative purposes and there are numerous types that have soft kernels ideal for milling (Van Wyk & Gericke 2000:16). Precolonial farming communities might have cultivated a number of these varieties.

The types of *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata* chosen for cultivation would, similar to grain crops, have been affected by a number of factors. Resistance to disease, yield, the time it takes to mature and marketability all play a vital role in which varieties of *A. hypogaea* are chosen for cultivation. Thus, sweet seeded varieties, early maturing types and prolific bearers could have been favoured (Wright 2012). Varieties of *V. subterranea* that are, currently, popular include the ones that produce large yields. Typically a mixture of the different varieties are used and cultivated, but early maturing varieties or small seeded types are also commonly used (Venter & Coetzee 1996:1-2).

Numerous varieties of *V. unguiculata* subsp. *unguiculata* are currently cultivated. Short-day as well as day-neutral types are common and used in areas where day length varies (D'Andrea *et al*. 2007: 692). Fast and slow maturing varieties are also available (National Research Council 2006:110). In some areas of West Africa *V. unguiculata* subsp. *unguiculata* with strong fibres are used to produce paper and fishing gear (Global Crop Diversity Trust 2013). Climbing, creeping and bushy kinds are all used and the types planted are usually dependant on factors, such as, the sorts of crops with which they are planted and the space available for cultivation (National Research Council 2006:110). Precolonial farmers may have cultivated a combination of varieties, similar to present day agriculturalists.

Conclusion

None of the taxa chosen for this study were domesticated in southern Africa, but they all spread into the region with agriculturalist communities and became an essential source of sustenance. A good understanding of the agricultural practices of EFCs, MFCs and LFCs is essential to gaining a holistic picture of past agriculturalist's lives and determining which crops were cultivated by these communities can add to our current knowledge. As shown in

this chapter, macro-botanical evidence of domesticated plants at archaeological sites is often rare. Thus, it is important to find alternative ways of determining plant usage at sites.

CHAPTER 3: LITERATURE REVIEW OF PHYTOLITH RESEARCH

Introduction

The use of phytoliths to study plant usage at archaeological sites is a relatively new concept. Researchers (see e.g. Pearsall 1978, 1982; Piperno 1984) have only used them for this purpose since the 1970s, with some of the earliest studies employing phytoliths to investigate whether early agriculturalists were cultivating crops, such as *Z. mays*, *Oryza sativa* (Asian rice) and *Triticum aestivum* (wheat) (e.g. Ball *et al.* 1993; Piperno & Pearsall 1993; Zhao *et al.* 1998). While various studies have focussed on the diagnostic potential of the phytoliths of major crops, limited research (e.g. Logan 2012; Out & Madella 2015) is available on the phytoliths produced by domesticated Poaceae indigenous to Africa, for example *E. coracana* subsp. *coracana*, *S. bicolor* subsp. *bicolor* and *P. glaucum*.

In order to fully understand phytolith morphology and morphometrics and their potential as proxies for past plant usage, it is important to understand the processes that govern their formation and deposition. It is also essential to know how environmental conditions affect phytolith preservation. These factors are discussed in this chapter. I also highlight the research that has been done on the domesticated plants chosen for this project and explore the links between family, subfamilies and phytolith morphology.

A general history of phytolith research

The history of the research conducted on phytoliths is long and encompasses numerous articles, books and other research outputs from scholars around the world. Since phytoliths' discovery in the 19th century, numerous studies have investigated the factors which influence phytolith production, preservation and distribution, in order to determine the diagnostic potential of phytoliths (Piperno 2006:2).

Some of the earliest research conducted on phytoliths was done by German and other European scientists, for example Struve (1835) and Ehrenberg (1841; 1854). These studies were geared toward understanding phytolith taxonomy and produced the first phytolith classification systems which could be employed to identify phytoliths found in an archaeological context (Piperno 2006:2). Although these early studies identified some of the plants which create phytoliths, it wasn't until the 1950's that more thorough investigations into the phytoliths produced by each plant family were conducted (Piperno 2006:3).

Poaceae, the family to which grain crops belong, has seen the most systematic research and Twiss *et al*. (1969), Parry and Smithson (1964; 1966), as well as Fredlund and Tiezen (1994), among others, have investigated the diagnostic value of the phytoliths produced by each grass subfamily. Less work has been done on non-grass taxa, however numerous monocotyledon and dicotyledonous specimens have been evaluated for phytoliths (see Pearsall 2000; see Piperno 2006 for reviews). Some of the plants which have been studied, apart from monocotyledon taxa, include woody dicotyledonous plants (Amos 1952; Ter Welle 1976; Bozarth 1992), *Cucurbita* species (Bozarth 1986; 1987; Piperno *et al.* 2002), as well as Fabaceae (Bozarth 1990; Piperno 2006).

In addition to identifying which plants create phytoliths, more emphasis was also placed on the taxonomy and taphonomy of phytoliths. Studies by Jones and Handreck (1965), Blackman and Parry (1968), as well as Hartley and Jones (1972) investigated the transportation of silica and the formation of phytoliths within plants. Research by Rovner (1983), Kaufman *et al*. (1985), Agarie *et al*. (1996) and Massey and Hartley (2006), among others, looked at the function of phytoliths in plants, while Parry and Smithson (1964; 1966) and Hayward and Parry (1980) studied phytolith distribution within plants. The link between plant age and silica deposition has also received attention (see e.g. Blackman 1968; Motomura *et al.* 2004; 2006). These research projects fostered a better understanding of where in plants diagnostic phytoliths might be produced, which allowed for the creation of more detailed phytolith identification keys (Piperno 2006:3).

The effects that environmental conditions have on phytolith preservation, transportation and distribution after the plant decays have also received systematic research (see e.g. Dunn 1983; Carrión *et al.* 2000; Pearsall 2000; Piperno 2006; Ghosh *et al*. 2008; Osterrieth *et al*. 2009; Fishkis *et al*. 2009, 2010). An understanding of how phytoliths are influenced by the environment in which they are deposited greatly affects how researchers interpret phytolith assemblages. It also determines whether phytoliths are used in conjunction with, or instead of macro-botanical remains or other micro-botanical remains (e.g. diatoms and pollen) at archaeological and palaeontological sites.

The use of phytoliths as a proxy for environmental change started earlier than the use of phytoliths to determine plant usage (Piperno 2006:175). Various studies (see e.g. Fredlund *et al.* 1998; Thorn 2004) have used phytoliths to determine terrestrial palaeoenvironments, while others looked at lake sediments, or samples from peat bogs to determine past climatic

and environmental conditions (see e.g. Tsutsuki *et al.* 1993; Iriarte *et al.* 2004). These studies employed the information available on taxonomy, taphonomy and phytolith morphology to determine the ratios between C4 and C3 grasses. The majority of these research projects were conducted in the American tropics, as well as areas in the Amazon, China, Japan and New Zealand (Piperno 2006:175-183). These studies, not only showed how durable phytoliths could be, but also paved the way for research into the phytoliths of domesticated taxa.

Research on the diagnostic value of the phytoliths produced by domesticated plants started in earnest during the 1970s (Shillito 2013). Some of the earliest work conducted on crop phytoliths was done in South America on *Z. mays* (see e.g. Pearsall 1978, 1982; Piperno 1984, 1998). Research on other domesticated plants, for example, wheat (*Triticum* spp.) and barley (*Hordeum vulgare*) (see e.g. Rosen 1992; Ball *et al.* 1999; Hodson *et al.* 2001), as well as bananas (*Musa* spp.) (see e.g. Wilson 1985; Lentfer 2003; Vrydaghs *et al.* 2009) and Asian rice (*Oryza sativa*) (see e.g. Kealhofer & Penny 1998; Zhao *et al.* 1998) have also received a substantial amount of attention. Apart from ensete, not much research has, however, focussed on African domesticates such as *E. coracana* subsp. *coracana* and *P. glaucum*.

Despite the extent to which phytoliths have been used in the Americas and other continents, few research projects in Africa have employed phytoliths as a proxy for plant usage at archaeological sites. The majority of studies done in eastern and central Africa used phytoliths to determine palaeoenvironmental conditions (see e.g. Runge 1999; Bamford *et al.* 2006, Bremond *et al.* 2008; Neumann *et al*. 2009). Similarly, the studies in southern Africa have mainly focussed on answering palaeobotanical questions. One of the earliest studies to use phytolith analysis in southern Africa was done by Oberholser (1968), and his research was geared toward explaining the presence of phytoliths in sediments taken from the Springbok flats. A later study by Scott and Rossouw (2005) examined soils from Florisbad to re-evaluate conclusions made about palaeoenvironments based on botanical remains, while McLean and Scott (1999) used phytoliths as a proxy for palaeoclimatological processes. Finné *et al.* (2010) employed phytoliths to determine palaeoenvironments at Braamhoek wetland and Rossouw (2009) looked at the application of phytoliths to late Cenozoic environments. Mercader *et al.* (2010) noted the types of grasses commonly located in the present day Zambezian Miombos in order to produce better reference collections. Hahn *et al*. (2015) on the other hand merely noted observing phytoliths during their study of core

samples taken to determine Holocene paleo-climatic conditions in the South African Namaqualand mudbelt.

While phytolith identification keys developed for research areas on other continents are useful to determine past environmental conditions in southern Africa, they are of limited use at archaeological sites in the region. Schiegl *et al.* (2004), Schiegl and Conard (2006), Albert and Marean (2012), Sjöström (2013), as well as Blackwell *et al.* (2014) are among the few researchers who have used phytoliths for archaeological studies in southern Africa. Schiegl *et al.* (2004) used phytoliths to determine which plants were burned in fires at the Middle Stone Age site, Sibudu Cave, while a later study by Schiegl and Conard (2006) employed phytolith analysis to identify hearth features at the same site. Albert and Marean's (2012) research at Pinnacle Point, tried to establish what fuel early *Homo sapiens* used in hearths. Sjöström (2013), on the other hand, employed phytoliths from peat cores near Lydenburg as a proxy for climate change in the 17th century. Lastly, Blackwell *et al.* (2014) utilised phytoliths in order to provide information on the climate change, as well as the human occupation at Wonderkrater, southern Africa.

Some studies in southern Africa, for example Esteban *et al.* (2017) and Leonard *et al.* (2015) have attempted to broaden our understanding of phytoliths and its possible uses at archaeological sites. Esteban *et al.*'s (2017) research, for instance, investigated the phytoliths from modern soil samples in order to improve analogies for the reconstruction of environmental conditions. Leonard *et al.* (2015), on the other hand, employed phytoliths in a study of the dental calculus of modern Kwe communities to establish whether phytolith could be used to accurately determine past plant consumption.

Despite this research, few studies have employed phytoliths to establish which crops were cultivated by precolonial farmers. This is partly due to the limited amounts of work done on the phytoliths created by plants domesticated in Africa. An insufficient understanding of the processes that affect the production, preservation and distribution of phytoliths also influence the extent to which phytoliths can be used in archaeological studies (Piperno 2006:79; Shillito 2013:72).

The processes that influence phytolith production

Phytoliths are the result of the deposition of silica in cellular and intercellular areas within plants. The process starts when soluble monosilicic acid ($SiO_2.nH_20$) is absorbed by roots along with water and other minerals. It is then transported via xylem to various sections within the plant where it settles and solidifies, taking on the shape of whatever space it was deposited in (Piperno 2006:5).

Researchers (e.g. Okuda & Takahashi 1964; Jones & Handreck 1965; Van der Vorm 1980; Piperno 1988) are still debating whether silica absorption is an active or a passive process. If it is a passive process then the plants do not control the uptake or deposition of silica. The amount of monosilicic acid absorbed by the plant is dependent on environmental factors such as soil silica content, while the areas within plants where it settles is determined by biological elements, for example transpiration and plant age (Handreck & Jones 1969).

Various studies, for example Jones and Handreck (1965) and Jones and Handreck (1969) have examined passive silica uptake and have shown it is possible to predict the amount of silica contained within a taxon, provided one knows the amount of silica in the growth medium and the amount of water absorbed by the plant. Studies (e.g. Blackman 1968; Piperno 1988) have also shown that phytoliths are common in areas where transpiration is high, for example leaves. Thus, passive silica uptake can be responsible for phytolith formation.

While the passive uptake of silica is a feasible theory, other studies, for examples those done by Van der Vorm (1980) and Jarvis (1987) suggest that silica uptake by plants is an active process whereby plants control silica absorption through metabolic processes (Piperno 2006:9). Okuda and Takahashi (1964) indicated that silica can pass into the xylem sap against a concentration gradient. Van der Vorm (1980) confirmed this by showing that the concentration of silica in five different plant species is higher than would have been expected if silica was absorbed passively. If silica uptake is an active process then silica deposition might also be regulated by plants. Thus phytoliths might not be localized to areas where transpiration takes place and might serve a higher function within plants (Mitani & Ma 2005:1255; Piperno 2006:9).

While there is compelling evidence that supports both active and passive uptake of silica Liang *et al*. (2005) stress that the research conducted on the processes that govern silica

absorption is still poorly understood. Consequently, researchers might have overlooked more diverse methods of silica uptake, for example, rejective silica uptake, whereby plants are able to stop or limit the uptake of silica (Mitani & Ma 2005:1256), as well as the employment of a combination of active and passive uptake procedures by plants (Liang *et al.* 2005:803).

A good understanding of the processes that govern silica absorption is needed, because it informs on the types of taxa within which phytoliths might be observed. It could also give information about how long it takes for phytoliths to form within plants and where diagnostic phytoliths might be located. It is generally accepted that various aspects of plant physiology, for example photosynthetic pathways and plant age, also play a role in phytolith production (Blackman 1968; Motomura *et al*. 2004). The amount of research available on the morphological and morphometrical changes of phytoliths during a plant's growth cycle is, however, limited.

Generally, phytoliths collected for comparative samples are taken from mature plant specimens (cf. Rovner 1983), and the phytoliths contained by younger taxa are rarely investigated. If differences exist between the phytoliths in mature and immature samples, this can have a profound impact on the interpretations made about plant usage and domestication at archaeological sites. This is partly due to the fact that some plants are used before they reach maturity and because not all crops reach the end stages of development, because of environmental stresses, for example drought.

Some researchers, for example, Blackman (1968), Handreck and Jones (1968) and Motomura *et al.* (2002) have looked at silica accumulation during different stages of a plant's life. Most of these studies used taxa from the Poaceae family and focussed on the rate of silica deposition in leaves. The results of these studies varied greatly. Blackman (1968), for example, showed that the majority of silica is set down in grass leaves after their expansion and that areas such as the base of the leaf sheath contains the highest numbers of phytoliths. Motomura *et al.* (2002, 2006), on the other hand, indicated that silica deposition in plants is not limited to the period after leaves expand. Silica sedimentation in cells starts early in leaf tissue and continues well after the plant has reached maturity (Motomura *et al.* 2002, 2006). Thus, it is possible that diagnostic phytoliths form early in juvenile taxa and phytoliths might be present in the samples analysed for this study.

Blackman (1968) and Motomura *et al*. (2006) showed that several types of phytoliths are present in juvenile Poaceae specimens. Motomura *et al*. (2006) suggested that silica is

deposited in prickle hairs and guard cells first, before other cells are filled. Blackman (1968) noted that apart from prickle hair phytoliths, which are abundant, copious amounts of short cell phytoliths also form after leaf expansion. These types of phytoliths might be abundant in the juvenile samples of domesticated grasses.

While it is important to note the types of phytoliths that might be encountered, understanding the factors that influence phytolith formation within juvenile taxa is also essential. Plant physiology, for example, could affect how silica is set down and which phytoliths are formed first (Motomura *et al.* 2002). Environmental conditions also affect the rate at which silica is absorbed and deposited (Blackman 1968). Researchers should, thus be aware of how the availability of silica and water in soils can affect the results of their studies.

Advantages and disadvantages of the use of phytoliths at archaeological sites

A few researchers, e.g. Ball *et al.*(1992), Rosen & Weiner (1994) and Jenkins *et al.* 2011, have examined the impact that environmental conditions can have on phytolith production. The limited amount of information on this subject poses several challenges when it comes to determining whether phytoliths can be employed as a proxy for plant usage at archaeological sites. Apart from silica and water availability, it has been suggested that climatic conditions, such as temperature, humidity and soil types, can have an effect on phytolith creation (Ball *et al.*1992; Piperno 2006:5; Shillito 2013:77). Jenkins *et al.* (2011) state that because aridity and humidity have an impact on transpiration rates, they have a large influence on not only water uptake, but also silica uptake. The number and size of phytoliths is dependent on the amounts of water and silica absorbed by plants (Jenkins *et al.* 2011; Shillito 2013:77), thus researchers who rely on morphometric attributes to identify domesticated plants at archaeological sites could have inaccurate results because of a misidentification of taxa.

The link between phytolith size and climatic conditions is not, however, purely a disadvantage. Several studies (e.g. Rosen & Weiner 1994; Jenkins *et al.* 2011) have looked at the possibility of using the number and size of conjoined phytoliths to determine whether crops were irrigated, or whether dryland farming was practiced at certain sites. Rosen and Weiner (1994) indicated that more conjoined phytoliths could be observed in plant samples which were irrigated and therefore, theoretically phytoliths could be used as a proxy for water availability at archaeological sites. Jenkins *et al.* (2011), however, stressed that more

research is needed to determine how other environmental and climatic elements influence the morphometrics of conjoined phytoliths before those attributes are used as an indication of irrigation. Shillito (2013) also added that the context of a site should be considered before employing phytoliths to answer questions about water regimes.

In addition to testing the effect of water availability on phytolith size, several studies (Madella *et al.* 2009; Jenkins *et al.* 2016) have investigated the effect that the amount of water a plant receives may have on phytolith concentrations. Madella *et al.* (2009) showed that short cell and long cell phytolith ratios can be affected by water availability, but the variability in ratios is dependent on the species and plant organ analysed. A study by Jenkins *et al.* (2016) confirmed some of the results presented by Madella *et al.* (2009) and showed that long cell phytoliths increase when crops are irrigated. While these studies further our understanding of how phytoliths formation is influenced by the environment, more research is needed before it can be effectively used as a proxy for water availability.

It is important to note that environmental and climatic factors not only influence phytolith production, but also phytolith preservation (Piperno 2006:108). One of the main benefits to employing phytoliths as a proxy for plant usage at archaeological sites is that silica is inorganic and survives better in a number of environments where other micro- and macro-botanical remains decay (Rovner 1983:234-235). Originally it was thought that because phytoliths are composed of water soluble silica, that phytoliths would decay rapidly in sediments (Baker 1960). However, researchers have not only found phytoliths in sediments from precolonial sites (see e.g. Pearsall 1978; Piperno 1984), but have also identified phytoliths in paleoanthropological sites such as Olduvai Gorge (see e.g. Bamford *et al.* 2006) and Florisbad (Scott & Rossouw 2005), which suggests that phytoliths can preserve for much longer than first estimated.

While phytoliths preservation is not affected by moisture, acidic soils and aerobic conditions like other botanical remains (Piperno 2006:107-108), they are still vulnerable to soil pH. Phytoliths preserve well in acidic soils, but alkaline soils with a pH value of nine and above can lead to phytolith dissolution (Rovner 1983:235). Areas such as middens and agricultural fields may lack phytoliths because of soil pH (Piperno 2006:108), however Pearsall and Trimble (1984) as well as Piperno (1985; 1988) have shown there are exceptions where well preserved phytoliths have been identified in alkaline sediments.

Of course phytolith preservation is not just dependant on the nature of the soil. Rovner

(1983) contended that one of the main factors which influences phytolith decay is the size and shape of the phytolith. Tree phytoliths, for example, dissolve rapidly, because of their large and flat surface area, while grass phytoliths preserve better with their polyhedral body shapes (Rovner 1983:235; Piperno 2006:21-22). The degree to which a taxon's cells are silicified also plays a role in how long its phytoliths preserve, as do environmental conditions and the rate of phytolith burial after deposition (Piperno 2006:108). It should be noted, however, that in some cases phytoliths resist decay despite the environments in which they are set down, resulting in the survival of taxa that usually dissolves rapidly (Rovner 1983:235).

While preservation affects which types of phytoliths will be visible in a sample, the role that phytolith mobility plays should not be discounted. Several researchers (see e.g. Dunn 1983; Fishkis *et al.* 2009, 2010; Osterrieth *et al.* 2009) have stressed the high mobility of phytoliths, and how this can influence interpretations based on phytolith evidence. Phytoliths are easily transported by wind, water, animal and human activities because of their relatively small size. Samples taken from a ship's sails, which contained numerous phytolith morphotypes (Darwin 1909), demonstrated that phytoliths can be transported over long distances. Dunn (1983), for example, attributed the lack of phytolith evidence in her samples of irrigation channels and archaeological fields in the Moche Valley, Peru, to phytolith mobility. She stated that since preservation was good enough at the site to ensure the survival of pollen that it was reasonable to assume that the movement of phytoliths though soil was responsible for their absence in samples (Dunn 1983). Pearsall (2000), however, disagreed with Dunn's (1983) conclusions and pointed out that pollen is similar in size to phytoliths and should be just as susceptible to downwards movements as phytoliths. Therefore the lack of phytoliths was due to other factors, not phytolith mobility (Pearsall 2000:495).

Regardless of phytoliths' post depositional mobility, there are still advantages to employing them rather than other botanical remains. Phytoliths are bound to organic material while the plant is still alive and for varying periods of time after the plant dies and starts to decay. Phytoliths are, thus, released into a micro-environment as plants decompose, as opposed to pollen and seeds which are released from plants before being distributed to a macro-environment by wind and water (Rovner 1983:236; Pearsall 2000:495; Rovner 2001:119). This makes phytoliths a better indicator of micro-environments than many other botanical remains, however the abundance in which phytoliths are produced may be a serious drawback, as well as the fact that not all taxa produce phytoliths.

Phytoliths, unlike pollen, are not produced as a single repetitive form by a taxon (Rovner 1983:226). A single plant species can produce multiple phytolith morphotypes and various different taxa may create the same phytolith forms (Barboni & Bremond 2009:29). It is this multiplicity and redundancy that makes it difficult to correctly identify certain taxa. It also introduces the possibility of overrepresentation of some plant groups which can lead to a skewed understanding of past plant assemblages (Piperno 2006:25). It thus is important that researchers take issues related to multiplicity and redundancy into account when they establish their research methodology, so that an accurate picture of past vegetation is obtained.

Poaceae phytolith morphology

One example where multiplicity and redundancy can be observed is within the Poaceae family. Poaceae comprise approximately 700 genera which house 10 000 species, each of which produce a number of phytoliths (Piperno 2006:27). *E. coracana* subsp. *coracana, P. glaucum, S. bicolor* subsp. *bicolor* and *Z. mays* all belong to the Poaceae family. Research by Twiss *et al*. (1969), Fredlund and Tiezen (1994), Twiss (2001) and Rossouw (2009), among others, have shown that Poaceae produce a number of phytoliths including undiagnostic bulliform and long cell phytoliths. Grasses also create short cell phytoliths which are diagnostic to a subfamily level and in rare instances to a species level (Rovner 1983:229-230: Twiss *et al.* 1969).

Grasses belonging to the Aristidoideae, Arundinoideae, Bambusoideae, Chloridoideae, Danthionioideae, Ehrhartiodeae, Panicoideae and Pooideae subfamilies commonly occur in southern Africa (Gibson 2009; Rossouw 2009:40). Various studies (e.g. Twiss *et al.* 1969; McClaren & Coder 2003; Rossouw 2009) have looked at which short cell phytoliths correspond to these grasses and they have indicated that Panicoideae, for example, are the main producers of bilobate, cross and polylobate phytoliths. Bambusoideae and Chloridoideae also create small amounts of these phytoliths, however the amounts which they produce are not statistically relevant in the regions where they were studied (see Figure 3.1) (Fredlund & Tiezen 1994:326; McClaren & Coder 2003:24).

While cross, polylobate and bilobate phytoliths are considered diagnostic of Panicoideae, depressed saddle phytoliths, also known as variant 1 saddles, are commonly produced by Chloridoideae. Aristidoideae also create saddle phytoliths, however variant two saddles,

referred to as elongated saddle phytoliths, are associated with this grass subfamily. Elongated saddles may also be viewed in Chloroid grasses, but they occur in low numbers (see Figure 3.1) (Twiss *et al.* 1969; Rossouw 2009:48).

Taxa associated with the Pooideae subfamily are the main producers of rondel, square, oblong, orbicular and rectangular phytoliths (see Figure 3.1) (Twiss *et al.* 1969:111). Trapezoid phytoliths have also been observed in Pooid grasses, however they are mostly produced by Danthioniodeae and Ehrhartiodeae and can be considered diagnostic of grasses belonging to these subfamilies (Rossouw 2009:67-70).

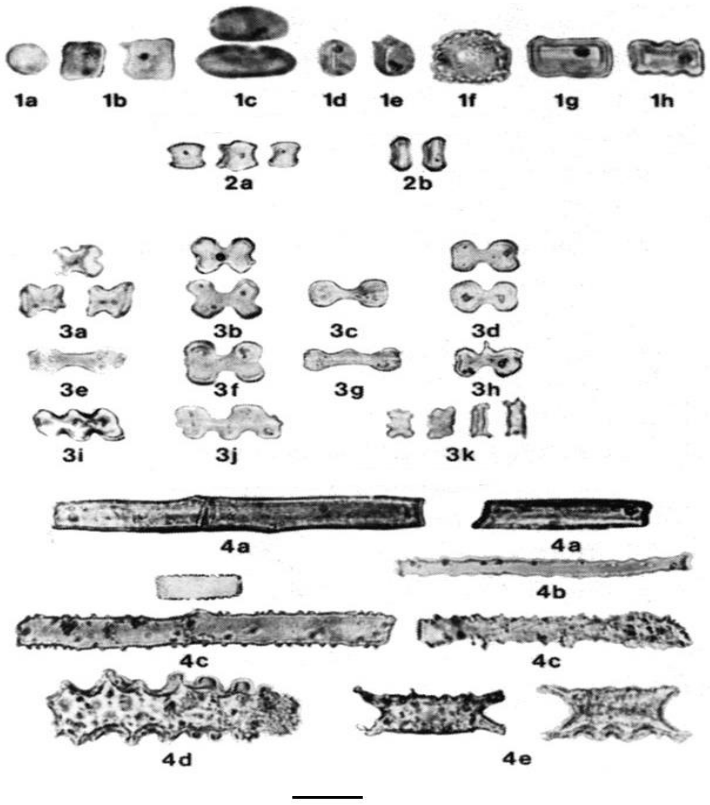

Figure 3.1. Classification of phytoliths produced in Poaceae. (1a-h) Orbicular, oblong, rectangular and square phytoliths produced by Pooid grasses. (2a-b) Saddle phytoliths from Chloridoideae and Aristidoideae. (3a-k) Bilobate, cross and polylobate phytoliths produced by Panicoideae. (4a-e) Undiagnostic phytoliths created by all Poaceae (adapted from Twiss et al. 1969:111).

By linking certain short cell phytoliths to specific Poaceae subfamilies, usage of grass phytoliths as proxies for environmental reconstruction has become feasible (Bremond *et al.* 2005). However, in order to establish whether domesticated grasses, such as the ones chosen for this project, produce diagnostic phytoliths, a more in-depth study of the morphology of the phytoliths created by Poaceae is needed.

Studies by Piperno and Pearsall (1993), Pearsall (2000) and Rossouw (2009) have indicated that variations of Poaceae short cell phytoliths exist and that they can be observed, in among others, bilobate, cross and saddle phytoliths (Pearsall 2000; Rossouw 2009:47). Bilobate phytoliths comprise two rounded lobes held together by a neck or shank of varying length and thickness. Based on Rossouw's (2009) bilobate classifications system, which is built around symmetry and shank length, four types of bilobate phytoliths exist and they can be differentiated from one another based on morphological attributes observed in the planar view (cf. Rossouw 2009:47).

Variant one bilobates (see Figure 3.2.A) have symmetrical orbicular lobes and the length of the shanks comprises more than a third of the total phytolith length. The lobes are also symmetrical in the lateral view. Variant two (see Figure 3.2.B) has symmetrical elongated or orbicular lobes and a shank which is equal or smaller than a third of the length of the phytolith. In side view the phytolith may appear trapezoidal or tabular (Rossouw 2009:47; Fredlund & Tiezen 1994:326). Variant three bilobates (see Figure 3.2.C) have a shank that is smaller than one third of the length of the phytolith. In planar view these bilobates are asymmetrical and in lateral view they are tabular or trapezoidal. Lastly variant four bilobates have asymmetrical lobes and a shank that is more than a third of the total phytolith length (Figure 3.2.D.) (Rossouw 2009:47; Twiss *et al*. 1969).

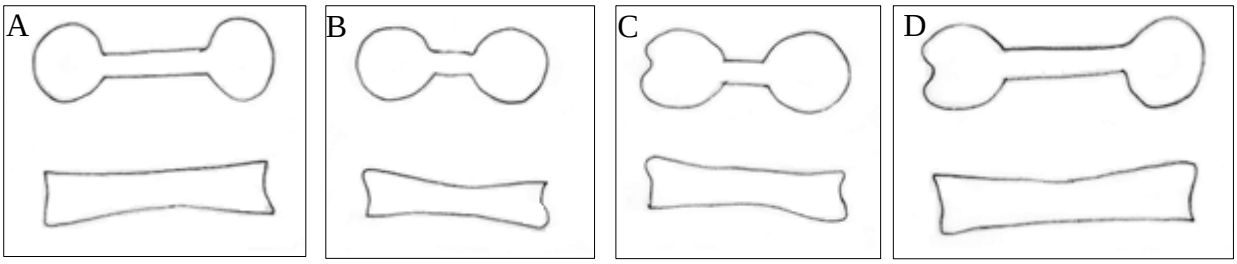

Figure 3.2. (A) Variant 1 bilobate, (B) Variant 2 bilobate, (C) Variant 3 bilobate and (D) Variant 4 bilobate.

Cross phytoliths, similar to bilobates comprise lobes connected to each other via a shank or neck. Unlike bilobates, however, cross phytoliths consist of four lobes instead of two. Generally, the lobes can be either symmetrical or irregular in shape (Rossouw 2009:47). The length and width of cross-shaped phytoliths in planar view often differ. According to Piperno (1984:362) and Pearsall (2000:384), however, the length disparity between the two can be as large as 9,16 µm and still be considered a cross phytolith. This distinction is made in order to

differentiation between bilobates, crosses or transitional phytolith forms (Piperno 1984; Pearsall 2000).

For this PhD research I used Piperno (1984) and Pearsall's (2000) cross classification system which identified eight variants of cross-shaped phytoliths. These can be differentiated from one another based on the morphological attributes observed in the planar view. Cross-shaped phytoliths can be viewed from four angles, namely dorsal and ventral as well as two side views. In side view most cross shaped phytoliths appear trapezoidal or rectangular, regardless of the variant. In planar view when the ventral side is being observed the dorsal side is observed as a shape inside the cross (Pearsall 2000).

In variant 1 crosses (see Figure 3.3) the dorsal and ventral surfaces of the phytolith are the same shape, thus when the ventral side is observed the dorsal side is visible and gives the appearance of a cross contained inside a larger cross (Piperno 1984:368). Variant 2 (see Figure 3.4), when examined, contains a vertical line across its axis, because the dorsal surface is tent-like. Variant 3 (see Figure 3.7) has four projections on the dorsal side which appear as small lines in each of the lobes when observed in planar view. Variant 4 (see Figure 3.5) has a thin rectangular dorsal side which is visible as a vertical rectangle in the centre of the cross shape. Variant 5 and 6 (see Figure 3.6) are very closely related as both have two pieces of silica protruding along the length of the phytolith. In planar view these appear as parallel lines confined to the sides of the cross shape. Variant 7 (see Figure 3.7) has a bilobate shaped dorsal surface, which appear as bilobate contained in a cross when observed in planar view. Lastly variant 8 (see Figure 3.7) has a rondel shaped dorsal side and in planar view sections of the circumference can be seen in the tips of the lobes of the cross (Piperno 1984:368-370; Pearsall 2000:387-388).

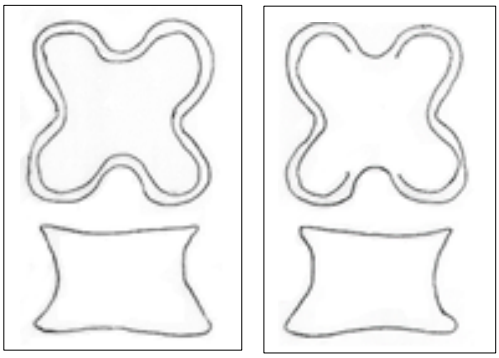

Figure 3.3. Planar and side view of variant 1 crosses (after Pearsall 2000:387).

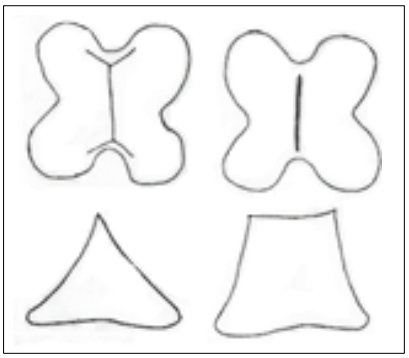

Figure 3.4. Planar and side view of variant 2 crosses (after Pearsall 2000:387).

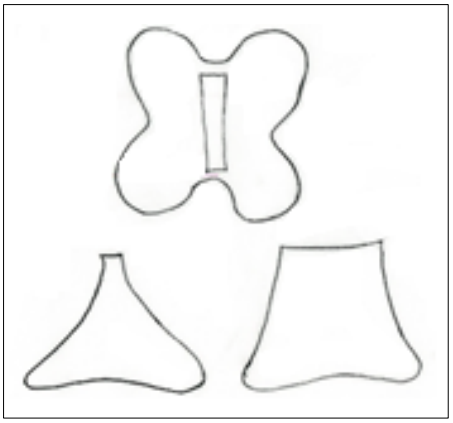

Figure 3.5. Planar and side view of variant 4 crosses (after Pearsall 2000:387).

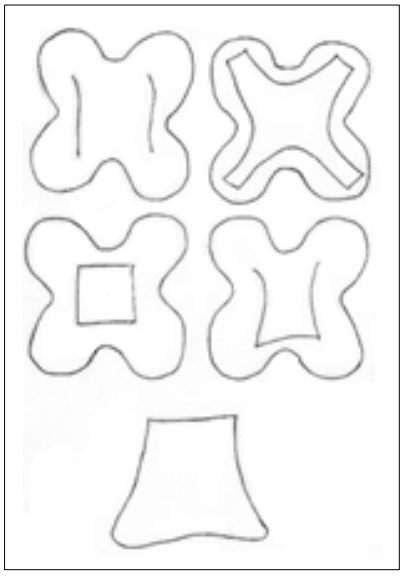

Figure 3.6. Planar and side view of variant 5/6 crosses (after Pearsall 2000:387).

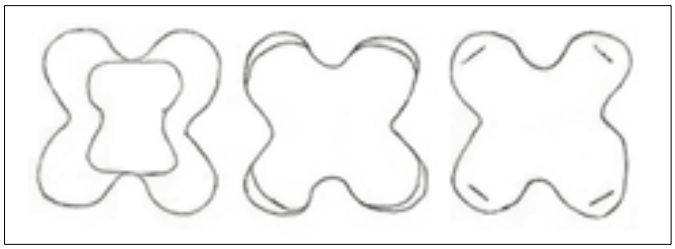

Figure 3.7. Planar and side view of variant 7, 8 and 3 crosses (after Pearsall 2000:387).

The variants of cross phytoliths are more easily distinguished from one another than the two types of saddle phytoliths that I observed. In side view both saddle variants are trapezoidal with a concave base and in planar view both have square to rectangular plateaus. The main difference between variant one (depressed) and two (elongate) saddles can be observed by looking closely at the plateau. Depressed saddles have a plateau with one or two medially constricted margins and convex sides. They are often tabular in shape (see Figure 3.8.B). Elongate saddles also have constricted margins, but there is a more pronounced difference between their length and width than depressed saddles. In some cases these phytoliths resemble bilobates with underdeveloped lobes (see Figure 3.8.A) (Thorn 2004:174; Logan 2012:101).

Unlike saddles, crosses and bilobates, few studies have documented variability in the rest the short cell phytoliths produced by Poaceae. While different polylobate morphotypes have been noted (Fahmy 2008:15), few studies make distinctions between each of the variants. Type 1 polylobates, referred to as nodular bilobates by Fahmy (2008), have three lobes, one of which is located on the shank that connects the two larger lobes (see Figure 3.9.A). Variant 2 polylobates, known as trilobates (Fahmy 2008), also have three lobes which are connected by two short shank portions (see Figure 3.9.B). Both variants are tabular in side view (Rossouw 2009:47).

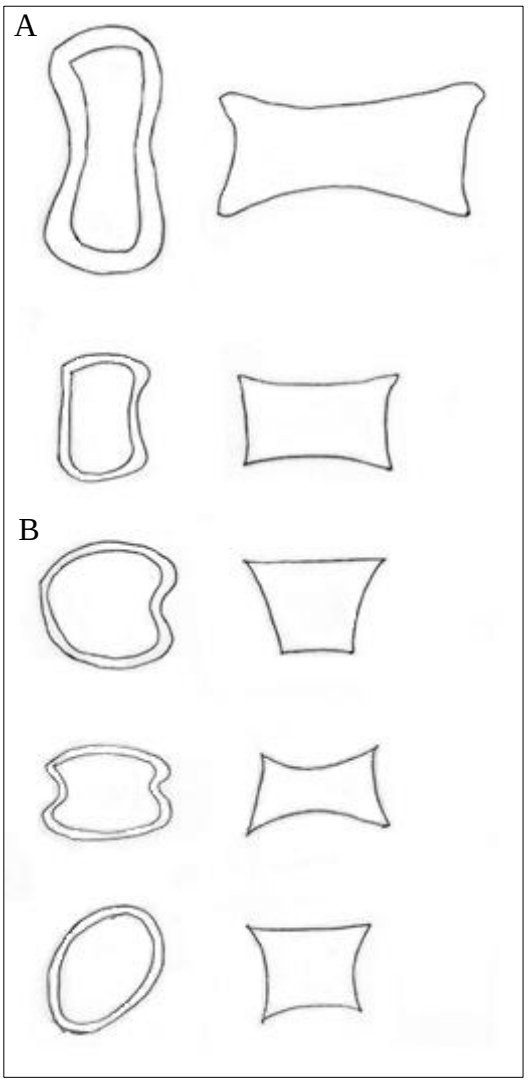

Figure 3.8. Planar and side view of elongate and depressed saddle phytoliths.

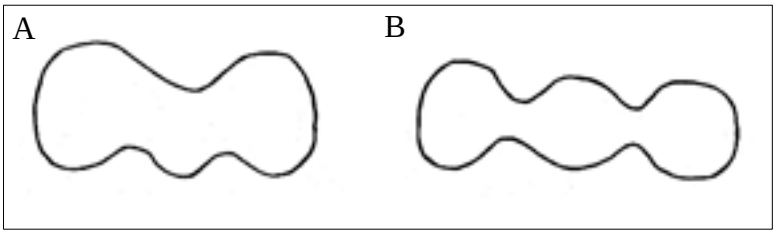

Figure 3.9. Planar view of polylobate phytoliths.

The variability of rectangular, square or trapezoid phytolith forms is not commonly noted in studies. These phytoliths can be observed from six sides and they often have parallel sides with angular margins which, unlike saddles, are not medially constricted (Rossouw 2009:49).

Rondel phytoliths appear elliptical, circular, acicular, or elongate in planar view, and often resembles a truncate cone in side view (see Figure 3.10). Rondels have distally tapered ends and are sometimes medially constricted (Fredlund & Tiezen 1994:324; Thorn 2004:174; Rossouw 2009:49). Thorn (2004) suggests that there are three different types of rondels, however, her classifications are not widely accepted.

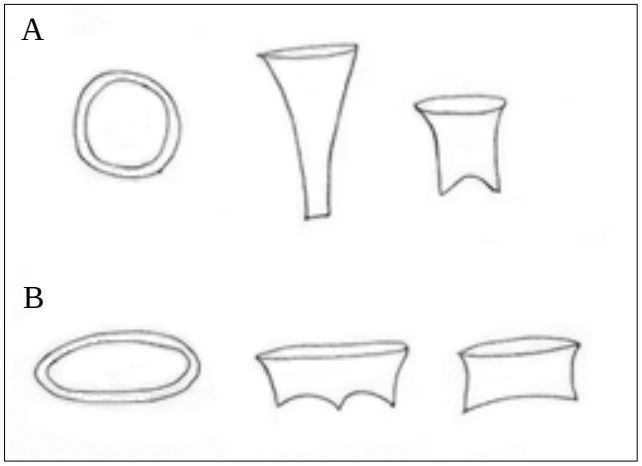

Figure 3.10. Planar and side view of round and elongate rondel phytoliths.

Oblong phytoliths similar to rectangular and square phytoliths are six-sided. They are usually twice as long as they are wide and have smooth, crenate or sinuous edges in planar view (Twiss *et al*. 1969:111; Rossouw 2009:49). Lastly, reniform phytoliths are as suggested by their name, crescent- or kidney-shaped, with rounded or angular edges and one medially constricted margin (Rossouw 2009:50).

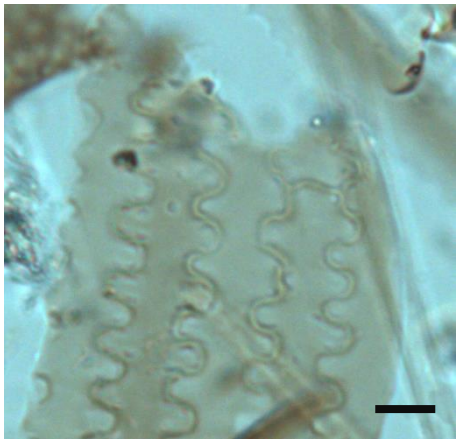

Figure 3.11. Example of sinuous long cell phytoliths (Type 1 long cells) (Scale 20 µm).

Figure 3.12. Example of dendritic long cell phytoliths (Type 2 long cells) (Scale 20 µm).

While short cell phytoliths are generally thought to be the most diagnostic phytolith morphotypes, some studies (e.g. Logan 2012) suggest that it is possible that some taxa produce distinct long cell phytoliths. Two types of long cell phytoliths were identified by Logan (2012). Variant 1 long cells occur in sheets and have sinuous edges (see Figure 3.11.), while variant 2 long cells have irregular, dendritic edges (see Figure 3.12.). Logan (2012) suggested that the latter is the most diagnostic, while the former might be redundant and occur in various taxa.

A detailed analysis of grass phytolith morphotypes has given insight into the diagnostic value of phytoliths, however, differences in naming criteria, methodologies and description styles should be addressed in order to establish a universally recognized key for distinguishing Poaceae phytoliths (Madella *et al.* 2005).

Phytoliths produced by the Poaceae domesticates chosen for this study

Eleusine coracana* subsp. *coracana

The phytoliths produced by *E. coracana* subsp. *coracana* have received very little attention (Piperno 2006:79) and, thus, it is unclear whether researchers can use them to determine crop presence at archaeological sites. Rossouw (2009:62) showed that the Chloridoideae subfamily, to which *E. coracana* subsp. *coracana* belongs, is one of the main contributors of depressed saddle phytoliths. These phytoliths are common in *E. coracana* subsp. *coracana* leaves and in planar view they can be symmetrical or asymmetrical with rounded corners, convex anterior/posterior margins and concave lateral edges (see Figure. O.3.C) (Hattingh 2014:44).

E. coracana subsp. *coracana* does not solely produce depressed saddles, it also makes elongate saddle phytoliths. These, similar to the other phytoliths produced within *E. coracana* subsp. *coracana*'s leaves, have convex anterior/posterior margins and concave lateral margins in planar view (see Figure O.4.B). In side view depressed and elongate saddles have concave plateaus and lateral edges (see Figure O.4.D). In terms of size both depressed and elongate saddles are between 10 µm and 20 µm long (Hattingh 2014:44-45). It should, however, be noted that extensive analysis of the morphometric attributes of *E. coracana* subsp. *coracana* is still needed in order to distinguish between it and wild taxa.

The phytoliths produced by the Poaceae closely related to *E. coracana* subsp. *coracana*, for example *Eleusine indica*, have received almost no attention. Jattisha and Sabu (2012) noted that *E. indica* produced a number of phytoliths in its leaves, including bilobates and saddles. *E. indica* creates variant two bilobates with concave outer margins and elongated saddles that closely resemble those made by *E. coracana* subsp. *coracana* (Jattisha & Sabu 2012:6). Unfortunately, no studies have focussed on the morphometrics of *E. indica* phytoliths, therefore it is unclear how similar they are to those produced by *E. coracana* subsp. *coracana*.

In addition to the limited number of studies done on the phytoliths produced by *E. coracana* subsp. *coracana* and its relatives' leaves, almost no studies have explored the phytoliths created within the reproductive structures of these plants. Radomski and Neumann (2011:157) noted that *E. indica* produces an abundance of saddle, rondel, hair and skeleton phytoliths, but apart from recording the rondel variants little morphometric analysis was published on these phytoliths and no research on *E. coracana* subsp. *coracana* inflorescence phytoliths is available for comparison.

Pennisetum glaucum

P. glaucum, similar to *E. coracana* subsp. *coracana*, has received little attention (Piperno 2006:79), and therefore it is unclear if the phytoliths that it produces have any diagnostic value. *P. glaucum*, a member of the Panicoideae subfamily, commonly produces bilobate and cross phytoliths within its leaves (Logan 2012:101; Hattingh 2014:47-48; Out & Madella 2015). Variant 2 bilobates are generally created in *P. glaucum*. In planar view these phytoliths have symmetrical or asymmetrical lobes which have concave outer margins (see Figure O.5.F) (Hattingh 2014:47). Hattingh (2014) noted that these phytoliths are approximately 20 µm long, but she did not do an in-depth morphometric study on them.

Out and Madella (2015), who conducted a more extensive morphometric analysis of the bilobate phytoliths produced by *P. glaucum* leaves, concluded that this domesticate cannot be distinguished from other Panicoideae based on size alone. Bilobate phytoliths are created in many grasses, therefore the chance for size overlap between species is likely. It is for this reason that Piperno and Pearsall (1993:349) advised against the use of bilobates in the identification of grasses. They suggested that cross phytoliths should rather be used and that they are perhaps easier to link to specific taxa (Piperno & Pearsall 1993:349).

P. glaucum creates variant 5/6 cross phytoliths in its leaves and they vary in size (Hattingh 2014:47). It, however, is unclear how big the size variations are among these crosses and how these influence diagnostic value. Cross phytoliths are not only produced in the crop's leaves, but also in its inflorescences along with bilobates, triangular trilobates, hair and skeleton phytoliths (Radomski and Neumann 2011:157-159). Radomski and Neumann (2011:162) noted that variant 2 crosses commonly occur in *P. glaucum*'s reproductive structures and Logan (2012:100) established that the crop creates large percentages of cross phytoliths smaller than 10 µm. She also found that bilobates and rondels, similar in size to the crosses were abundant in *P. glaucum*'s reproductive structures. She suggested that researchers might be able to use these small phytoliths to identify *P. glaucum* at archaeological sites (Logan 2012:100-101).

This theory is still untested, even though the phytoliths produced by some of the grasses closely related to *P. glaucum* have received a fair amount of attention. Fahmy (2008) and Rossouw (2009) have both conducted studies on the phytoliths made by Poaceae and have noted the size and morphology of leaf phytoliths produced by two grasses related to *P. glaucum*, namely *C. ciliaris* and *P. purpureum*. Both of these create numerous types of bilobates and crosses. Fahmy (2008:8-11) and Rossouw (2009:157) established that *C. ciliaris* produces variant 2 bilobates that can have notched, flattened or convex outer margins on its lobes (see Figure O.12.E and G). Fahmy (2008:8-11) also noted that its bilobates are generally larger than 20 µm. *P. purpureum*, similar to *C. ciliaris*, produces bilobate phytoliths with notched or rounded outer margins. These bilobates can be variant one or two and commonly range between 18 µm and 30 µm in length (Lu & Liu 2003:79-80; Fahmy 2008:10).

The crosses that *P. purpureum* creates in its leaves range between small and large (10-20 µm) (Lu & Liu 2003:13) and Piperno (1984:367) noted that the majority of these phytoliths are

variant 2 or 6 crosses. In contrast to *P. purpureum*'s large bilobates, *C. ciliaris* produces relatively small cross phytoliths which are between 10 µm and 15 µm wide (Fahmy 2008:13). It is unclear which cross variants are common in this grass, however Piperno (1984) noted that other species belonging to the genus *Cenchrus* generally create variant 1, 2, 5 and 6 cross phytoliths. It is thus possible that these types of phytoliths are also made by *C. ciliaris*.

Since both *C. ciliaris* and *P. purpureum*'s leaf phytoliths may be morphologically similar to those of *P. glaucum* it is possible that the crop's phytoliths are not distinguishable from those made by wild taxa. Researchers, however, should first combine data from morphologic and morphometric studies before ruling out the possibility of *P. glaucum* leaf phytoliths being diagnostic.

More research is also needed on the phytoliths produced in the reproductive structures of *P. glaucum* and its close relatives to establish whether they are similar. The phytoliths created in these areas of *C. ciliaris* and *P. purpureum* have received no attention and therefore it is unclear whether the phytoliths common to *P. glaucum* inflorescence can be distinguished from them.

Sorghum bicolor* subsp. *bicolor

Similar to *P. glaucum*, *S. bicolor* subsp. *bicolor* is a member of the Panicoideae subfamily, and thus produces bilobate phytoliths in its leaves. Numerous researchers (Rossouw 2009; Out & Madella 2015) have included these phytoliths in their studies. Rossouw (2009) noted that variant 2 bilobates are common in *S. bicolor* subsp. *bicolor* and that these phytoliths have ovate lobes with convex margins. Hattingh (2014) confirmed this, but she also observed that the convex lobes can have bifids or notches in them.

Bilobates make up approximately 97% of the short cell phytoliths that are formed in *S. bicolor* subsp. *bicolor* leaves (Rossouw 2009:217). Out and Madella (2015) determined that based on size alone, these phytoliths cannot be used to distinguish the crop from other domesticates such as *P. glaucum*. More research is also needed to establish whether *S. bicolor* subsp. *bicolor*'s bilobates are similar to the phytoliths made by grasses such as *Sorghum versicolor* (Hattingh 2014:49).

Rossouw (2009:154) noted that *S. versicolor* produces variant 2 bilobates, similar to *S. bicolor* subsp. *bicolor*, while Hattingh (2014:49) observed that the shape and size of *S. versicolor* phytolith's lobes varies from those observed in *S. bicolor* subsp. *bicolor*. It might

be possible to use these morphological variations to distinguish between *S. bicolor* subsp. *bicolor* and its close relatives (Hattingh 2014:49). The sample size analysed to establish these morphological differences, however, is too small to make definite conclusions about the diagnostic value of *S. bicolor* subsp. *bicolor*'s phytoliths. Furthermore, there is no published research available on the morphometrics of *S. versicolor*, making it difficult to determine whether *S. bicolor* subsp. *bicolor* can be distinguished from it based on size alone.

Research on the phytoliths formed within *S. bicolor* subsp. *bicolor*'s inflorescence has received much more attention than the phytoliths produced in its leaves. Logan (2012:99) noted that a multitude of phytoliths are created in the crop's reproductive structures, including bilobates, saddles, polylobates, rondels, long cell and hair cell phytoliths. Radomski and Neumann's (2011) investigated these phytoliths and determined the frequency at which each phytolith occurs. They established that long cell phytoliths comprise up to 36,9% of the phytoliths produced in *S. bicolor* subsp. *bicolor*'s reproductive structures (Radomski & Neumann 2011:157).

Logan (2012) identified two types of long cell phytoliths made by *S. bicolor* subsp. *bicolor*. The first type (variant 1) is heavily silicified with regular and sometimes parallel waves. It also has what appears to be a double outline (see Figure 3.10). Variant 2 long cells are dendritics which are also heavily silicified, but have no double outline and have waves which are irregularly spaced (Logan 2012:97) (see Figure 3.11). Logan (2012:97) suggests that only variant 2 long cells are diagnostic.

The width and length of the long cells produced by *S. bicolor* subsp. *bicolor* vary substantially. Logan (2012:97) observed that they have a width that ranges between 7,5 µm and 22,5 µm with waves of approximately 2,5 µm to 5 µm in height. She did not specify the length of these long cells, however judging by photographic material they can exceed 50 µm.

Long cell phytoliths might not be the only diagnostic silica bodies in *S. bicolor* subsp. *bicolor*'s reproductive structures. Radomski & Neumann (2011:159) noted complex rondels which have one bilobate and one saddle shaped side. These saddle-like rondels are approximately 12,5 µm in size and because they may be unique to *S. bicolor* subsp. *bicolor* (Logan 2012:101), Logan (2012:97) suggested using them in conjunction with long cell phytoliths to identify the domesticate in archaeological samples.

The rest of the phytoliths observed in *S. bicolor* subsp. *bicolor*'s inflorescence are of less diagnostic value, because they are common in various other grasses (Logan 2012:99),

including *Sorghum bicolor* subsp. *arundinaceum.* Bilobates, polylobates, crosses, rondels, as well as hair cell phytoliths were also noted in *S. bicolor* subsp. *arundinaceum*'s inflorescence (Radomski & Neumann 2011:157-158). Radomski and Neumann (2011:159) noted the frequency at which each phytolith type occurs in *S. bicolor* subsp. *arundinaceum*, as well as the variants of each short cell phytolith type. They indicated that, for the most part, *S. bicolor* subsp. *bicolor* and *S. bicolor* subsp. *arundinaceum* create similar phytolith variants. They, however, did not do an in-depth morphological or morphometric analysis of each phytolith type. It, therefore is unclear whether there is an overlap between the phytoliths created by *S. bicolor* subsp. *bicolor* and *S. bicolor* subsp. *arundinaceum* (Radomski & Neumann 2011:159).

In addition to the lack of available information on *S. bicolor* subsp. *arundinaceum* phytoliths, there is also no research to consult on the phytoliths made within *S. versicolor*'s or *S. bicolor subsp. drummondii*'s reproductive structures. Thus it is impossible to know the exact diagnostic value of *S. bicolor* subsp. *bicolor*'s inflorescence phytoliths.

Zea mays

Unlike some of the crops mentioned above, *Z. mays* phytoliths have received large amounts of attention. An in-depth study of the morphology of cross-shaped phytoliths have enabled researchers (see e.g. Piperno 1984, 2006; Pearsall 2000) to establish a regional key with which it can be identified at South American archaeological sites (Piperno 2006; Pearsall 2000). *Z. mays* belongs to the Panicoideae subfamily and thus produces cross, bilobate and polylobate phytoliths, as well as undiagnostic epidermal long cell phytoliths, bulliforms and hair cell phytoliths (Pearsall 1982; Piperno 1984).

Pearsall (1978) and Piperno (1979, 1984) were two of the pioneering researchers to investigate the phytoliths formed by *Z. mays*. They established that the cross-shaped phytoliths created within *Z. mays* leaves, as well as some of the rondels formed in *Z. mays* cobs are diagnostic. A number of grasses which are closely related to *Z. mays*, including *Zea mays* subsp. *parviglumis* (teosinte), *Z. mays* subsp. *mexicana* and *Tripsacum dactyloides*, also produce cross phytoliths (Piperno 1984).

Pearsall (1978) and Piperno (1979, 1984) showed that *Z. mays* crosses could, in some instances, be differentiated from the crosses made by wild South American Poaceae based on size alone. Their studies investigated the phytoliths formed by approximately 350 species of

grasses and determined that up to 33% of the crosses made by *Z. mays* can be classified as large (16,03-20,56µm) and extra-large (20,61-25,19µm), while wild taxa commonly produce small (6,87-11,4µm) or medium (11,45-15,98µm) cross phytoliths. There, however, are some Bambusoideae and Panicoideae that create an abundance of large and extra-large crosses (Pearsall 2000; Piperno 1984, 2006). It is therefore important to combine size and morphological attributes in order to correctly identify *Z. mays* in archaeological samples (Pearsall & Piperno 1990:329).

Z. mays mostly produces variant 1 cross phytoliths, which are not created in large numbers by wild grasses (Piperno 1998:407). Piperno (1984) showed that various wild taxa associated with *Z. mays* create more than one type of cross variant. She indicated that variant 2 and 6 are abundant in *Z. mays'* wild progenitor teosinte, as well as other grasses belonging to the genus *Zea*. Species which make large and extra-large crosses, for example *Oplismenus hirtellus*, *Pennisetum setosum* and *Cenchrus echinatus*, were also shown to produce high frequencies of variant 2 and 6 crosses which enables researchers to differentiate between them and *Z. mays* (Piperno 1984:370).

Though cross-shaped phytoliths are abundant in *Z. mays*, they are not the only phytolith produced within the domesticate's leaves. Many researchers (see e.g. Piperno 1984; Russ & Rovner 1989; Pearsall 2000) have noted that bilobate phytoliths are also common in *Z. mays*. Published information available on these bilobates is, however, limited and few researchers have adequately analysed them.

Piperno (1984:371) noted that *Z. mays* creates variant 1 bilobates, i.e. bilobates which structurally resemble variant 1 crosses. She also indicated that they occur in a much lower frequency in *Z. mays* than crosses, as opposed to wild taxa where they are more common than cross-shaped phytoliths (Piperno 1984:362). Piperno (1984) suggested that *Z. mays* could, on the basis of its high ratios of cross 1 phytoliths, be distinguished from its wild progenitor teosinte which produces high ratios of variant 2 and 6 phytoliths. She, however, noted that some Bambusoid taxa have similar cross 1 to bilobate ratios and while it is important to note the ratios in which phytoliths occur in *Z. mays*, this information alone is not enough to establish the crop's presence at sites.

In addition, Piperno and Pearsall (1993) advised against the use of bilobates as a proxy for *Z. mays*. Bilobates are common in wild grasses and there is a possibility of a size and shape overlap between wild taxa and *Z. mays* (Piperno & Pearsall 1993:349). The lack of available

information on bilobate phytoliths, however, unfortunately limits our understanding of their diagnostic value and more research is needed to exclude the possibility of them being used as a proxy for *Z. mays*.

Unlike bilobates there is a wealth of information available on the rondel phytoliths produced in *Z. mays* inflorescence. Pearsall (2003) identified several types of rondels produced in *Z. mays* cobs and described them as 'wavy-top', 'ruffle' or 'spooled' rondels because of their characteristic shape (Pearsall *et al.* 2003:613). Most of them have two ovate or orbicular faces connected by a shank, which may vary in length and width and could taper to one end (Piperno 2006:64). The majority of these rondels are not decorated, however, those that are have jagged, 'saw tooth' or sinuate edges (Pearsall *et al.* 2003:613; Piperno 2006:64) (see Figure O.9.K-P).

Z. mays rondels are easily distinguishable from the phytoliths made in the reproductive structures of closely related plants such as *Tripsacum* and teosinte (Piperno 2006:63). Rondel phytoliths are generally dominant in *Z. mays* cobs and fruit cases (Dorweiler & Doebley 1997:1317-1318). *Tripsacum* and teosinte, however, not only create rondel phytoliths in their reproductive structures, but also produce characteristic long cell phytoliths, as well as crosses (Piperno & Pearsall 1993:351).

Tripsacum generally produces elongate phytoliths which are diagnostic to a genus level. These phytoliths have a square or rectangular outline, with serrated edges and ridges which are visible in the planar view. *Tripsacum* also creates cross phytoliths in its reproductive structures which closely resemble those produced in *Z. mays* leaves. In order to determine whether the crosses in a sample were deposited by *Tripsacum* researchers should first establish whether the unique elongate phytoliths are present, because neither will appear in a sample without the other (Piperno 2006:64).

Similar to *Tripsacum*, teosinte also creates large numbers of long cell phytoliths. These phytoliths range from rectangular to trapezoidal in shape, have irregular margins and are commonly decorated with protuberances which are knob-shaped. The rondels found in tesosinte's reproductive structures are also highly decorated. They, like the *Z. mays* rondels, have two circular faces which are connected by a shank. The two faces are usually similar in size and in planar view the larger of the two faces sports a sinuous or undulating outer margin (Piperno & Pearsall 1993; Piperno 2006:63).

Teosinte and *Z. mays* rondels are morphologically distinct enough to differentiate between them and other closely related South American grasses (Piperno & Pearsall 1993). The phytoliths produced by the Poaceae which commonly occur in southern Africa have, however, not been compared to those produced within *Z. mays*. Thus, more research is required in order to establish whether *Z. mays* phytoliths are distinct enough to be used as a proxy for crop usage at southern African archaeological sites.

Phytoliths produced by the Fabaceae domesticates chosen for this study

Arachis hypogaea

While researchers' main focus has been on crops belonging to the Poaceae family; that does not mean that plants belonging to other families have received no attention. Numerous studies have investigated the phytoliths created by domesticates such as *Musa* spp. (banana and plantains) (Tomlinson 1969; Lentfer 2003), *Maranta arudinacea* (arrowroot) (Tomlinson 1969; Piperno 2006) and *Cucurbita spp.* (squashes) (Bozarth 1987, 1992; Piperno 1989). *Arachis hypogaea* (peanuts), though not as thoroughly investigated, has also featured in a number of studies (see Piperno 2006).

The Fabaceae family, to which *A. hypogaea* belongs, is one of the families in which phytolith production varies substantially (Piperno 2006:7). Piperno (1991:159; 2006:48) noted that while *A. hypogaea* produces phytoliths, they are of little taxonomic value and therefore they are not good indicators of crop presence at archaeological sites. The crop mostly creates polyhedral epidermis phytoliths (Piperno 2006:48), as well as fibrous mesh phytoliths in its pods (Chandler-Ezell 2006:105; Pearsall 2015) (see Figure O.11.A). Chandler-Ezell (2006:107) pointed out that silica is also present in *A. hypogaea* seeds, but these phytoliths are not diagnostic.

Although numerous studies (e.g. Bozarth 1992; Cummings 1992; Chandler-Ezell 2006) have focussed on the phytolith production of plants belonging to Fabaceae, there is no readily available research for the wild progenitors of *A. hypogaea* or the plants closely related to the crop.

Vigna subterranea

No published research has focussed on the phytoliths produced by *Vigna subterranea*, however, several researchers (see e.g. Bozarth 1992; Cummings 1989, 1992) have looked at the phytoliths made by other members of the Fabaceae family, including taxa belonging to the genus *Vigna*.

Some species belonging to the genus Fabaceae create polyhedral to circular shaped phytoliths that are sometimes arranged to resemble honeycombs (Bozarth 1992:195-203; Cummings 1992:181-185). Each phytolith is approximately 5 to 20 microns in size. Some structures including tracheids, stomata and epidermal cells are also silicified (Bozarth 1992:195-203). Cummings (1992:185) noted that hair cell phytoliths with ovoid or orbicular bases are also present in some taxa belonging to the genus *Vigna* (see Figure O.11.C-F.). No morphometric analysis was done on the phytoliths of the plants that formed part of Bozarth (1992) and Cumming's (1992) studies, thus there is no clear indication of whether there are any differences between the phytoliths formed by domesticates or non-domesticates. *Vigna subterranea*, as well as the plants closely related to it, could produce any of the above mentioned phytoliths.

Vigna unguiculata* subsp. *unguiculata

Similar to *V. subterranea*, almost no research is available on *V. unguiculata* subsp. *unguiculata*. Hattingh (2014:50-51) noted that silicified stomata and epidermal cells are formed in *V. unguiculata* subsp. *unguiculata*'s leaves and stems. She indicated that they are on average larger than 20 µm, but she did not do a more in-depth morphometric analysis. Both the stomata and the epidermal cells are irregularly shaped and are commonly articulated. She also established that trichome base phytoliths are produced by *V. unguiculata* subsp. *unguiculata*. They have an orbicular centre with a segmented outer layer and acute protrusions (Hattingh 2014:50-51) (see Figure O.11.G-J). Orbicular phytoliths in a honeycomb arrangement was also noted (Hattingh, pers. notes).

No readily accessible information on the phytoliths produced by *V. unguiculata* subsp. *unguiculata*'s close relative is available. It is therefore unclear whether its phytoliths are diagnostic.

Conclusion

The phytoliths of African crops have not received as much attention as plants domesticated in Asian, such as *Oryza sativa* (Asian rice) and *Musa* spp. or South American domesticates such *Zea mays* (Maize) and *Cucurbita* spp. (squashes). The extent to which phytoliths can be used to establish African crop presence and use at archaeological sites is therefore limited. In the last decade more researchers have focussed on African crops, such as *S. bicolor* subsp. *bicolor*, which has provided valuable information which can lead to crop identification keys. There are, however, still large gaps in our understanding of the processes that govern phytolith formation and preservation that need to be addressed in order to get a firm grasp on the limitations and potential of phytolith analysis.

CHAPTER 4: METHODS AND METHODOLOGY

Introduction

Early, Middle and Later Farming Communities cultivated a number of different crops including *A. hypogaea*, *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor*, *V. subterranea*, *V. unguiculata* subsp. *unguiculata* and *Z. mays* (Davies 1975; Maggs 1980; Greenfield et al. 2005).

The object of this study is to determine whether these crops produce phytoliths that can be distinguished from those created by closely related wild taxa in southern Africa. It is also my aim to establish if the phytoliths found in different varieties of each species are unique and whether the phytoliths of plants at different growth stages are diagnostic.

In this chapter I discuss the criteria used to select the different varieties of each species, the methods employed to cultivate each crop, as well as the procedures followed to extract and analyse phytoliths from each plant.

Crop selection criteria

Table 4.1. Taxonomic information of the domesticate plants chosen for cultivation at the Bokoni Farmscapes Experimental Farm (Valizadeh 2001; Rossouw 2009).

Domesticated plants	Taxonomic classification: Subfamily	Taxonomic classification: Tribe	Taxonomic classification: Genus
Eleusine coracana subsp. *coracana*	Chloridoideae	Cynodonteae	Eleusine
Pennisetum glaucum	Panicoideae	Paniceae	Pennisetum
Sorghum bicolor subsp. *bicolor*	Panicoideae	Andropogoneae	Sorghum
Zea Mays	Panicoideae	Andropogoneae	Zea
Arachis hypogaea	*Faboideae*	Aeschynomeneae	Arachis
Vigna subterranea	*Faboideae*	*Phaseoleae*	Vigna
Vigna unguiculata subsp. *unguiculata*	*Faboideae*	*Phaseoleae*	Vigna

One of the most important aspects of this project involved the selection of crops for cultivation and analysis. Precolonial farming communities had access to various domesticated plants which included taxa from the Cucurbitaceae, Fabaceae and Poaceae families, among others. For this project I chose to examine the phytoliths from the domesticated taxa commonly associated with precolonial archaeological sites in southern Africa. This included crops such as *A. hypogaea*, *E. coracana* subsp. *coracana*, *P. glaucum*,

S. bicolor subsp. *bicolor*, *V. subterranea*, *V. unguiculata* subsp. *unguiculata* and *Z. mays* (Table 4.1).

Hundreds of different varieties of each of these domesticates are currently available (see Chapter 2), many of which are genetically modified or hybrid types used by commercial farmers. Heirloom[1] and non-genetically modified crops are still available, however, they are becoming increasingly rare.

Certain varieties of crops are adapted to different environmental conditions, e.g. high or low rainfall, infertile soils and short or long day length. Although many of these share the same physiology, there are types which differ greatly from each other in terms of colour, size and physical characteristics (see examples National Research Council 1996, 2006, 2008). These differences may not only be limited to physical features and it is possible that each variant creates distinct cells and, thus, unique phytoliths.

In order to establish whether different varieties produce different phytoliths, I had to procure several types of each crop. Due to time constraints I chose to collect no more than three varieties. The majority of the crops cultivated by commercial farmers are genetically modified (non-GMO) or hybrid taxa from commercial seed companies (Starke Ayres 2017; Pannar 2017). It is highly unlikely that precolonial farming communities in southern Africa had access to these types of plants (Then 2013:10). Thus, I chose to only collect the most popular heirloom ad non-GMO varieties from local communities and companies.

My aim was to grow the varieties that physically differ from each other the most in order to improve my chances of finding possible morphological differences among the phytoliths produced by each crop variety.

Crop cultivation methods

The seeds acquired for my study were grown at the Bokoni Farmscapes Experimental Garden situated on the Kranskloof farm in the Carolina district. A maximum of ten seeds of each variant was planted to ensure that there was enough space to cultivate multiple species during a growing season without negatively impacting the development of any of the plants.

[1] For the purposes of this study 'Heirloom crops' are defined as varieties of domesticated taxa which have been handed down from generation to generation and were not originally cultivated or bred from GMO or hybrid taxa (Livingseeds 2017).

The majority of the species chosen for cultivation were annual plants, which can only be grown during the summer months. In order for seeds to germinate soil moisture levels had to be optimum. In southern Africa the first summer rains appear between August and December and crops were planted during this period (see Tables M.1 and M.2). Regional temperatures were also monitored and seeds were only sown when temperatures were high enough to enable unobstructed germination and growth. Many of the different domesticate varieties were planted simultaneously in order to ensure that they received exposure to the same environmental conditions. Care was, however taken to ensure that cross pollination did not occur. This ensured that the seeds that were formed were not hybrids in case more study material was needed.

Careful records were kept of the daily rainfall, the watering regiment and regional temperatures (see Appendix M) in order to determine whether deviations in phytolith size and morphology were due to environmental factors, e.g. the amount of water, received by taxa (cf. Jenkins *et al.* 2011), or plant physiology.

Specimens of each plant were harvested at various growth stages. Stage 1 was right after the first true leaves developed, namely 1-2 weeks after germination. The second stage at which the domesticates were collected was at approximately 1 month after germination, thus before seeds/fruit formed. The last stage was after the seeds/fruit were fully developed.

Phytolith extraction and analysis procedures

For the purposes of this study entire plant specimen were used. Ball *et al.* (2015) showed that there is some variance between the phytoliths produced in different areas of plant sections. In an archaeological context, however, plants decay as a whole and phytoliths from different areas of a plant organ are mixed (Piperno 2006). Thus, in order to produce data that can be used to determine if phytoliths are a reliable proxy for domesticated plants at southern African archaeological sites, I chose to not sample specific areas of each plant section.

Approximately two hundred grams of each sample was sorted into leaves, stems, inflorescence, roots and seeds. Each plant section was rinsed with distilled water before being washed in an ultrasonic cleaner for an hour. After the samples were cleaned they were dried in an oven at 50℃ and stored until they could be processed further.

In order to extract phytoliths from plant material I had to effectively eliminate all organic material that could obscure phytoliths during analysis. Wet ashing (wet oxidation), as well as

dry ashing is commonly used to remove organic matter (Parr *et al.* 2001a). Wet ashing involves the use of chemicals, for example nitric acid (HNO_3), potassium chloride (KCl_3) and hydrogen peroxide (H_2O_2) (Rovner 1972:591; Rovner 1983:238), in order to get rid of unwanted plant material. This method is quick, however some chemical solutions require constant supervision and regular stirring to prevent the chemicals spilling out of the containers and the samples possibly getting contaminated. In some cases, for the method to work effectively the sample and the chemicals it is immersed in needs to be heated. Wet ashing has been proven efficient, however, some plants resist the process and require the procedure to be repeated multiple times, which can make it costly (Parr *et al.* 2001b:203-204).

Dry ashing, on the other hand, is a time consuming technique, which requires several hours to complete. Samples are placed in a furnace at 500℃ for approximately 8 hours in order to remove organic material. One of the advantages of using this method is that it does not require constant monitoring, however, there is a higher risk of samples becoming contaminated during the process than there is with wet ashing. While the majority of organic residue can be eliminated by using this method unwanted elements, such as phosphates, might require researchers to use chemicals for cleaner samples (Parr *et al.* 2001a:877; Parr *et al.* 2001b:204).

For the purposes of my study I used dry ashing, because it enabled me to process more material at a time without constantly having to supervise samples. Plant samples were wedged between two microscope slides, which were wrapped in aluminium foil in order to eliminate the chance of contamination. At 600℃ phytolith morphology and size starts to change (cf. Piperno 2006:97), thus care was taken to ensure that temperatures did not exceed 500℃ while plant samples were burned.

Most of the samples I processed did not require the use of chemicals, because very little organic and mineral components remained after ashing. When further treatment was, however, required I used the standard laboratory techniques described in Albert *et al*. (1999), which aided in the removal of the residual organic matter as well as other unwanted agents. The methods employed by Albert *et al.* (1999) were chosen above those used by Sjöström (2013) and Piperno (2006), because they were less time consuming and the combination of chemicals, though different than those employed by Sjöström (2013) and Piperno (2006), proved to be effective enough to provide clear samples.

The first step to the Albert *et al.* (1999) method required the elimination of carbonates and phosphates. I added a 10 ml solution of 3N HCl and 3N $HN0_3$ to 1 gram of burned sample and heated it at 70℃ for half an hour. The mixture was then left to cool and centrifuged at 3000 rpm for 5 minutes before being rinsed three times with distilled water. The next step was to remove any organic material not destroyed during burning. I used 10ml of 30% hydrogen peroxide (H_2O_2) and heated the solution to 70℃ until the reaction stopped (cf. Albert *et al.* 1999:1252; Bamford *et al*. 2006:3). After the sample was thoroughly rinsed and the excess water was decanted, it was left to dry.

Slides were prepared by placing 1 mg of dried, processed material onto a microscope slide and adding three drops of Entellan New (Merck) before placing a cover slide over the suspension. Phytoliths were analysed with an Olympus BX51 microscope at 400x and 1000x magnification under polarized light (cf. Albert *et al.* 1999; Mercader *et al.* 2009), and I used a ColorView Soft Imaging System, an AxioCam ICc 1 camera, and Analysis™ software to take photographs.

For the purposes of this study I performed a 200 particle count in order to obtain an accurate representation of the phytoliths commonly produced by each species (cf. Piperno 2006:115). A 200 particle count is a time saving and effective method and the data collected using this technique has been proven to be statistically accurate (cf. Piperno 2006:115). Since some plants, such as Poaceae, produce a whole suite of phytoliths, all the phytoliths encountered including highly redundant forms such as epidermal long cells were included in the count (cf. Carnelli *et al.* 2002:346).

Scanning took place in a linear fashion, from left to right and careful records were kept of the morphological attributes of the phytoliths encountered during the analysis. Where applicable, phytolith descriptions and illustrations adhered to the standards set by Madella *et al.* (2005).

For the purposes of this study width and length measurements were obtained from the phytoliths which were most frequently encountered in each sample (see Figure 4.1.). In Poaceae samples this included a selection of short cell and long cell phytoliths, while in Fabaceae rhomboidal phytoliths were measured. It should be noted that a more thorough examination of other morphometric attributes, for example surface area and circumference, could have added vital information to this study. These measurements could also prove more diagnostic than simple linear measurements. However, time constraints of a PhD thesis had to be considered. Thus, only simple linear measurements were conducted.

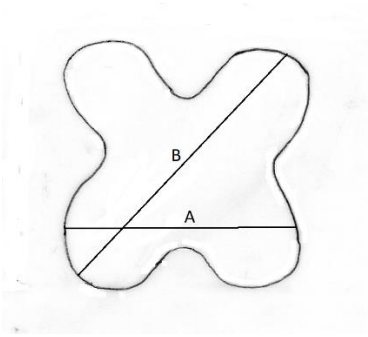

Figure 4.1. Illustration of how phytoliths were measured: (A) Width measurement. (B) Length measurement.

The majority of studies which have focussed on phytolith morphometrics (see e.g. Pearsall 1978, 2000; Piperno 1984) concentrated on measurements taken from the planar view of the phytoliths. My measurements were also taken when phytoliths were positioned in the planar view, thus enabling me to compare the data collected during my study with the data from previous research projects.

In order to determine the number of phytoliths that needed to be measured to obtain a statistically relevant sample I used the following calculation obtained from Out and Madella (2015) and Ball *et al.* (2016) (see Appendix P):

$$n_{min} = Z^2_{\alpha/2} S^2/(ME)^2$$

The minimum adequate sample = n_{min} with the value of $Z^2_{\alpha/2}$ being 1,64. The variance is represented by S^2 and $(ME)^2$ stands for the margin of error (Madella *et al.* 2005:254; Out and Madella 2015; Ball *et al.* 2016).

The phytolith morphology, as well as length and width measurements of each adult specimen were compared with those from other varieties of the same domesticate to establish whether they were different form each other. Furthermore, phytoliths from juvenile plants and wild taxa were compared to the phytoliths of mature specimens to gauge if there were difference between them. Anova (Analysis of variance) was used to test if the differences between the means of sample sets were statistically relevant and boxplots were used to give a visual representation of differences in phytolith sizes between sample sets.

Wild taxa

Table 4.2. Taxonomic information of the wild taxa chosen for this study *(*Germishuizen and Meyer 2003; Rossouw 2009; Fish *et al*. 2015).

Taxa	Taxonomic classification: Subfamily	Taxonomic classification: Tribe	Taxonomic classification: Genus	Collection information
C. ciliaris	Panicoideae	Paniceae	Cenchrus	L. Smook 002822
D. ciliaris	Panicoideae	Paniceae	Digitaria	L. Smook 4400
E. coracana subsp. africana	Chloridoideae	Cynodonteae	Eleusine	G. Hemm 377
E. indica	Chloridoideae	Cynodonteae	Eleusine	C.J. Ward 11966
E. multiflora	Chloridoideae	Cynodonteae	Eleusine	L. Smook 6359
E. tristachya	Chloridoideae	Cynodonteae	Eleusine	J.P.H. Accocks 23824
P. purpureum	Panicoideae	Paniceae	Pennisetum	Brynard and Pienaar 4249
S. bicolor subsp. arundinaceum	Panicoideae	Andropogoneae	Sorghum	G.J. Bredenkamp 486
S. bicolor subsp. drummondii	Panicoideae	Andropogoneae	Sorghum	W. Ellery 279
S. halepense	Panicoideae	Andropogoneae	Sorghum	Ellis 4429
S. versicolor	Panicoideae	Andropogoneae	Sorghum	R.G. Strey 5657

In Chapter 2, I identified the wild Poaceae genetically related to the domesticated taxa commonly cultivated by precolonial farming communities in southern Africa (cf. Global Crop Diversity Trust 2013). Since data from my study will mostly be applied to determine crop usage at southern African sites, I decided to acquire and analyse only Poaceae species that commonly occur in the area.

The wild specimens that were processed for this project were collected from the South African National Biodiversity Institute (SANBI) in Pretoria and the C.E Moss herbarium located on the east campus of the University of the Witwatersrand (Table 4.2). These plant sections were the only ones obtained, because phytoliths with diagnostic value mostly occur in leaves and inflorescences.

Herbarium specimens were chosen for sampling for several reasons. Firstly, due to drought and severe overgrazing in the areas of southern Africa where a number of these grasses generally occur, it was not possible to collect the taxa from natural sources. Secondly, by using herbarium specimens the possibility of misidentification was eliminated. Thirdly, time constraints prevented me from collecting taxa from the usual sources, i.e. in the field.

In addition to the Poaceae specimens, I also identified several Fabaceae species related to *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*. Most of these are not

common in southern Africa, but some, for example, *Vigna unguiculata* subsp. *stenophylla* and *Vigna unguiculata subsp. dekindtiana var. huillensis*, occur in the region (Nkonki & Swelankomo 2003:557). A preliminary investigation of *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata* samples revealed that they produce similar phytolith morphotypes. These phytoliths are redundant and of no diagnostic value. It ,therefore, was deemed unnecessary to collect the wild taxa related to these plants.

Conclusion

Numerous methods are currently used to extract and analyse phytoliths. The methods employed during this project have all been extensively tested and have proved to be effective when processing and analysing samples. The crops and closely related taxa used in this study were all specifically chosen in order to create a reference collection which researchers would be able to employ at southern African archaeological sites. More in-depth research, however, is needed to establish whether the data from this study can be used at sites in other regions.

CHAPTER 5: RESULTS

Introduction

In the previous chapters I identified the domesticated plants that commonly occurred at precolonial southern African sites. I also discussed the phytolith research conducted on each of those crops, along with the factors that influence phytolith formation and distribution within plants. Two to three varieties of each crop were cultivated and each plant was harvested at three different growth stages (Table M.1-M.2). The results of the analyses done on all these samples are discussed in this chapter. I also present the results of the examinations done on the indigenous plants chosen for this study.

Firstly, information is given on the phytoliths which were observed in each plant species. Two diagnostic counts were completed for each of the plant sections analysed in Poaceae. The first count included all the phytoliths encountered during analysis. During the second count, I noted only the short cell phytoliths. One phytolith count was performed for the Fabaceae taxa and all the phytolith morphotypes encountered were recorded. It included all the morphotypes observed. I also present the data obtained on the length and width of a number of short and long cell phytoliths that were encountered in the samples.

Domesticated plants: Poaceae

Eleusine coracana subsp. *coracana*

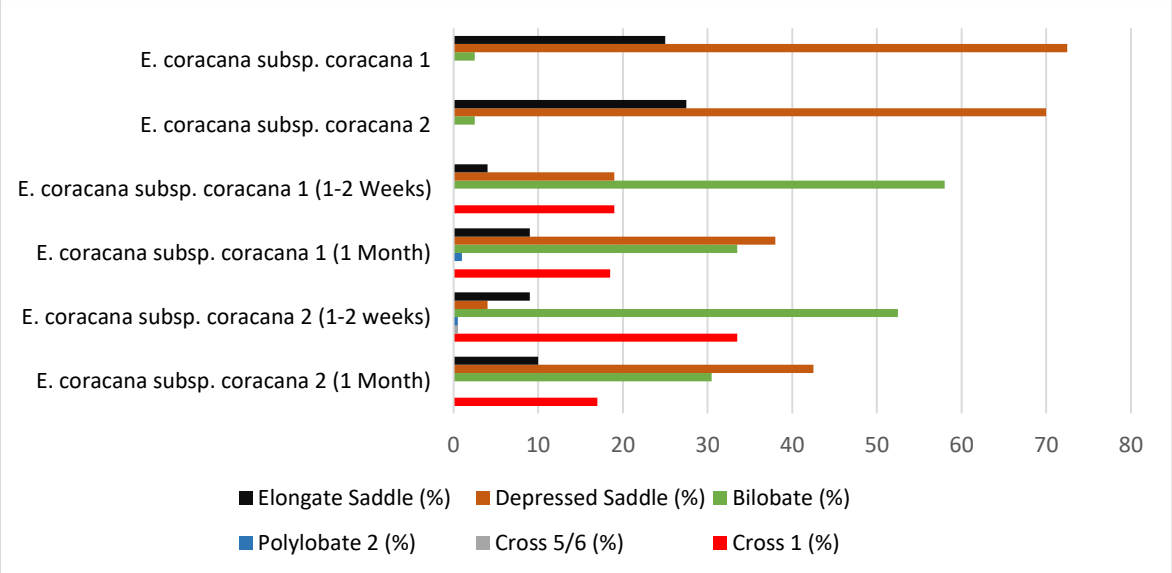

Figure 5.1. Percentages of short cell phytolith morphotypes observed in *mature E. coracana* subsp. *coracana* leaf samples and juvenile *E. coracana* subsp. *coracana* specimens.

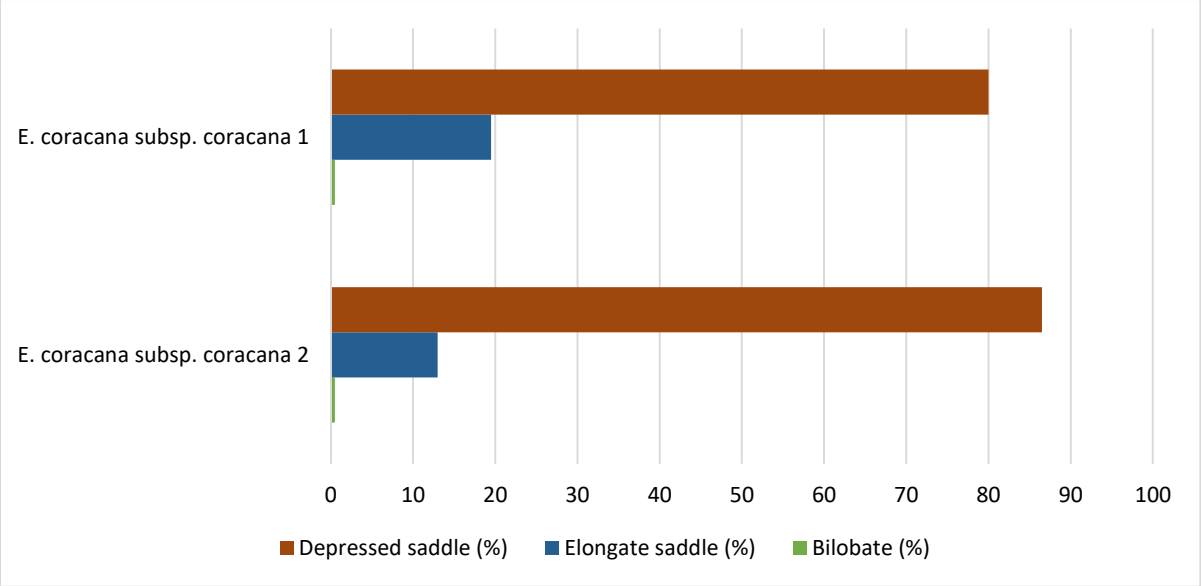

Figure 5.2. Percentages of short cell phytolith morphotypes observed in *E. coracana* subsp. *coracana* inflorescences samples.

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Short cell phytoliths were dominant in both variant's leaves. Sixty-nine percent (69%) of the phytoliths observed in *E. coracana* subsp. *coracana* 1 and 67,5% of those from *E. coracana* subsp. *coracana* 2 were short cells. Moderate numbers of epidermal cell phytoliths were also observed. Seventeen-and-a-half percent (17,5%) of variety 1 and 12% of variety 2 phytoliths comprised them. The number of hair cell phytoliths varied between the two samples. They were rare in variety 1 *E. coracana* subsp. *coracana* (7%), but common in variety 2 (14,5%). Papillae, bulliforms and hair cell mesophyll phytoliths were rare in both varieties and each phytolith morphotypes accounted for less than 5% of the samples (Figure O.4.A). Stomata phytoliths were absent in all leaf samples (see Table E.1).

Saddles, as well as bilobate phytoliths formed part of the short cell assemblage (see Figure 5.1, Table E.2.). Seventy-two-and-a-half percent (72,5%) of the phytoliths from variety 1 were depressed saddles and 25% were elongate saddles. In variety 2, 70% of the short cells were depressed saddles and 27,5% were elongate saddles. Length and width measurements were obtained for both types of saddle phytoliths. Bilobates were rare and too few were encountered for measurements of a statistically relevant sample (see Table G.1 to Table G.4) (Figure O.4.B-D).

Inflorescence phytoliths

The majority of the phytoliths encountered in the inflorescence samples were short cells (55% of variety 2 and 59% of variety 2). Epidermal and hair cells were common. Twelve-and-a-half percent (12,5%) of variety 1 and 15,5% of variety 2 comprised hair cell phytoliths. Seventeen-and-a-half percent (17,5%) of the *E. coracana* subsp. *coracana* 1 sample and 15,5% of the *E. coracana* subsp. *coracana* 2 assemblage were epidermal phytoliths. Up to 8,5% of variety 1 and 5,5% of variety 2 samples were made up of hair cell mesophyll phytoliths. Epidermal long cells (5,5% of variety 1 and 2% of variety 2) and bulliform phytoliths (less than 2% of both samples) were rare in both varieties (Figure O.3.A-C). Papillae were absent from *E. coracana* subsp. *coracana* 1 and rare in *E. coracana* subsp. *coracana* 2 (1% of the assemblage) (see Table E.3).

In a short cell count, depressed saddles were dominant in both samples. Eighty percent (80%) of variety 1 samples and 86,5% of the variety 2 assemblage were comprised of them. Elongate saddles were also present in moderate numbers in *E. coracana* subsp. *coracana* 1 (19,5%) and 2 (13,5%) (Figure O.3.D). Bilobates were rare (less than 1% of both varieties samples) (see Figure 5.2 and Table E.4), consequently measurements were only obtained for the saddle phytoliths (see Table G.1 to Table G.4).

Phytoliths from the seeds, stems and roots

A small number of epidermal cell, bulliform and stomata phytoliths were noted during the analysis of the stems samples (Figure O.3.E-F.). No short cell phytoliths were noted in the stems, roots or seeds.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

Short cell phytoliths were dominant in both varieties of *E. coracana* subsp. *coracana*, with 88,5% of the variety 1 sample and 77,5% of variety two assemblage being composed of them. In addition small numbers of hair cell phytoliths (9% of the sample), as well as hair cell mesophyll, epidermal cell, epidermal long cell and bulliform phytoliths (less than 1% of the total assemblage) were observed in variety 1. In *E. coracana* subsp. *coracana* 2 hair cell

phytoliths were common (11% of the sample) and low numbers of epidermal cells (9% of the phytoliths observed) and stomata (2,5% of the sample) were encountered (see Table E.9).

The short cells observed in the 1-2 weeks samples, included bilobates, cross 1 and 5/6 phytoliths, depressed and elongate saddles and polylobate 2 phytoliths. A short cell count revealed that in variety 1 *E. coracana* subsp. *coracana* bilobates were dominant (58% of the assemblage) (Figure O.4. E). Only variant 2 and 3 bilobates were observed (see Table E.12 and Table E.17). Depressed saddles (19% of the sample) and cross 1 phytoliths (19% of the phytoliths) were present in moderate numbers and elongate saddles were rare (4% of the assemblage) (see Table E.10).

In variety 2, bilobates were also dominant (52,5% of the sample), while cross 1 phytoliths were common (33,5% of the phytoliths) and elongate (9% of the sample) and depressed saddles (4% of the assemblage), as well as polylobate 2 and cross 5/6 phytoliths (0,5% each) were rare (see Table E.10 and Figure 5.1). All bilobate variants were encountered during analysis and various different lobe shapes were noted (see Table E.12 and Table E.17). Length and width measurements were obtained for cross 1, bilobate and elongate saddles from both samples. Data were also obtained for the depressed saddles from *E. coracana* subsp. *coracana* 1 (see Table G.5 to Table G.8).

Phytoliths from specimens harvested at 1 month

The most frequently observed phytoliths in both *E. coracana* subsp. *coracana* samples were short cells. Eighty-four-and-a-half percent (84,5%) of the phytoliths from variety 1 and 82,5% of the phytoliths from variety 2 were short cells. Hair cells were common in the two varieties, with 10% of *E. coracana* subsp. *coracana* 1 assemblage and 10,5% of the *E. coracana* subsp. *coracana* 2 assemblage consisting of them. Rare phytoliths included epidermal long cells (5% of the phytoliths from both assemblages), epidermal cells (0,5% of variety 1 and 1,5% of variety 2 phytoliths) and stomata (0,5% of the variety 2 samples) (see Table E.9).

Short cell only counts revealed that depressed saddle and bilobate phytoliths were abundant in *E. coracana* subsp. *coracana* 1 and 2 (Figure O.3.G). Thirty-eight percent (38%) of the phytoliths from variety 1 were depressed saddles and 33,5% were bilobates. Forty-two-and-a-half percent (42,5%) of the variety 2 phytoliths were depressed saddles and 30,5% were

bilobates. The bilobate variants and shapes were recorded in Table E.12 and Table E.16. Cross 1 phytoliths were common in both samples (18,5% of variety 1 and 17% of variety 2 phytoliths) and in variety 1 elongate saddles (9% of the sample) and polylobate 2 phytoliths were rare (1% of the phytoliths). In variety 2 elongate saddles were present in moderate numbers (10% of the phytoliths). No variant 2 polylobates were encountered in *E. coracana* subsp. *coracana* 2 (see Figure 5.1 and Table E.10).

Apart from polylobate 2 phytoliths, length and width measurements were obtained for all the short cell phytoliths observed in *E. coracana* subsp. *coracana* 1 and 2. See Table G.5 to Table G.8 for a summary of the measurements.

Pennisetum glaucum

Phytolith morphotypes observed in the mature samples

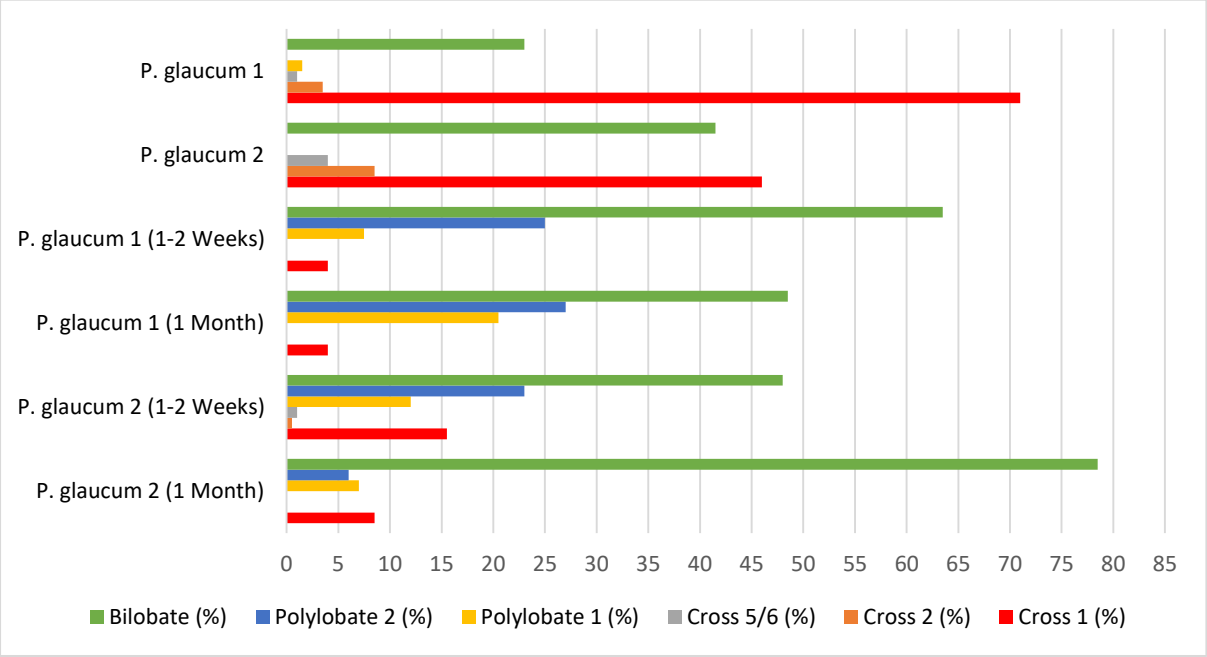

Figure 5.3. Percentages of short cell phytolith morphotypes observed in mature *P. glaucum* leaf samples and juvenile *P. glaucum* specimens.

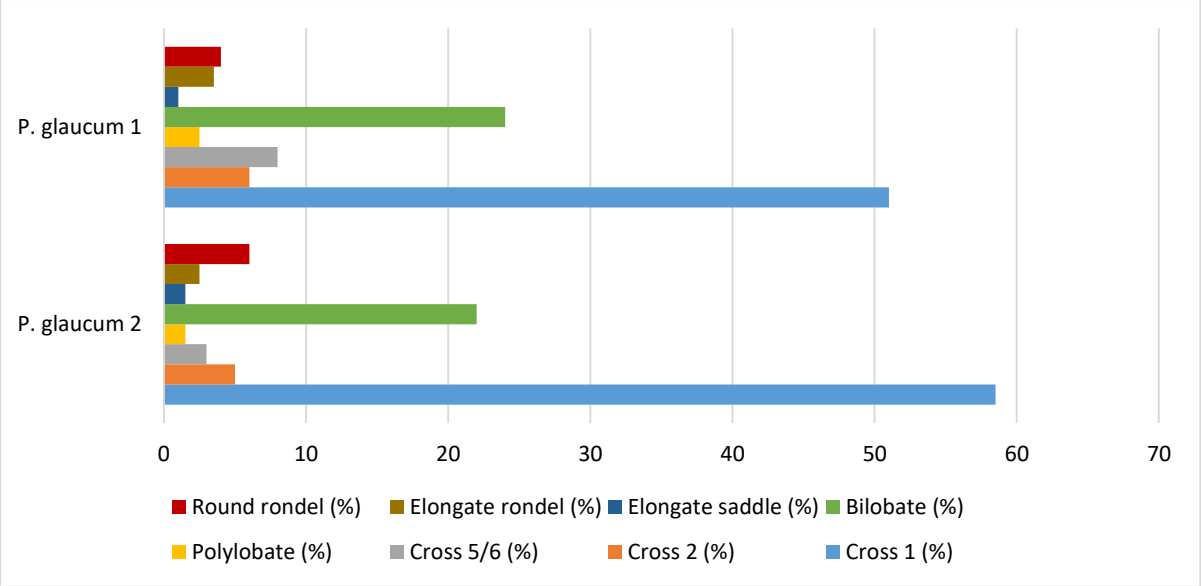

Figure 5.4. Percentages of short cell phytolith morphotypes observed in *P. glaucum* inflorescences samples.

Leaf phytoliths

Epidermal long cells were the most frequently observed phytoliths in *P. glaucum* leaf samples. Thirty-nine-and-a-half percent (39,5%) of variety 1 and 42% of variety 2 phytoliths comprised them. In *P. glaucum* 1 short cell phytoliths were abundant (32% of the phytolith sample), but in *P. glaucum* 2 they were only present in moderate numbers (22% of the assemblage). Papillae were common in both *P. glaucum* varieties (13,5% of variant 1 and 16% of variant 2 phytoliths). Hair cells were also common in variety 2 (11% of the phytoliths), but they were rare in variety 1 (7% of the sample). Low numbers of bulliform phytoliths were recorded in both *P. glaucum* 1 (7% of the phytoliths) and 2 (9% of the assemblage). Stomata were only present in variety 1 (1% of the phytoliths) (see Table E.1).

A short cell count revealed that different concentrations of each short cell morphotype was present in the two varieties of *P. glaucum* analysed. Variety 1 was dominated by cross 1 phytoliths (71% of the assemblage), while bilobates were common (23% of the short cells). In variety 2 neither cross 1 (46% of the short cells) nor bilobate phytoliths (41,5% of the assemblage) were dominant (Figure O.5. F-G). Both varieties produced low numbers of cross 2 and 5/6 phytoliths. Three-and-a-half percent (3,5%) of the variety 1 and 8,5% of the variety 2 short cells were cross 2 phytoliths. One percent (1%) of the *P. glaucum* 1 and 4% of the *P. glaucum* 2 assemblage were cross 5/6 phytoliths. Polylobate 1 phytoliths were only

present in *P. glaucum* 2 and they were rare (1,5% of the short cells) (see Figure 5.3 and Table E.2).

Length and width measurements were obtained for cross 1 and bilobate phytoliths (see Table G.1 to Table G.4). *P. glaucum* 1 bilobates fell into the variant 2 and 3 categories, while *P. glaucum* 2 produced bilobates from all four categories. Numerous lobe shapes were recorded (see Table E.11 and Table E.14).

Inflorescence phytoliths

Hair cell and short cell phytoliths were abundant in both the *P. glaucum* inflorescence samples (Figure O.5.A). Thirty-six-and-a-half percent of variety 1 and 45,5% of variety 2 phytoliths comprise hair cells. Forty-six-and-a-half percent (46,5%) of *P. glaucum* 1 and 41,5% of *P. glaucum* 2 assemblages were made up of short cell phytoliths. Epidermal long cells were rare in both samples, with 9% of variety 1 and 5% of variety 2 samples being composed of them. Papillae and bulliforms were also rare in *P. glaucum* 1 and 2. Two percent (2%) of *P. glaucum* 1 and 1,5% of *P. glaucum* 2 phytoliths were papillae. Two percent (2%) of the phytoliths from variety 1 and 1,5% of the ones from variety 2 were bulliform.

Hair cell clusters were also noted (4% of variety 1 and 5,5% of variety 2 phytoliths) (see Table E.3). These phytoliths form when a number of single hair cell phytoliths are joined together to form a composite phytolith. For this study each cluster was counted as a single phytolith.

A multitude of phytoliths were observed during the short cell only count, including cross 1, 2 and 5/6 phytoliths, bilobates, polylobates, elongate rondels, as well as depressed and elongate saddles. Cross 1 phytoliths were dominant in both *P. glaucum* varieties (51% of the variety 1 and 58,5% of the variety 2 short cells) and bilobates were common (24% of the *P. glaucum* 1 and 22% of the *P. glaucum* 2 assemblages). The remaining short cells were present in low numbers in *P. glaucum* 1 and 2. Eight percent (8%) of the variety 1 and 3% of the variety 2 phytoliths were variant 5/6 crosses. Six percent (6%) of the variety 1 and 5% of the variety 2 short cells were cross 2 phytoliths. Four percent (4%) of the short cell phytoliths from *P. glaucum* 1 and 6% of the ones from *P. glaucum* 2 were round rondels. Elongate rondels,

elongate saddles and polylobates (less than 5% each) were the rarest phytoliths in both samples (see Figure 5.4 and Table E.4).

Length and width measurements were obtained for cross 1 and bilobate phytoliths (see Table H.1 to Table H.4). In *P. glaucum* 1 bilobates from all four categories were observed. In *P. glaucum* 2 bilobates fell into groups 2 and 3. A multitude of different lobe shapes were observed (see Table E.11 and Table E.15).

Phytoliths from the seeds, stems and roots

No phytoliths were observed in the seeds of the *P. glaucum* samples. Epidermal cells, as well as low numbers of short cell phytoliths were present in the stems and in the roots several unidentified phytoliths (see Figure O.5.B) were also observed.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

Short cell phytoliths were dominant in both samples (68,5% of variety 1 and 64% of variety 2 phytoliths). Hair cells were abundant in *P. glaucum* 2 (29% of the sample), but only common in *P. glaucum* 1 (16% of the assemblage). Epidermal long cells and bulliforms were rare in *P. glaucum* 1 and 2. Six-and-a-half percent (6,5%) of the phytoliths from variety 1 and 4,5% of the ones from variety 2 were epidermal long cells. Eight-and-a-half percent (8,5%) of the *P. glaucum* 1 and 2,5% of the *P. glaucum* 2 assemblages were bulliforms. Papillae (0,5% of the phytoliths) were only observed in variety 1 samples (see Table E.9).

In a short cell only count it was established that bilobate phytoliths were dominant in *P. glaucum* 1 (63,5% of the short cells) and abundant in the other sample (48% of the assemblage). Variant 2 and 3 bilobates were encountered in *P. glaucum* 1 and variant 1 to 4 were observed in *P. glaucum* 2 (see Table E.12 and Table E.17). Polylobate 2 phytoliths were present in high numbers in variety 1 (25% of the short cells) and 23% of the variety 2 assemblage was composed of them. Cross 1 (15,5% of the short cells) and polylobate 1 phytoliths (12% of the sample) were common in variety 2. Both cross 1 (4% of the short cells) and polylobate 1 phytoliths (7,5% of the sample) were rare in *P. glaucum* 1 (Figure O.5.C-E). Cross 2 (0,5% of the phytoliths) and cross 5/6 phytoliths (1% of the assemblage)

were only encountered in variety 2 samples and low numbers of them were observed (see Figure 5.3 and Table E.10.). Length and width measurements were obtained for all the short cell phytoliths identified, except variant 2 and 5/6 crosses (see Table H.5 to Table H.8).

Phytoliths from specimens harvested at 1 month

Short cell phytoliths were dominant in all the varieties of *P. glaucum* observed. Seventy-two-and-a-half percent (72,5%) of the phytoliths from variety 1 and 61,5% of the ones from variety 2 were short cells. Hair cell phytoliths were abundant in both samples (27,5% of the *P. glaucum* 1 and 30% of the *P. glaucum* 2 assemblage) and in *P. glaucum* 2 epidermal long cells (5% of the sample) and epidermal cells were rare (3,5% of the phytoliths) (see Table E.9).

Four types of short cell phytoliths were encountered in *P. glaucum* 1 and 2 samples. Bilobates were dominant in variety 2 (78,5% of the short cells) and were present in high numbers in variety 1 (48,5% of the assemblage). Variant 1 to 3 bilobates were observed in *P. glaucum* 1, while variant 1 to 4 was visible in *P. glaucum* 2 (see Table E.12 and Table E.16). Polylobate 2 phytoliths were abundant in *P. glaucum* 1 (27% of the short cells) and rare in the other sample (6% of the assemblage). In *P. glaucum* 1 polylobate 1 phytoliths were common (20,5% of the sample). They were present in low numbers in *P. glaucum* 2 (7% of the short cells). Cross 1 phytoliths were rare in all varieties. Four percent (4%) of variety 1 and 8,5% of variety 2 short cell phytoliths were variant 1 crosses (see Figure 5.3 and Table E.10). Length and width measurements were obtained for the bilobates of both samples. Measurements were also taken of the polylobate 1 and 2 phytoliths of *P. glaucum* 1 (see Table H.5 to Table H.8).

Sorghum bicolor subsp. bicolor

Phytolith morphotypes observed in the mature samples

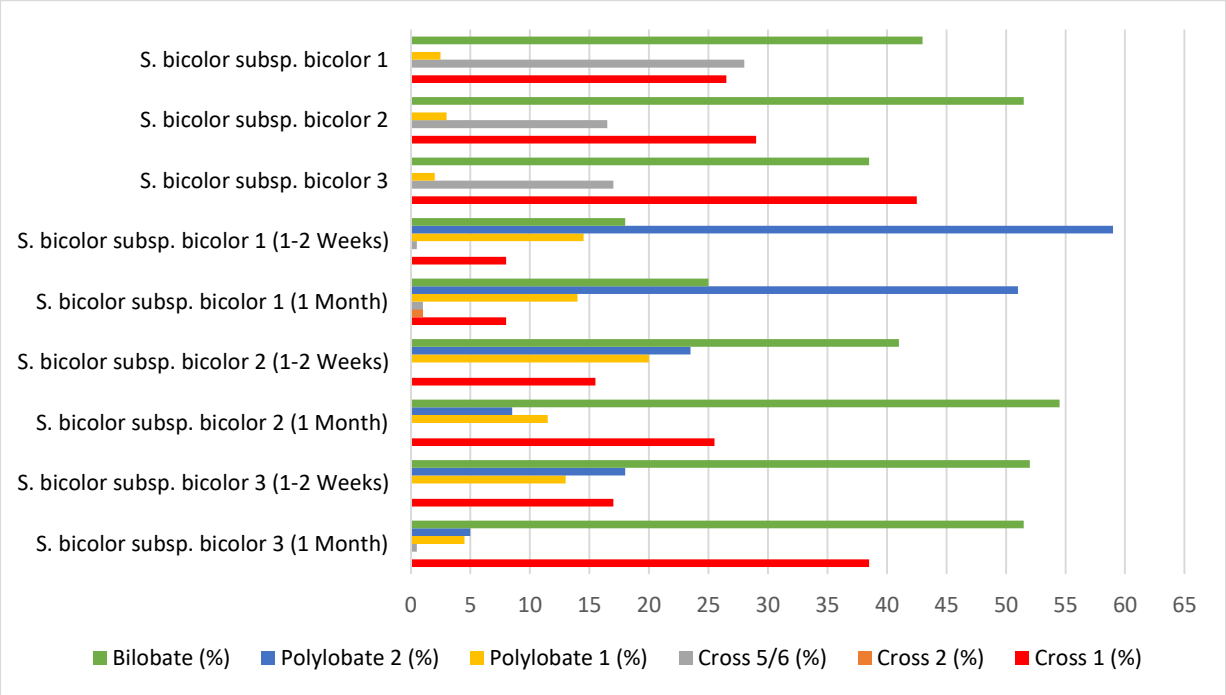

Figure 5.5. Percentages of short cell phytolith morphotypes observed in mature *S. bicolor* subsp. *bicolor* leaf samples and juvenile *S. bicolor* subsp. *bicolor* specimens.

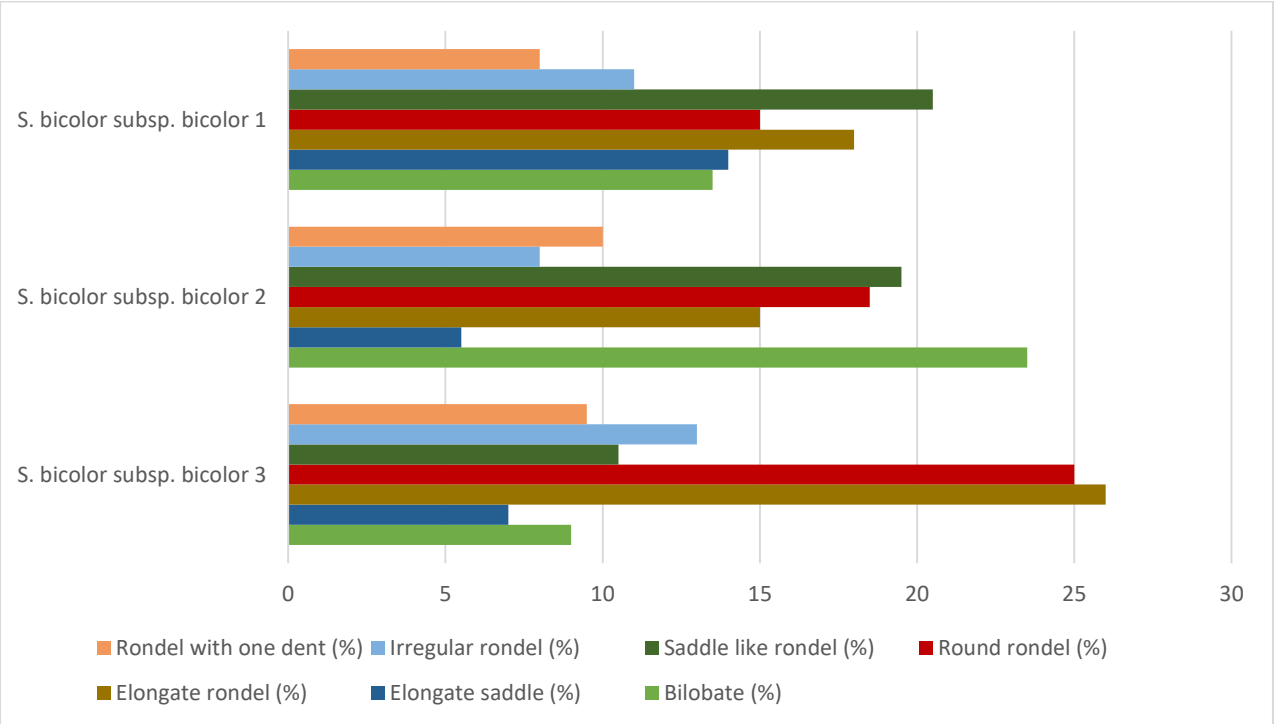

Figure 5.6. Percentages of short cell phytolith morphotypes observed in *S. bicolor* subsp. *bicolor* inflorescences samples.

Leaf phytoliths

Short cell phytoliths were dominant in all varieties of *S. bicolor* subsp. *bicolor*. Fifty-seven-and-a-half percent (57,5%) of the phytoliths from variety 1, 76,5% of the ones from variety 2 and 75% of the phytoliths from variety 3 were short cells. Papillae, epidermal long cells, stomata, hair cells and bulliform phytoliths were also observed in the leaf samples. Papillae were common in *S. bicolor* subsp. *bicolor* 1 (20% of the sample), rare in variety 2 (2% of the assemblage) and absent in variety 3. Epidermal long cells were common in *S. bicolor* subsp. *bicolor* 1 (16% of the phytoliths) and 3 (15% of the assemblage), but present in low numbers in the second variety (9% of the sample). Hair cell, stomata and bulliform phytoliths were rare in all samples (see Table E.1). Two percent (2%) of the phytoliths from variety 1, 1,5% of the ones from variety 2 and 1,5% of the phytoliths from variety 3 were hair cells. Three percent (3%) of the assemblage from variety 1 and 10% of the sample from variety 2 were made up of stomata. These phytoliths were absent in variety 3. One-and-a-half percent (1,5%) of the phytoliths from *S. bicolor* subsp. *bicolor* 1, 1% of the ones from *S. bicolor* subsp. *bicolor* 2 and 8,5% of the phytoliths from *S. bicolor* subsp. *bicolor* 3 were bulliforms.

Different concentrations of phytoliths were noted in each sample during a short cell only count. In *S. bicolor* subsp. *bicolor* 1, variant 1 (26,5% of the short cells) and 5/6 crosses (28% of the assemblage) as well as bilobates (43% of the sample) were abundant (Figure O.6.D-F). Bilobates (51,5% of the assemblage) were dominant in *S. bicolor* subsp. *bicolor* 2, while cross 1 phytoliths (29% of the short cells) were present in high numbers and cross 5/6 phytoliths (16,5% of the sample) were common. In *S. bicolor* subsp. *bicolor* 3 cross 1 (42,5% of the short cells) and bilobate phytoliths (38,5% of the sample) were abundant and cross 5/6 phytoliths (17% of the assemblage) were present in moderate numbers. Polylobate phytoliths were rare in all the samples analysed (less than 5% of the phytoliths) (see Figure 5.5 and Table E.2).

Length and width measurements were obtained for cross 1 and 5/6 phytoliths, as well as bilobates (see Table I.1 to Table I.6). Category 2 and 3 bilobates were observed in all the *S. bicolor* subsp. *bicolor* varieties. In *S. bicolor* subsp. *bicolor* 2, variant 4 bilobates were also noted. A multitude of bilobate lobe shapes were encountered (see Table E.11 and Table E.14).

Inflorescence phytoliths

Dendritic long cells were dominant in *S. bicolor* subsp. *bicolor* 2 samples (43,5% of the phytoliths) and abundant in varieties 1 (53% of the assemblage) and 3 (46,5% of the phytoliths). In variety 1 short cell phytoliths were dominant (51,5% of the sample), and in varieties 2 (42% of the phytoliths) and 3 (44,5% of the assemblage) they were present in large numbers. Other phytoliths observed in the inflorescence samples included sinuous long cells and papillae (Figure O.7.E-F). The latter was absent from variety 1 samples and rare in the *S. bicolor* subsp. *bicolor* 2 (2,5% of the phytoliths) and 3 (0,5% of the sample). Low numbers of the former was observed. In *S. bicolor* subsp. *bicolor* 1, five percent (5%) of the assemblage was composed of sinuous long cells. Two-and-a-half percent (2,5%) of *S. bicolor* subsp. *bicolor* 2 and 8,5% of *S. bicolor* subsp. *bicolor* 1 comprised these phytoliths (see Table E.3).

During a short cell count moderate numbers of saddle-like rondels (20,5% of the short cells), elongate rondels (18% of the assemblage) and round rondels (15% of the sample), elongate saddles (14% of the short cells), bilobates (13,5% of the sample) and irregular rondels (1% of the assemblage) were observed in *S. bicolor* subsp. *bicolor* 1 (Figure O.7. A-D; G-P). Rondels with one dent were rare (8% of the short cells) (see Table E.4). Round rondels included all rondels that were round to ovate in planar view and conical in side view. Elongate rondels were classified as all rondels that were oblong in shape in the planar view and tabular in side view.

Bilobates (23,5% of the short cells), saddle-like- (19,5% of the assemblage), round (18,5% of the sample) and elongate rondels (15% of the short cells) and rondels with one dent (10% of the sample) were common in *S. bicolor* subsp. *bicolor* 2. Elongate saddles (5,5% of the assemblage) and irregular rondels (8% of the short cells) were present in low numbers. In *S. bicolor* subsp. *bicolor* 3 elongate (26% of the sample) and round rondels (25% of the short cells) were abundant. Irregular (13% of the assemblage) and saddle-like-rondels (10,5% of the short cells) were common. Rondels with one dent (9,5% of the assemblage), bilobates (9% of the short cells) and elongate saddles (7% of the sample) were rare (see Figure 5.6 and Table E.4).

Length and width measurements were obtained for all the short cell phytoliths, as well as the long cell phytoliths (see Table I.1 to Table I.6). The vast majority of the bilobates

encountered fell into the variant 2 category and they had convex outer margins (see Table E.11 and Table E.15).

Phytoliths from the seeds, stems and roots

Silica was present in the slides produced from seeds, however, no phytoliths were observed. In the stems mesophyll phytoliths, ranging in shape from ovoid to circular, were present. Stomata and epidermal long cell phytoliths were also noted (Figure O.6.C).

Epidermal long cell phytoliths were observed during analysis of *S. bicolor* subsp. *bicolor* roots. Cylindrical phytoliths with orbicular protrusions extended along its surface were also noted. In most instances several of these phytoliths appeared together and were articulated (Figure O.6.A-B). No measurements were taken, because too few phytoliths were encountered.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

Short cell phytoliths were dominant in all of the *S. bicolor* subsp. *bicolor* varieties. Eighty-four-and-a-half percent (84,5%) of the phytoliths from variety 1, 79% of the ones from variety 2 and 88% of the phytoliths from variety 3 were short cells. Epidermal long cells were common in variety 2 (19% of the assemblage), rare in variety 1 (1,5% of the phytoliths) and absent from variety 3. Hair cell phytoliths were present in moderate numbers in *S. bicolor* subsp. *bicolor* 3 (10% of the assemblage). They were observed in low numbers in variety 1 (9,5% of the assemblage) and 2 (% of the phytoliths). Epidermal cell phytoliths were rare in variety 1 (3,5% of the phytoliths) and 3 (1% of the sample). They were absent from variety 2 samples. In *S. bicolor* subsp. *bicolor* 1 hair cell mesophyll was noted (1% of the phytoliths), variety 2 (0,5% of the assemblage) had low numbers of bulliforms and stomata were present in *S. bicolor* subsp. *bicolor* 3 (1% of the sample) (see Table E.9).

Different numbers of each of the short cell phytoliths were observed in the varieties of *S. bicolor* subsp. *bicolor*. In variety 1 polylobate 2 phytoliths (59% of the short cells) were dominant, bilobates (18% of the sample) and polylobate 1 phytoliths (14,5% of the assemblage) were common and cross 1 (8% of the short cells) and 5/6 phytoliths (0,5% of the

sample) were rare. In *S. bicolor* subsp. *bicolor* 2 bilobates (41% of the assemblage) were abundant and polylobate (20% of the short cells) 1 and 2 (23,5% of the assemblage), as well as cross 1 phytoliths (15,5% of the sample) were present in moderate numbers. In variety 3 bilobates (52% of the short cells) were dominant and cross 1 (17% of the sample), polylobate 1 (31% of the assemblage) and 2 phytoliths (18% of the short cells) were common (see Figure 5.5 and Table E.10). Different bilobate variants were observed in the three samples (see Table E.12 and Table E.17) (Figure O.8.A-B).

With the exception of cross 1 phytoliths, length and width measurements were obtained for all of the short cell phytoliths observed in the three varieties of *S. bicolor* subsp. *bicolor* (see Table I.7 to Table I.12).

Phytoliths from specimens harvested at 1 month

In all the *S. bicolor* subsp. *bicolor* samples, short cells were the most frequently observed phytoliths. Seventy-three (73%) of the phytoliths from variety 1, 74,5% of the ones from variety 2 and 78% of the phytoliths from variety 3 were short cells. Hair cell phytoliths were common in variety 2 samples (20,5% of the assemblage), but rare in the other varieties (4,5% of variety 1 and 3% of variety 3 phytoliths). In *S. bicolor* subsp. *bicolor* 1 (11% of the phytoliths) and 3 (13,5% of the sample) epidermal long cells were present in moderate numbers. They were, however, rare in variety 2 samples (1,5% of the assemblage) (see Table E.9).

Other phytoliths encountered in *S. bicolor* subsp. *bicolor* samples were stomata, epidermal cells and bulliforms. Six-and-a-half percent (6,5%) of the phytoliths form variety 1, 0,5% of those from variety 2 and 4,5% of the phytoliths from variety 3 were stomata. Four-and-a-half percent of variety 1, 2% of variety 2 and 0,5% of variety 3 phytoliths were epidermal cells. Similar numbers of bulliform phytoliths (0,5% of the sample) were encountered in all varieties. Low numbers of papillae (0,5% of the assemblage) were encountered in *S. bicolor* subsp. *bicolor* 2 samples (see Table E.9).

During short cell counts up to six types of phytoliths were noted in the varieties of *S. bicolor* subsp. *bicolor* (Figure O.8.C-D). In variety 1 polylobate 2 phytoliths (51% of the short cells) were dominant, bilobates (25% of the assemblage) were present in high numbers and polylobate 1 phytoliths (14% of the sample) were common. Cross 1 (8% of the short cells), 2

(1% of the sample) and 5/6 phytoliths (1% of the assemblage) were rare. In *S. bicolor* subsp. *bicolor* 2 bilobates were dominant (54,5% of the short cells), cross 1 phytoliths were abundant (25,5% of the sample), polylobate 1 phytoliths were common (11,5% of the assemblage) and low numbers of polylobate 2 (8,5% of the sample) phytoliths were observed. In variety 3 bilobates were also dominant (51,5% of the short cells). High numbers of cross 1 phytoliths (38,5% of the sample) were encountered and rare phytoliths included polylobate 1 (4,5 of the assemblage) and 2 (5% of the short cells), as well as cross 5/6 phytoliths (0,5% of the sample) (see Figure 5.6 and Table E.10). Length and width measurements were obtained for all the phytoliths observed except variant 2 and 5/6 crosses (see Table I.7 to Table I.12). Variant 2 and 3 bilobates were found in all the samples. In addition, variant 1 bilobates were present in *S. bicolor* subsp. *bicolor* 3 (see Table E.12 and Table E.16).

Zea mays

Phytolith morphotypes observed in the mature samples

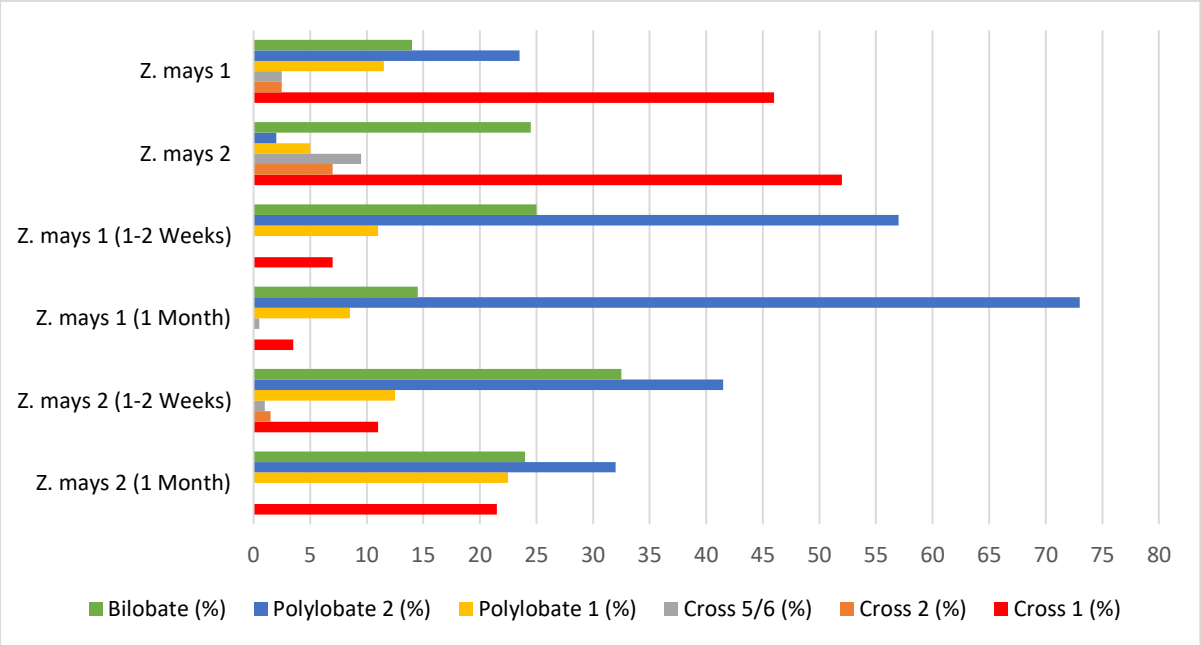

Figure 5.7. Percentages of short cell phytolith morphotypes observed in *mature* Z. mays *leaf samples and juvenile* Z. mays *specimens*.

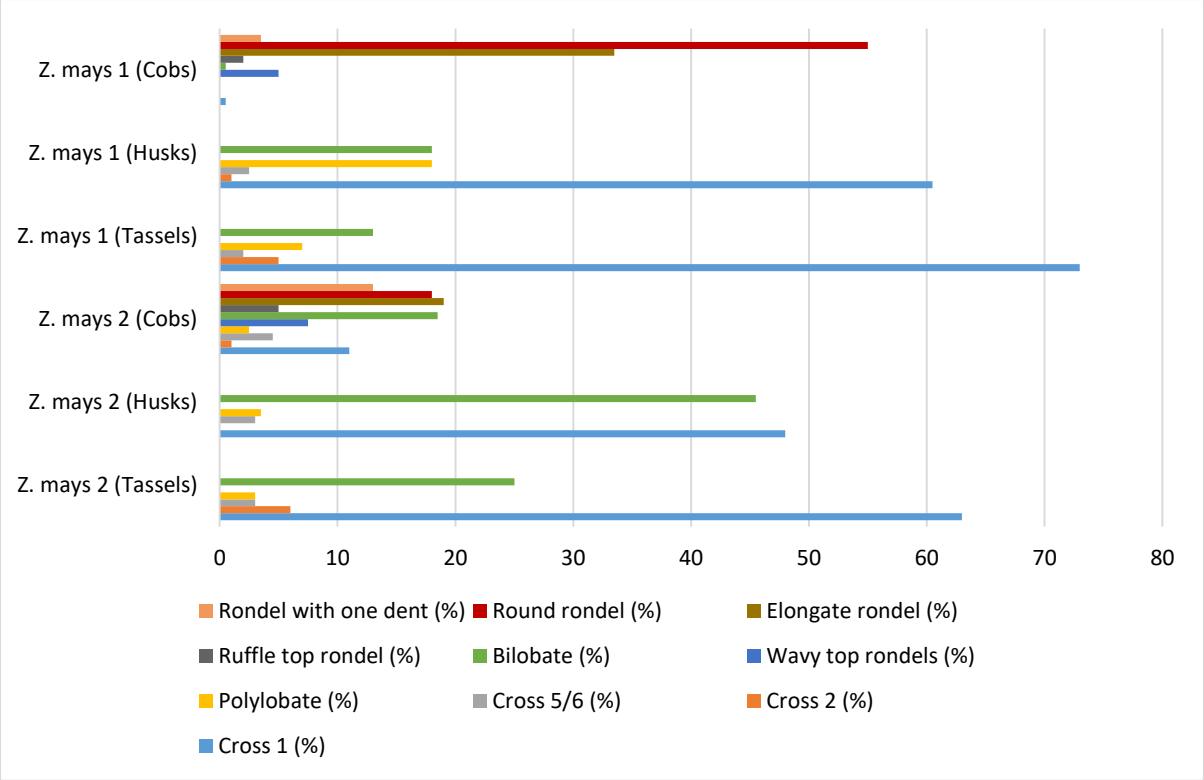

Figure 5.8. Percentages of short cell phytolith morphotypes observed in *Z. mays* inflorescences samples.

Leaf samples

The phytoliths most frequently observed in *Z. mays* leaves were short cells (Figure O.9.B-F; H-I). In *Z. mays* 1 they were abundant (49,5% of the phytoliths), while they were dominant in variety 2 (70,5% of the sample). Epidermal cells, papillae, hair cells, bulliforms and stomata were also encountered (Figure O.9.A, G). Hair cell phytoliths were abundant in *Z. mays* 2 (27,5% of the assemblage) and common in *Z. mays* 1 (12,5% of the sample). Papillae (15% of the phytoliths) and epidermal long cells (15% of the assemblage) were present in moderate numbers in *Z. mays* 1. In variety 2 the former was absent and the latter was rare (2% of the phytoliths). Low numbers of bulliforms (6% of the sample) and stomata (2% of the assemblage) were observed in variety 1. None were encountered in variety 2 samples (see Table E.1).

During a short cell only count, high numbers of cross 1 phytoliths (46% of the short cells) were encountered in variety 1 samples. These phytoliths were dominant in *Z. mays* 2 (52% of the assemblage). Moderate numbers of bilobates were present in both samples (14% of

variety 1 and 24,5% of variety 2 short cells). In *Z. mays* 1 polylobate 1 (11,5% of the sample) and 2 phytoliths (23,5% of the assemblage) were common, but they were rare in variety 2 samples. Only 5% of the short cells from variety 2 were polylobate 1 and 2% of the assemblage were polylobate 2. Low numbers of cross 2 and 5/6 phytoliths were observed in *Z. mays* 1 and 2. Two-and-a-half percent (2,5%) of the variety 1 assemblage and 9,5% were cross 5/6 phytoliths. Two-and-a-half percent (2,5%) of *Z. mays* 1 and 7% of *Z. mays* 2 short cells were variant 2 crosses (see Figure 5.7 and Table E.2).

Length and width measurements were obtained for the cross 1 and bilobate phytoliths of both samples. In addition data were obtained for the variant 1 and 2 polylobates of *Z. mays* 1 and for cross 5/6 phytoliths of *Z. mays* 2 (see Table J.1, Table J.2, Table J.5 and Table J.6). In both the samples category 2 and 3 bilobates were observed. These had lobes that varied in shape (see Table E.11 and Table E.14).

Cob (Female inflorescence) phytoliths

Both *Z. mays* 1 and 2 samples were dominated by short cell phytoliths (89% of variety 1 and 95,5% of variety 2 phytoliths) (Figure O.9.K-P). Epidermal long cells and hair cell phytoliths were also observed. The latter was common in *Z. mays* 1 (10% of the sample) and rare in *Z. mays* 2 (2,5% of the assemblage). The former was present in low numbers in both samples (1% of variety 1 and 2% of variety 2 phytoliths) (see Table E.3).

In a short cell only count round rondels were dominant in *Z. mays* 1 (55% of the short cells) and elongate rondels were abundant (33,5% of the sample). Rare phytoliths in variety 1 included wavy (5% of the assemblage) and ruffle top rondels (2% of the short cells), cross 1 (0,5% of the sample) and bilobate phytoliths (0,5% of the assemblage) and rondels with one dent (3,5% of the short cells). In variety 2 round (18% of the assemblage) and elongate rondels (19% of the sample), bilobates (18,5% of the short cells), rondels with one dent (13% of the assemblage) and cross 1 phytoliths (11% of the short cells) were present in moderate numbers. Wavy top (7,5% of the sample) and ruffle top rondels (5% of the short cells), polylobates (2,5% of the assemblage), as well as cross 2 (1% of the short cells) and 5/6 phytoliths (4,5% of the sample) were rare (see Figure 5.8 and Table E.4).

Length and width measurements were obtained for the round and elongate phytoliths of both samples. Statistically relevant data were also collected for *Z. mays* 2 bilobates, variant 1 and

5/6 crosses and rondels with one dent (see Table J.3, Table J.4, Table J.7 and Table J.8). Only category 2 bilobates were observed in the samples (see Table E.11 and Table E.15).

Husk phytoliths

Short cell phytoliths were dominant in the husks of both of the varieties analysed (Figure O.9. Q-Z.). Eighty-two-and-a-half percent (82,5%) of the phytoliths in variety 1 and 73,5% of the ones from variety 2 were short cell phytoliths. Hair cell phytoliths were common in *Z. mays* 2 (20% of the phytoliths) and *Z. mays* 1 (15,5% of the sample). Rare phytoliths in *Z. mays* 1 and 2 included papillae, epidermal long cells and bulliforms (see Table E.3). Four-and-a-half percent (4,5%) of the phytoliths from variety 2 and 0,5% of the ones from variety 2 were papillae. The same amount of epidermal long cells (1,5%) were encountered in both varieties. Bulliform phytoliths (0,5% of the assemblage) only occurred in *Z. mays* 2.

In short cell only counts, cross 1 phytoliths were dominant in *Z. mays* 1 (60,5% of the sample) and bilobates were common (18% of the assemblage). In *Z. mays* 2 variant 1 crosses (48% of the short cells) and bilobates (45,5% of the sample) were abundant and present in similar numbers. Polylobates were common in *Z. mays* 1 (18% of the assemblage) and rare in *Z. mays* 2 (3,5% of the short cells). Low numbers of cross 5/6 phytoliths were observed in both samples. Two-and-a-half percent (2,5%) of the short cells in variety 1 and 3% of the ones from variety 2 were variant 5/6 crosses. Variant 2 crosses were rare in *Z. mays* 1 (1% of the assemblage), but absent in other samples (see Figure 5.8 and Table E.4).

Length and width measurements were obtained for the cross 1 and bilobate phytoliths of both samples. Enough variant 5/6 crosses were encountered in *Z. mays* 1 to acquire statistically relevant data based on their measurements (see Table J.3, Table J.4, Table J.7 and Table J.8). Category 2 and 3 bilobates with a multitude of different lobe shapes were observed in both samples (see Table E.11 and Table E.15).

Tassel (Male inflorescence) phytoliths

Hair cell phytoliths were dominant in all of the *Z. mays* tassel samples. Fifty-two-and-a-half percent (52,5%) of the phytoliths from variety 1 and 74% of the ones from variety 2 were hair cells. Short cell phytoliths were abundant in *Z. mays* 1 (36% of the assemblage) and were

common in *Z. mays* 2 (17,5% of phytoliths). Papillae (4% of the phytoliths in both varieties), epidermal long cells (5% of variety 1 and 3% of variety 2 phytoliths) and bulliform phytoliths (2,5% of variety 1 and 1% of variety 2 phytoliths) were also observed. Stomata (0,5% of the sample) were only observed in *Z. mays* 2 samples (see Table E.3).

In a short cell only count, cross 1 phytoliths were dominant in both varieties. Seventy-three percent (73%) of the short cells from variety 1 and 63% of the ones from variety 2 were variant 1 crosses. Bilobates were present in high numbers in *Z. mays* 2 (25% of the assemblage) and common in the other variety (13% of the sample). Polylobates, cross 2 and 5/6 phytoliths were rare in both samples. Seven percent (7%) of the *Z. mays* 1 and 3% of the *Z. mays* 2 assemblages were polylobates. Five percent (5%) of the short cells of variety 1 and 6% of the ones from variety 2 were cross 2 phytoliths. Two percent (2%) of the *Z. mays* 1 and 3% of the *Z. mays* samples were variant 5/6 crosses (see Figure 5.8 and Table E.4). Length and width measurements were only obtained for cross 1 phytoliths (see Table J.3, Table J.4, Table J.7 and Table J.8).

Phytoliths from the seeds, stems and roots

Unlike the other parts of *Z. mays*, few diagnostic phytoliths were noted in the stems and roots. No distinguishable phytoliths were observed in the seeds, however, there were epidermal long cells present in the stems. In addition, a small number of cross-shaped phytoliths were noted and vascular tissue was encountered. No diagnostic phytoliths were observed in the roots, but similar to the stems, epidermal long cell phytoliths were encountered.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

All of the *Z. mays* samples were dominated by short cell phytoliths (84,5% of variety 1 and 87% of variety 2 phytoliths) (Figure O.10.A-C). In variety 1 hair cell phytoliths were common (13,5% of the assemblage) and they were rare in *Z. mays* 2 (9% of the sample). Low numbers of epidermal cells were observed in both samples. One percent (1%) of the Z. mays 1 and 3,5% of the Z. mays 2 assemblages were epidermal cells. Epidermal long cells

were noted in *Z. mays* 1 (1% of the phytoliths) and rare numbers of bulliforms were observed in variety 2 (0,5% of the sample) (see Table E.9).

In a short cell only count polylobate 2 phytoliths were dominant in *Z. mays* 1 (57% of the short cells) and abundant in variety 2 (41,5% of the assemblage). Bilobates were present in high numbers in both samples and polylobate 1 phytoliths were common. Twenty-five percent (25%) of the *Z. mays* 1 and 32,5% of the *Z. mays* 2 samples were bilobates. Only variant 2 and 3 bilobates were observed (see Table E.12 and Table E.17). Eleven percent (11%) of the short cells from variety 1 and 12,5% of the ones from variety 2 were polylobate 1 phytoliths. Moderate numbers of variant 1 crosses were encountered in *Z. mays* 2 (11% of the assemblage), but they were rare in *Z. mays* 1 (7% of the short cells). Cross 2 (1,5% of the sample) and 5/6 phytoliths (1% of the short cells) were only noted in variety 2 (see Figure 5.7 and Table E.10). Length and width measurements were collected for all the short cell phytoliths observed except cross 2 and 5/6 phytoliths (see Table J.9 to Table J.10).

Phytoliths from specimens harvested at 1 month

Short cell phytoliths were dominant in all the *Z. mays* varieties. Sixty-nine-and-a-half percent (69,5%) of the phytoliths from variety 1 and 75% of the ones from variety 2 were short cells. Epidermal long cell phytoliths were common in both samples (11% of the phytoliths from both varieties). In variety 1 hair cells (9% of the phytoliths), tracheids (7,5% of the assemblage), papillae (2% of the phytoliths), and bulliforms (1% of the sample) were rare. While hair cell phytoliths were common in *Z. mays* 2 (12% of the phytoliths), stomata (1,5% of the assemblage) and epidermal cell phytoliths (0,5% of the phytoliths) were only present in low numbers (see Table E.9).

Various short cell phytoliths were encountered. In *Z. mays* 1 polylobate 2 phytoliths (73% of the assemblage) were dominant, but they were only abundant in variety 2 (32% of the short cells). Bilobates were common in both samples (14,5%of variety 1 and 24% of variety 2 short cells) and all four types were observed (see Table E.12 and Table E.16). Polylobate 1 (22,5% of the sample) and cross 1 phytoliths (21,5% of the short cells) were also common in *Z. mays* 2. Rare phytoliths in *Z. mays* 1 included polylobate 1 (8,5% of the assemblage), cross 1 (3,5% of the short cells) and 5/6 phytoliths (0,5% of the sample) (see Figure 5.7 and Table E.10). Length and width measurements were collected for all the phytoliths apart from variant 5/6 crosses (see Table J.9. to Table J.10.).

Domesticated plants: Fabaceae

Arachis hypogaea

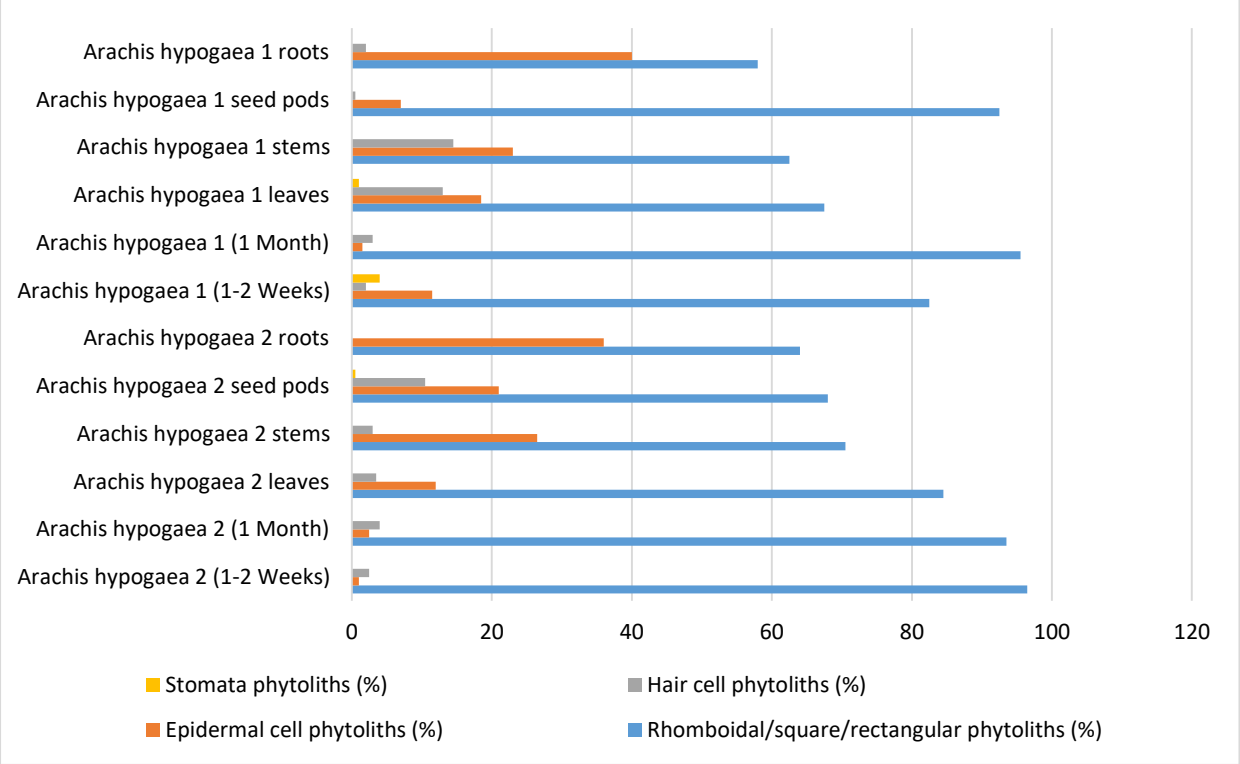

Figure 5.9 Percentages of phytolith morphotypes observed in *A. hypogaea* samples.

Phytolith morphotypes observed in the mature samples

Phytoliths from the leaves, seed pods, stems and roots

Several phytolith types were observed in *A. hypogaea* samples, including epidermal cells, stomata, hair cells and rhomboidal/square/rectangular (six-sided phytoliths) phytoliths (Figure O.11.A.). The latter was dominant in all the plant sections analysed. Sixty-seven-and-a-half percent (67,5%) of the phytoliths from variety 1 leaves and 84,5% of the ones from variety 2 leaves comprised of six-sided phytoliths. In the stems 62,5% of the phytoliths from variety 1 and 70,5% of the ones from variety 2 were rhomboidal/square/ rectangular phytoliths. In the seed pods 92,5% of the phytoliths observed in variety 1 and 68% of those from variety 2 were six-sided phytoliths). In the root samples 58% of the phytoliths from variety 1 and 64% of those from variety 2 were rhomboidal/square/ rectangular phytoliths (see Figure 5.9 and Table L.1).

Epidermal cells were abundant in all root samples (40% of variety 1 and 36% of variety 2 phytoliths), as well as variety 2 stems (26,5% of the assemblage). In the stems of variety 1 23% of the phytoliths were epidermal cells. In *A. hypogaea* leaves epidermal cells were common, with 18,5% of the variety 1 and 12% of the variety 2 assemblages being composed of them. These phytoliths were rare in *A. hypogaea* 1 seed pods (7% of the phytoliths). In *A. hypogaea* 2 moderate numbers of epidermal cells were encountered (21% of the assemblage) (see Figure 5.9 and Table L.1).

Hair cell phytoliths were common in *A. hypogaea* 1 leaves (13% of the phytoliths) and stems (14,5% of the assemblage), as well as *A. hypogaea* 2 seed pods (10,5% of the sample). In all the other samples they were rare and comprised less than 10% of the overall phytoliths. Hair cell phytoliths were absent from variety 2 roots. Stomata were only encountered in variety 1 leaves (1% of the phytoliths) and variety 2 seed pods (0,5% of the sample) (see Figure 5.9 and Table L.1).

Only rhomboidal/square/rectangular phytoliths were measured (see Table L.2 and Table L.3). The appearance of the six-sided phytoliths were largely dependent on their orientation within the solution in which they were mounted. Thus, when observed, they often resembled five-or six-sided polygons. Unlike these phytoliths, epidermal cells were articulated and thus were mainly orientated so that they could be regarded in their planar view. On rare occasions they were orientated so that the side view was visible. They were rectangular in shape.

Phytoliths from seeds

No phytoliths were observed in any of the seed samples, but silica was present.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

The majority of the phytoliths observed in all varieties were rhomboidal/square/rectangular (six-sided) phytoliths (82,5% of variety 1 and 96,5% of variety 2 phytoliths). Epidermal cells were common in *A. hypogaea* 1 samples (11,5% of the assemblage), but rare in variety 2 (1% of the sample). Low numbers of hair cell phytoliths were encountered in all samples. Two percent (2%) of the phytoliths from variety 1 and 2,5% of the ones from variety 2 were hair

cells. Stomata phytoliths were also noted in *A. hypogaea* 1 (4% of the assemblage) (see Figure 5.9 and Table L.12).

Phytoliths from specimens harvested at 1 month

Rhomboidal/square/rectangular (six-sided) phytoliths were dominant in all the samples. Ninety-five-and-a-half percent (95,5%) of variety 1 and 93,5% of the variety 2 assemblages were composed of these phytoliths. Epidermal cell and hair cell phytoliths were rare in both varieties (less than 5% of each sample) and no stomata phytoliths were observed (see Figure 5.9 and Table L.12).

Vigna subterranea

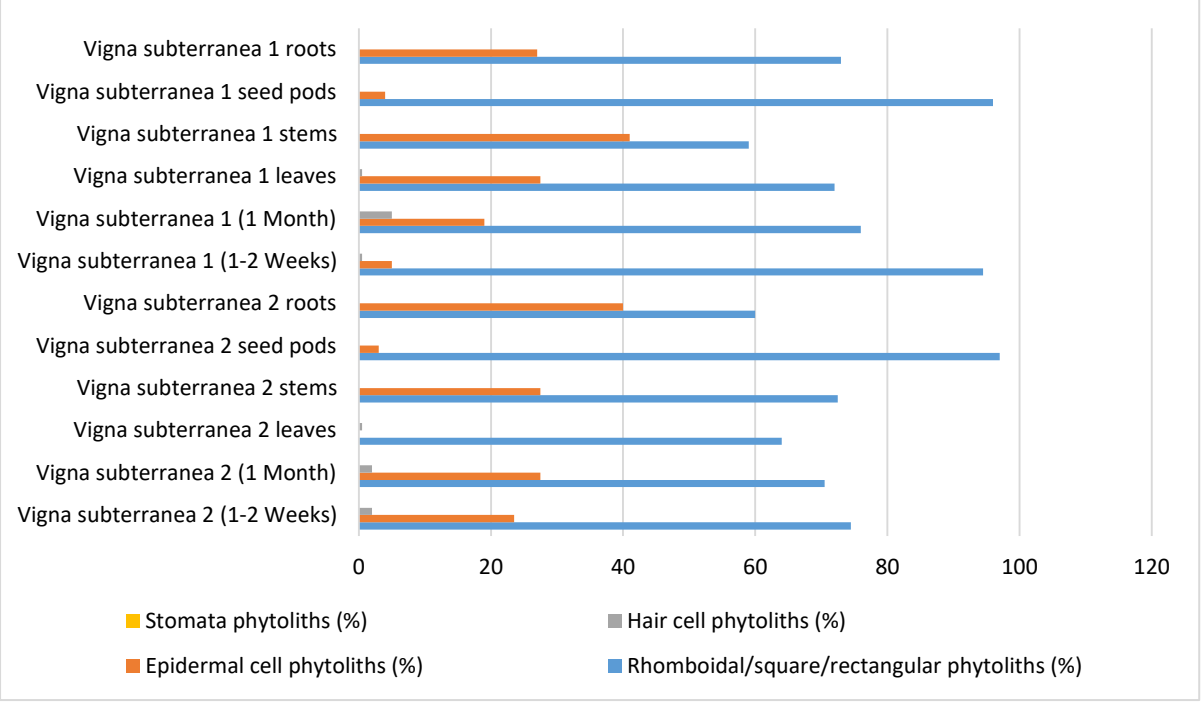

Figure 5.10. Percentages of phytolith morphotypes observed in *V. subterranea* samples.

Phytolith morphotypes observed in the mature samples

Phytoliths from leaves, seed pods, stems and roots

The only phytoliths that were observed during analysis of *V. subterranea* samples were rhomboidal/square/rectangular (six-sided) phytoliths, as well as epidermal and hair cells

(Figure O.11.B-E). Six-sided phytoliths were dominant in all the plant sections. In the leaf samples 72% of variety 1 and 64% of variety 2 assemblages were composed of them. In the stems 59% of the phytoliths from variety 1 and 72,5% of the ones from variety 2 were four side. Ninety-six percent (96%) of the phytoliths from *V. subterranea* 1 seed pods and 97% of the ones from *V. subterranea* 2 seed pods were rhomboidal/square/rectangular. In the roots 73% of the phytoliths from variety 1 and 60% of the phytoliths from variety 2 were six-sided (see Figure 5.10 and Table L.4).

Epidermal cells were abundant in the roots (27% of the phytoliths), leaves (27,5% of the assemblage) and stems (41% of the phytoliths) of *V. subterranea* 1 and rare in the seed pod samples (4% of the sample). In *V. subterranea* 2 epidermal cells were present in high numbers in the leaves (35,5% of the phytoliths), stems (27,5% of the assemblage) and roots (40% of the phytoliths). They were rare in the seed pods (3% of the sample). Hair cell phytoliths were only present in leaf samples and they were present in low numbers (0,5% of the phytoliths in both leaf samples) (see Figure 5.10 and Table L.4).

Phytoliths from seeds

No phytoliths were observed in the seed samples of *V. subterranea* 1 and 2.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

Rhomboidal/square/rectangular phytoliths were dominant in all the varieties chosen for study. Ninety-four-and-a-half percent (94,5%) of the phytoliths from variety 1 and 74,5% of the ones from variety 2 comprised them. Epidermal cell phytoliths were common in *V. subterranea* 2 (23,5% of the phytoliths), but were rare in variety 1 samples (5% of the assemblage). Hair cells were present in low numbers in *V. subterranea* 1 (0,5% of the phytoliths) and 2 (2% of the phytoliths) (see Figure 5.10 and Table L.12).

Phytoliths from specimens harvested at 1 month

The majority of the phytoliths observed in *V. subterranea* samples were rhomboidal/square/ rectangular (six-sided). Seventy-six percent (76%) of the phytoliths from variety 1 and 70,5% of the phytoliths from variety 2 comprised them. Epidermal cells were abundant in variety 2 (27,5% of the sample) and common in *V. subterranea* 1 (19% of the assemblage). Hair cell phytoliths were rare in all the samples, with 5% of variety 1 and 2% of variety 2 samples being composed of them (see Figure 5.10 and Table L.12).

Vigna unguiculata subsp. *unguiculata*

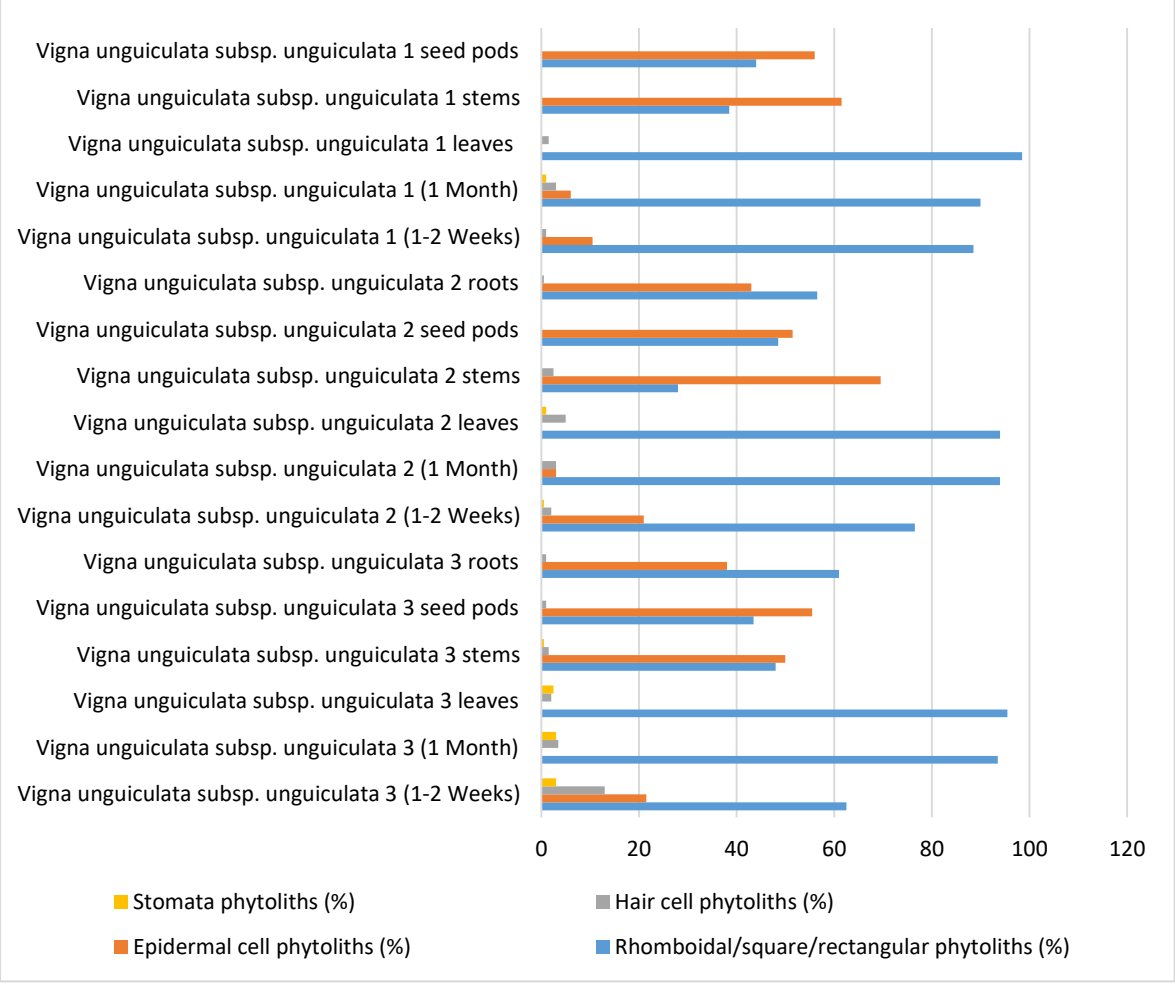

Figure 5.11. Percentages of phytolith morphotypes observed in *V. unguiculata* subsp. *unguiculata* samples.

Phytolith morphotypes observed in the mature samples

Phytoliths from leaves, seed pods, stems and roots

Numerous phytoliths were observed in *V. unguiculata* subsp. *unguiculata*, including hair cells, hair cell bases, epidermal cells and rhomboidal, square or rectangular shaped (also referred to as six-sided) phytoliths (cf. Cummings 1992:185) (Figure O.11.G-J). In the leaves of variety 1 98,5% of the phytoliths were rhomboidal/square/rectangular and the remaining 1,5% were hair cells. In the stems (61,5% of the phytoliths) and seed pods (56% of the sample) epidermal cell phytoliths were dominant. Rhomboidal/ square/rectangular phytoliths are abundant in the stem (38,5% of the phytoliths) and seed pod samples (44% of the assemblage). Hair cell phytoliths were only present in the leaves and were rare (1,5% of the sample). Too few phytoliths were encountered in the roots to do a diagnostic count.

In *V. unguiculata* subsp. *unguiculata* 2 rhomboidal/square/rectangular phytoliths were dominant in the leaves (94% of the phytoliths) and roots (56,5% of the assemblage). In the stems (28% of the phytoliths) and seed pods (48,5% of the sample) they were abundant. Epidermal cell phytoliths were dominant in stems (69,5% of the assemblage) and seed pods (51,5% of the phytoliths) and were abundant in the roots (43% of the sample). They were absent in from variety 2 leaves. Less than 5% of the phytoliths from the leaf, stem and root assemblages were hair cell phytoliths and these phytoliths were absent from the seed pod samples. Stomata were only observed in the leaves (1% of the phytoliths).

Lastly, rhomboidal/ square/rectangular phytoliths were dominant in the leaves (95,5% of the sample) and roots (61% of the phytoliths) of *V. unguiculata* subsp. *unguiculata* 3. In the stems (48% of the assemblage) and seed pods (43,5% of the sample) they were present in high numbers. Epidermal cell phytoliths were dominant in the stems (50% of the phytoliths) and seed pods (55,5% of the assemblage) of variety 3. In the roots they were abundant (38% of the phytoliths), but in the leaves they were absent. Less than 5% of the phytoliths of all the plant sections were hair cell phytoliths. Only leaves (2,5% of the phytoliths) and stems (0,5% of the sample) contained stomata and they were rare (see Figure 5.11 and Table L.7).

Seeds

V. unguiculata subsp. *unguiculata* seeds contained no visible phytoliths despite the fact that there was evidence of silica in each slide.

Phytolith morphotypes observed in the juvenile samples

Phytoliths from specimens harvested at 1-2 weeks

Rhomboidal/square/rectangular phytoliths were dominant in all three of the *V. unguiculata* subsp. *unguiculata* varieties. Eighty-eight-and-a-half percent (88,5%) of the phytoliths from variety 1, 76,5% of the ones from variety 2 and 62,5% of the phytoliths from variety 3 were six-sided. Epidermal cell phytoliths were common in all the samples. Ten-and-a-half percent (10,5%) of variety 1 phytoliths, 21% variety 2 phytoliths and 21,5% of the variety 3 phytoliths are epidermal cells. In *V. unguiculata* subsp. *unguiculata* 3 hair cell phytoliths were present in moderate numbers (13% of the phytoliths). They were rare in the other two varieties (2% of variety 2 and 1% of variety 1 samples). Stomata phytoliths were noted in varieties 2 (0,5% of the assemblage) and 3 (3% of the phytoliths) (see Figure 5.11 and Table L.12).

Phytoliths from specimens harvested at 1 month

The most frequently observed phytoliths in all the varieties were rhomboidal/square/ rectangular phytoliths. Ninety percent (90%) of variety 1, 94% of variety 2 and 93,5% of variety 3 phytoliths were six-sided. Epidermal cell phytoliths were rare and only present in *V. unguiculata* subsp. *unguiculata* 1 (6% of the phytoliths) and 2 (3% of the assemblage). Less than 5% of the phytoliths recorded in all of the samples were hair cells. Stomata phytoliths were noted in *V. unguiculata* subsp. *unguiculata* 1 (1% of the sample) and 3 (3% of the phytoliths) (see Figure 5.11 and Table L.12).

Wild taxa: Poaceae

Cenchrus ciliaris

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

In *C. ciliaris* leaves short cell phytoliths were dominant (5% of the sample), hair cells were abundant (22,5% of the phytoliths) and epidermal long cells were common (12,5% of the assemblage). Papillae (4,5% of the phytoliths), bulliform (2,5% of the sample), epidermal

cell (2% of the phytoliths) and stomata phytoliths (1% of the assemblage) were rare (see Table E.5 and Figure O.12.F).

In the short cell only count variant 1 crosses were dominant (57% of the sample) (Figure O.12.E) and bilobates were abundant (40% of the phytoliths). Only variant 2 and 3 bilobates were observed. Less than 5% of the leaf samples comprised cross 5/6, polylobate 1 and polylobate 2 phytoliths (see Table E.6).

Measurements were obtained for bilobate and cross 1 phytoliths, but due to the low frequency of cross 5/6 phytoliths and variant 1 and 2 polylobates their dimensions could not be recorded. The size characteristics of bilobates and cross 1 phytoliths are summarized in Table K.1 and Table K.2.

Inflorescence phytoliths

While numerous research projects (see e.g. Twiss *et al.* 1969; Rossouw 2009) have looked at the phytoliths produced in Panicoideae leaves, relatively few projects have focussed on the phytoliths produced within their inflorescences. Short cell phytoliths were also abundant in the inflorescence samples (43% of the assemblage) (Figure O.12.B-D). Cross 1 phytoliths were dominant (51,5% of short cells), while round rondels (17% of the short cells) and cross-rondels (13,5% of the short cells) were common (see Table E.8). Cross-rondels were classified as complex phytolith. One side of the phytolith was cross shaped while the other was rondel shape. The rondel was clearly visible within the cross in planar view. In side view the phytolith was tabular. Bilobates, elongate rondels, elongate saddles, variant 5/6 crosses and polylobates were also observed in the inflorescence samples, but they were rare. Seven-and-a-half percent (7,5%) of the short cell phytoliths were bilobates, 6% were elongate rondels, 3,5% were elongate saddles, 0,5% were polylobates and 0,5% were variant 5/6 crosses (see Table E.8)s. The bilobates encountered fell into the variant 2 and 3 categories and the outer margins of their lobes varied in shape (see Table E.13 and Table E.15).

Measurements were taken of variant 1 crosses, bilobates and cross-rondels, as well as round and elongate rondels. Too few cross 5/6, polylobate and elongate saddle phytoliths were encountered to obtain statistically relevant results based on their measurements. The available data is summarized in Table K.1 and Table K.2.

Other phytoliths identified in *C. ciliaris* inflorescence included hair cells (40% of the phytoliths), which were abundant and hair cell clusters (15% of the assemblage) which were common (Figure O.12.A). Epidermal cell phytoliths (2% of the phytoliths) were rare (see Table E.7). Hair cell clusters, as the name suggests, were large numbers of hair cell phytoliths grouped together to form a composite phytolith.

Digitaria ciliaris

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

The typical Panicoid short cell phytoliths were observed in the leaf specimens of *D. ciliaris* (Figure O.12.G-H.). Bilobate phytoliths were dominant (96,5% of the short cells), with variant 1, 2 and 3 bilobates occurring in the sample (see Table E.13 and E.14). Cross 1 (2,5% of the short cells) and polylobate (1% of the short cells) phytoliths were present, but extremely rare (see Table E.6).

While short cell phytoliths were dominant in the leaf samples (83% of the phytoliths), other phytoliths were rare. Hair cells (9,5% of the assemblage), epidermal cells (4,5% of the sample), papillae (1,5% of the phytoliths), stomata (1% of the sample) and epidermal long cells (0,5% of the assemblage) were among the phytoliths that were also observed (see Table E.5).

Due to the low frequency at which most phytoliths occurred, measurements were only taken of bilobates. The data set is summarized in Table K.4 and Table K.5.

Inflorescence phytoliths

Similar to the leaf samples, the inflorescences were dominated by short cell phytoliths (86,5% of the assemblage) (Figure O.12.I-K). Other phytoliths observed included hair cells (10% of the phytoliths), epidermal long cells (1,5% of the sample), hair cell mesophyll (1,5 of the phytoliths) and epidermal cells (0,5% of the assemblage) (see Table E.7).

In terms of short cells, variant 1 crosses were the most abundant phytoliths encountered (71% of the assemblage). Bilobates were common (21,5% of the sample) and low numbers of

polylobate (7% of the short cells) and cross 5/6 phytoliths (0,5% of the sample) were identified (see Table E.8).

Variant 1, 2 and 3 bilobates were encountered during analysis. These had lobes with convex, concave or flattened outer margins. On occasion bifids were also noted in the bilobates with rounded margins (see Table E.13 and Table E.15). Measurements were obtained for bilobates, as well as cross 1 phytoliths (for summery see Table K.4 and Table K.5). Too few cross 5/6 and polylobate 1 and 2 phytoliths were encountered to determine size ranges.

Eleusine coracana* subsp. *africana

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

E. coracana subsp. *africana* forms part of the Chloridoideae subfamily which frequently produces saddle phytoliths (Twiss *et al.* 1969; Rossouw 2009). Short cell phytoliths (38% of the assemblage) were abundant in the leaves of this specimen (Figure O.12.L-O). Hair cell phytoliths occurred in larger numbers (49,5% of the sample) and epidermal long cells (8% of the phytoliths), epidermal cells (3,5% of the assemblage), papillae (0,5% of the phytoliths) and bulliforms (0,5% of the sample) were present, but rare (see Table E.5).

Cross 1 and bilobate phytoliths are predominantly associated with Panicoid grasses. They, however, were not only present in *E. coracana* subsp. *africana* leaves, but they were more abundant than any of the other short cells (see Table E.6). Thirty-nine percent (39%) of the short cell phytoliths were variant 1 crosses and 24% were bilobates. The bilobates observed fell into the variant 2 and 3 categories and had concave, convex or flattened outer margins (see Table E.13 and Table E.14). Depressed saddles, as well as elongate saddles were also observed. Six-and-a-half percent (6,5%) of the short cells were depressed saddles and 4,5% were elongate saddles. Cross 5/6 phytoliths (13,5% of the assemblage), round (13,5% of the sample) and elongate rondels (6,5% of the short cells) were rare (see Table E.6). Data based on length and width were gathered for all the short cells observed, except for elongate saddles which occurred too infrequently (see Table K.7 and Table K.8).

Inflorescence phytoliths

Unlike the leaf specimens, the most frequently observed phytoliths in the short cell count were depressed saddles (78% of the assemblage) and elongate saddles (19% of the short cells) (Figure O.12.L-O). Low numbers of bilobates (2% of the assemblage) and variant 1 crosses (1% of the sample) were also encountered (see Table E.8). Length and width measurements were only obtained for saddle phytoliths (see Table K.7 and Table K.8)

Apart from the short cells, which were dominant (58% of the phytoliths), hair cell (27,5% of the sample), epidermal cell (13,5% of the assemblage) and bulliform phytoliths (1% of the phytoliths) were also noted. Hair cells were abundant and epidermal cells were common, but bulliforms were rare (see Table E.7).

Eleusine indica

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

E. indica short cell samples were dominated by depressed saddle phytoliths (84,5% of the sample) (Figure O.12.Q-T). Elongate saddles (10% of the assemblage), variant 1 crosses (3,5% of the short cells) and bilobates (2% of the assemblage) were also noted during my analysis, but they were rare (see Table E.6). Enough of both types of the saddle phytoliths were available to measure a statistically relevant number of specimens (see Table K.10 and Table K.11). Data based on the length and width measurements of the remaining morphotypes were not collected due to the low frequencies at which they occurred.

While short cell phytoliths were most frequently encountered (39% of the sample), they were not the only phytoliths that were abundant. Copious numbers of epidermal long cell (21,5% of the phytoliths) and epidermal cell phytoliths (20% of the assemblage) were also observed. Hair cell mesophyll was common (13,5% of the phytoliths) in these samples and, while rare, hair cell (1% of the sample) and stomata phytoliths (5% of the assemblage) were also noted (see Table E.5) (Figure O.12.P).

Inflorescence phytoliths

Short cell phytoliths were dominant (60% of the sample) in *E. indica*'s inflorescence samples (Figure O.12.Q-T). Most of these were depressed saddles (42,5% of the phytoliths) and elongate saddles (53% of the assemblage), but variant 1 crosses (0,5% of the phytoliths) and bilobates (4% of the sample) were also present (see Table E.8). The measurements for the saddles are summarized in Table K.10 and Table K.11, but the bilobates and crosses appeared at such low frequencies that no morphologic or length and width measurement data could be obtained.

Apart from short cells, epidermal long cell phytoliths were present in moderate numbers (22,5% of the sample) and so were hair cells (12% of the phytoliths). Epidermal cells (2,5% of the assemblage), stomata (1,5% of the sample) and hair cell mesophyll (0,5% of the phytoliths) were encountered, but they were rare (see Table E.7).

Eleusine multiflora

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

E. multiflora is a Chloridoid grass, but while depressed saddles were abundant (28,5% of the phytoliths) and elongate saddles were present in moderate numbers (16% of the assemblage); bilobate (20,5% of the sample), round rondel (22,5% of the phytoliths) and cross 1 phytoliths (12,5% of the assemblage) were also observed (see Table E.6) (Figure O.13.A-B). Morphological and length and width measurements were obtained for all the short cell phytolith types encountered (see Table K.13 and Table K.14).

While short cell phytoliths were dominant (57,5% of the sample), epidermal long cells were abundant (28,5% of the phytoliths) in *E. multiflora* leaf samples and stomata phytoliths were common (11,5% of the assemblage). Rare phytoliths included hair cells (1,5% of the phytoliths), bulliforms (0,5% of the sample) and epidermal cell phytoliths (0,5% of the assemblage) (see Table E.5).

Inflorescence phytoliths

The short cell phytoliths (59% of the sample) that were most widespread in these samples were bilobates (31% of the sample) and variant 1 crosses (30,5% of the short cells). Elongate saddles (12% of the assemblage) and depressed saddles (17,5% of the short cells) were present in moderate numbers and variant 5/6 crosses (1% of the sample), round (5% of the assemblage) and elongate rondels (3% of the short cells) were rare (see Table E.8) (Figure O.13.C-D). Length and width measurements were obtained for both types of saddles, bilobates and cross 1 phytoliths (see Table K.13 and Table K.14).

Hair cells were, by far, the most abundant non-short cell phytoliths encountered (29,5% of the phytoliths). Epidermal cell phytoliths (9,5% of the sample), as well as epidermal cells (1,5% of the assemblage) and bulliforms (0,5% of the phytoliths) were present in low numbers (see Table E.7).

Eleusine tristachya

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Depressed saddles dominated the short cell sample of this grass (76,5% of the assemblage), while elongate saddles were present in moderate numbers (22,5% of the short cells). Bilobate phytoliths were also noted (1% of the sample) (see Table E.6) (Figure O.13.E-G). Measurements could only be obtained for the saddle phytoliths (see Table K.16 and Table K.17).

Despite the majority of the phytoliths being short cells (78% of the sample), moderate numbers of epidermal long cells were also observed (11,5% of the phytoliths). Rare phytoliths included stomata (4% of the phytoliths), hair cells (3% of the assemblage), epidermal cells (3% of the sample) and hair cell mesophyll (0,5% of the phytoliths) (see Table E.5).

Inflorescence phytoliths

Short cell (90% of the phytoliths), hair cell (9,5% of the sample) and epidermal cell phytoliths (0,5% of the assemblage) were the only phytoliths observed in *E. tristachya* inflorescence samples. The majority of the phytoliths were short cells and low numbers of the other phytoliths were present (see Table E.7).

Similar to the leaves, depressed saddles were dominant (74,5% of the short cells) and elongate saddles were common (24% of the sample) in the short cell counts (Figure O.13.E-F). Cross 1 (1% of the assemblage) and bilobate phytoliths (0,5% of the short cells) (Figure O.13.G) were noted, but they occurred in such low numbers that length and width measurements could not be obtained for them (see Table E.8, Table K.16 and Table K.17).

Pennisetum purpureum

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Short cell phytoliths were abundant in the leaf samples (40% of the phytoliths) (Figure O.13.I-K) and were made up of variant 1(51% of the short cells), variant 2 (1% of the sample), variant 5/6 (5,5% of the assemblage) and variant 7 crosses (4% of the short cells), as well as bilobates (32,5% of the samples) and variant 1 (4% of the short cells) and 2 polylobates (2% of the sample). Cross 1 phytoliths dominated the short cell sample and bilobates were abundant (see Table E.6). Only bilobates from the variant 2 and 3 categories were observed and the shapes of these lobes differed greatly (see Table E.13 and Table E.14). Length and width measurements could only be obtained for bilobates, cross 1 and cross 5/6 phytoliths (see Table E.6, Table K.19 and Table K.20).

Hair cell phytoliths (37,5% of the phytoliths) were almost as abundant as the short cells and epidermal long cells were common (11,5% of the sample). Rare phytoliths included stomata (5,5% of the assemblage) and epidermal cells (5,5% of the phytoliths) (see Table E.5).

Inflorescence phytoliths

Hair cell phytolith dominated the inflorescence sample (54,5% of the sample), but short cells were still abundant (35,5% of the phytoliths) (Figure O.13.I-K). The short cell phytoliths

observed included bilobates (61,5% of the sample), variant 1 and 2 polylobates (16,5% of the assemblage), as well as variant 1 (15,5% of the short cells), 2 (0,5% of the sample) and 5/6 crosses (6% of the short cells) (see Table E.8). The bilobates encountered were predominantly variant 2, but some fell into the variant 3 category. A multitude of different lobe shapes were recorded (see Table E.13 and Table E.15). Statistically relevant data based on measurements were obtained for bilobate, cross 1 and polylobate phytoliths (see Table K.19 and Table K.20). The other short cell morphotypes occurred too infrequently to determine their sizes.

Apart from hair and short cells, hair cell clusters (6% of the phytoliths) and sinuous long cell phytolith (4% of the sample) were also noted (Figure O.13.H). Sinuous long cells (also known as variant 1 long cells), which are common in *S. bicolor* subsp. *bicolor*, are long cell phytoliths which have regular, sometimes parallel waves. These phytoliths almost exclusively occur articulated in sheets (Logan 2012:97). Both of these phytoliths occurred in low numbers (see Table E.7).

Sorghum bicolor* subsp. *arundinaceum

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Short cell phytoliths were dominant in *S. bicolor* subsp. *arundinaceum* leaves (73% of the sample) (Figure O.13. L, N). Only cross 1 (65% of the short cells), cross 5/6 (4,5% of the sample) and bilobate phytoliths (30,5% of the assemblage) were encountered in the short cell sample (see Table E.6). Cross 5/6 phytoliths appeared too infrequently to do any measurements, however enough variant 1 crosses and bilobates were observed to obtain statistically relevant data (see Table K.22 and Table K.23). The majority of the bilobates in this sample fell into the variant 2 category, but variant 3 bilobates were also noted (see Table E.14). Differences in the lobe shapes were recorded (see Table E.13).

Epidermal long cell (11,5% of the assemblage) and stomata phytoliths (11% of the samples) were common in *S. bicolor* subsp. *arundinaceum* leaves (Figure O.13.M). Rare phytolith that were noted included hair cells (2,5% of the phytoliths), epidermal cells (1% of the sample) and bulliform phytoliths (1% of the assemblage) (see Table E.5).

Inflorescence phytoliths

Short cell phytoliths were not as abundant in the inflorescence samples as they were in other indigenous taxa, and only 29,5% of the assemblage comprised them (Figure O.13.P-Q). Dendritic long cells were dominant (66% of the phytoliths). They are irregular in shape, with sharp pointed peaks and indentations that varied in size (cf. Logan 2012). Sinuous long cells (3,5% of the sample), as well as hair cell phytoliths (1% of the assemblage) occurred in low numbers (see Table E.7).

Several types of short cells were noted, including depressed saddles (59% of the short cells) and elongate saddles (19,5% of the sample), bilobates (8,5% of the assemblage), round (8% of the sample) and elongate rondels (1,5% of the assemblage) and variant 1 crosses (0,5% of the phytoliths). In addition, saddle-like-rondels, similar to those observed in *S. bicolor* subsp. *bicolor* were also present in the sample (3% of the sample). Depressed saddles were dominant and elongate saddles were common. The remaining phytoliths were present in low numbers (see Table E.8) and, thus, length and width measurements could not be obtained for them. Measurement data were collected for depressed and elongate saddles, bilobates and dendritic long cells (see Table K.22 and Table K.23). Only variant 2 and 3 bilobates were noted (see Table E.13 and Table E.15).

Sorghum bicolor* subsp. *drummondii

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

The most frequently observed phytolith in *S. bicolor* subsp. *drummondii* leaves were short cells (73% of the sample) (Figure O.13.R-U). Bilobates (63% of the short cells), variant 1 (32% of the sample) and variant 5/6 crosses (3% of the assemblage) and polylobate 1 phytoliths (2% of the short cells) formed part of this sample. Since bilobates were dominant and cross 1 phytoliths were abundant (see Table E.6), enough of both of these phytoliths were present to obtain statistically relevant data based on their size and morphology (see Table K.25 and Table K.26). All of the bilobates fell into the variant 2 or 3 categories and numerous types of lobe shapes were observed (see Table E.13 and Table E.14). No length

and width measurements were collected for cross 5/6 or polylobate 1 phytoliths, because too few of them were encountered.

Apart from short cells, epidermal cells (9% of the sample) and epidermal long cells (9% of the phytoliths), as well as hair cell (4,5% of the assemblage), stomata (3% of the sample), bulliform (1% of the phytoliths) and hair cell mesophyll phytoliths (0,5% of the assemblage) were observed. These phytoliths were, however rare (see Table E.5).

Inflorescence phytoliths

Short cell phytoliths were dominant in the inflorescence samples of *S. bicolor* subsp. *drummondii* (60,5% of the assemblage) (See Figure O.13.V-Y.). Dendritic long cells, though not as abundant short cells, were observed in high numbers (36,5% of the phytoliths). Hair cells (2,5% of the sample) and sinuous long cell phytoliths (0,5% of the assemblage) were noted, but they were rare (see Table E.7).

During the short cell phytolith count depressed and elongate saddles, bilobates, saddle-like-rondels, round rondels and polylobates were encountered. Depressed saddles were abundant (48% of the short cells), while elongate saddles (24,5% of the sample) and bilobates (21% of the assemblage) were common (see Table E.8). Enough of these phytoliths were, thus, available to obtain length and width measurements (see Table K.25 and Table K.26). All of the bilobates observed fell into the variant 2 category and they had lobes with convex outer margins (see Table E.13 and Table E.15). Too few saddle-like-rondels (3% of the short cells), round rondels (2% of the sample) and polylobates (1,5% of the short cells) were encountered in the sample to measure.

Sorghum halepense

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Short cell phytoliths were dominant in the leaf samples (77% of the assemblage) and bilobates, variant 1 and variant 5/6 crosses, as well as polylobate 1 phytoliths were observed (Figure O.14.A). Epidermal long cells were common (11% of the phytoliths), but epidermal

cells (5,5% of the sample), stomata (4,5% of the assemblage), hair cells (1,5% of the phytoliths) and bulliform phytoliths (0,5% of the sample) were rare (see Table E.5).

The most frequent phytolith observed during short cell counts were bilobates (50% of the sample) and moderate numbers of cross 1 phytoliths were encountered (37,5% of the short cells). The remaining short cell phytoliths were rare (see Table E.6). Eight percent (8%) of the assemblage were variant 5/6 crosses and 4,5% were polylobate 1 phytoliths. Enough bilobates and crosses were measured to obtain statistically relevant data (see Table K.28 and Table K.29). Length and width measurements were not obtained for polylobate 1 phytoliths. The bilobates present in the sample fell into the variant 2 and 3 categories. Numerous lobe shapes were recorded (see Table E.13 and Table E.14).

Inflorescence phytoliths

Epidermal long cell phytoliths were dominant in *S. halepense* inflorescence samples (55,5% of the sample). These resembled those produced in the leaves rather than the dendritic or sinuous ones often observed in genus *Sorghum*'s inflorescence. Short cells were abundant (25,5% of the assemblage), while hair cell phytoliths were common (18% of the phytoliths). Epidermal cell phytoliths (0,5% of the sample) and hair cell clusters (0,5% of the phytoliths) were also noted, but they were rare (see Table E.7).

Several types of short cell phytoliths were encountered (Figure O.14.B-E). Depressed saddles (28,5% of the sample) and elongate saddles (20% of the short cells), round rondels (23% of the assemblage) and bilobates (23% of the short cells) were all present in moderate numbers. Saddle-like-rondels (2,5% of the sample), elongate rondels (1,5% of the short cells) and variant 1 (1% of the assemblage) and 5/6 cross phytoliths (0,5% of the sample) were rare (see Table E.8). Length and width measurements were obtained for both types of saddles, as well as round rondels and bilobates (see Table K.28 and Table K.29). The majority of the bilobates observed were classified as variant 2 and the outer margins of their lobes were convex. Variant 3 bilobates were rare (see Table E.13 and Table E.15.).

Sorghum versicolor

Phytolith morphotypes observed in the mature samples

Leaf phytoliths

Short cell phytoliths were dominant (67,5% of the sample) and several types were observed in the leaf samples of *S. versicolor* (See Figure O.14.I-K). Hair cell mesophyll was common (21% of the phytoliths) and rare phytoliths included epidermal cells (5,5% of the assemblage), epidermal long cells (2,5% of he sample), bulliforms (2% of the phytoliths), as well as hair cell phytoliths (1,5% of the assemblage) (see Table E.5).

In the short cell count, variant 1 crosses (32% of the sample), bilobates (27,5% of the phytoliths) and polylobate 2 phytoliths (23,5% of the sample) were abundant and variant 1 polylobates were common (17% of the assemblage) (see Table E.6). Length and width measurements were obtained for all the short cell phytoliths encountered in *S. versicolor* leaf samples (see Table K.31 and Table K.32). Bilobates from all four categories were identified and these often had lobes with outer margins that were convex, concave or flattened (see Table E.13 and Table E.14).

Inflorescence phytoliths

Dendritic epidermal long cell phytoliths were dominant in *S. versicolor'*s inflorescence samples (55% of the phytoliths) (See Figure O.14.F), while short cell phytoliths were abundant (32,5% of the sample) (See Figure O.14.G-H). Other phytoliths that were noted during analysis were hair cell (8% of the assemblage) and sinuous long cell phytoliths (4,5% of the phytoliths) (see Table E.7).

In the short cell count, elongate saddles (36% of the short cells) and depressed saddles (25% of the sample) were present in high numbers and bilobates were common (22,5% of the assemblage). Round and elongate rondels (6% and 4% of the short cells respectively), variant 1 and 5/6 crosses (4% and 1% of the sample) and saddle-like-rondels (1,5% of the assemblage) were rare (see Table E.8). Measurements were obtained for depressed and elongate saddles, bilobates and dendritic long cell phytoliths (see Table K.31 and K.32). The bilobate phytoliths observed fell into the variant 2 and 3 categories. The majority of these phytoliths had lobes with convex outer margins (see Table E.13 and Table E.15).

Phytolith sizes

Domesticated Poaceae

Phytolith widths

Several studies (e.g. Pearsall 1978; Piperno 1991) have suggested that phytolith size is of great importance and this in conjunction with morphology was key to distinguishing between domesticated grasses and indigenous taxa in their study region. Phytolith width, instead of length, is commonly used to determine phytolith size categories (cf. Piperno 1991). In this study I also looked at phytolith width in order to compare my data with those from other studies.

The phytolith width of the domesticated grasses chosen for this study ranged in size from extra-small (smaller than 6,87 µm) to double extra-large (larger than 25,19 µm). This included phytoliths from the leaves, as well as the inflorescence of each plant. Phytoliths from both mature *E. coracana* subsp. *coracana* varieties, for example, were not larger than medium in size. In rare instances large phytoliths were, however, noted in the juvenile samples (see Table G.9 to Table G.12 and Figures 5.12 and 5.13).

Statistically there was no difference between the widths of the depressed saddles from the leaves or the elongate saddles from the inflorescences of the two varieties of *E. coracana.* subsp. *coracana*. There was also no difference between the widths of the elongate saddle phytoliths from *E. coracana.* subsp. *coracana* 2 and the phytoliths from its juvenile samples harvested at 1 month (see Table F.1, F.2, F.10, F.11).

There was a difference between the widths of the other phytoliths observed in the mature and juvenile samples of this domesticate. However, the majority of the phytoliths observed fell into the same size category (see Table G.9 to Table G.12 and Figures 5.12 and 5.13) and boxplots showed an overlap in the widths of many of the phytoliths from *E. coracana* subsp. *coracana* specimens (Figure D.1 and D.2, D.10 and D.11).

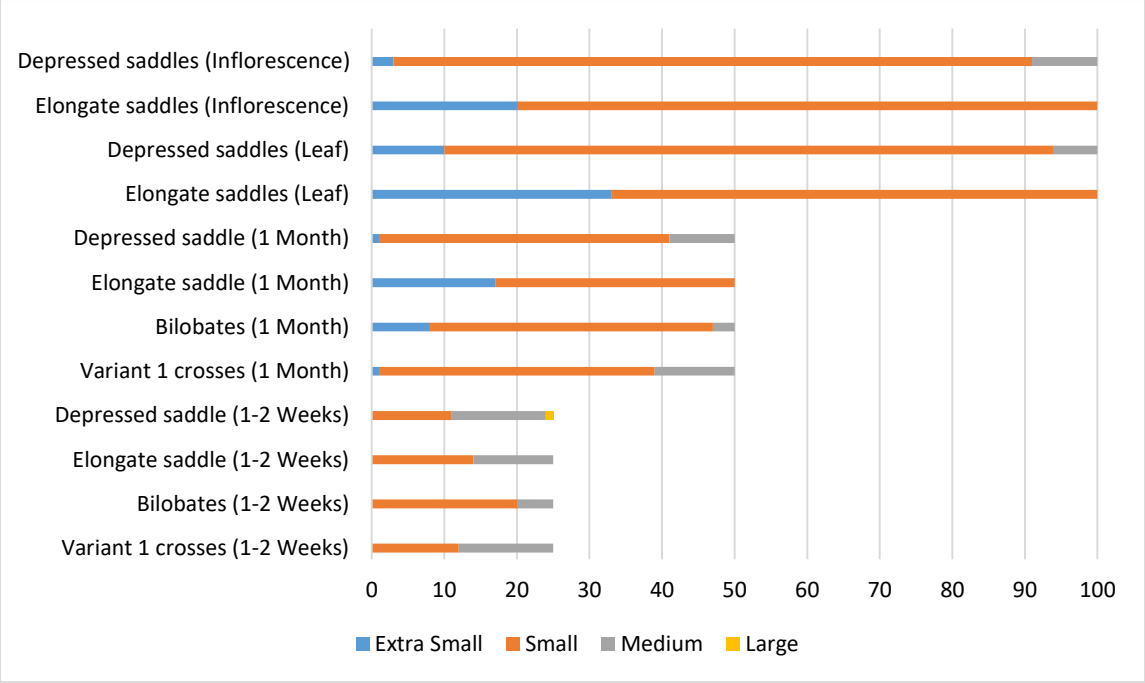

Figure 5.12. Size of phytoliths from *E. coracana* subsp. *coracana* 1.

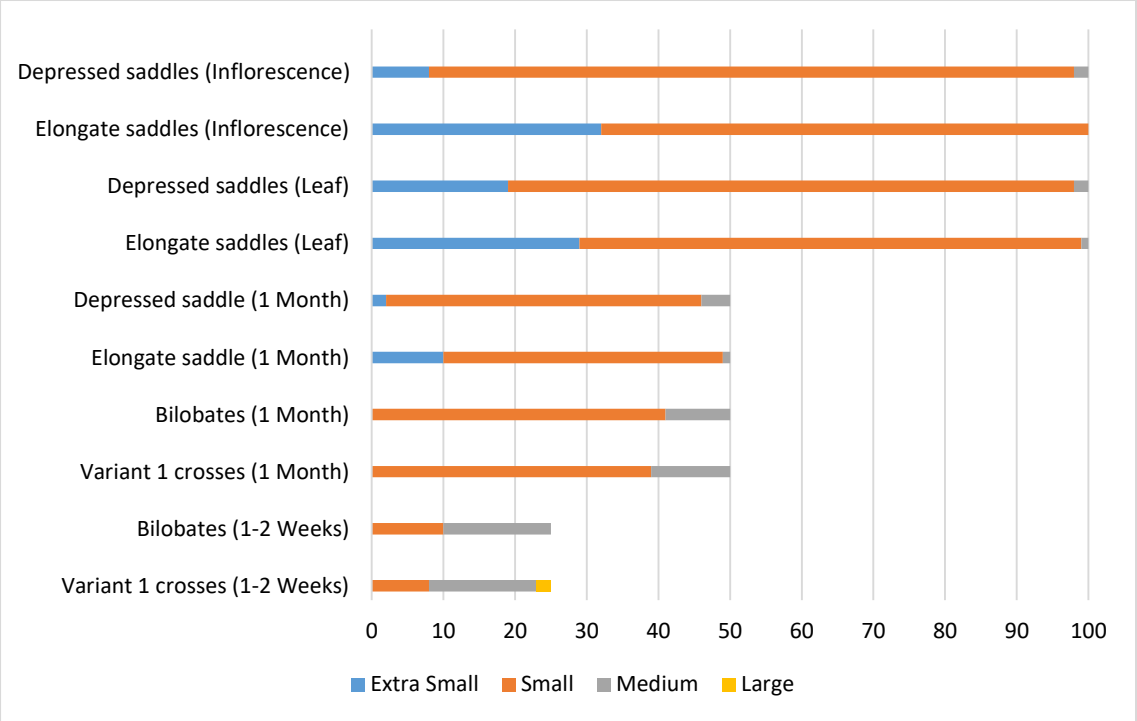

Figure 5.13. Size of phytoliths from *E. coracana* subsp. *coracana* 2.

In the mature *P. glaucum* 1 and 2 samples the majority of the phytoliths ranged between extra-small and medium (11,4 - 15,98 µm) in size. In the mature variety 2 samples, however, rare numbers of large (16,03 - 20,56 µm) bilobate phytoliths were recorded. In the juvenile variant 1 samples harvested at 1 month of age the biggest phytoliths observed were medium sized. The majority of the phytoliths from variant 1's 1 week samples were also extra-small to medium sized, but rare numbers of large cross 1 and polylobate phytoliths were encountered. In both of the juvenile samples taken from *P. glaucum* 2 phytoliths ranged between small and large in size. The large phytoliths were bilobates or cross 1 phytoliths (see Table H.9 to Table H.12 and Figures 5.14 and 5.15).

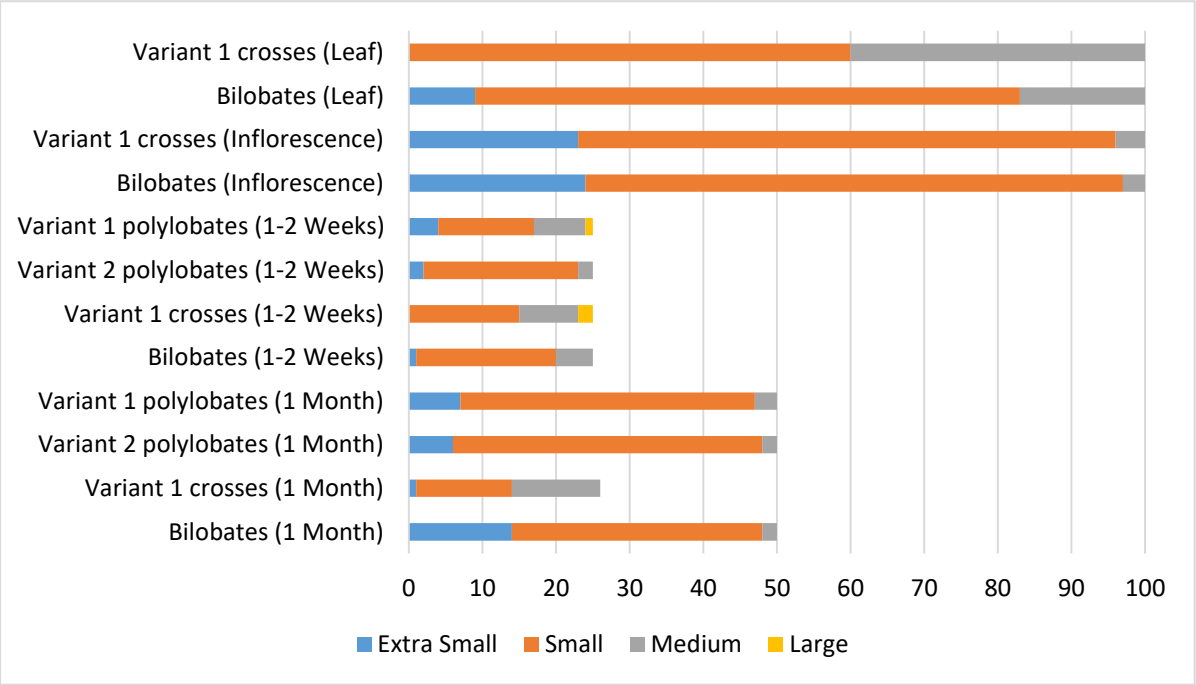

Figure 5.14. Size of phytoliths from *P. glaucum* 1.

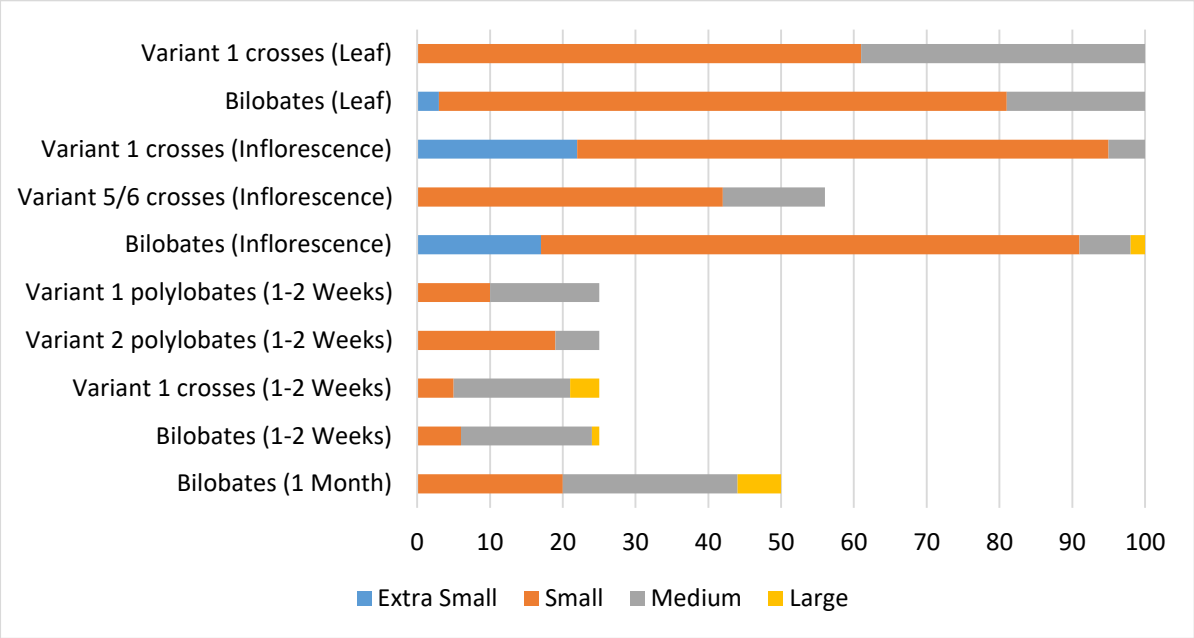

Figure 5.15. Size of phytoliths from *P. glaucum* 2.

There was no statistical variance between the widths of the cross 1 phytoliths from mature specimens of *P. glaucum* 1 and 2. This included the phytoliths from the leaves and inflorescences. The variant 1 crosses from the mature variety 1 leaves and those from the leaves of the juvenile taxa harvested at 1 week also showed no difference. Statistically, variances in width dimensions were noted for the other phytoliths observed in the mature and juvenile specimens of this domestic (see Figure F.4, F.7, F.12, F.13).

Despite the overall differences in the widths of the phytoliths observed in the *P. glaucum* 1 and 2 assemblages, there was still some size overlap between each of the phytolith morphotypes (see Figure D.3, D.4, D.8, D.9) which resulted in *P. glaucum* 1 and 2 phytoliths being sorted into the same size categories (see Figure 5.14 and 5.15).

Phytoliths from mature *S. bicolor* subsp. *bicolor* specimens ranged between extra-small and large in size. The majority of the phytoliths observed, in all the varieties of mature *S. bicolor* subsp. *bicolor*, fell into the small and medium categories. Rare numbers of large phytoliths were encountered and extra-small phytoliths were rare to common, depending on the phytolith morphotypes. Similar trends were observed in the 1-2 weeks and 1 month samples (see Table I.13 to Table I.18 and Figures 5.16-5.18).

Short cells were not the only phytoliths measured. The length and width of sinuous and dendritic long cell phytoliths were also recorded (see Table 5.1 and Tables I.-6). Statistically, the dendritic long cells from variety 2 and 3 were similar in size, while those from variety 1 differed from them (see Figure F.16 and Table D.12).

Table 5.1. Long cell phytolith widths from the inflorescences of *S. bicolor* subsp. *bicolor*.

Species	**Phytolith morphotypes**	**Minimum width (µm)**	**Maximum width (µm)**
***S. bicolor* subsp. *bicolor* 1**	Dendritic long cells	6,8	27,03
	Sinuous long cells	8,45	16,48
***S. bicolor* subsp. *bicolor* 2**	Dendritic long cells	2,79	24,09
	Sinuous long cells	10,41	22,17
***S. bicolor* subsp. *bicolor* 3**	Dendritic long cells	3,56	23,1
	Sinuous long cells	7,63	18,76

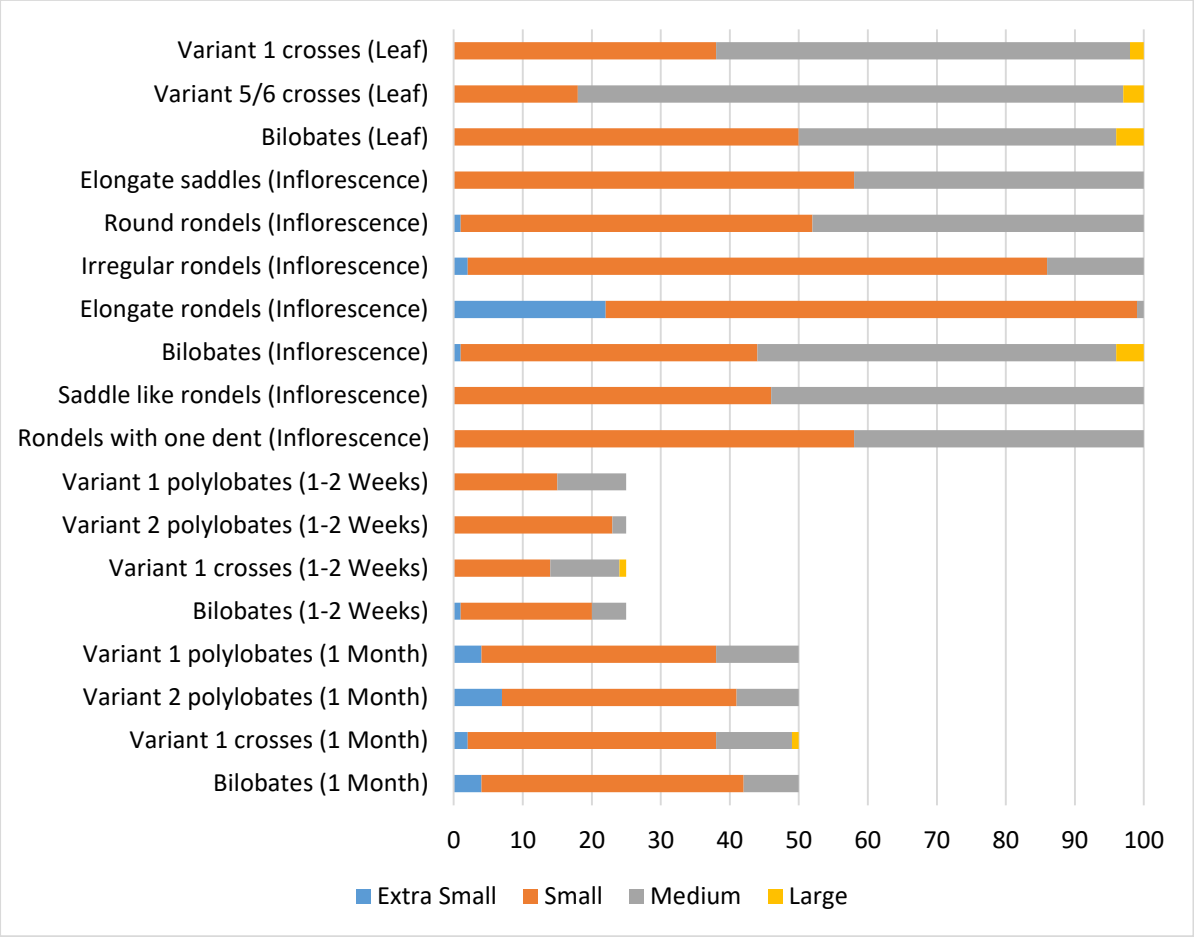

Figure 5.16. Size of phytoliths from *Sorghum bicolor* subsp. *bicolor* 1.

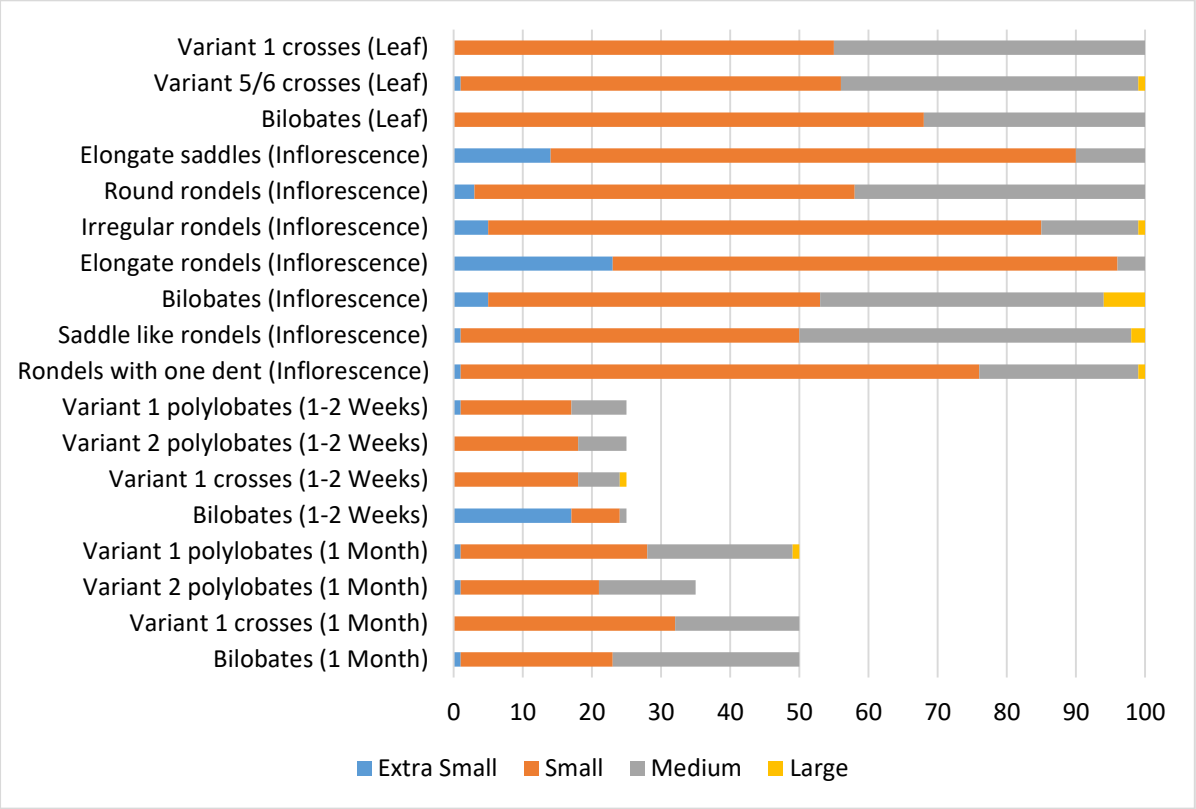

Figure 5.17. Size of phytoliths from *Sorghum bicolor* subsp. *bicolor* 2.

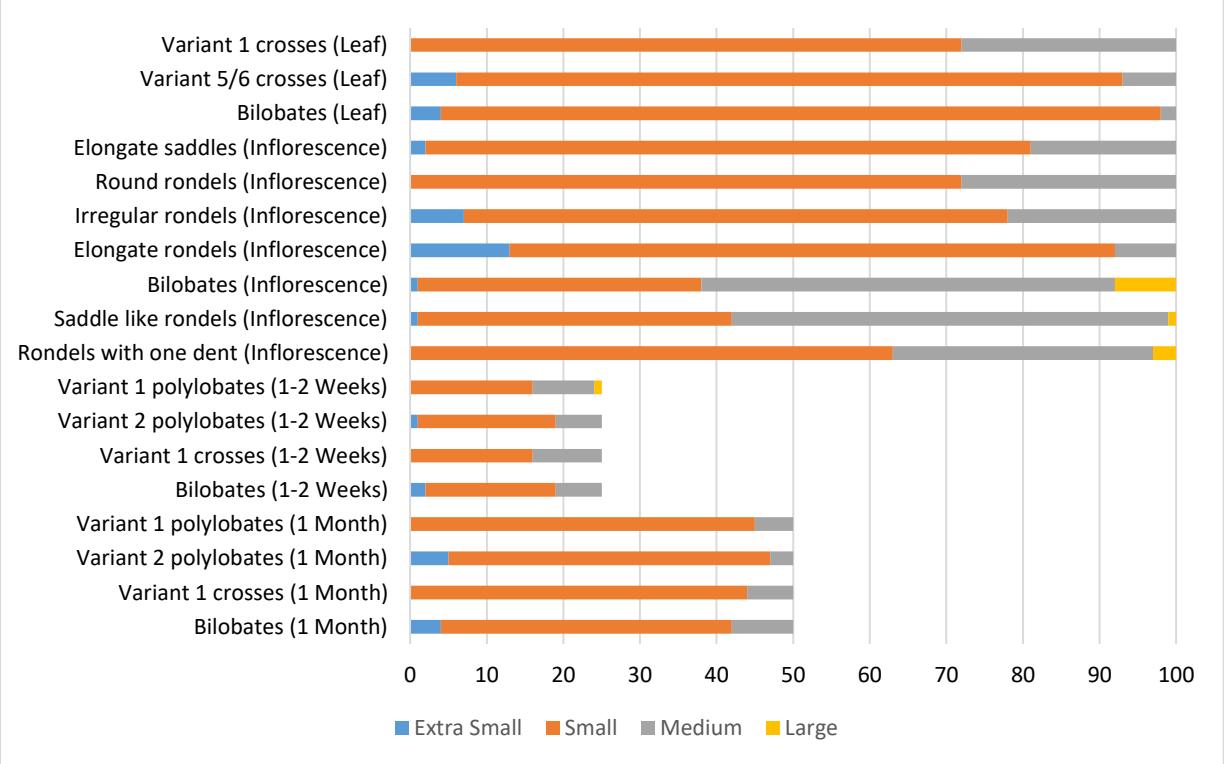

Figure 5.18. Size of phytoliths from *Sorghum bicolor* subsp. *bicolor* 3.

The majority of the short cell phytoliths from the *S. bicolor* subsp. *bicolor* taxa produced phytoliths that were also, in terms of size, statistically different from each other. However, the variant 5/6 crosses from the leaves of *S. bicolor* subsp. *bicolor* 1 and 2, as well as the elongate and round rondels from the inflorescences of all three varieties were similar in size.

There was little difference, in terms of width dimensions, between the variant 1 crosses from mature variety 1 leaves and those from *S. bicolor* subsp. *bicolor* 1 (1 week) samples. The leaf bilobates from the mature and juvenile variety 2 specimens, as well as the ones from the mature and juvenile variety 3 assemblages were also similar in size. Mature leaves from variety 3 and specimens of it harvested at 1 week had cross 1 phytoliths of similar sizes. In addition, no difference was noted in the size of the cross 1 phytoliths from mature leaves and juvenile specimens of variety 2 (see Figures F.3, F.5, F.8, F.11, F.14 and F.16-F.19).

Although statistically there were differences in the size of the majority of the phytoliths produced by the three varieties of *S. bicolor* subsp. *bicolor*, many of the phytolith morphotypes fell into the same size categories and overlapped in size (see Figures 5.16-5.18 and Figures D.3- D.7, D.9, and D.11-D.12).

While large phytoliths were rare in most of the domesticated grasses in this study, they were abundant in mature *Z. mays* specimens. In *Z. mays* 1, leaf phytoliths ranged in size from extra-small to extra-large, but the majority of the phytoliths were medium or large in size. Extra-small and extra-large phytoliths were rare and small phytoliths were rare to common. In the cobs, phytoliths were, at most medium, in size. In the tassels (male inflorescence) and husks phytoliths were small to extra-large (see Table J.13 and Table J.14; Table J.17 and Figures 5.19-5.20).

In *Z. mays* 2 leaf samples the majority of the phytoliths were small, medium or large. On rare occasions cross phytoliths were extra-large. Cob and tassel phytoliths were extra-small to large in size. Husk phytoliths were medium to double extra-large in size. In the 1-2 week and 1 month samples phytoliths from both specimens were extra-small to large in size. The majority of the phytoliths fell into the small or medium categories. Large phytoliths were rare (Table J.15; J.16 and J.18 and Figures 5.19-5.20).

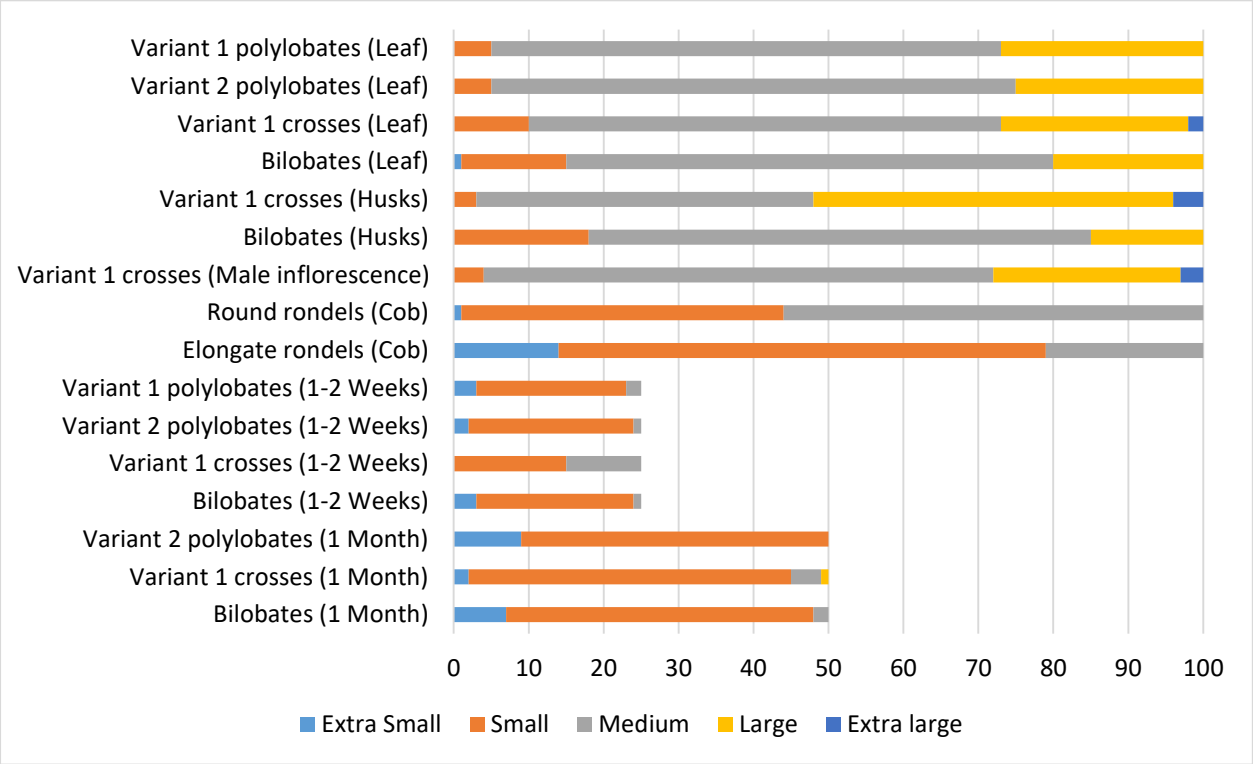

Figure 5.19. Size of phytoliths from *Z. mays* 1.

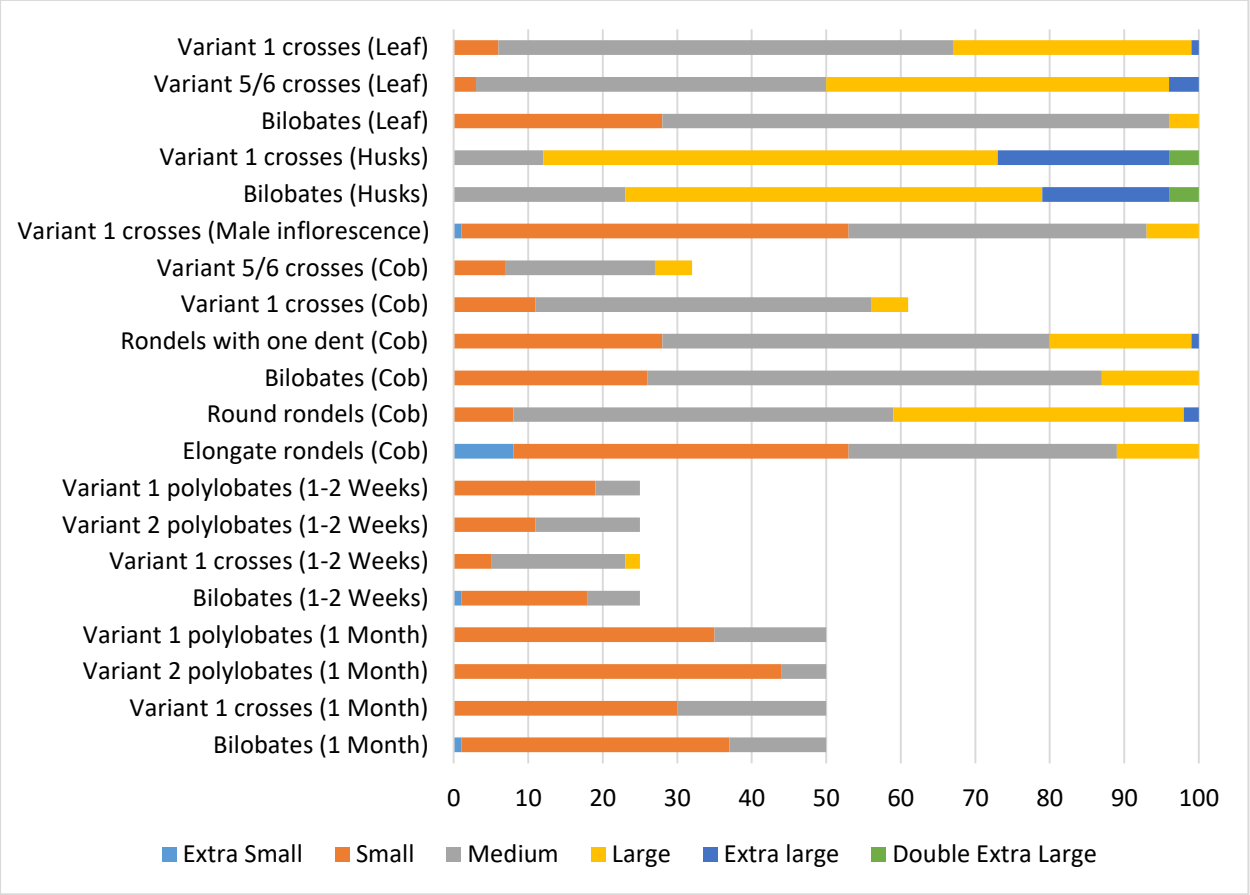

Figure 5.20. Size of phytoliths from *Z. mays* 2.

Although many of the phytoliths produced by *Z. mays* 1 and 2 fell into the same size categories, statistically the phytoliths viewed in the two varieties were not similar in width (see Figures D.3, D.4 and D.6-D.9).

Phytolith lengths

While the majority of the studies consulted for this project focus on phytolith width, I included a statistical analysis of the lengths of the phytoliths which were analysed (see Appendix F). Using ANOVA, I determined that in some cases there was no statistical difference between the phytoliths produced by different varieties of the same species.

In mature *E. coracana* subsp. *coracana* specimens, for example, there is no difference, statistically, between the depressed or the elongate saddles from the leaves of variety 1 and 2. The elongate saddles from the inflorescences of varieties of this crop were also similar in size, but the lengths of the depressed saddles in variety 1 and 2 differed (see Table F.22 and F23; Table F.31 and F.32). In the majority of the cases there were substantial differences in the lengths of the phytoliths observed in the juvenile and mature samples.

In *P. glaucum* 1 and 2 there were also phytoliths that were similar in length. A comparison of the phytoliths from variety 1 and variety 2 showed that there was little difference in the lengths of the bilobates from the inflorescences and leaves. In addition, the variant 1 crosses from the inflorescences of these varieties were similar in size. The rest of the phytoliths were not the same size and very few juvenile phytoliths were similar in length to those from the mature assemblages (see Tables F.25, F.28, F.33, F.34).

There were substantial differences in the lengths of the majority of the phytoliths viewed in the three varieties of *S. bicolor* subsp. *bicolor*. Apart from the bilobate phytoliths produced by the inflorescences, none of the other phytoliths were similar in size in all three of the varieties. Similarly, none of the juvenile phytoliths were similar in size to those viewed in the mature assemblages (see Tables F.24, F.26, F.29, F.32, F.35 and F.37-F.40).

A comparison between the lengths of the phytoliths from *Z. mays* 1 and 2 indicated that only the bilobate and the cross phytoliths from the leaves of the two varieties were similar in size. None of the inflorescences phytoliths were the same lengths and only a few of the phytoliths from the juvenile specimens were similar in size (see Tables F.27, F.30, F.33, F.36, F.39 and F.40).

Wild Poaceae

Phytolith widths

The majority of the short cell phytoliths observed in the leaves and inflorescences of the indigenous grasses chosen for this study fit into the extra-small (smaller than 6,87 µm), small (6,87 - 11,4 µm) or medium (11,4 - 15,98 µm) categories. Only two grasses, namely S. *bicolor* subsp. *arundinaceum* and *S. bicolor* subsp. *drummondii*, had phytoliths that were large (16,03 - 20,56 µm) in size (see Figure 5.21 and 5.22). Dendritic long cell phytoliths were also measured (see Table 5.2 and Tables K.22-K.23; K.25-K.26 and K.31- K.32).

A statistical comparison of the widths of the phytolith from domesticated and wild grasses showed that a number of wild grasses produce phytoliths which are similar in size to those from the domesticated plants chosen for this study. The elongate saddle phytoliths from the inflorescences of *E. coracana* subsp. *coracana* 1 and 2 were, for example, similar in width to those from *E. tristachya*'s inflorescences. Also, bilobates from the leaves of *S. bicolor* subsp. *bicolor* 1 and 2 were similar in size to the ones produced in the leaves of *S. versicolor* (see Table 5.3).

Table 5.2. Long cell phytolith widths from the inflorescences of wild Poaceae.

Species	**Phytolith morphotypes**	**Minimum width (µm)**	**Maximum width (µm)**
S. bicolor* subsp. *arundinaceum	Dendritic long cells	19,93	7,42
S. bicolor* subsp. *drummondii	Dendritic long cells	19,34	7
S. versicolor	Dendritic long cells	16,05	7,64

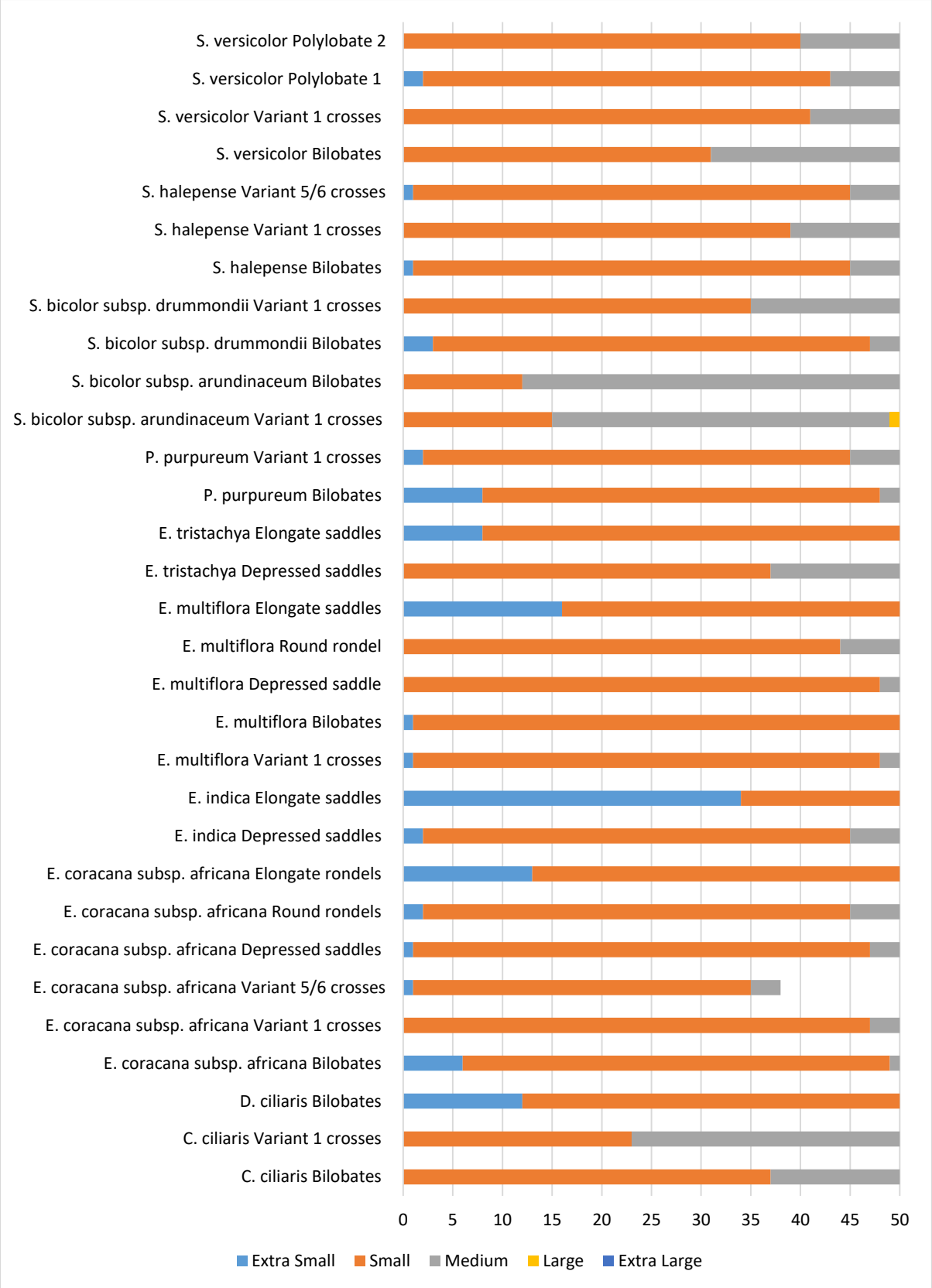

Figure 5.21. Size of leaf phytoliths from wild Poaceae.

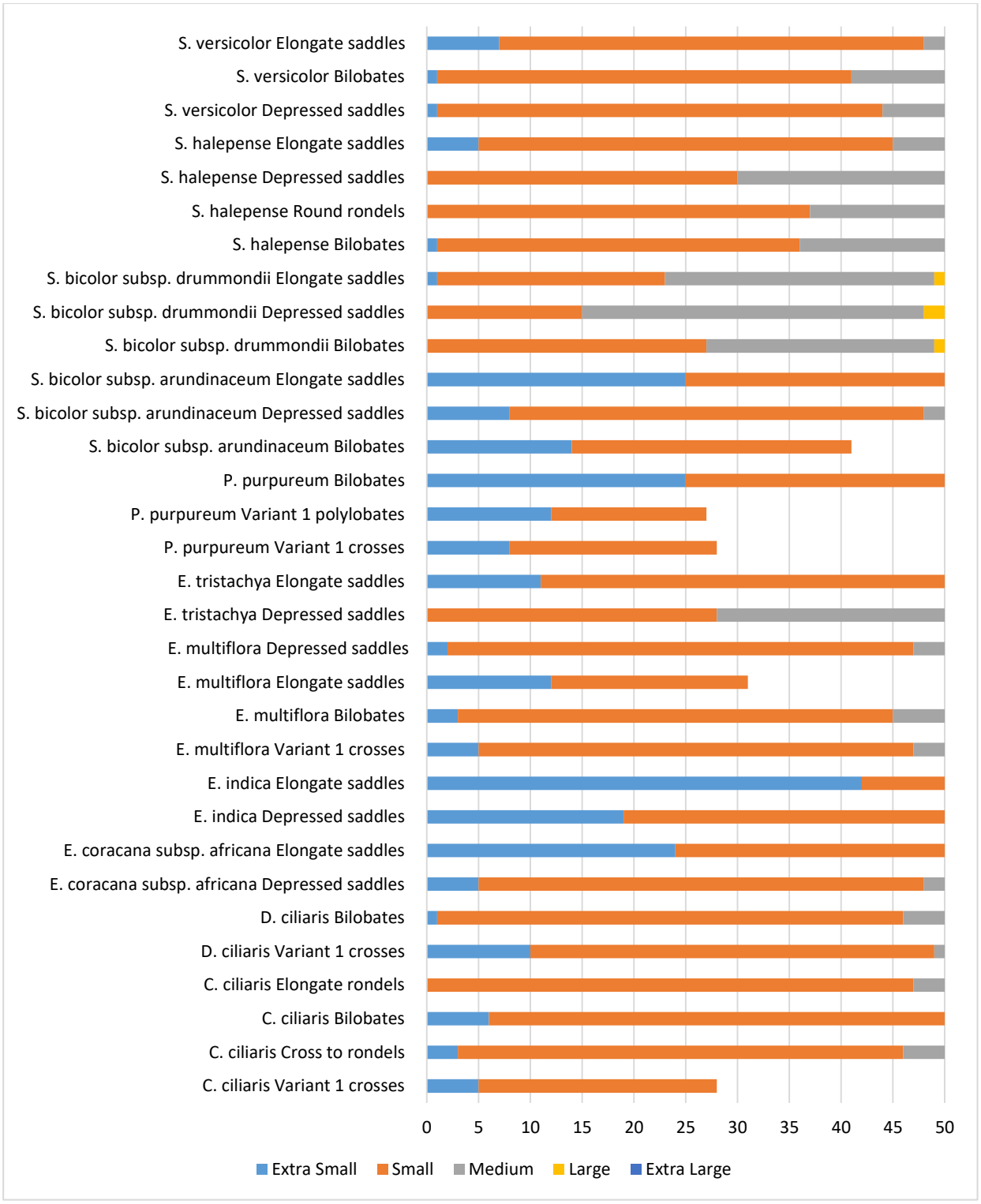

Figure 5.22. Size of inflorescences phytoliths from wild Poaceae.

Table 5.3. Domesticated and wild taxa which have phytoliths that are similar in width (statistically).

Phytolith morphotypes and plant section	**Domesticated taxa**	**Wild taxa**
Depressed saddles from leaves	*E. coracana* subsp. *coracana* 1	*E. indica*
	E. coracana subsp. *coracana* 2	*E. indica*
Elongate saddles from inflorescences	*E. coracana* subsp. *coracana* 1	*E. tristachya* *S. versicolor*
	E. coracana subsp. *coracana* 2	*E. multiflora* *E. tristachya*
	S. bicolor subsp. *bicolor* 1	*S. bicolor* subsp. *drummondii*
	S. bicolor subsp. *bicolor* 2	*S. versicolor*
	S. bicolor subsp. *bicolor* 3	*S. halepense*
Depressed saddles from inflorescences	*E. coracana* subsp. *coracana* 1	*E. coracana* subsp. *africana* *E. multiflora* *S. versicolor*
	E. coracana subsp. *coracana* 2	*E. multiflora*
Elongate saddles from leaves	*E. coracana* subsp. *coracana* 1	*E. multiflora*
	E. coracana subsp. *coracana* 2	*E. multiflora* *E. tristachya*
Bilobates from leaves	*P. glaucum* 1	*E. multiflora* *S. bicolor subsp. drummondii*
	P. glaucum 2	*C. ciliaris* *S. halepense*
	S. bicolor subsp. *bicolor* 1	*S. bicolor* subsp. *arundinaceum* *S. versicolor*
	S. bicolor subsp. *bicolor* 2	*C. ciliaris* *S. versicolor*
	S. bicolor subsp. *bicolor* 3	*S. halepense*
	Z. mays 2	*S. bicolor* subsp. *arundinaceum*
Bilobates from inflorescences	*P. glaucum* 1	*C. ciliaris* *D. ciliaris*
	P. glaucum 2	*E. multiflora*
	S. bicolor subsp. *bicolor* 1	*S. bicolor* subsp. *drummondii*
	S. bicolor subsp. *bicolor* 2	*S. bicolor* subsp. *drummondii*
Variant 1 crosses from leaves	*P. glaucum* 1	*C. ciliaris* *S. halepense*
	P. glaucum 2	*S. bicolor* subsp. *drummondii* *S. versicolor*
	S. bicolor subsp. *bicolor* 1	*C. ciliaris* *S. bicolor* subsp. *arundinaceum*
	S. bicolor subsp. *bicolor* 2	*C. ciliaris*
	S. bicolor subsp. *bicolor* 3	*S. bicolor* subsp. *drummondii* *S. halepense*

Phytolith morphotypes and plant section	Domesticated taxa	Wild taxa
		S. versicolor
Variant 1 crosses from inflorescences	*P. glaucum* 1	*P. purpureum*
	P. glaucum 2	*E. multiflora* *P. purpureum*
Variant 5/6 crosses from leaves	*S. bicolor* subsp. *bicolor* 3	*E. coracana* subsp. *africana*
Elongate rondels from inflorescences	*S. bicolor* subsp. *bicolor* 1	*C. ciliaris*
	S. bicolor subsp. *bicolor* 2	*C. ciliaris*
Round rondels from inflorescences	*S. bicolor* subsp. *bicolor* 2	*S. halepense*
	S. bicolor subsp. *bicolor* 3	*S. halepense*
Dendritic long cells	*S. bicolor* subsp. *bicolor* 1	*S. bicolor* subsp. *arundinaceum* *S. bicolor* subsp. *drummondii*
	S. bicolor subsp. *bicolor* 3	*S. bicolor* subsp. *arundinaceum* *S. bicolor* subsp. *drummondii*

Phytolith lengths

While the majority of the domesticated and wild grasses had phytoliths which were different in size, the lengths of some of the phytoliths from different taxa were similar. Using ANOVA I determined that the elongate saddles from the inflorescences of *S. bicolor* subsp. *bicolor* 1 and 2, for example, were similar in size to those from *S. halepense* and *S. versicolor*. There were no statistical differences between the variant 1 crosses from *P. glaucum* 1, *P. glaucum* 2 and many of the wild taxa chosen for study. Also, interesting to note, none of the phytoliths from the leaves of *Z. mays* 1 and 2 were similar in length to any of the phytoliths observed in the leaves of the wild grasses chosen for this study (see Table 5.4).

Table 5.4. Domesticated and wild taxa which have phytoliths that are similar in length (statistically).

Phytolith morphotypes and plant section	Domesticated taxa	Wild taxa
Depressed saddles from leaves	*E. coracana* subsp. *coracana* 2	*E. indica*
Elongate saddles from inflorescences	*E. coracana* subsp. *coracana* 1	*E. multiflora* *E. tristachya*
	E. coracana subsp. *coracana* 2	*E. multiflora* *E. tristachya*
	S. bicolor subsp. *bicolor* 1	*S. halepense* *S. versicolor*
	S. bicolor subsp. *bicolor* 2	*S. halepense* *S. versicolor*
	S. bicolor subsp. *bicolor* 3	*E. multiflora* *E. tristachya*

Phytolith morphotypes and plant section	Domesticated taxa	Wild taxa
Depressed saddles from inflorescences	*E. coracana* subsp. *coracana* 1	*E. multiflora* *E. tristachya* *S. versicolor*
Bilobates from leaves	*P. glaucum* 1	*C. ciliaris*
	P. glaucum 2	*C. ciliaris*
	S. bicolor subsp. *bicolor* 1	*D. ciliaris*
	S. bicolor subsp. *bicolor* 2	*S. bicolor subsp. arundinaceum* *S. bicolor subsp. drummondii* *S. versicolor*
	S. bicolor subsp. *bicolor* 3	*D. ciliaris* *S. bicolor subsp. drummondii* *S. versicolor*
Bilobates from inflorescences	*P. glaucum* 1	*E. multiflora* *S. halepense* *S. versicolor*
	P. glaucum 2	*E. multiflora* *S. halepense* *S. versicolor*
	S. bicolor subsp. *bicolor* 1	*D. ciliaris* *E. multiflora*
	S. bicolor subsp. *bicolor* 2	*E. multiflora* *S. halepense*
	S. bicolor subsp. *bicolor* 3	*E. multiflora* *S. halepense*
	Z. mays 2 (cobs)	*S. bicolor subsp. drummondii*
Variant 1 crosses from leaves	*P. glaucum* 1	*C. ciliaris* *S. bicolor subsp. arundinaceum*
	P. glaucum 2	*S. bicolor subsp. arundinaceum* *S. bicolor subsp. drummondii*
	S. bicolor subsp. *bicolor* 1	*E. coracana subsp. africana* *S. bicolor subsp. arundinaceum* *S. bicolor subsp. drummondii*
	S. bicolor subsp. *bicolor* 2	*E. coracana subsp. africana* *S. bicolor subsp. arundinaceum* *S. bicolor subsp. drummondii* *S. halepense*
	S. bicolor subsp. *bicolor* 3	*E. coracana subsp. africana* *S. bicolor subsp. arundinaceum* *S. bicolor subsp. drummondii* *S. halepense*
Variant 1 crosses from inflorescences	*P. glaucum* 1	*C. ciliaris* *E. multiflora* *P. purpureum*
	P. glaucum 2	*C. ciliaris* *E. multiflora* *P. purpureum*
Variant 5/6 crosses from leaves	*S. bicolor* subsp. *bicolor* 1	*S. halepense*
	S. bicolor subsp. *bicolor* 3	*S. halepense*
Round rondels from inflorescences	*S. bicolor* subsp. *bicolor* 2	*S. halepense*
	S. bicolor subsp. *bicolor* 3	*S. halepense*

Domesticated Fabaceae

Phytolith widths

Phytoliths from the Fabaceae taxa chosen for this study, namely *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*, were also measured. Rhomboidal/square/rectangular phytoliths were abundant or dominant in most of the plant sections of these domesticates,

while other phytoliths were rare (see Table 5.5 and Appendix L). Length and width measurements were only obtained for the six-sided phytoliths from each plant.

An analysis of the variance (ANOVA) of *A. hypogaea* rhomboidal/square/rectangular phytoliths showed that there was no statistical difference between the size of the phytoliths from the roots, leaves, seed pods or stems from variety 1. Similarly, there was also little variance in size between the six-sided phytoliths from the different plant sections of variety 2. It should, however, be noted that a comparison of the phytoliths from *A. hypogaea* 1 and 2 showed that they were not similar in size (see Table F.20).

Unlike the phytoliths from *A. hypogaea* 1 and 2, the six-sided phytoliths from the leaves, roots, seed pods and stems of *V. subterranea* 1 were different from one another in terms of size. The phytoliths from the plant sections in *V. subterranea* 2 were also dissimilar in size. A comparison between the leaf phytoliths from the two varieties showed that there was no statistical difference in size. The same is true for the phytoliths from the roots of the two varieties. There were, however, significant size variations between the phytoliths from the seed pods and stems of *V. subterranea* 1 and 2 (see Table F.20).

Leaf, stem, and seed pod phytoliths from *V. unguiculata* subsp. *unguiculata* 1 were not similar in size. Neither were the phytoliths from plant sections in *V. unguiculata* subsp. *unguiculata* 2. There was, however, no size variance between the phytoliths from the leaves, stems, roots and seed pods of *V. unguiculata* subsp. *unguiculata* 3. A comparison of the six-sided phytoliths from the same plant sections of different varieties showed that there is no difference, in terms of size, between the phytoliths from stem and root assemblages. The phytoliths produced in the roots and leaves were dissimilar in size (see Table F.20).

An analysis of the phytoliths from the juvenile specimens of each of the Fabaceae taxa showed that in many cases the phytoliths from the mature and juvenile specimens were similar in size (see Table F.20).

Lastly, a comparison between the phytoliths from the different domesticated plants have shown that there is often no statistical difference between them in terms of size. For example, *A. hypogaea* 1 leaf phytoliths are similar in size to those produced by both varieties of *V. subterranea*. While the seed pod phytoliths from *V. subterranea* 2 and all the varieties of *V. unguiculata* subsp. *unguiculata* shows little size variation (see Table F.21).

Table 5.5. Length and width measurements from the leaves, roots, stems and seed pods of the Fabaceae taxa.

Species and plant section	**Minimum width (µm)**	**Maximum width (µm)**
***A. hypogaea* 1 (leaves)**	4,3	13,21
***A. hypogaea* 1 (stems)**	3,46	14,17
***A. hypogaea* 1 (seed pods)**	3,05	10,22
***A. hypogaea* 1 (roots)**	4,92	13,24
***A. hypogaea* 1 (1 Month)**	4,11	13,25
***A. hypogaea* 2 (leaves)**	3,34	9,37
***A. hypogaea* 2 (stems)**	3,48	11,47
***A. hypogaea* 2 (seed pods)**	2,68	9,57
***A. hypogaea* 2 (roots)**	4,18	11,69
***A. hypogaea* 2 (1 Month)**	2,97	12
***V. subterranea* 1 (leaves)**	3,16	11,26
***V. subterranea* 1 (stems)**	4,74	11,66
***V. subterranea* 1 (seed pods)**	4,16	13,03
***Vigna subterranea* 1 (roots)**	3,77	12,6
***V. subterranea* 1 (1 Month)**	4,6	10,39
***V. subterranea* 2 (leaves)**	4,15	9,97
***V. subterranea* 2 (stems)**	4,41	14,02
***V. subterranea* 2 (seed pods)**	3,8	9,72
***V. subterranea* 2 (roots)**	3,54	9,62
***V. subterranea* 2 (1 Month)**	3,05	9,09
***V. unguiculata* subsp. *unguiculata* 1 (leaves)**	4,2	8,3
***V. unguiculata* subsp. *unguiculata* 1 (stems)**	4,51	9,69
***V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	4,11	9,41
***V. unguiculata* subsp. *unguiculata* 1 (1-2 Weeks)**	3,9	8,62
***V. unguiculata* subsp. *unguiculata* 1 (1 Month)**	3,88	13,4
***V. unguiculata* subsp. *unguiculata* 2 (leaves)**	4,15	7,95
***V. unguiculata* subsp. *unguiculata* 2 (stems)**	4,29	9,03
***V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	4,42	8,59
***Vigna unguiculata* subsp. *unguiculata* 2 (roots)**	4,62	13,84
***V. unguiculata* subsp. *unguiculata* 2 (1-2 Weeks)**	3,45	6,77
***V. unguiculata* subsp. *unguiculata* 2 (1 Month)**	3,12	7,85
***V. unguiculata* subsp. *unguiculata* 3 (leaves)**	3,31	11,32
***V. unguiculata* subsp. *unguiculata* 3 (stems)**	4,01	8,87
***V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	4,23	9,23
***V. unguiculata* subsp. *unguiculata* 3 (roots)**	4,09	9,84
***V. unguiculata* subsp. *unguiculata* 3 (1 Month)**	3,88	8,62

Phytolith lengths

ANOVA results showed that the six-sided phytoliths produced by different plant sections of *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata* were not often similar in length. The phytoliths produced by different sections of *A. hypogaea* 1 were roughly the same length, but in the rest of the taxa there were differences in the lengths of the phytoliths viewed in leaf, seed pod, stem and root assemblages (see Table F.41).

A comparison between the phytoliths from *A. hypogaea* 1 and 2 showed that the phytoliths from the leaves of these taxa were different in length. However, the phytoliths from the seed pods, stems and roots of the two varieties were similar in size. The majority of the phytoliths from the different varieties of *V. subterranea* were also similar in length, however there were size differences between the phytoliths viewed in the seed pods. The phytoliths from the roots and stems of the three *V. unguiculata* subsp. *unguiculata* specimens were similar in length, but the phytoliths from the other plant sections were not (see Table F.41).

An analysis of the phytoliths from the juvenile specimens of each of the three Fabaceae taxa showed that the phytoliths from the mature and juvenile assemblages were in some cases similar in length. However, in the majority of the cases there were size differences between these phytoliths (see Table F.41).

Lastly, a comparison between the lengths of the six-sided phytoliths from the different domesticated Fabaceae have shown that these phytoliths are often similar in size. For example, the phytoliths from *A. hypogaea* 2 stems are similar in length to those from the stems of all three varieties of *V. unguiculata* subsp. *unguiculata*. In addition, there is no difference in the lengths of the phytoliths observed in the stems of *V. subterranea* 1 and the varieties of *V. unguiculata* subsp. *unguiculata* (see Table F.42).

Conclusion

In this chapter I presented the results of my analysis of the phytoliths produced by the mature and juvenile Poaceae and Fabaceae taxa commonly used by precolonial farming communities in southern Africa. I also provided information on the phytoliths observed in the wild Poaceae specimens chosen for this study.

I gave a summary of the phytoliths that were observed in each of the plant sections analysed of domesticated and wild taxa and presented the data on the frequencies of certain phytolith morphotypes. In addition, I gave information on the length and width measurements of certain short and long cell phytoliths.

CHAPTER 6: DISCUSSION OF RESULTS

Introduction

The main aim of this project was to determine whether phytoliths could be used to establish what crops precolonial farming communities in southern Africa were cultivating. Southern African EFC's, MFC's and LFC's had access to a variety of crops, including Poaceae indigenous to Africa, such as *E. coracana* subsp. *coracana*, *P. glaucum* and *S. bicolor* subsp. *bicolor*, as well as Fabaceae, namely *V. subterranea* and *V. unguiculata* subsp. *unguiculata*. Naturalized plants, for example *A. hypogaea* and *Z. mays* were also available to LFC's.

Several researchers (e.g. Pearsall 1978; Piperno 1984; Ball *et al.* 1999) have shown that it is possible to use phytoliths to distinguish between domesticated plants, their wild ancestors and closely related taxa. These studies have emphasised the importance of using phytolith morphometrics in conjunction with phytolith morphology to correctly identify taxa. They have also highlighted the limitations of phytolith studies, as well as problems such as multiplicity and redundancy.

Numerous studies (see e.g. Pearsall 1982; Piperno 1984) have explored the diagnostic potential of *Z. mays* phytoliths, however, they have not compared these phytoliths to those from wild southern African grasses. This is problematic because it limits the extent to which phytoliths can be used at archaeological sites in the area. Similarly, the limited research on crops indigenous to Africa makes it impossible to use them as indicators of crop presence at southern African sites. Recent research projects (e.g. Radomski & Neumann 2011; Logan 2012; Out & Madella 2015) have attempted to rectify this problem by exploring the diagnostic value of the phytoliths from *P. glaucum* and *S. bicolor* subsp. *bicolor*. These studies have not, however, sufficiently documented the differences between the domesticates' phytoliths and those from closely related plants. Consequently, it is difficult to determine the diagnostic potential of each crops phytoliths.

The results of my study of the phytoliths from the above mentioned domesticated plants are discussed in this chapter. I firstly discuss the phytoliths produced by each of the crop varieties in order to highlight differences and similarities in phytolith morphology, concentrations and length and width measurements (size). Secondly, I compare the phytoliths from the leaves and inflorescences of each of the domesticated Poaceae and their close relatives in order to establish the diagnostic potential of the phytoliths from the Poaceae

crops. In addition I compare the phytoliths from juvenile specimens of the domesticated plants to those from the leaves of their mature counterparts in order to emphasise similarities and differences in phytolith morphology, concentrations and size.

The phytoliths produced by mature Fabaceae domesticates and their juvenile counterparts are also discussed and lastly I address some of the methodological issues encountered during this project. Key themes such as phytoliths morphology and size (length and width measurements) are highlighted throughout this chapter.

Phytoliths from Poaceae

A comparison of the short cell phytoliths produced by different varieties of mature domesticated Poaceae

Numerous varieties of each of the crops chosen for cultivation exist at present (National Research Council 1996:40, 46) and while many of them share the same physical characteristics, there are types which differ greatly from one another (see examples National Research Council 1996, 2006). It is possible that dissimilarities in plant morphology could result in differences in the size or shape of the phytoliths produced by these crop varieties. Other factors, for example dissimilarities in the environmental conditions during the growth stages of each of the different varieties, could also affect phytolith formation which could impact size and shape (see e.g. Jenkins *et al.* 2011).

Assessing the degree to which phytoliths differ among crop varieties was essential in order to create an accurate identification key for each of the domesticate plants analysed. It has already been shown that dissimilarities between the size of the phytoliths, as well as the frequency at which they occur in different crop varieties, for example varieties of *Z. mays*, are possible (Piperno 1984). In order to ensure that the morphologic and morphometric dissimilarities could only be attributed to physical differences between different plant varieties, great care was taken to ensure that all of the different crop varieties were exposed to the same environmental conditions (see Appendix M).

E. coracana subsp. *coracana* 1 and 2 were grown simultaneously (see Table M.1) and, thus, were exposed to the same environmental conditions. Both varieties of the crop also share similar physical characteristics (see Appendix B), for example seed size. These similarities could be responsible for the lack of size and morphological differences between some of the saddle phytoliths from the leaf and inflorescence samples of the different crop varieties (see

Figures 5.12-5.13, D.1-D.2, D.10-D.11 and Table 5.3). The concentrations of each of the phytoliths viewed were also similar in the different samples of *E. coracana* subsp. *coracana*.

Similar to *E. coracana* subsp. *coracana*, there are negligible differences between the lengths and widths of some of the phytoliths, for example variant 1 crosses, from the leaves and inflorescences of *P. glaucum* 1 and 2 (see Table F.7, F.12, F.33 and F.34, Figure D.3 and D.8). However, there are significant variations in the widths of other phytoliths, for example the bilobates (see Table F.4 and F.13, Figure D.4 and D.9) from the two varieties. Differences between the concentrations at which certain phytoliths occurred in the leaves were also observed. As opposed to the leaves, only small variations were noted in the concentrations of the phytoliths from the inflorescences (see Figures 5.3, 5.4 and 7.11).

The differences in phytolith concentrations could be attributed to dissimilarities in the environmental conditions during the growth stages of each of the varieties. The two *P. glaucum* varieties were not grown simultaneously and, therefore, there could be differences in, for example, the temperatures each were exposed to or the amount of water received by them (see Table M.1). A close look at the environmental data from the period that these crops were cultivated showed that there were small fluctuations in the temperature during each cultivation period. It did not, however, negatively affect crop growth (see Appendix M.24 and M.25). There were also differences in the rainfall received by the crops during the two growing seasons (see Appendix M), but a watering regime was implemented and it ensured that all plants received the same amounts of water. Both plants were grown in the same soil and received similar amounts of sunlight.

Since the two variants were grown under similar environmental conditions, it is, thus likely that the differences in phytolith size and concentration were caused by the physical characteristics of each of the varieties rather than the environment they were cultivated in. The most notable difference between the two crop types are the number of culms each produces. *P. glaucum* 1 has multiple culms, while *P. glaucum* 2 has only one. Minor differences include the lengths of each of the plants sections (see Appendix B).

Similar to *P. glaucum*, there are no significant differences in the morphology of the phytoliths observed in the *S. bicolor* subsp. *bicolor* varieties. In terms of the size, the majority of the phytoliths observed in the leaves and inflorescences of *S. bicolor* subsp. *bicolor* 1, 2 and 3 fall into the same size categories (see Figures 5.16-5.17). Boxplots (see Figure D.3-D.7, D.9, D.11 and D.12) also suggest that there is a size overlap between the phytoliths from the

different varieties. While this suggests that the size differences between the phytoliths are negligible, a statistical analysis of the phytolith lengths and widths using ANOVA, showed that there are dissimilarities in the sizes of some of the phytoliths produced by this domesticate (see Appendix F).

Another major difference between the three varieties of *S. bicolor* subsp. *bicolor* is the phytolith concentrations. Varieties 1, 2 and 3 did not produce the same amounts of short cell, long cell and other phytoliths. The concentrations of the different types of short cell phytoliths also differed between the three varieties. For example, while polylobate phytolith numbers are similar in all the *S. bicolor* subsp. *bicolor* varieties, there are differences in the numbers of cross and bilobate phytoliths viewed in the leaves. Similarly, there are differences in the concentrations of the phytoliths observed in the inflorescences of this crop type and some phytoliths, for example bilobates and rondels, are more common in certain varieties (see Tables E1-E.2 and E.3-E.4).

Madella *et al.* (2009) and Jenkins *et al*. (2016) suggested that short cell and long cell phytolith ratios can be affected by water availability. It has also been suggested that phytolith morphometrics can be influenced by the amount of water a plant receives during its growth stage. Rainfall varied during the periods that each of the *S. bicolor* subsp. *bicolor* varieties were cultivated. However, a watering regime was implemented in order to ensure that each of the crops received the same amounts of water (see Appendix M), thus ensuring optimum growth. Temperatures also varied during the cultivations of each crop (see Appendix M), but these fluctuations were not extreme enough to have an impact on plant development. The soil and other environmental conditions were all the same.

Since the dissimilarities in the environmental conditions were negligible it is possible that the differences in phytolith concentration and size were the result of the physical dissimilarities of the crop varieties (see Appendix B).

Similar to *S. bicolor* subsp. *bicolor* some dissimilarities were noted in the size of certain phytoliths from the *Z. mays* samples. While some of the leaf phytoliths, for example variant 1 crosses and bilobates, fall into the same size categories, statistically only the variant 1 crosses have similar dimensions. The size of the inflorescence phytoliths of both *Z. mays* types also varies greatly. None of the measured cob phytoliths from *Z. mays* 1 are larger than medium in size, low to moderate numbers of the same phytolith morphotypes from *Z. mays* 2 fall into the large category. In addition, while the majority of the phytoliths viewed in the

husks of *Z. mays* 1 are small to large in size, the phytoliths observed in the same plant section of *Z. mays* 2 are medium to double extra-large (see Tables J.13- J.16 and Figures 5.19 and 5.20). Using ANOVA it was determined that none of the inflorescence phytoliths produced by the two varieties are statistically similar in size (see Appendix F).

In terms of phytolith concentrations, there are significant differences in the concentrations of certain *Z. mays* phytoliths. The ratios of short cell, long cell and other phytoliths in the leaves and inflorescences of *Z. mays* 1 and 2 varies substantially (see Table E.1 and E.3). There are also differences in the numbers of short cell phytoliths which appear in the two varieties. The majority of the leaf phytoliths in both types of *Z. mays* are cross 1 phytoliths. Polylobates are more abundant in variety 1 than variety 2, while bilobates appear more frequently in *Z. mays* 2 than in the other variety. In the inflorescences major differences were also noted in the concentrations of short cell phytoliths and the number of rondel phytoliths observed in each of the samples fluctuated significantly (see Table E.2 and E.4, Figure 5.7 and 5.8).

The possibility that dissimilar environmental conditions during the cultivation of *Z. mays* 1 and 2 were responsible for variations in the phytolith concentrations and size was considered. Similar to some of the other domesticated plants the two varieties of *Z. mays* were not cultivated in the same growing season (see Table M.1). However, a watering regime ensured that all plants got the same amount of water and temperature variations were not enough to negatively affect crop development (see Appendix M). All other environmental conditions were the same. Thus, only variations in the physical characteristics of the two *Z. mays* types (see Appendix B) could be responsible for the differences in phytolith concentration and size.

The dissimilarities in the concentrations of phytolith morphotypes in different crop varieties, including *Z. mays*, indicate that phytolith ratios, on their own, cannot be used to distinguish between domesticated plants and other Poaceae taxa. These results mirrored the findings from Piperno (1984). There are negligible morphological differences between the phytoliths from different crop varieties. The similarities and differences of the phytoliths assemblages of each of the crops varieties were taken into account during the creation of the identification keys.

A comparison between the phytoliths from wild grasses and mature domesticated Poaceae

Leaves

Several of the domesticated grasses, including *P. glaucum*, *S. bicolor* subsp. *bicolor* and *Z. mays* belong to the Panicoideae subfamily. Wild Poaceae such as *C. ciliaris, D. ciliaris, P. purpureum, S. bicolor* subsp. *arundinaceum, S. bicolor* subsp. *drummondii, S. halepense* and *S. versicolor* also form part of this collection. Phytoliths associated with this group of grasses include crosses, bilobates and polylobates (Twiss *et al.* 1969; Rossouw 2009). *E. coracana* subsp. *coracana* and the taxa to which it is related, namely *E. coracana* subsp. *africana*, *E. indica, E. multiflora* and *E. tristachya,* form part of the Chloridoideae subfamily. Chloroid grasses generally produce depressed and elongate saddles (Twiss *et al.* 1969; Rossouw 2009).

Since the Poaceae chosen for this study are closely related, an overlap in the phytolith morphotypes produced by them was expected. This required investigation in order to determine the diagnostic value of the phytoliths observed in the domesticated plants. For the most part, the taxa analysed produce the phytoliths associated with the subfamily they were assigned to. This is, at least, true for the phytoliths from their leaves (see Table E.2 and Table E.6).

Based on phytolith morphology alone, it is impossible to distinguish between the Panicoid grasses chosen for this project. The majority of the wild and domesticated taxa produce the same phytolith variants. This includes not only similar cross variants, but also bilobate and polylobate types that overlap in shape (see Table E.11 to E.15). Therefore, none of the leaf phytoliths can be linked to a specific taxon in order to aid identification.

Since the use of morphology on its own is not sufficient to identify specific taxa, I looked at using it in conjunction with cross 1 to bilobate phytolith ratios and length and width measurements to determine the diagnostic potential of the phytoliths produced by domesticated plants. Piperno (1984) suggested that *Z. mays* could, on the basis of its high ratios of cross 1 phytoliths, be distinguished from its wild progenitor teosinte which produces high ratios of variant 2 and 6 cross phytoliths. The wild southern African grasses linked to *Z. mays*, as well as *P. glaucum* and *S. bicolor* subsp. *bicolor* (see Table 2.2), however, all produce variant 1 crosses.

In *D. ciliaris* variant 1 crosses are rare, but in all the other wild Panicoideae grasses they are abundant or dominant. They are also present in some of the Chloridoideae taxa. Even if the fluctuations in phytolith ratios among different varieties of each of the crops are ignored, it is difficult to use them to distinguish between domesticates and wild taxa. In some cases, e.g. *S. bicolor* subsp. *arundinaceum* and *P. purpureum*, the cross 1 to bilobate ratios are almost identical to those observed in *Z. mays* 1 and 2 samples. Taxa such as *S. bicolor* subsp. *drummondii* and *S. versicolor* also have ratios which are similar or close to those of *P. glaucum* and *S. bicolor* subsp. *bicolor*, thus making it impossible to distinguish between the domesticated taxa and other grasses based solely on cross morphology and phytolith ratios (see Table E.18).

Phytolith length and width measurements, on their own, are also of limited value. As shown in the results chapter phytolith widths in the leaves of mature domesticated grasses range between extra-small and extra-large (see Figure 5.12 to 5.20). On the other hand, the majority of the phytoliths from the leaves of wild grasses range between extra-small and medium in size (see Figure 5.21). Since many of the phytoliths from wild and domesticated grasses belong to the same size categories, it is difficult to confidently identify different grasses.

A statistical analysis of the phytoliths from the plants chosen for this study also showed that phytolith size alone has limited diagnostic potential. A comparison between the phytoliths from of *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor*, *Z. mays* and the wild taxa linked to them showed that in many instances theses taxa produce phytoliths which are statistically similar in size (see Appendix F). Thus, in order to distinguish between crops and their wild relatives a combination of size and morphology is required.

Pearsall (1982) and Piperno (1984) showed that by combining size and morphology it was possible to differentiate *Z. mays'* cross 1 phytoliths from those produced by other grasses indigenous to South-and Mesoamerica. Similar to their studies, the abundance of large cross 1 phytoliths, as well as the presence of extra-large specimens of this phytolith set *Z. mays* apart from the wild taxa studied during this project. Large variant 1 crosses were only encountered in *S. bicolor* subsp. *arundinaceum* and they are extremely rare. Also, none of the wild taxa produce cross 1 phytoliths with a mean width that exceeded 12,8 µm.

In both varieties of *Z. mays* large sized bilobate and cross 5/6 phytoliths were also identified. Since none of the wild grasses investigated during this project produce phytoliths of this size,

it is possible that these phytoliths can also be used as indicators of the presence of *Z. mays* at a site (see Appendix A).

A statistical analysis done on the phytoliths from *Z. mays* and the wild taxa chosen for this study confirmed that it is possibly to distinguish between the crop and wild grasses based solely on the length and width measurements of variant 1 crosses. All calculations showed that the variant 1 crosses from the *Z. mays* varieties are significantly larger than those from the wild taxa analysed for this study. Similarly, cross 5/6 phytoliths are also larger in *Z. mays* than in the wild taxa, which suggests it can be used to identify the crop at archaeological sites. On the other hand, while the bilobates produced by *Z. mays* are statistically larger than those observed in the majority of the wild taxa, there is little difference between the ones from *S. bicolor* subsp. *arundinaceum* and *Z. mays* 2 (see Tables F.3, F.6, F.9 and Tables F.24, F.27, F.30). Therefore, care needs to be taken when trying to use bilobates to identify *Z. mays*.

Unlike *Z. mays*, it is more difficult to differentiate between wild grasses and the other domesticated Panicoideae. An analysis of the cross 1 phytoliths produced by the varieties of *P. glaucum* and *S. bicolor* subsp. *bicolor* analysed showed that statistically there is little size difference between the variant 1 crosses from the crops and those from many of the grasses closely related to them (see Table F.7 and F.8; Table F.28 and F.29). In addition, the cross 1 phytoliths from *P. glaucum* and *S. bicolor* subsp. *bicolor* fall into the same size categories as those observed in the leaves of their close relatives (see Tables 5.14-5.18 and 5.21). It is therefore impossible to separate these grasses from one another using the length and width measurements of these phytoliths.

Bilobate phytolith sizes could not be used to distinguish between taxa either. The majority of the domesticated plants and the wild grasses have bilobates which are alike in terms of morphology (see Table E.11 and E.13). In addition, these phytoliths are statistically similar in size to one another, making it difficult to distinguish between the varieties of *P. glaucum*, *S. bicolor* subsp. *bicolor* and wild grasses (see Table F.4 and F.5; Table F.25 and F.26).

The phytoliths observed in the domesticated Chloridoideae taxa are also of limited diagnostic value. Depressed and elongate saddles were noted in *E. coracana* subsp. *coracana*, as well as all of the wild Chloridoid grasses. No morphological differences were observed between the saddle phytoliths produced by any of these plants. In addition, the phytoliths from both domesticated and wild taxa not only fall into the same phytolith size categories (extra-small

to medium), they also overlap in size (see Figure D.1 and D.2). A statistical analysis of the elongate and depressed saddles in the domesticated and wild taxa showed that there is no size difference between some of the taxa (see Table F.1 and F.2; Table F.22 and F.23). Therefore, neither morphology nor size nor a combination of the two can be used to differentiate between the leaf phytolith of *E. coracana* subsp. *coracana* and its close relatives.

Inflorescences

As opposed to the leaves, the inflorescence of the grasses chosen for this project frequently produce phytoliths not associated with their subfamilies. The majority of the Panicoid grasses, including the domesticated ones, produce copious amounts of rondel and saddle phytoliths in their inflorescence. *E. coracana* subsp. *coracana, E. indica*, and *E. tristachya* mainly produce Chloridoid phytoliths, but low numbers of cross and bilobate phytoliths were also viewed. In *E. multiflora* Panicoid phytoliths are dominant and saddle phytoliths are present in moderate numbers (see Table E.4 and Table E.8).

Based on morphology alone it is difficult to distinguish between some of the domesticated grasses and their close relatives. *E. coracana* subsp. *coracana*, for example, and various other taxa produce depressed and elongate saddles within their inflorescences. These phytoliths not only share the same morphology, but in many cases they also overlap in size (see Figures D.10 and D.11). The phytoliths viewed in both *E. coracana* subsp. *coracana*, as well as *E. coracana* subsp. *africana, E. indica, E. multiflora and E. tristachya* ranged between extra-small and medium in size (see Figure 5.12, 5.13 and 5.22). This made it difficult to determine the origins of a specific phytolith morphotypes.

A statistical analysis also showed that there is little difference between the sizes of the phytoliths observed in some of the wild and domesticated taxa (see Table F.10 and F.11; Table F.31 and F.32). Thus, a combination of length and width measurements and phytolith morphology cannot be used to identify *E. coracana* subsp. *coracana* at archaeological sites.

Similarly, the short cell phytoliths encountered in *P. glaucum* cannot be used to distinguish between it and its close relatives or other taxa belonging to the Panicoideae subfamily. The cross and bilobate phytoliths observed in the *P. glaucum* specimens show no unique morphological traits and are similar in size to those from many of the wild grasses analysed (see Figure D.8 and D.9; Table F.12, F.13 and Table F.33, F.34). The hair cell clusters from *P. glaucum*'s inflorescences, which were initially thought to be diagnostic, also occur in *C.*

ciliaris and *P. purpureum*. It was therefore concluded that none of the phytoliths from this crop are distinct enough to use as a diagnostic tool.

Two types of phytoliths, namely dendritic long cells and the saddle-like rondels, were encountered in *S. bicolor* subsp. *bicolor* inflorescences and it was thought that they could be diagnostic (Logan 2012:98; Radomski & Neumann 2011:159). Unfortunately, during my analysis of the wild taxa chosen for this project, dendritic long cell phytoliths were observed in *S. versicolor*, *S. bicolor* subsp. *arundinaceum* and *S. bicolor* subsp. *drummondii*. Morphologically these phytoliths are similar to those encountered in the samples of the domesticated plant's inflorescence. In addition, the differences between the widths of the dendritic long cells from the domesticated and some of the wild species are negligible (see Table D.12, Table F.16). Therefore, based on the measurements that I took, these phytoliths cannot be used to distinguish between the above mentioned taxa. It should, however, be noted that while dendritic long cells cannot be used as an indicator of the presence of *S. bicolor* subsp. *bicolor* at archaeological sites, it may be unique to the genus Sorghum.

The saddle-like rondel phytoliths, thought to be characteristic of *S. bicolor* subsp. *bicolor* (Logan 2012:98; Radomski & Neumann 2011), were also noted in other wild taxa belonging to the genus *Sorghum*. They are morphologically similar to those viewed in the domesticated plant samples. They are, however, so rare in the inflorescence of the wild *Sorghum* grasses that morphometric data could not be obtained for them. This makes it difficult to determine the diagnostic value of those observed in *S. bicolor* subsp. *bicolor*, but, at the very least, these phytoliths can be seen as a possible indicator of the presence of taxa belonging to the genus Sorghum.

Other types of rondel phytoliths were also observed in *S. bicolor* subsp. *bicolo*r. These included undecorated round, elongate and irregular rondels, as well as rondels with one dent. The undecorated round and elongate rondels were not considered diagnostic, because they were not only present in other taxa, but a statistical analysis showed that these phytoliths are similar in size to those from other domesticates, such as *Z. mays*, as well as some wild taxa, for example *S. halepense* (see Table F.18 and F.19; Table F.39 and F. 40).

While it was determined that round and elongate rondels are undiagnostic, it was not possible to determine the diagnostic value of irregular rondels and the rondels with one dent. Rondel phytoliths are generally associated with taxa linked to the Pooideae subfamily and without an

assessment of the phytoliths from these grasses it is not possible to determine if those from *S. bicolor* subsp. *bicolo*r are unique.

Apart from rondels, *S. bicolor* subsp. *bicolor* also produced bilobate phytoliths in its inflorescences. These are of no diagnostic value because they not only have the same morphology as the bilobates produced by the wild taxa related to the crop (see Table E.11 and E.13), but they are also similar in size to wild grasses such as *S. bicolor* subsp. *drummondii* (see Figure D.9).

Unlike S. *bicolor* subsp. *bicolor*, determining the diagnostic value of the phytoliths produced in *Z. mays* inflorescences was easy. Pearsall *et al.* (2003:613) and Piperno (2006:64), among others, indicated that wavy-top and ruffle-top rondels are morphologically unique and can be used to determine *Z. mays*' presence at an archaeological site. While these phytoliths were present in all the *Z. mays* cob samples that were analysed, they are absent from the wild southern African grasses linked to the domesticate. Thus, based solely on morphology these *Z. mays* inflorescences phytoliths are diagnostic.

The other rondel phytoliths noted in *Z. mays* cobs, namely undecorated round and elongate rondels, are not, however, of any diagnostic value. These phytoliths occur in low to moderate numbers in several of the wild grasses that were analysed and they are morphologically similar to those produced by *Z. mays*. In addition, as mentioned earlier, undecorated rondels are linked to Pooideae and since taxa from this subfamily were not analysed, it is difficult to establish whether they produce phytoliths which can be confused with those from *Z. mays*.

In terms of size, an analysis of the round and elongate rondels showed that they were larger in *Z. mays* 2 than in any of the other domesticated and wild taxa chosen for this study (see Figure D.8 and D.9; Table F.18 and F.19; Table F.39 and F.40). *Z. mays* 1 round rondels and elongate rondels, however, overlapped in size with those from *S. bicolor* subsp. *bicolor* (see Figure D.8 and D.9). It is also possible that Pooideae taxa produce phytoliths similar in size to those from Z. mays. Thus, until morphometric data is available for Pooideae rondels, it is not possible to determine the diagnostic potential of the ones from *Z. mays*.

A comparison between the phytoliths from juvenile and mature domesticated Poaceae

Although it was important to compare the phytoliths produced by wild grasses and mature domesticated Poaceae, it was also important to consider the phytoliths created by juvenile specimens of the domesticated taxa. The phytoliths from juvenile plants have not received

much attention. Studies by Jones and Handreck (1965), Blackman (1968) and Blackman and Parry (1968) focussed on the transportation and deposition of silica in plants at different growth stages. Their studies noted the effect of soil silica concentrations on plants, areas where silica was deposited, as well as the concentrations of silica within the studied taxa. They, however, failed to note the types and sizes of the phytoliths produced by the plants chosen for analysis. In addition, while they determined how much silica was present in the plants, they also did not note whether fully formed phytoliths were present.

For my study specimens of domesticated Poaceae were collected after the formation of the first true leaves (one to two weeks of age), as well as halfway through the growth cycle (approximately 1 month of age). The most important thing to note is that fully formed phytoliths were visible in the youngest plant samples, as well as samples taken at around 1 month.

The juvenile Poaceae specimens mainly mirror their mature counterparts and produce the phytoliths associated with the subfamilies they belong to. Thus, juvenile *P. glaucum, S. bicolor* subsp. *bicolor* and *Z. mays* samples contain the same phytoliths as the leaves of their mature counterparts. The concentrations of these short cell phytoliths, however, often vary between the mature and juvenile specimens. Therefore, phytoliths that are rare in mature taxa are often common or abundant in the juvenile specimens (see Table E.10 and E.12). For example, in the mature *Z. mays* leaf samples polylobate 2 phytoliths are rare or common, but in the juvenile samples they are abundant or dominant.

In addition, the juvenile specimens often contain phytoliths that were not viewed in the mature samples. *E. coracana* subsp. *coracana*, for instance, only produces depressed and elongate saddles in the leaf samples taken from mature taxa. Bilobate phytoliths, though noted, are extremely rare. In the juvenile samples, however, bilobates are either present in high numbers or dominant. Cross 1 phytoliths are also common in most of the juvenile samples that were analysed (see Table E.10).

In terms of size, the phytoliths from the mature and juvenile specimens often differ and only a few taxa have phytoliths which have the same length and width measurements in all the samples (see Table F.1-F.9; F.22-F.30). *S. bicolor* subsp. *bicolor* 3, for example, has bilobate phytoliths that are similar in width in all the juvenile and mature samples, while *S. bicolor* subsp. *bicolor* 1 has cross 1 phytoliths that are similar in width in all the samples analysed (see Table F.5 and F.8). Some of the other taxa, for instance *P. glaucum*, do have phytoliths

in their mature and juvenile specimens that overlap in size, but others, for example *Z. mays* has phytoliths which are often not similar in size at all (see Table F.1-F.9, F.22-F.30 and Figures D.1).

The differences in the length and the width measurements of the phytoliths encountered in the juvenile and mature samples did not affect the conclusions made about the diagnostic value of the phytoliths from the mature assemblages. While many of the phytoliths from the juvenile assemblages of *E. coracana* subsp. *coracana*, *P. glaucum* and *S. bicolor* subsp. *bicolor* are not statistically the same size as those from mature samples, they still fall into the same size categories (extra-small to medium). This means that they, like the phytoliths from the mature assemblages, cannot be readily distinguished from wild grasses (see Figure 5.12-5.20, Figure D.1-D.4).

The cross 1 and bilobate phytoliths produced in *E. coracana* subsp. *coracana* samples are undiagnostic too. These phytoliths fall into the same size categories as those produced in a number of other domesticated plants and wild taxa (see Figure 5.12 and 5.13; Table D.3 and D.4). Thus, based on length and width measurements alone they could not be used to distinguish between the juvenile specimens of this crop and other grasses.

Lastly, the phytoliths from the juvenile specimens of *Z. mays* are significantly smaller than those from the mature samples and the majority of the variant 1 crosses and bilobates fall into the same size categories as those from wild grasses and other domesticates. Thus, while the cross 1 phytoliths from mature *Z. mays* leaves can be distinguished from those of other grasses based on a combination of phytolith morphology and length and width measurements, the juvenile variant 1 crosses were undiagnostic.

The exact causes of the differences in size and phytolith morphology in some juvenile and mature specimens are unknown. The reasons for the variations in the concentrations of each phytolith morphotypes are also unknown and it is unclear whether this is a common trend that might appear in other Poaceae.

It is possible that sampling error, misidentification of taxa, environmental factors, and physical changes in the plant as it matures played a role in these variations. Ball *et al.* (2015) showed that the morphology and morphometrics of phytoliths can differ depending on which sections of the plant organs were sampled. Therefore, phytoliths taken from specific areas in, for example the leaves and inflorescences, should be compared phytoliths taken from the same regions in order to avoid sampling error.

The main aim of this project was to determine if the phytoliths from the African domesticates chosen for study are diagnostic and if phytoliths can be used to determine which crops precolonial farming communities were using at archaeological sites. Since phytoliths from all plant sections would be mixed together in an archaeological context, it was decided that entire leaf sections would be processed for phytoliths. Thus, the phytoliths from entire leaf sections of the mature specimens were compared to the phytoliths from whole leaf sections of the juvenile taxa (see Chapter 4). It can, therefore, be concluded that the differences in phytolith size and concentrations were not due to a sampling error.

Although misidentification of juvenile taxa could also be to blame for the differences in phytolith size and concentrations, it is highly unlikely. Varieties of each of the domesticated grasses were cultivated under controlled conditions and were carefully labelled. Thus, there was never any confusion about the identity of any of the plants. During the period that each of the crops were cultivated careful records were also kept on the environmental conditions they were grown in (see Appendix M). All of the juvenile taxa were cultivated in the same area as the mature specimens. Thus, they were grown in the same soil, received the same amounts of sunlight and experienced the similar temperatures during cultivation. While the rainfall might have differed during the period that each of the samples were grow, a watering regime was implemented to ensure that all the crop varieties received the same amounts of water. Therefore, since the environmental conditions were the same during the cultivation of all the plant samples, it could not have been responsible for the dissimilarities in the size and phytolith concentrations viewed between the mature and juvenile assemblages.

It is more likely that the plant morphology or the processes that govern phytolith production are liable for differences in the phytolith assemblages observed in mature and juvenile samples. These processes are not sufficiently understood (Piperno 2006) and therefore more research is required in order to test theories about phytolith formation.

The phytoliths produced by mature and juvenile Fabaceae

Unlike the phytoliths from Poaceae, limited research (see e.g. Bozarth 1992; Cummings 1992) has been done on the phytoliths that are produced by mature and juvenile Fabaceae. Cummings (1992) suggested that Fabaceae phytoliths are distinct to a family level and could be used to differentiate between taxa (Cummings 1992:185). Bozarth (1992), however stated that polyhedral phytoliths are common in many plants, including deciduous trees (Bozarth 1992:194) and would therefore have limited diagnostic potential.

Only three Fabaceae taxa, namely *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*, were analysed for this project. Since their phytoliths were not compared to those produced by other dicot plants, it is not possible to assess Cummings' (1992) assertion. I did, however, establish that below family level there is little variance in the phytolith morphotypes produced by different members of the Fabaceae family. Rhomboidal, square or rectangular phytoliths (six-sided phytoliths) were present in all the domesticated Fabaceae analysed for this project and these phytoliths are present in all plant sections, except for the seeds. Each of the plants also contained epidermal cell phytoliths, as well as hair cell and stomata phytoliths.

Cummings' (1992:185) suggested that hair cell phytoliths should be investigated in order to determine their diagnostic potential. She submitted that the distribution and number of spikes surrounding the hair base could be used to differentiate between plants on a generic level (Cummings 1992:185). Hair cell phytoliths are, however, extremely rare in the majority of the samples that were analysed and there were not enough specimens available to obtain morphometric data. Therefore, I could not test this theory.

Only rhomboidal/square/rectangular phytoliths were measured and in some of the taxa analysed there are only negligible differences between the lengths and widths of the phytoliths from different plant sections. In addition, a comparison of the six-sided phytoliths from the different domesticated plants showed that there is an overlap in phytolith size among Fabaceae taxa (see Figure D.13; Table F.20 and F.21).

The juvenile specimens are also dominated by rhomboidal, square or rectangular phytoliths. Little or no variance in size was noted for many of the six-sided phytolith viewed in the juvenile and mature assemblages (see Table F.20). This led me to believe that the majority of the phytoliths observed in the three Fabaceae taxa are redundant and, thus, phytoliths cannot be used to identify specific Fabaceae species at precolonial archaeological sites in southern Africa.

Methodological considerations

One of the most common problems in phytolith research is the lack of standardized sampling, extraction and analysis techniques. A number of factors can influence the methods used during a study, including a researcher's personal preferences, time or monetary constraints, availability of materials, or the type of data needed to answer the research questions. Several

studies (see e.g. Zhao & Pearsall 1998; Lentfer & Boyd 1999; Parr *et al.* 2001b; Horrocks 2005) have tested the effects of different methods and materials, but researchers have, however, not reached a consensus on the techniques that should be used. The differences in techniques are a cause for concern, because they may cause varying results.

During the initial stages of my project I realized that the only way to determine which methods would be best suited for my study, would be to test several of the most common techniques in order to see which provided the best results. The sampling, extraction and analysis techniques used for this project were chosen because they were not only time and cost effective, but compared to other methods, they yielded superior results. In order for researchers to be able to replicate my results, careful records were kept on any deviations of these common methods (see Chapter 4).

Although there is no consensus on how to sample, extract and analyse phytoliths, attempts have been made to standardize nomenclature and descriptive techniques. Madella *et al.*'s (2005) work established a glossary of descriptive terms aimed towards simplifying the way we depict phytoliths. In addition, the authors listed the acceptable names for phytoliths in an effort to eliminate the confusion raised by the large volume of names assigned to some phytolith morphotypes (Madella *et al.* 2005).

The usefulness of this article is, however, limited. Phytolith morphology plays a large role in determining which subfamily or species phytoliths belong to. Madella *et al.*'s (2005) article failed to clarify which names should be used for the multitude of variations of each of the Poaceae phytolith morphotypes. The way different variants are classified, named and identified are, thus, still up to the researchers.

Numerous classification systems exist. Piperno (1984) for example established an identification key for cross phytoliths which recognised different variants based on their three-dimensional attributes. Rossouw, on the other hand, divided bilobates into categories based on their symmetry and shank length, while Fahmy (2008) assigned bilobates into groups based on the shapes of their lobes. Since there is no consensus on how phytolith morphotypes should be subdivided, confusion is often created when phytolith assemblages are compared.

As far as it was possible, I used the descriptive terms from Madella *et al.* (2005) to describe and name the phytoliths that I observed during my analysis of the domesticated and wild taxa. However, in some cases where I had to describe variations of short cell morphotypes, I often

opted to use the 'common' names assigned to them by other researchers. For example, I chose to use the descriptive terms employed by Piperno (1984; 2006) and Pearsall (2000) to describe cross and rondel phytoliths. This was done in order to avoid the confusion which would have resulted from renaming phytoliths such as the 'ruffle-top' or 'wavy-top' rondels.

Another problem is analyst bias. Which group phytoliths are assigned to is solely based on the researcher's interpretation of the three-dimensional shape and his/her understanding of phytolith morphology. In many cases there are transitional phytoliths, i.e. phytoliths that do not clearly fall into any category. For example, there are often cases where it is unclear whether a phytolith is a cross or bilobate. In these cases phytoliths are assigned into categories at the analyst's discretion. Researchers (e.g. Pearsall 2000) have attempted to rectify this problem by clearly defining phytolith morphotypes such as crosses in order to differentiate them from bilobates (Crosses are no more than 9,16 µm longer than wide). This has not, however, been done for many other phytoliths types and needs to be addressed.

For my study I used Pearsall's (2000) classification system to distinguish between cross and bilobate phytoliths, while Rossouw's (2009) descriptions of phytoliths were useful when distinguishing between rondel and saddle phytoliths. Logan's (2012) methods of classifying long cells were used for the identification of inflorescence phytoliths and her description of cross-rondels helped with the distinction between it and other phytoliths. Lastly, images from Madella *et al.* (2005) were used to differentiate between different types of non-short cell phytoliths.

It should be noted that while these sources were helpful in the identification of different phytolith morphotypes, a more standardized method is still required to correctly identify transitional and complex phytoliths such as the ones viewed in grass inflorescences. In addition, more research is needed into the phytoliths produced in the inflorescences of Poaceae taxa.

Various researchers (e.g. Twiss *et al.* 1969; Rossouw 2009) have used the phytoliths from Poaceae leaves to investigate the link between phytolith morphology and grass subfamilies. This has led to classification systems which are widely used to interpret data in order to reconstruct past environments. As shown in this study, however, the phytoliths produced within the leaves and inflorescences of Poaceae can differ. Unfortunately, to my knowledge, no studies have compared the phytoliths from Poaceae leaves and inflorescences to one another and this poses a major problem.

Phytolith classification systems are based on the phytoliths from the leaves of grasses (Twiss *et al.* 1969; Rossouw 2009). When plants decay, however, not only leaf phytoliths are deposited into sediments and it is likely that inflorescences phytoliths are mixed with those from the leaves. If it is common for plants to produce different phytolith morphologies in different plant section, then inflorescence phytoliths may be erroneously linked to other taxa which may influence interpretations made about particular phytolith assemblages. It is, thus, essential to examine the phytoliths from inflorescence samples and determine if the short cell classification systems employed to interpret data needs to be reviewed.

Conclusion

The main goal of this project was to determine the diagnostic value of the phytoliths produced by several Poaceae and Fabaceae taxa by analysing the phytolith morphology and width and length measurements of select morphotypes. Using this criteria my study showed that *Z. mays* phytoliths can be distinguished from those of closely related southern African grasses, as well as from other Panicoid domesticates commonly used by precolonial farmers. *E. coracana* subsp. *coracana*, *S. bicolor* subsp. *bicolor* and *P. glaucum* phytoliths cannot be distinguished from those made by their close relatives using this criteria. *S. bicolor* subsp. *bicolor* phytoliths may, however, be diagnostic to a genus level. My analysis showed that based on phytolith morphology and length and width measurements none of the phytoliths produced by *A. hypogaea*, *V. subterranea* and *V. unguiculata subsp. unguiculata* can be used to determine plant usage at archaeological sites in southern Africa.

Apart from establishing whether phytoliths can be used as a tool to determine what plants were used by precolonial farming communities, I also compared the phytoliths from juvenile taxa to those from mature specimens. In the Panicoideae grasses the phytoliths made by juvenile taxa often had the same phytolith morphotypes as the mature plants. They were, however, not always similar in size. The Chloridoideae samples produced phytoliths not observed in the mature specimens, but the phytoliths which were observed in all the samples often fell into the same size categories. There were no difference is the phytoliths produced in mature or juvenile Fabaceae.

Methodological problems encountered during my study were also discussed.

CHAPTER 7: GENERAL CONCLUSION

Summary

Despite the rapid growth in the field of phytolith analysis since the 1960s, relatively little is still known about the phytoliths produced by plants domesticated in Africa. Recent studies (e.g. Radomski & Neumann 2011; Logan 2012; Out & Madella 2015) have sought to rectify this, but there are still gaps in our knowledge. My aim, as stated in Chapter 1, was to determine the diagnostic value of the phytoliths produced by domesticated taxa in order to establish whether they could be used to identify what plants precolonial farming communities cultivated at sites in southern Africa. The taxa chosen for study included Poaceae, such as *E. coracana* subsp. *coracana*, *P. glaucum*, *S. bicolor* subsp. *bicolor* and *Z. mays*, as well as Fabaceae, including *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata*. Phytoliths extracted from two to three varieties of each mature specimen of these plants were compared to their close relatives and juvenile specimens of themselves to determine diagnostic value.

My research of the phytoliths produced by varieties of each of the domesticated taxa supplemented the information already available on phytolith morphology and morphometrics. A comparison of the phytoliths produced by *Z. mays* and indigenous grasses from southern Africa confirmed Pearsall (1978, 1982) and Piperno's (1984, 1998) assertions that *Z. mays* phytoliths are diagnostic to a species level. Large and extra-large cross 1 phytoliths in *Z. mays* leaves, as well as ruffle- and wavy-top rondels in *Z. mays* inflorescences can be used to identify the crop at southern African archaeological sites.

Analysis of the bilobate phytoliths viewed in *P. glaucum* and *S. bicolor* subsp. *bicolor* confirmed the results of Out and Madella's (2015) research which showed that there is no morphological difference between the bilobate phytoliths of the two species. In addition, it is not possible to differentiate between the cross 1 phytoliths produced by these species and their close relatives. Research into the long cell and complex short cell phytoliths viewed in *S. bicolor* subsp. *bicolor* disproved, among others Logan's (2012), assertion that they are distinctive and can be used to identify the crop at archaeological sites. These phytoliths were viewed in the taxa closely related to *S. bicolor* subsp. *bicolor* and thus they are, at most, indicative of grasses belonging to the genus *Sorghum*. Similarly the hair cell clusters observed in *P. glaucum* inflorescences, which I initially thought were unique, occur in taxa related to the crop and are, thus, of limited diagnostic value.

I also showed that based on phytolith morphology and length and width measurements, *E. coracana* subsp. *coracana* leaf and inflorescence phytoliths cannot be differentiated from those made by indigenous taxa and are, therefore, of no diagnostic value.

After comparing the phytoliths from mature and juvenile specimens, I concluded that there is little variance in the morphology of short cell phytoliths. *E. coracana* subsp. *coracana* juvenile samples are the exception, because they produce phytoliths not commonly associated with the mature specimens. While statistically the phytoliths from juvenile and mature specimens often differ in size, they can fall into the same size categories. The most notable difference between phytoliths from mature and juvenile specimens are the concentrations at with they occur.

My research into *A. hypogaea*, *V. subterranea* and *V. unguiculata* subsp. *unguiculata* showed that neither the mature, nor the juvenile specimens produce diagnostic phytoliths. This led to the conclusion their phytoliths cannot be used to determine plant usage at archaeological sites.

Challenges and future research

I faced several challenges during this project, the first being the limited amount of work done on the phytoliths produced in the inflorescence and juvenile specimens of, not only domesticated plants, but also wild indigenous taxa. Various researchers (e.g. Twiss *et al.* 1969; Rossouw 2009) documented the major trends in phytolith morphology in grass subfamilies. These studies not only contributed to our understanding of the phytoliths produced within Poaceae, but also made it possible to use phytoliths as a proxy for past environmental conditions.

The phytoliths from grass inflorescence need to be studied in more detail in order to establish how they affect conclusions made about past environmental conditions. In some cases, as shown in this study, inflorescence and leaves produce different phytoliths and the phytoliths in the former are not always associated with the subfamily to which the specific taxa belong. Currently only leaf phytoliths are used in environmental reconstruction. This is problematic, because nobody has established how many of the phytoliths produced in the inflorescence make it into sediment samples.

In addition, phytoliths from juvenile plants also need to be studied in more detail. This will not only foster a better understanding about how phytoliths are formed, but will also give

valuable information on how plant structures change with age. Also, since juvenile phytoliths might form part of the phytolith assemblages studied when reconstructing past environments, it might be useful to know whether juvenile taxa produce the same phytoliths as leaves.

Another issue that needs attention is how we classify phytoliths and their variants. Since each researcher decides how they subdivide phytolith morphotypes, for example bilobates, into groups or variants, there is a lot of confusion when the work of different authors is compared. In addition, consensus needs to be reached on how to categorize phytoliths that do not conform to any short cell shape or are transitional. This will mitigate analyst bias and improve the standardized nomenclature guide by Madella *et al.* (2005).

Lastly, phytolith analysts should start giving more attention to long cell phytoliths. Several researchers (e.g. Radomski & Neumann 2011; Logan 2012) have noted that dendritic long cells produced in *S. bicolor* subsp. *bicolor* might have diagnostic potential. Researchers should analyse the long cells from other Poaceae taxa to determine whether they make long cells that have any diagnostic potential.

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APPENDIX A: PHYSICAL DESCIPTIONS OF DOMESTICATED AND WILD TAXA

Physical description of domesticated Poaceae

Eleusine coracana (L.) Gaertn. subsp. *coracana* (Finger millet)

E. coracana subsp. *coracana*, which belongs to the Chloridoideae subfamily, is a small tufted grass that grows to between 40 cm and 130 cm tall (National Research Council 1996:55). It has basal leaves which are linear or linear-lanceolate in shape, 30-60 cm long and 0,6-1,2 cm wide. Leaf sheaves are keeled and the outer margins are hairy. Culms are branched, erect and topped with numerous digitate-shaped inflorescences. Spikelets are multi-flowered, with glumes that are shorter than the spikelet. Upper glumes are elliptic, membranous, 1-keeled and winged on the keel. Lower glumes are lanceolate, membranous and also 1-keeled (Clayton *et al*. 2006a).

The fertile lemma is lanceolate in profile, 3-veined, membranous and approximately 4 mm long. The apex of the lemma is acute and the palea is the same length as the lemma. The apical florets closely resemble the fertile lemma, it is however underdeveloped. Seeds are orbicular in profile and biconvex in side view. They are approximately 0,2 cm in length and seed colour varies between white, yellow, brown and red (De Wet *et al.* 1984:552; Clayton *et al*. 2006a).

Pennisetum glaucum (L.) R. Br. (Pearl millet/Babala)

P. glaucum, previously known as *Pennisetum americanum*, belongs to the Panicoideae subfamily. It is a robust, annual grass which can reach heights of up to 500 cm (National Research Council 1996:89; Van Wyk & Gericke 2000:12). It has erect culms which are between 150 and 300 cm long, bearded culm-nodes and leaf blades that are approximately 30-100 cm long and 8-70 cm wide (Gibbs Russel *et al*. 1990:249; Clayton *et al.* 2006b). *P. glaucum* has panicle inflorescences which are spiciform, linear or cylindrical in shape and are commonly 4 cm to 200 cm long and 0,8-5,5 cm wide. The primary panicle branches are accrescent to the central axis (National Research Council 1996:89; Clayton *et al*. 2006b).

Spikelets are subtended by an involucre. Fertile spikelets comprise of a basal sterile floret and a fertile floret. The spikelets are obovate, between 0,3 cm and 0,6 cm long and dorsally compressed. Lower glumes are shorter than the spikelets, while upper glumes are oblong, without keels and a third of the length of the spikelets (Clayton *et al*. 2006b). *P. glaucum* seeds are tear-shaped, approximately 0,4 cm in length and can be grey, olive green or white

in colour (National Research Council 1996:89; Williamson 2005:189; Clayton *et al*. 2006b; Van Wyk & Gericke 2000:12).

***Sorghum bicolor* (L.) Moench *subsp. bicolor* (Sorghum)**

S. bicolor subsp. *bicolor* belongs to the Panicoideae subfamily and is a robust, annual grass which reaches heights of 50-600 cm (Clayton *et al.* 2006c; National Research Council 1996:138; Van Wyk & Gericke 2000:14). It has erect culms that are 5-30 cm in diameter, glabrous culm-nodes and cauline leaves. Leaf blades are 10-100 cm long, 0,5-3 cm wide and broadly rounded at the base (Gibbs Russel *et al.* 1990:302; Clayton *et al.* 2006c).

The inflorescence of *S. bicolor* subsp. *bicolor* is a compact panicle and the branches are tipped by racemes (National Research Council 1996:140; Clayton *et al.* 2006c; Van Oudsthoorn 2012:190). The penducle is straight or deflexed. The panicle is between 4 cm and 50 cm long, 2-20 cm wide and can be contracted or open. The panicle varies in shape and can be lanceolate, ovate, elliptical or glabrous. The primary panicle's branches are appressed, moderately divided and pubescent or villous (Clayton *et al*. 2006c).

Each racemes bears 1-6 fertile spikelet. Rachids are tough with ciliate margins and filiform or linear internodes. Spikelets occur in pairs. Fertile spikelets comprise one basal sterile floret and one fertile floret without a rachilla extension. Fertile spikelets are 0,3 to 1 cm long, oblong, obovate, orbicular or ovate in shape and dorsally compressed. The spikelet callus is glabrous or pilose and its base is obtuse. Sterile spikelets are male, lanceolate in shape, separately deciduous and similar in size to fertile spikelets. They are muticous, herbaceous and enclosed in glumes (De Wet & Harlan 1971:131; Clayton *et al.* 2006c).

S. bicolor subsp. *bicolor* glumes are wider at the lower margins than at the upper ones and are firmer than fertile lemmas. Lower glumes are ovate, the same length of the spikelet, two-keeled and characeous or coriaceous. The surface of the lower glume is glabrous or pilose and the apex is obtuse or acute. The upper glume is also ovate, chartaceous or coriaceous, but it is 1-keeled. The surface of the upper glumes is pubescent or glabrous and it has ciliate margins with an entire or dentate apex (Clayton *et al*. 2006c).

The sterile basal florets are barren, do not have a palea and have an elliptic lemma which is shorter than the spikelets. The lemma is veined, ciliolate on the margins and hyaline. The fertile lemma is also hyaline, obovate and 0,1-0,3 cm long. The lemma's apex is entire or dentate, muticous or awned. Principle lemmas awn from a sinus and are geniculate with a

twisted column. The column for the lemma awn pubescent and is hairy on the spiral (Clayton *et al.* 2006c). Seeds are 0,3-0,4 cm in diameter, yellow to dark brown in colour and exposed between a gaping lemma (Clayton *et al.* 2006c; Van Wyk & Gericke 2000:14).

***Zea mays* L. (Maize)**

Z. mays is a sturdy, domesticated, annual grass with erect culms which grow up to 300 cm high. It has solid culm-internodes and cauline leaves. Leaf blades are linear or lanceolate, 25-100 cm long and 2-10 cm wide. Inflorescences are monoecious with male and female spikelets in different inflorescence. Male inflorescences are composed of racemes which are located along a central axis. The female inflorescences have an enlarged woody rachids, elliptical spatheoles and spikelets that are crowded into rows. Spikelets are obovate and dorsally compressed. Glumes are oblate, approximate the same length as the spikelets, scarious and without keels (Williamson 2005:70; Clayton *et al*. 2006d). Seeds can be white, yellow, red, purple or black in colour.

Physical description of domesticated Fabaceae

***Arachis hypogaea* L. (Peanut)**

A. hypogaea is an erect or strangling, annual herb that grows to approximately 30 cm in height. Its culms are pilose, but become glabrescent as it matures. It has 4-foliolate leaves with the leaflets being ovate or elliptic. Leaflets are mucronate, rounded or emarginate at the apex. They are rounded at the base and glabrous or pilose as well as ciliate. The free part of the petiole is 1,5-7 cm long, linear-lanceolate, acute and ciliate. Flowers are axillary, solitary and stalked. The primary bracts are ovate-lanceolate or apiculate. The secondary bracts are similar to the primary bracts, but are 2-fid. The receptacle is shorter than four centimetres and pilose. *A. hypogea*'s corolla is usually yellow with red nerves and is 0,7-1,3 cm long. The seeds are 1-2 cm in size and irregularly ovoid. The gynophore is 1-20 cm long (Verdcourt 2000).

***Vigna subterranea* (L) Verdc. (Bambara groundnut)**

V. subterranea is a creeping, annual herb with short, sparsely pubescent culms. The internodes are short and the leaves are held erect. *V. subterranea* leaflets are elliptic, obovate or oblanceolate. They are cuneate at the base, emarginate or rounded at the apex and glabrous. Petioles are between 5 and 30 cm long, while rachids are 1-2,5 cm long. Stipules

are three millimetres long, multi-nerved, striate and somewhat bilobed at the base (Mackinder *et al*. 2001).

The penduncles are pubescent and flower above ground before bending downward which enables seeds to develop underground (Mackinder *et al.* 2001; Van Wyk & Gericke 2000:28). Rachids are 1-noded and the flowers are yellow. Pedicels are 0,1-0,5 cm long and expand as the pod matures. Bracteoles are one nerved and approximately 0,25 x 0,05 cm. Calyculus are glabrous; tubes and lobes are each 0,1 cm long with the upper pair of lobes joined to form a bifid lip (Mackinder *et al.* 2001).

Ovaries are 1-4 ovuled. The pods are irregularly oblong-ovoid, glabrous and beaked with a recurved base (Mackinder *et al.* 2001). One or two seeds occur in each pod. Seeds vary in size, bur are spherical or truncate in shape. Colour ranges between black, red, yellow, brown, cream or spotted (Svanevelder 1998:8; Mackinder *et al.* 2001; Van Wyk & Gericke 2000:28).

***Vigna unguiculata* (L.) Walp. subsp. *unguiculata* (Cowpea)**

V. unguiculata subsp. *unguiculata*, similar to *V. subterranea*, is an annual or perennial herb which can be erect, prostate or strangling and grows to approximately 200 cm in length. The leaves are positioned alternately along the culm and comprise three leaflets. The petiole is roughly 15 cm long, grooved and swollen at the base. The flowers are grouped toward the top of the raceme and vary from, white or yellow, to purple or pink in colour. Flowers are papilionaceous and have up to ten stamens, nine of which are fused together. The ovaries are approximately 1,5 cm long. Seeds are encased in a cylindrical seed pod of 8-30 cm long. The seeds are oblong to globose, about 1 cm in length and are black, purple, white, pink, red, yellow, brown or cream coloured. The hilium is oblong and white with a black rim (Mackinder *et al*. 2001; National Research Council 2006:115-116).

Physical description of wild taxa

***Cenchrus ciliaris* L.**

Cenchrus ciliaris, or blue buffalo grass, (syn. *Cenchrus glaucus*, *Pennisetum ciliare*, *Pennisetum cenchroides* or *Pennisetum incomptum*) is a perennial grass (Van Oudsthoorn 2012:82; Heuzé *et al.* 2013), which is tufted and grows to 100 cm in height (*Gibbs Russel et al. 1990:80;* Van Oudsthoorn 2012:82; Heuzé *et al.* 2013; Fish *et al.* 2015:158). The culms are geniculately ascending with basal, cauline leaves. Leaf-sheath are

ciliate and loose, with flattened margins. They have a glabrous surface and outer margins and they are also keeled and striately veined (Clayton *et al.* 2006e).

Leaf-blades are 3-25 cm long and between 0,4 cm and 1 cm wide. They have distinct venation, are pilose or glabrous on both surfaces and have an acute, hardened apex (*Gibbs Russel et al. 1990:80; Clayton et al. 2006e;* Fish *et al.* 2015:158*). C. ciliaris* inflorescences are panicle, spiciform, linear or oblong in shape, 2-14 cm long, approximately 0,25 cm wide and purple or yellow in colour. The panicle axis is angular and carries deciduous spikelets. Fertile spikelets are up to 0,55 cm long, dorsally compressed, lanceolate and supported by an involucre which is covered in bristles (*Gibbs Russel et al. 1990:80;* Van Oudsthoorn 2012:82; *Clayton et al. 2006e;* Fish *et al.* 2015:158*).*

Upper and lower glumes are both ovate and equal or shorter in length than the spikelets. Neither have keels, although both are hyaline and have acute apexes. Lemmas are ovate, dorsally compressed, chartaceous and between 0,2 and 0,55 cm long. Seeds are dark brown in colour, dorsally compressed, obovoid, glabrous and approximately 0,1 cm long (*Clayton et al. 2006e*).

***Digitaria ciliaris* (Retz.) Koel.**

Digitaria ciliaris, also known as tropical finger grass (Fish *et al.* 2015:215), is, similar to *C. ciliaris*, a tufted annual member of the Poaceae family that grows up to a meter tall. It has decumbent or erect culms and its leaves are 3- 25 cm long and 0,3- 1 cm wide. Leaf margins are scabrid and the ligule is an eciliate membrane (*Gibbs* Russel *et al.* 1990:108; Clayton *et al.* 2006f; Fish *et al.* 2015:215).
The inflorescences of *D. ciliaris* is digitate and is comprised of two to twelve racemes which are between 6 cm and 22 cm long, digitate and unilateral. The central axis of the inflorescence is up to 5 cm long. Rhachis are winged with a glabrous surface and scabrous margins (Clayton *et al.* 2006f).

Fertile spikelets appear in pairs, are packed contiguously, appressed and pedicelled. Each spikelet comprise a basal sterile floret and a fertile floret. Spikelets fall entirely and are elliptic. Upper glumes are lanceolate with a pubescent surface while lower glumes are ovate. The basal sterile florets are barren and its sterile lemma is elliptic, membranous and seven-veined. The lemma is also pubescent, villous, setose or puberulous. The fertile lemma is

dark brown or grey in colour, cartilaginous with flat margins and an acute apex (Clayton *et al.* 2006f; Fish *et al.* 2015:215).

Eleusine coracana* (L.) Gaertn. subsp. *africana

Eleusine coracana subsp. *africana*, also known as osgras, is a tufted, annual member of the Poaceae family (Gibbs Russel *et al.* 1990:129; Van Oudsthoorn 2012:214; Fish *et al.* 2015:262) which grows up to 90 cm long. The culms are robust, geniculately ascending and roots often grow from the lower nodes. The leaves are 5-50 cm long and 0,25 cm to 1 cm wide, flat and stem from the base of the plant (Gibbs Russel *et al.* 1990:129; Van Oudsthoorn 2012:214; Clayton *et al.* 2006c; Fish *et al.* 2015:262). Leaf-sheaths are keeled and the ligule is a ciliolate membrane (Clayton *et al*. 2006g; Fish *et al*. 2015:262).
The inflorescences are subdigitate with glabrous peduncles and slender racemes (Clayton *et al*. 2006g; Fish *et al*. 2015:262). Spikelets are elliptic and have between two and nine florets. They separate when the plant reaches maturity and disarticulate below the florets. Both the upper and lower glumes are membranous, have a one winged keel and have acute apexes. The upper glumes are elliptic in shape while the lower glumes are lanceolate and both glumes are shorter than the spikelet. The lemmas are also lanceolate, membranous and have an apex which is acute. Seeds are globose or oblong, black in colour and have a soft pericarp (Clayton *et al*. 2006g).

***Eleusine indica* (L.) Gaertn.**

Eleusine indica (goose grass), similar *Eleusine coracana* subsp. *africana*, is an annual, tufted grass (Gibbs Russel *et al*. 1990:130; Fish *et al.* 2015:262). It grows up to 85 cm long (Clayton *et al.* 2006h), with culms which are geniculately ascending and regularly originate from lower nodes. Leaves are basal, conduplicate, up to 35 cm long and 0,25-0,6 cm wide with hairy margins. The ligule is membranous and fringed (Gibbs Russel *et al*. 1990:130; Clayton *et al.* 2006h; Fish *et al.* 2015:262).

The subdigitate inflorescences has a glabrous penduncle, 1 to 14 racemes and the rachids are without wings. Spikelets occur in a two- rowed configuration, are elliptic in shape and compressed at the lateral end. Spikelets are deciduous and separate from the plant at the fertile florets. Both glumes are shorter than the spikelet, membranous and have wings on

their keels. The lower glumes are lanceolate, while the upper glumes are elliptical and both have acute apexes (Clayton *et al.* 2006h).

The lemmas are also lanceolate in shape and have acute apexes. They are membranous and veined. The seeds do not have pericarps and are hidden behind florets. They are elliptic or isodiametric in shape, striate and black in colour (Clayton *et al.* 2006h; Fish *et al.* 2015:262).

***Eleusine multiflora* Hochst. ex A. Rich.**

Similar to *E. indica, Eleusine multiflora* is a tufted, annual grass. It reaches lengths of between 12 and 45 cm, has slender culms which are geniculately ascending and has leaves that are up to 26 cm long and 6 mm wide. The leaf-blades are conduplicate or flat with glabrous margins, while leaf-sheaves are keeled (*Gibbs Russel et al. 1990:302; Clayton et al. 2006i;* Fish *et al.* 2015:632).

The inflorescences comprise spreading digitate racemes which are unilateral and up to 3 cm long. Spikelets are ovate or oblong to lanceolate in shape, compressed laterally and composed of up to 15 fertile florets. Spikelets are deciduous and separate below the florets. Upper and lower glumes are oblong, membranous and have acute or obtuse apexes. They are similar in size and both have wings on their keels (Clayton *et al.* 2006i; Fish *et al.* 2015:632).

Lemmas are lanceolate or ovate in shape with obtuse or muticous apexes. They are membranous and three- veined with subsidiary veins stemming from the midvein. The palea is scabrous. Seeds are black in colour and oblong in shape with a compressed lateral margin. They are approximately 1 mm long and are hidden by the floret (Clayton *et al.* 2006i).

***Eleusine tristachya* (Lam.) Lam.**

Eleusine tristachya is a tufted grass, but unlike the other members of the genus *Eleusine* described above in is a perennial grass. It grows 10- 45 cm tall (*Gibbs Russel et al. 1990:130;* Clayton *et al*. 2006j; Fish *et al.* 2015:263), has basal leaves which stems from elliptic culm-nodes and keeled leaf-sheaths with glabrous outer margins (Clayton *et al.* 2006j). Leaves are up to 25 cm long and 0,1-0,5 cm wide (*Gibbs Russel et al. 1990:130;* Clayton *et al.* 2006j; Fish *et al.* 2015:263). The digitate inflorescences comprise racemes which are linear and unilateral, up to 4 cm long and 0,4-1,6 cm wide (Clayton *et al.* 2006j).

Spikelets are deciduous and separate below the florets (Clayton *et al.* 2006j; Fish *et al.* 2015:263). They have up to 13 fertile florets, are ovate in shape and are compressed laterally (Clayton *et al*. 2006j). Lower glumes are lanceolate while upper glumes are elliptic in shape. Both are membranous, shorter than the spikelet and keeled with acute apexes (Clayton *et al.* 2006j; Fish *et al.* 2015:263).

Lemmas are also keeled and membranous with acute apexes. They are ovate in shape and veined. Seeds are isodiametric in shape with a soft pericarp, dark brown in colour and approximately 0,2 cm long (Clayton *et al.* 2006j).

***Pennisetum purpureum* Schumach.**

Unlike members of the genus *Eleusine*, which are rarely more than 100 cm in length, *P. purpureum* (Gibbs Russel *et al.* 1990:250; Van Oudsthoorn 2012:32), commonly known as elephant grass, grows up to 250 cm tall. It is a tufted, perennial grass with robust, erect or geniculately ascending culms. Its leaf-blades are 30-120 cm long and 2-4 cm wide, with cartilaginous or scaberulous margins and its ligule has a fringe of hair (Gibbs Russel *et al.* 1990:250; Clayton *et al.* 2006k; Fish *et al*. 2015:514).

The inflorescences of *P. purpureum* are panicle. It is spiciform, between 7 cm and 30 cm long, robust and linear. Deciduous spikelets appear on the axis which often has sessile scars or lateral stumps. The spikelets are 0,1 cm wide and up to 0,7 cm long. They mostly occur in clumps and are supported by an involucre which comprises bristles. Sterile (male) spikelets are pedicelled and occur in clusters of four. Both sterile and fertile spikelets are lanceolate and dorsally compressed (Gibbs Russel 1990:250; Clayton *et al.* 2006k; Fish *et al.* 2015:514).

Upper glumes are shorter than the spikelet, lanceolate or ovate. Lower glumes are commonly absent or obscure (Clayton *et al*. 2006k; Fish *et al.* 2015:514). Basal florets are sterile and smaller or equal in length to the spikelets (Clayton *et al.* 2006k). The lemmas are lanceolate acuminate, glabrous and veined. Seeds are ellipsoid to ovoid, have an adherent pericarp and are concealed behind the floret (Clayton *et al.* 2006k).

***Sorghum bicolor* (L.) Moench subsp. *arundinaceum* (*Sorghum verticiflorum*)**

Unlike *P. glaucum* which is a perennial grass, *Sorghum bicolor* subsp. *arundinaceum*, previously *Sorghum verticiflorum* (Van Oudsthoorn 2012:273), can be a perennial or annual

grass and it grows up to 4 m tall. It has erect culms which are not supported by rhizomes and has hollow culm internodes which are pubescent or glabrous. *S. bicolor* subsp. *arundinaceum*'s leaves are 2-7 cm wide, 5-75 cm long and cauline. Leaf blades are glabrous, without keels and are thicker at the collar than the leaf sheaths. The margins of the leaf blade are scabrous or glabrous and are acute at the apex (Gibbs Russel *et al.* 1990:302; Clayton *et al.* 2006l; Fish *et al*. 2015:631).

Sorghum bicolor subsp. *arundinaceum* has open, panicle inflorescences (Clayton *et al.* 2006l; Fish *et al*. 2015:631) and its racemes are located on branch tips. The panicle is 10-60 cm long with branches that are whorled at the nodes. The branches are scaberulous, pubescent or flexuous at the axils. Racemes consist of two to seven fertile spikelets. Sterile spikelets consist of two sub-equal glumes which are dorsally compressed, linear to lanceolate in shape and up to 0,8 cm long. Fertile spikelets comprise one sterile and one fertile floret and are lanceolate or ovate. They are between 0,4 cm and 0,9 cm long, dorsally compressed and deciduous (Clayton *et al.* 2006l).

The upper and lower glumes of *Sorghum bicolor* subsp. *arundinaceum* are ovate, coriaceous and keel-less. Both have pubescent surfaces and acute apexes. The lower glumes have hairs which are yellow or white in colour (Clayton *et al.* 2006l).

S. bicolor subsp. *arundinaceum* has fleshy, oblong flowers which are hairy across the apex. Seeds are dorsally compressed, oblong and up to 0,2 cm long. It has an adherent pericarp, a farinose endosperm and a punctiform hilum (Clayton *et al.* 2006l).

Sorghum bicolor* (L.) Moench subsp. *drummondii

Sorghum bicolor subsp. *drummondii*, or Sudan grass, is closely related to *S. bicolor* subsp. *arundinaceum.* It is an annual grass that grows up to 300 cm long (Gibbs Russel *et al.* 1990:302; Fish *et al.* 2015:631), has solitary, erect culms and cauline leaves. Leaf-blades are between 0,8 cm and 1,5 cm wide, 15- 20 cm long and the ligules are ciliolate membranes (Clayton *et al.* 2006m).

The inflorescences are compact and ovate to pyramidical in shape with spread, scaberulous and flexious branches. The inflorescences are up to 30 cm long and 8-15 cm wide and the racemes are located at the end of branches. Sterile spikelets are lanceolate, dorsally compressed and up to 0,8 cm long. The fertile spikelets are also dorsally compressed, but

are elliptic in shape with an obtuse base, longer than the sterile spikelets and awnless (Clayton *et al.* 2006m; Fish *et al.* 2015:631).

The upper and lower glumes are different sizes, but they are both elliptic in shape with an acute apex, coriaceous texture and neither has keels. Both are also veined and yellow or light brown in colour. Lemmas are elliptic or ovate, hyaline, veined with ciliate margins. Seeds are up to 0,45 cm long, are oval or elliptic in shape with attached pericarps (Clayton *et al.* 2006m).

***Sorghum halepense* (L.) Pers.**

Unlike *S. bicolor* subsp. *drummondii, S. halepense*, also known as Johnson grass or Columbus grass (*Gibbs Russel et al. 1990:130;* Van Oudsthoorn 2012:191; Fish *et al.* 2015:632), is a perennial member of the Poaceae family. It grows 50-300 cm long, is tufted with thick erect culms enforced by long rhizomes and has cauline leaves with a white midrib. Leaves are 20-90 cm long, 0,5-4 cm wide and scaberulous. *S. halepense* has panicle inflorescences which are between 10 cm and 55 cm long and 3-25 cm wide. The panicle is open, lanceolate or pyramidical with whorled primary branches. Racemes are located at the tip of each branch (*Gibbs Russel et al. 1990:130;* Clayton *et al*. 2006n; Van Oudsthoorn 2012:191).

Each raceme bears one to five fertile spikelets. Fertile spikelets are sessile and there is one per cluster. Fertile spikelets are dorsally compressed, elliptic and between 0,45 cm and 0,55 cm long. They comprise one fertile and one basal sterile floret. Sterile spikelets are male, lanceolate and 0,45-0,65 cm long. Both fertile and sterile spikelets, along with their attached branch systems, are separately deciduous (Clayton *et al.* 2006n).

The lemmas of the sterile spikelet is covered by glumes. The lower glumes have a dentate apex, are elliptic in shape and are similar in length to the spikelet while upper glumes are ovate or coriaceous. The lower glumes have two keels, but the upper glumes have none. Lower glumes can be red, black or dark brown in colour. Both the lower and upper glumes have pubescent or glabrous surfaces (Clayton *et al.* 2006n).

***Sorghum versicolor* Anderss.**

S. versicolor (black-seed sorghum) is closely related to *S. halepense* and it is a tufted perennial or annual grass that grows up to 120 cm high. It has erect culms, bearded culm-

nodes (*Gibbs Russel et al. 1990:302;* Van Oudsthoorn 2012:112; *Clayton et al. 2006p;* Fish *et al.* 2015:632) and cauline leaves which are 10-40 cm long and 0,3-1 cm wide. The panicle inflorescences are open and between 5 cm and 30 cm long. The inflorescences have drooping branches which with are whorled at the nodes and have racemes at the ends (Van Oudsthoorn 2012:112; Clayton *et al.* 2006p).

Racemes each have up to 7 fertile spikelets. Spikelets appear in pairs with one fertile and one sterile spikelet in each cluster. Sterile spikelets are linear or lanceolate, up to 0,5 cm long and male. Generally they are enclosed in glumes and shorter that the fertile spikelets. Fertile spikelets are elliptic or oblong in shape, up to 0,7 cm long and dorsally compressed (Clayton *et al.* 2006p). Spikelets are black when mature, with bearded calluses. Callus hairs are white or red (Gibbs Russel *et al.* 1990:302; Van Oudsthoorn 2012:112; Clayton *et al.* 2006p; Fish *et al.* 2015:632*).*

Glumes are dissimilar in size. Upper and lower glumes are ovate, dark brown or black and without keels. Both have glabrous or pilose surfaces. Lemmas have ciliate margins, are oblong or elliptic, hyaline and veined (Clayton *et al.* 2006p).

APPENDIX B:

Eleusine coracana* subsp. *coracana

Description of variety 1

E. coracana subsp. *coracana* (variety one) was collected from a farm in southern Zimbabwe in 2011 and this variety has been grown by the farmer and his family for generations. It was noted, during the cultivation of specimens for this project, that this variety is slow maturing (it took approximately 4 months to form seeds). It fared well in high temperatures and required moderate amounts of water. It tolerated long daylight hours.

It grew up to 120 cm in height and had multiple stems. The number of digitate-shaped inflorescences per culm varied, but five were the average. These were curled inwards when mature and resembled a fist. The inflorescences were approximately 5 cm in length. The seeds were dark red in colour, 0,2 cm long and orbicular in shape. Leaves were long and narrow, about 60 cm in length and, on average, 1 cm in width.

Description of variety 2

E. coracana subsp. *coracana* 1 was collected from a rural farm in Northern Cape. It, similar to *E. coracana* subsp. *coracana* 1, was slow maturing and it took approximately 5 months to form seeds. It was adapted to high temperatures and long daylight hours. It did not fare as well in dry conditions as variety 1, but was more tolerant of waterlogging. Thus, it was better adapted to clay soils.

It grew up to 1 m in height and had narrow, basal leaves of about 1 cm in width and approximately 100 cm in length. Inflorescences were up to 7 cm long and had a minimum of 5 digitate-shaped inflorescence sections. Seeds were white or pink in colour and were 0,1-0,2 cm in diameter.

Pennisetum glaucum

Description of variety 1

Babala or *P. glaucum* (Variety 1) seeds were collected from Agricol, a company which supplies seeds to commercial farmers. Although this company does supply hybrid and GMO versions of this crop, the variety chosen has not been genetically altered. During the period that this variety was cultivated, it was noted that it grew well in areas with low rainfall and high temperatures. It also tolerated long hours of direct sunlight, but it was negatively

affected by leached soils which caused stunted growth. *P. glaucum* 1 took four months to mature.

This variety of *P. glaucum* had multiple stems and grew up to 225 cm tall. It had relatively short roots that were roughly 30 cm long. Its leaves reach 100 cm in length and 10 cm in width and its inflorescences were approximately 30 cm long. Its seeds were grey and yellow in colour and 0,4 cm in length.

Description of variety 2

P. glaucum (variety 2) is commonly grown in rural areas and seeds were collected from a farm in southern Zimbabwe. It took between 120 and 150 days for this variety to produce a harvestable yield and it was extremely drought and heat resistant. It also grew well in clay soils and was day length neutral.

Unlike *P. glaucum* 1 it had a single culm and it grew up to 250 m tall. Its leaves were approximately 80 cm long and 5 cm wide. Its roots were up to 30 cm long and its inflorescences were 15 cm to 30 cm long. The seeds produced by this variety were grey in colour and between 0,3 cm and 0,4 cm in length.

Sorghum bicolor* subsp. *bicolor

Description of variety 1

Variety 1 *S. bicolor subsp. bicolor* is commonly grown in rural areas in southern Africa and the seeds were collected from a farmer in Mpumalanga. It took between 90 and 120 days to mature, and required moderate amounts of water and sunlight for optimum growth. It was not adversely affected by high temperatures, but it was sensitive to low temperatures. This variety had multiple stems and it did not exceed 130 cm in length. Leaves varied in length between 50 cm and 75 cm, and they were between 5 cm and 10 cm wide. The roots were approximately 20 cm long. The inflorescences were approximately 20-30 cm long with light yellow and red seeds that were 0,3 cm to 0,4 cm in size.

Description of variety 2

Variety 2 *S. bicolor* subsp. *bicolor* was collected from a rural community in Zimbabwe. This crop took approximately 90 days to mature, used moderate amounts of water and was adapted to tolerate high temperatures and exposure to long periods of daylight. Similar to other wild African crops it was sensitive to low temperatures.

Specimens of this crop grew to over two meters in length and had short roots that were approximately 20 cm long. Unlike many other varieties of *S. bicolor* subsp. *bicolor*, this plant did not have multiple stems, but a single culm. Its leaves were up to 75 cm long and less than 10 cm wide, while its inflorescences were between 25 cm and 30 cm in length and 6 cm to 10 cm in width. Seed bracts were dark red, while the seeds were creamy white in colour and approximately 0,4 cm long.

Description of variety 3

Variety 3 *S. bicolor* subsp. *bicolor* is a commercially available variety that was collected from a company that sells non-GMO crop specimens. It matured slowly and took 120 to 150 days to form mature seeds. It fared well at high temperatures, but was not drought tolerant. It was day length neutral.

This variant had a single stem and grew approximately 150 cm tall. It had short roots of about 20 cm long and its leaves grew up to 75 cm in length and 5 cm in width. The inflorescences were between 15 and 20 cm in length, roughly 10 cm in width with dark red seeds protected by cream coloured seed bracts. Seeds were 0,3 cm in length.

Zea mays

Description of variety 1

Variety 1 *Zea mays*, also known as bloody butcher corn, was collected from a rural community in Lesotho. It was noted, during the cultivation of samples at the experimental farm, that this variety was fast maturing, taking only 90 days to grow harvestable cobs. It fared well when exposed to high temperatures and long daylight hours, required high amounts of water and grew well in clay soils.

This variety grew up to 200 cm tall and had roots that did not penetrate deeply into the soil. Its leaves were 25 cm to 100 cm long and between 2 cm and 10 cm wide. Its cobs were approximately 20 cm long and 6,3 cm in diameter. Variety 1 *Z. mays* had dark red seeds that were about 1 cm in length.

Description of variety 2

Transkei flint corn (Variety 2 *Z. mays*) is a commercially available heirloom crop procured from Livingseeds. It took approximately 80 days to mature when cultivated at the

experimental farm and fared well in medium to high temperatures. It required moderate amounts of water and was adapted to days with more than 10 hours of sunlight.

It grew to approximately 225 cm tall, but had relatively short roots that only reached 20 cm in length. Leaves were between 46 cm and 96 cm long and 4 cm to 10 cm wide. The cobs were roughly 10 cm long with bright yellow seeds of about 1 cm in length.

Arachis hypogaea

Description of variety 1

Variety 1 *A. hypogaea* seeds were obtained from a colleague who collected it from a rural farmer in Limpopo. It matured at a medium rate (between 3 and 4 months), even though the seeds took more than a week to germinate. It was well adapted to grow in an area where it received up to 12 hours of direct sunlight a day. It grew well with moderate amounts of water and was not adversely affected by waterlogging.

This variety of *A. hypogaea* was small, bushy and only grew up to 20 cm in length. Its leaves were ovate, approximately 3 cm in length and around 2 cm in width. Its roots were roughly 10 cm long. Its seed pods were light brown in colour, while the seeds were a dark red-brown colour and 1 cm in length.

Description of variety 2

A. hypogaea 2 seeds were obtained from seed company that sells heirloom and non-GMO crops. It matured at a slow rate (between 4 and 5 months) and the seeds took up to two weeks to germinate. It grew well in clay soils, and was somewhat tolerant of high temperatures. It did not tolerate exposure to long hours of daylight and thus had to be intercropped with plants that provided shade for it to grow unrestricted.

This variety of *A. hypogaea* grew 20-30 cm in length and had roots that were roughly 10 cm long. It was bushy with small ovate leaves. Basal leaves were smaller in size than the top ones, which were 2-3 cm long and 1-2 cm wide. Seed pods and seeds were light brown in colour. Seeds were 1-2 cm in length.

Vigna subterranea

Description of variety 1

V. subterranea 1 seeds were obtained from a farmer in Limpopo and is commonly grown in rural areas. It took up to 2 weeks to germinate and approximately 4 months to mature. It was drought resistant, but grew best with moderate amounts of water. Long hours (10-12) of direct sunlight facilitate growth. It was tolerant of clay soils and was not adversely affected by waterlogging.

This variety grew to 30 cm in length and was bushy. It had oblong-shaped leaves which were up to 7,5 cm long and approximately 3 cm in width. Seeds were round, 1-2 cm in length and dark brown in colour.

Description of variety 2

V. subterranea 2 is a commercially available heirloom crop variety procured from Livingseeds. Similar to variety 1 it took up to 2 weeks to germinate and roughly 4 months to mature. It was also drought resistant and required more than 8 hours direct sunlight a day. It was not negatively affected by high daytime temperatures, but was sensitive to waterlogging and cold temperatures.

It grew 25-30 cm long and was bushy. The oblong-shaped leaves were up to 7 cm long and 2-3 cm wide. Seeds were round and 1-2 cm in diameter. Seed colour varied from light to dark brown and had dark brown or black spots on them.

Vigna unguiculata* subsp. *unguiculata

Description of variety 1

Variety 1 *Vigna unguiculata* subsp. *unguiculata* was collected from a farm in Zimbabwe and is commonly grown in rural areas. It was fast maturing and took approximately 90 days to form mature seeds. It was not very drought resistant and required moderate amounts of water. It was well adapted to grow in more than twelve hours of direct sunlight.

This variety was a creeper which grew to roughly 2 m in length. Its leaves occurred in clusters of three and were approximately 13 cm long and 9 cm wide. It had white flowers which were approximately 2 cm in size, short roots that penetrate less than 30 cm into the

ground and dark or light green seed pods of up to 30 cm long. Its seeds were dark purple with light brown spots.

Description of variety 2

Variety 2 *Vigna unguiculata* subsp. *unguiculata* is commercially grown and it was collected from an agricultural store. While this store sells GMO crops, this variety has not been genetically altered. It matured at a fast rate and was ready for harvest after 90 to 120 days. It required moderate amounts of water and grew well when exposed to direct sunlight for ten or more hours a day. It fared well in clay soils, but did not tolerate waterlogging.

This variety was a creeper and developed a main stem of more than a meter long. It had roots that measured to approximately 30 cm in length and its mature leaves were between 6,5 cm and 10,5 cm long and 3,9 cm to 10,4 cm wide. Its flowers were less than 3 cm in size and bright purple. The seeds were dark red with black or dark brown spots. Seed pods were 15 cm or more in length and contained varying numbers of seeds.

Description of variety 3

Vigna unguiculata subsp. *unguiculata* 3 was collected from a rural community living on the Portuguese islands. It matured slowly and took longer than 150 days to mature. It was extremely drought tolerant and was well adapted to long days with more than 12 hours of direct sunlight. It was adapted to grow in sandy soils with low amounts of nutrients, but it did tolerate clay soils.

This variety of *Vigna unguiculata* subsp. *unguiculata* was a small, bushy creeper and its stems measured approximately 100 cm in length. Leaf length ranges between 8,4 cm and 16 cm and leaf width was 5,3 cm to 11 cm. It had short roots which were less than 30 cm long, white flowers and cream coloured seeds. Seed pods were up to 16 cm long, 0.6 cm wide, light brown and contained varying numbers of seeds.

APPENDIX C: GLOSSARY

Adapted from:

1. Beentjie, H. 2010. The KEW plant glossary: An illustrated dictionary of plant terms. Kew Publishing: Royal Botanical Gardens, Kew.
2. Madella, M., Alexandre, A., and Ball, T. 2005. International code for phytolith nomenclature 1.0. *Annals of Botany* 96: 253-260.

Descriptive term

Accrescent: Increasing in width or length with age.

Acute: Terminating in a sharp point.

Annual: Maturing in one growing season or a year.

Apex: The tip or distal end.

Apical: Distal or of the apex.

Apiculate: Ending in a short, abrupt end.

Appressed: Lying close or against other parts of the plant.

Awned: A fine bristle ending on a plant organ.

Axis: The main line of development for an organ, e.g. inflorescence.

Axillary: Arising in an axis or the area between the leaf and culm.

Basal: Growing at or close to the base.

Base: The point of attachment.

Bearded: A tuft of hairs.

Biconvex: Domed on two sides.

Bifid: Dent/notch in the middle.

Bilobate: Having two lobes.

Cauline: Arising from the culm or inserted on the culm.

Chartaceous: Paper-like, or thin and stiff.

Ciliate: Bearing hairs on the outer margins.

Compact: Packet close together.

Concave: Having a surface that curves inwards.

Convex: Having a surface that cures outwards in the middle.

Cordate: Deeply notched at the base in such a way that a heart shape is formed.

Coriaceous: Tough and leathery.

Creeping: Growing flat or along the ground with or without roots at regular intervals.

Cuneate: Shaped like a wedge.

Cylindrical: Narrow and long with a circular cross-section; resembling a cylinder.

Deciduous: Not evergreen. Losing part or all of its leaves during certain parts of the year.

Dentate: Toothed with acute and symmetrical projections facing outwards.

Denticulate: Finely toothed.

Depressed: Flattened vertically.

Digitate: Resembling fingers.

Diploid: With twice the haploid (n) number of chromosomes.

Domesticated: Adapted from wild species by humans for domestic or other uses.

Dorsal: Upper or back.

Eliptic: Broad at the middle with rounded bases.

Elongate: Long or stretched.

Emarginate: With a clear sharp notch.

Entire: Not divided, smooth or unbroken.

Erect: Upright.

Female: Functional female parts without male parts.

Fertile: Able to produce fruit or give rise to the next generation of plants.

Filiform: Slender or resembling a thread.

Foliolate: Leaved.

Geniculate: Bent like a knee.

Glabrescent: Becoming glabrous.

Glabrous: Smooth or without hair, trichomes or scales.

Herbaceous: With the texture of an herb or an annual herb.

Hyaline: Almost transparent.

Keeled: With one or several ridges.

Lanceolate: Ovate at the base and tapered at the end (apex).

Linear: Longer than it is wide with narrow, parallel margins.

Lobed: A rounded margin with several sub-divisions.

Male: Staminate

Margins: Boundary or edge.

Membranous: Translucent, flexible or thin.

Monoecious: Bisexual or with male and female flowers on the same plant.

Mucronate: Terminating abruptly with a short sharp point.

Muticous: Blunt or without a sharp point.

Oblanceolate: Obovate with a tapered point at the apex.

Oblong: Longer than broad, with straight parallel sides and rounded ends.

Obovate: Egg shaped with the widest section near the apex.

Obtuse: Blunt, having a rounded base or not pointed.

Orbicular: With a circular outline.

Ovate: Broad at one end, with a rounded middle, and a narrow second end. Egg-shaped.

Papilionaceous: Shaped like a pea-flower with one posterior petal, two lateral petals and two conate lower flowers.

Planar: Lying flat or horizontally level.

Primary: First to develop or original.

Prostate: Lying flat.

Pubescent: With short, dense hairs.

Robust: Strong, thick or vigorous.

Scabrescent: Rough to the touch.

Scandent: Climbing.

Sinuate: Uneven margins with edges that resemble waves.

Solid: Free of cavities.

Spathulate: Oblong with an extended base. Shaped like a spatula.

Spiciform: Resembling a spike.

Sterile: Not functional, barren or unable to develop into flowers or fruit.

Subacute: Almost acute.

Subtended: Below the organ discussed or axillary to another organ.

Tufted: Clumped or growing in a tight group.

Veined: Visible vein structures on the outer surface of plant structures.

Villous/ Villose: With long, fragile hairs.

Winged: With flattened or blade-like protuberances on the sides.

Plant physiology

Awn: Fine bristle ending on a grass flower.

Bracteole: A small secondary bract or a small modified leaf near the flower or petiole.

Bract: A modified leaf in the inflorescence which forms below the flower, petiole or penduncle.

Callus: A horny or hard protuberance at the base of the floret or spikelet.

Corolla: The second whorl of flower organs consisting of petals, tubes or a combination of the two.

Culm: Stem; plant section which bears the leaves and inflorescence.

Culm-node: Area where leaves are or were attached to the stem.

Floret: Small flower.

Glume: Brackets occurring in pairs at the base of spikelets.

Gynophore: The stalk on which the ovary is located.

Hilium: The scar on the seed where it was attached to the placenta.

Inflorescence: Structure at the end of the culm which bears the flowers.

Internode: Section of the culm located between two nodes.

Involucre: A number of bracts which are close together, below or around the flowers.

Lamina: Expanded section of the leaf blade or flower petal.

Leaf blade: Extended part of the leaf.

Leaflet: A part of a compound leaf.

Leaf-sheaf: A section of the leaf that envelops part of the culm.

Lemma: The outermost or lower bracket which encloses the floret.

Multi-flowered: Consisting of numerous florets.

Palea: Colourless, upper bract which envelopes the floret.

Panicle: Branched inflorescence.

Pedicle: The stalk of a flower.

Penduncle: The flower stalk or the unbranched, lower section of the stalk that is distinct form the racemes.

Petal: An unit of a floral whorl.

Petiole: The short, narrow section of the leaf which connects the leaf to the culm.

Probract: Small glandular structure found at the base of the penduncle of in Cucurbitaceae.

Raceme: A monopodial inflorescence where flowers develop on pedicels along a central axis.

Rachilla: Axis or stem of the spikelet. The flower-bearing axis.

Rachis: Part of the main axis distal to the peduncle that carries the florets.

Receptacle: The expanded section of the flower stalk where the organs of a flower are inserted.

Sinus: Indent or recess between the lobes of a margin.

Spatheole: Modified or bladeless leaf sheaf that envelopes a section of the inflorescence.

Spikelet: The flower-bearing portion of the plant, which consists of the glumes, lemmas, paleas and stalks, awns, stigmas, stamens, anthers, stigmas and ovaries.

Trichome: An epidermal outgrowth, for example a hair or bristle.

APPENDIX D: BOXPLOTS ILLUSTRATING PHYTOLITH SIZES

Poaceae leaves

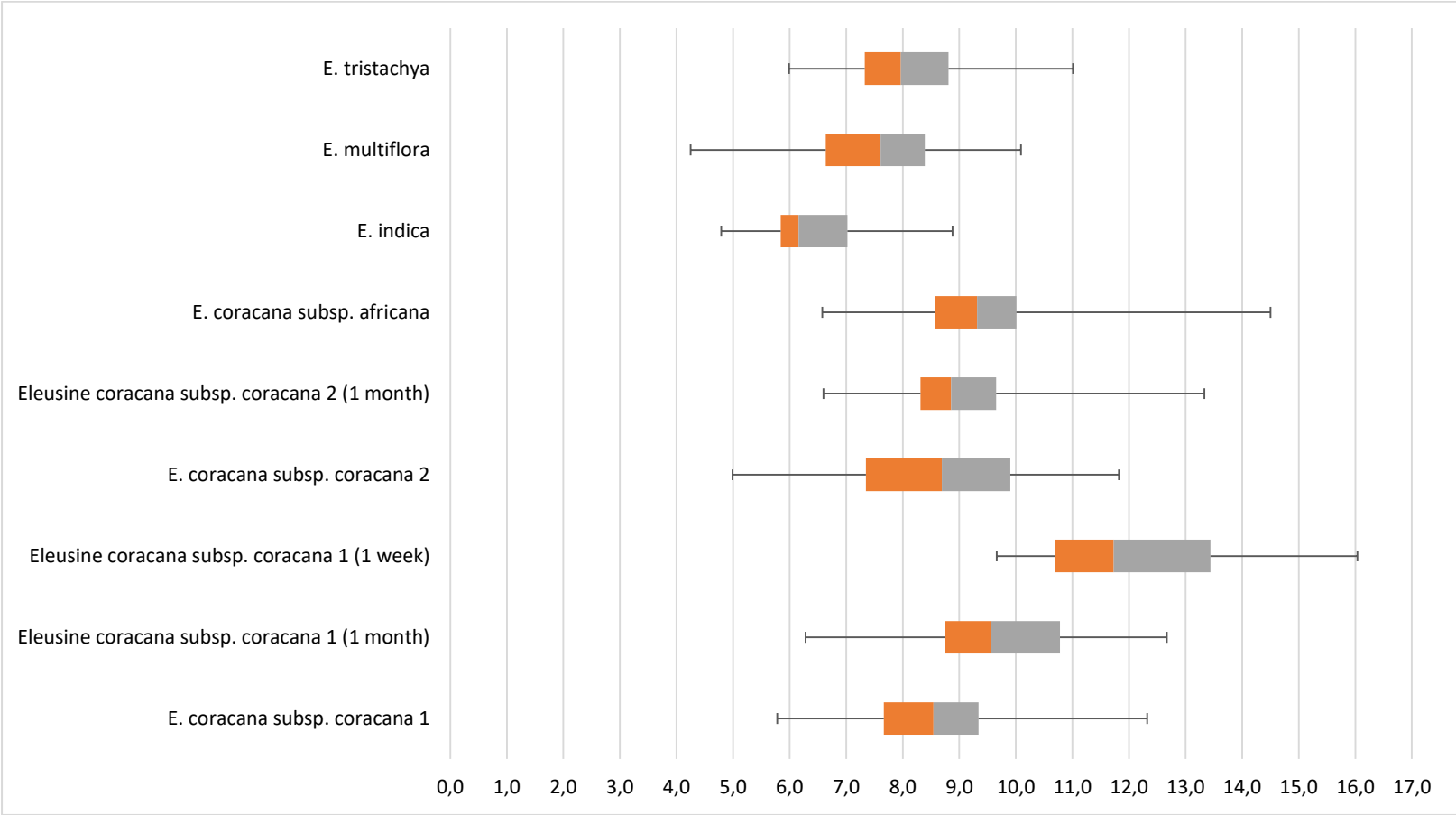

Figure D.1. Phytolith widths of depressed saddles from Poaceae leaves.

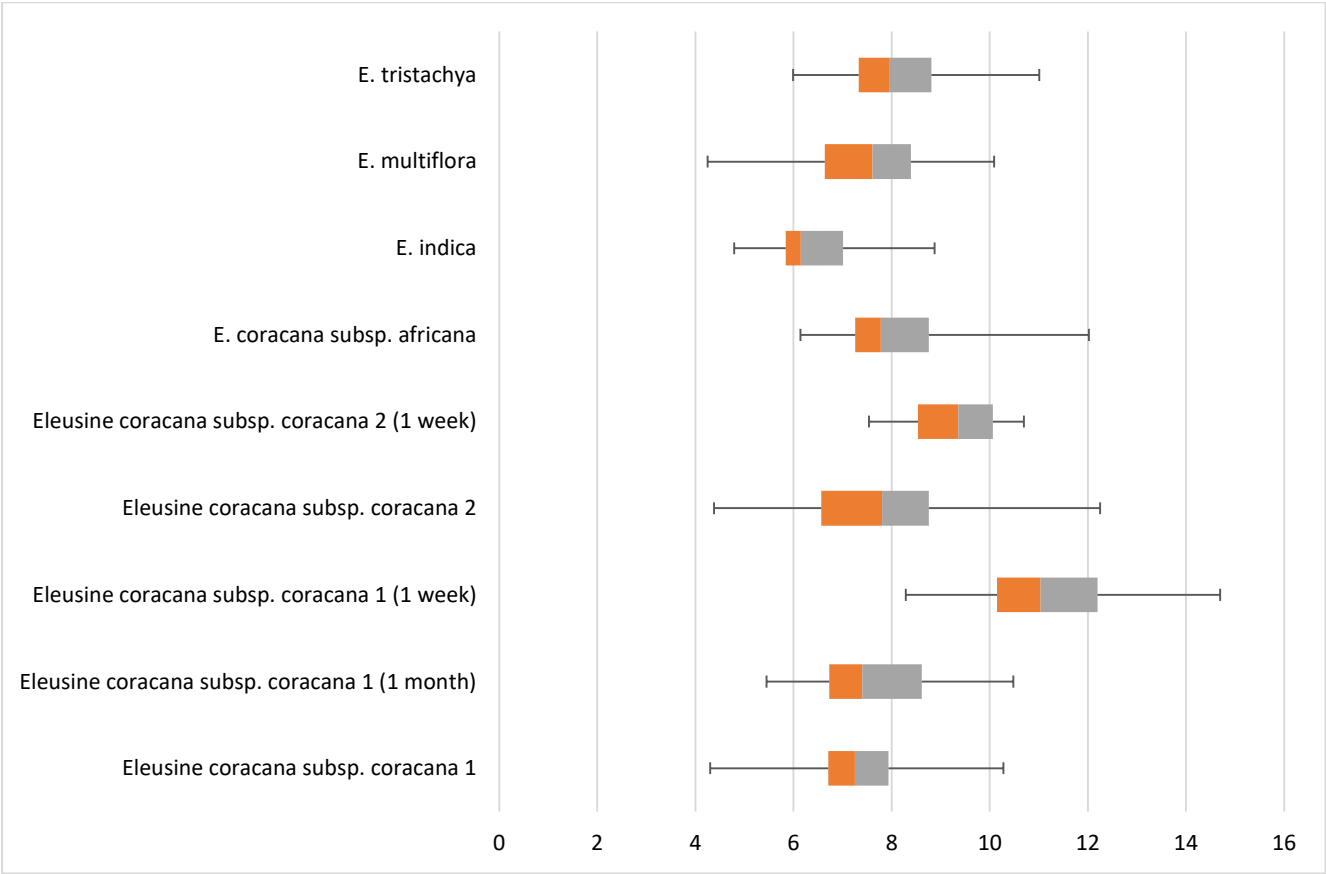

Figure D.2. Phytolith widths of elongate saddles from Poaceae leaves.

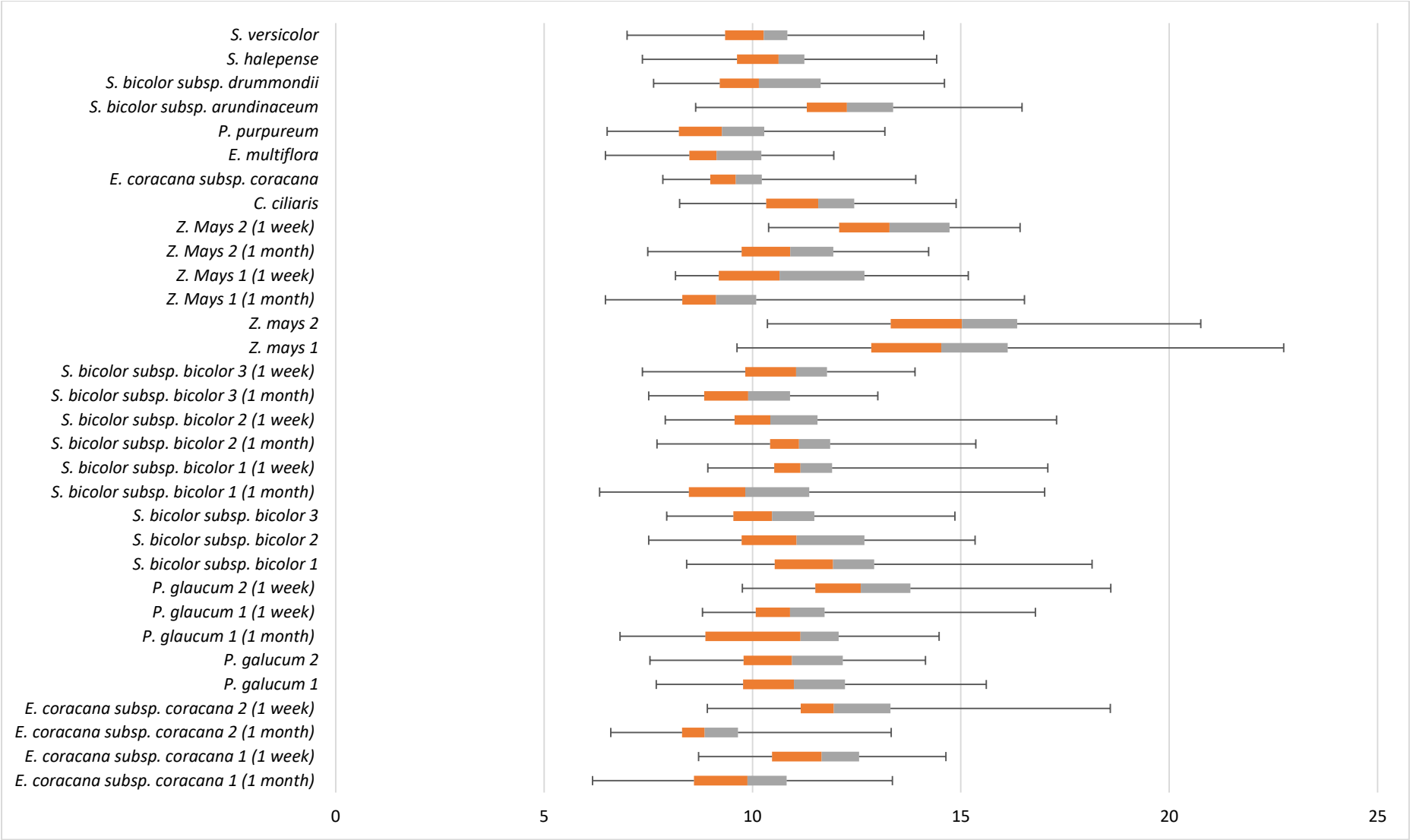

Figure D.3. Phytolith widths of variant 1 crosses from mature and juvenile Poaceae leaves.

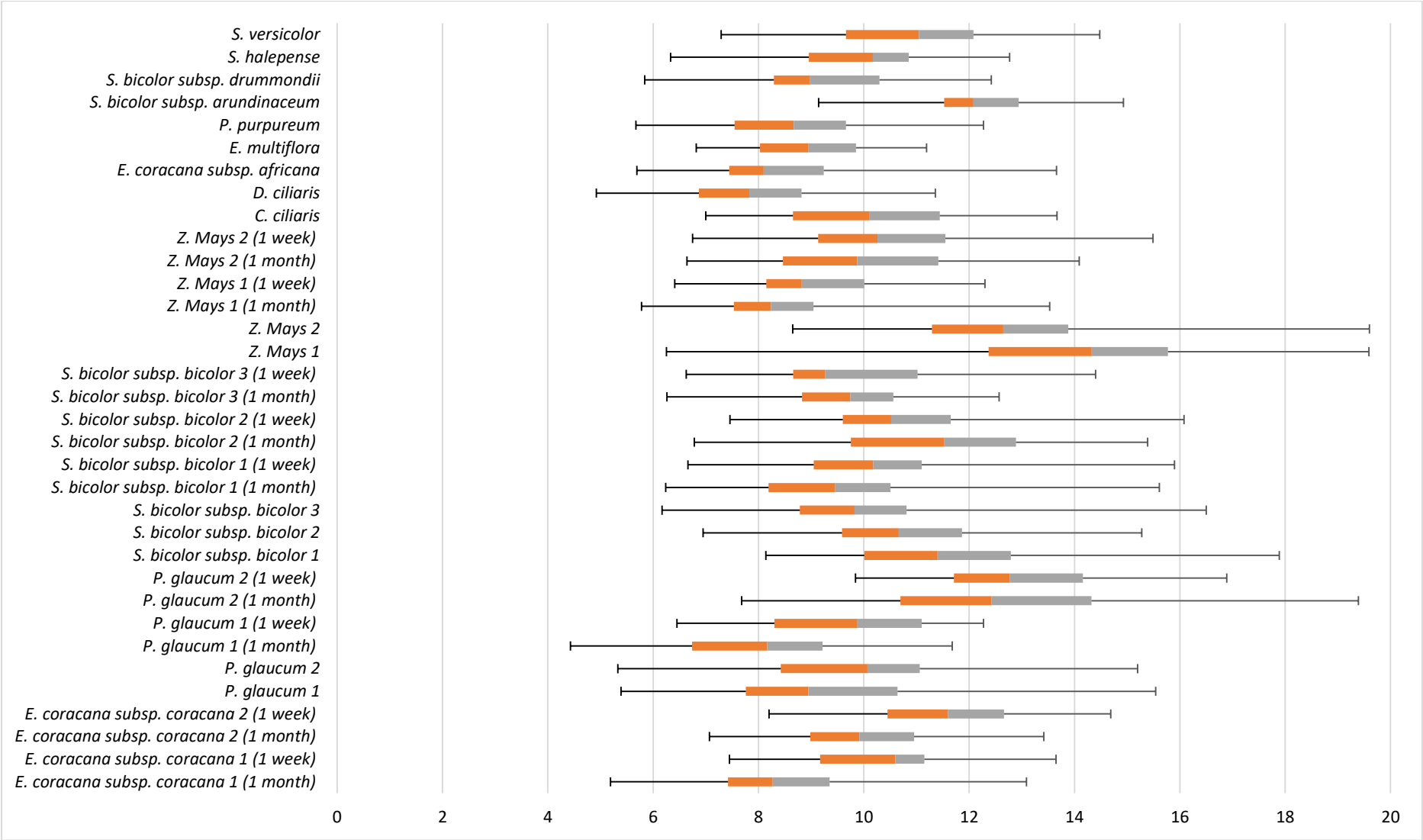

Figure D.4. Phytolith widths of bilobates from mature and juvenile Poaceae leaves.

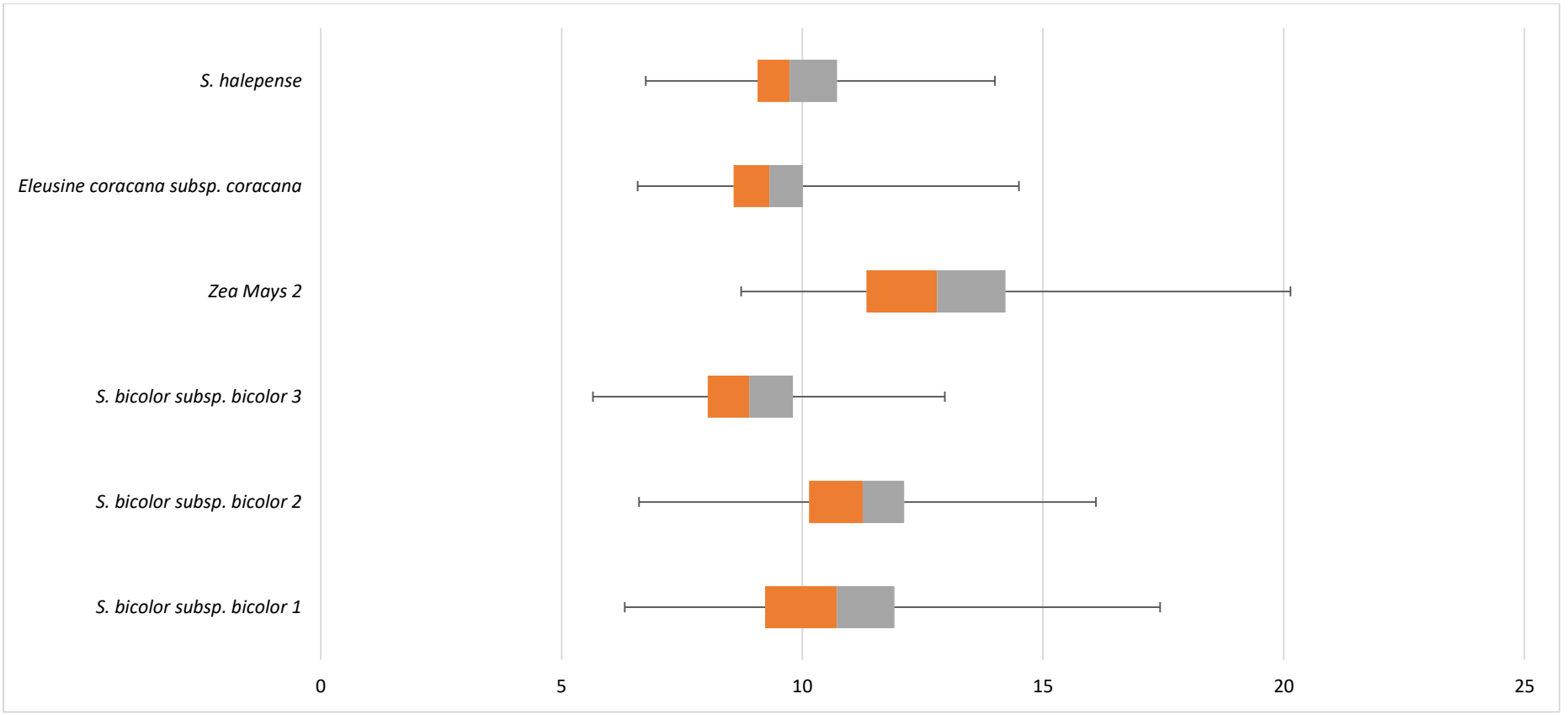

Figure D.5. Phytolith widths of variant 5/6 crosses from mature Poaceae leaves.

Poaceae inflorescences

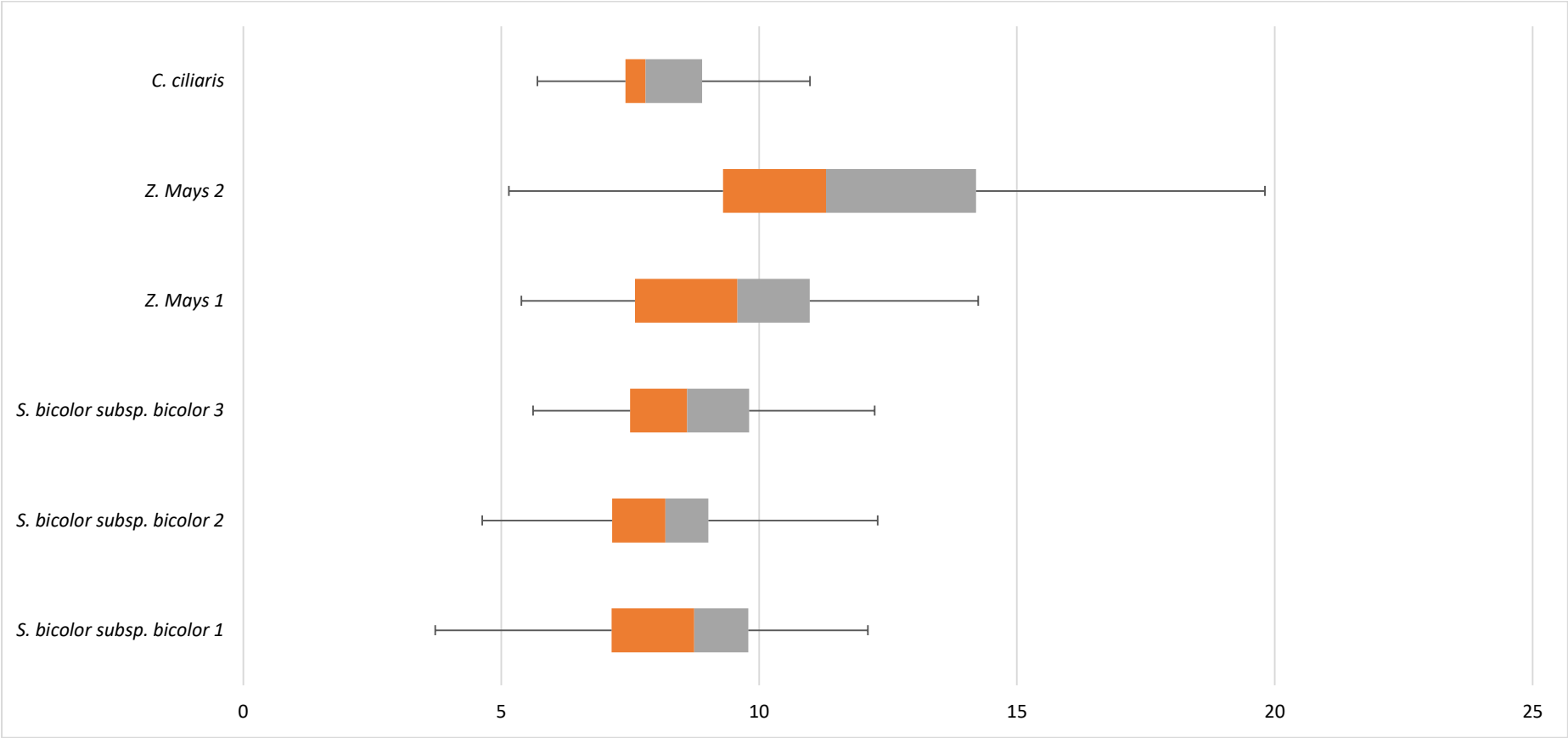

Figure D.6. Phytolith widths of elongate rondels from mature Poaceae inflorescences.

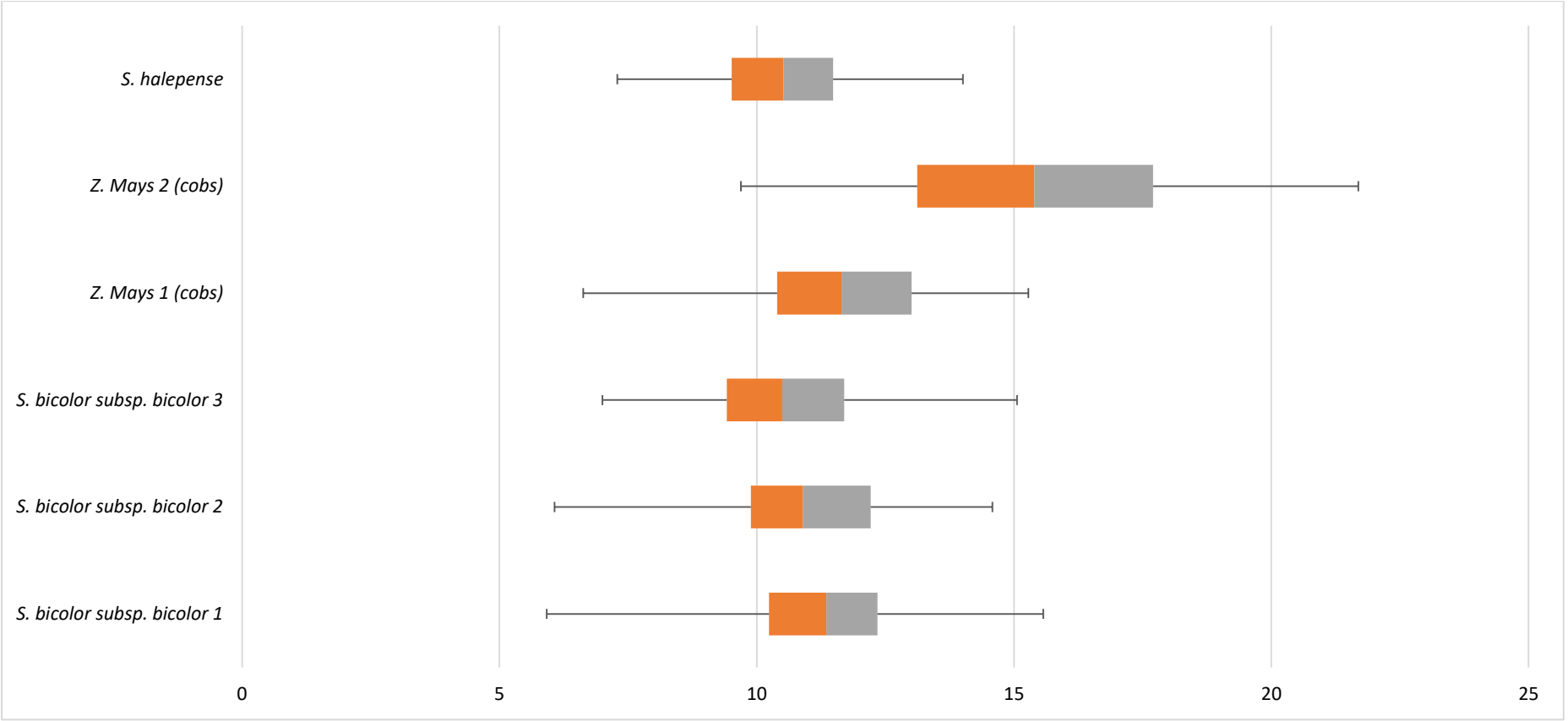

Figure D.7. Phytolith widths of round rondels from mature Poaceae inflorescences.

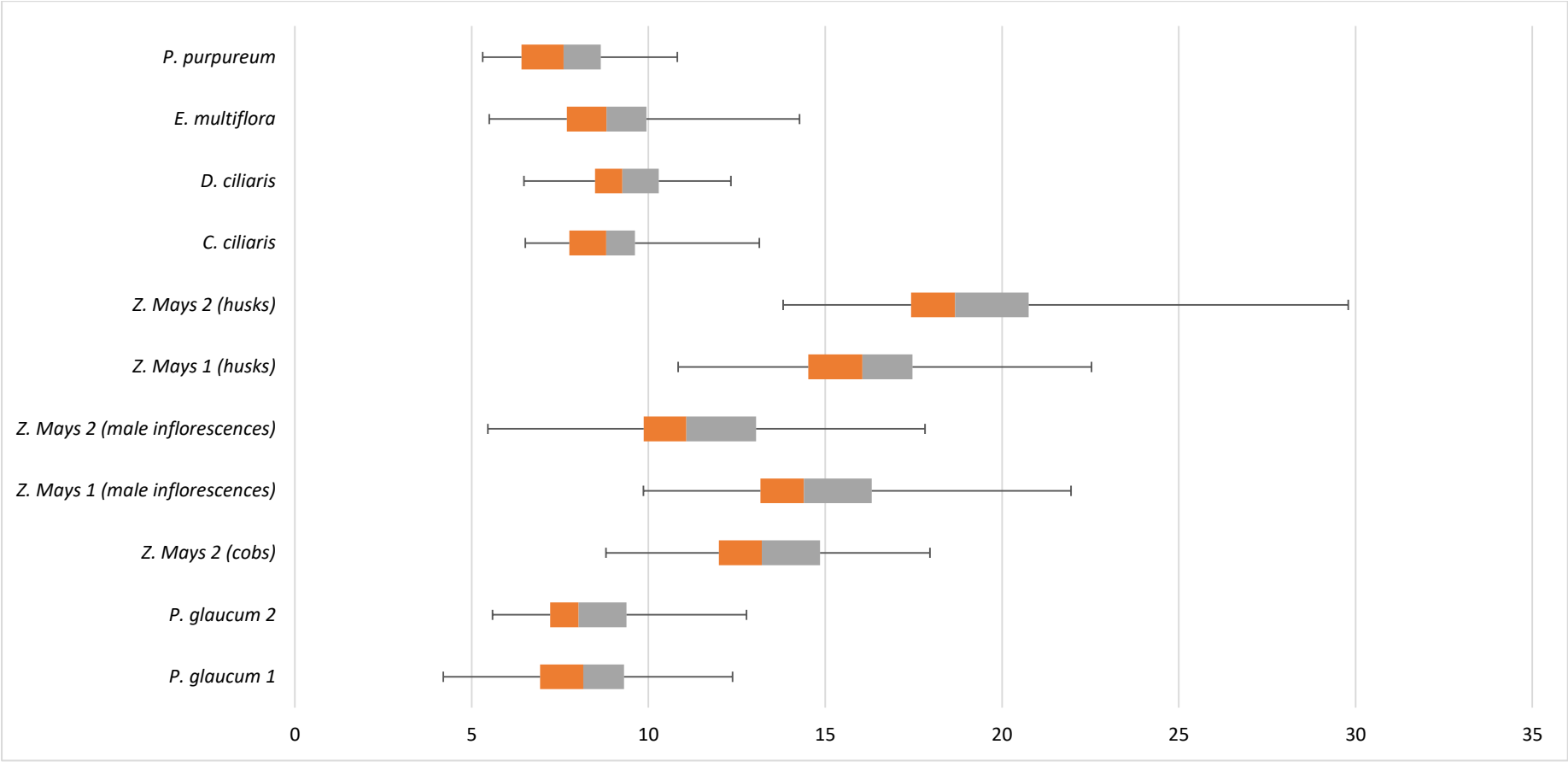

Figure D.8. Phytolith widths of variant 1 crosses from mature Poaceae inflorescences.

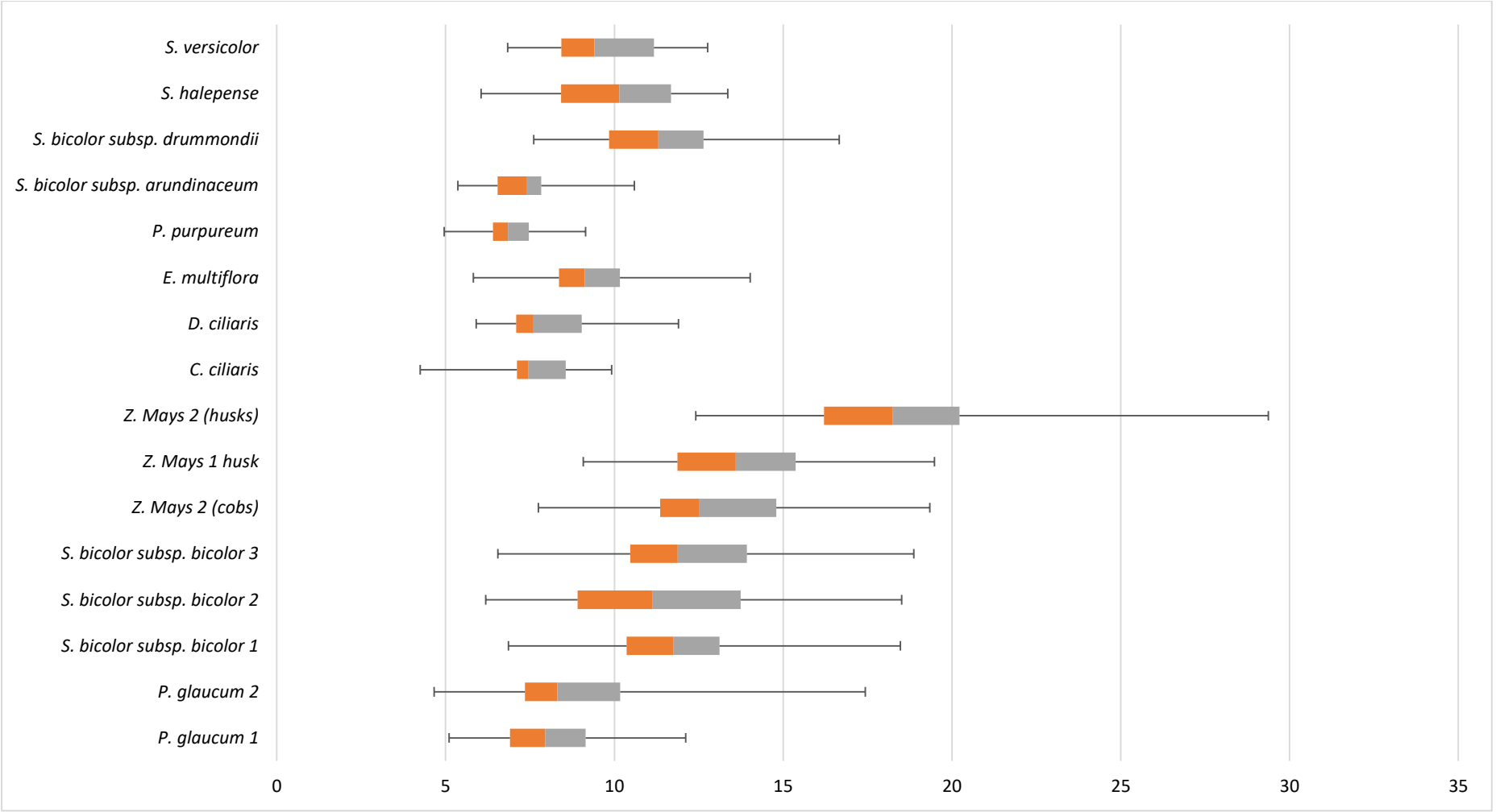

Figure D.9. Phytolith widths of bilobates from mature Poaceae inflorescences.

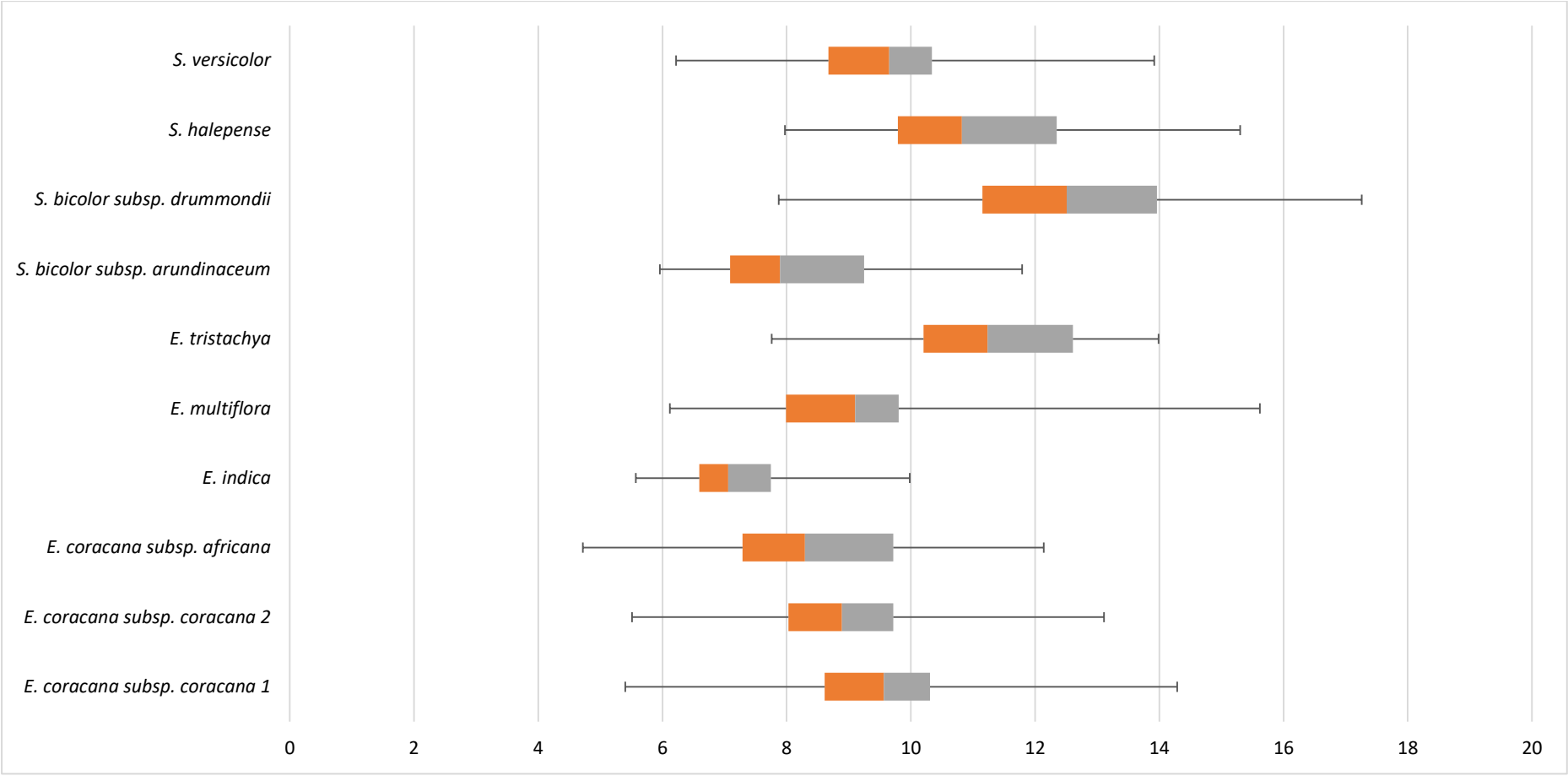

Figure D.10. Phytolith widths of depressed saddles from mature Poaceae inflorescences.

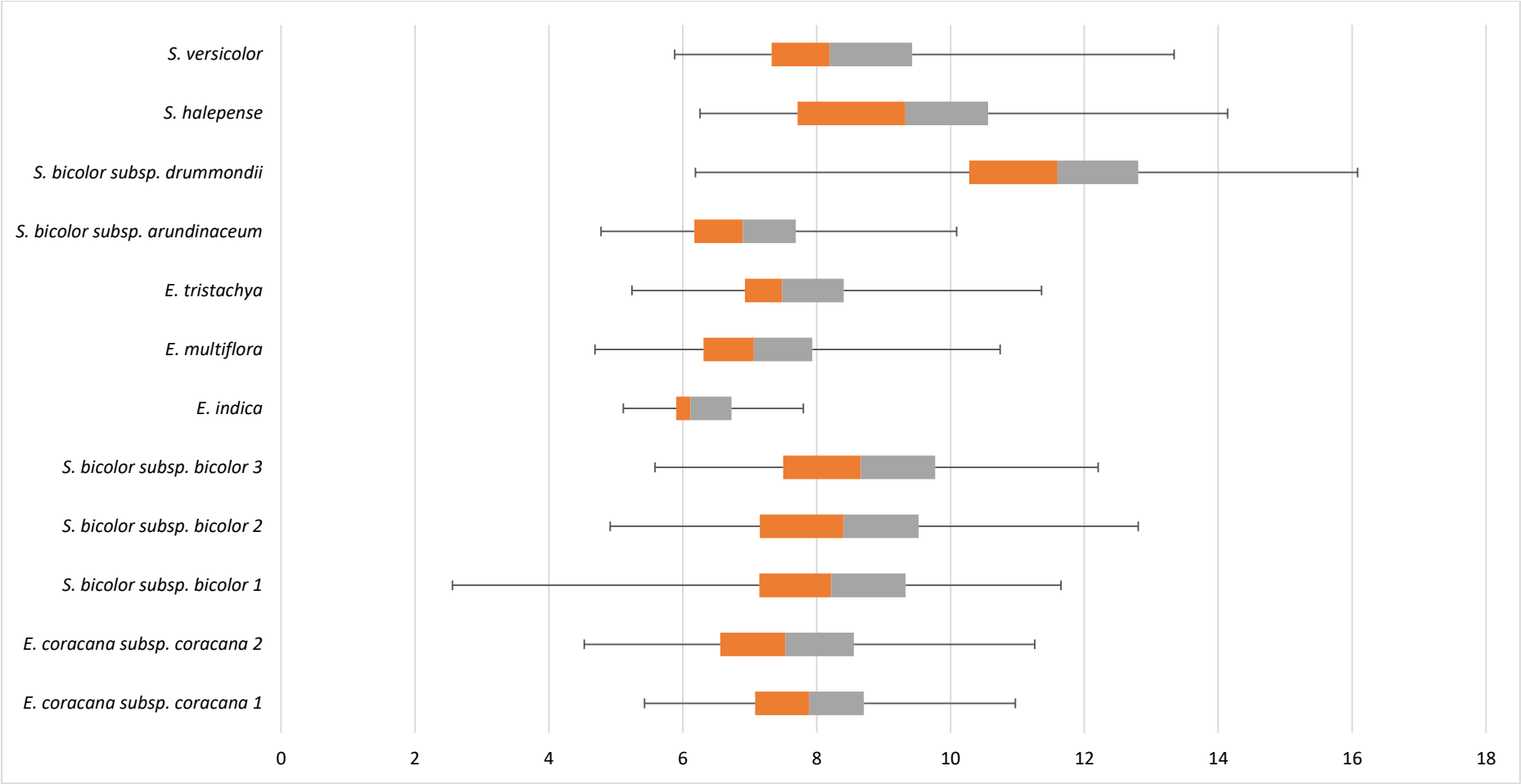

Figure D.11. Phytolith widths of elongate saddles from mature Poaceae inflorescences.

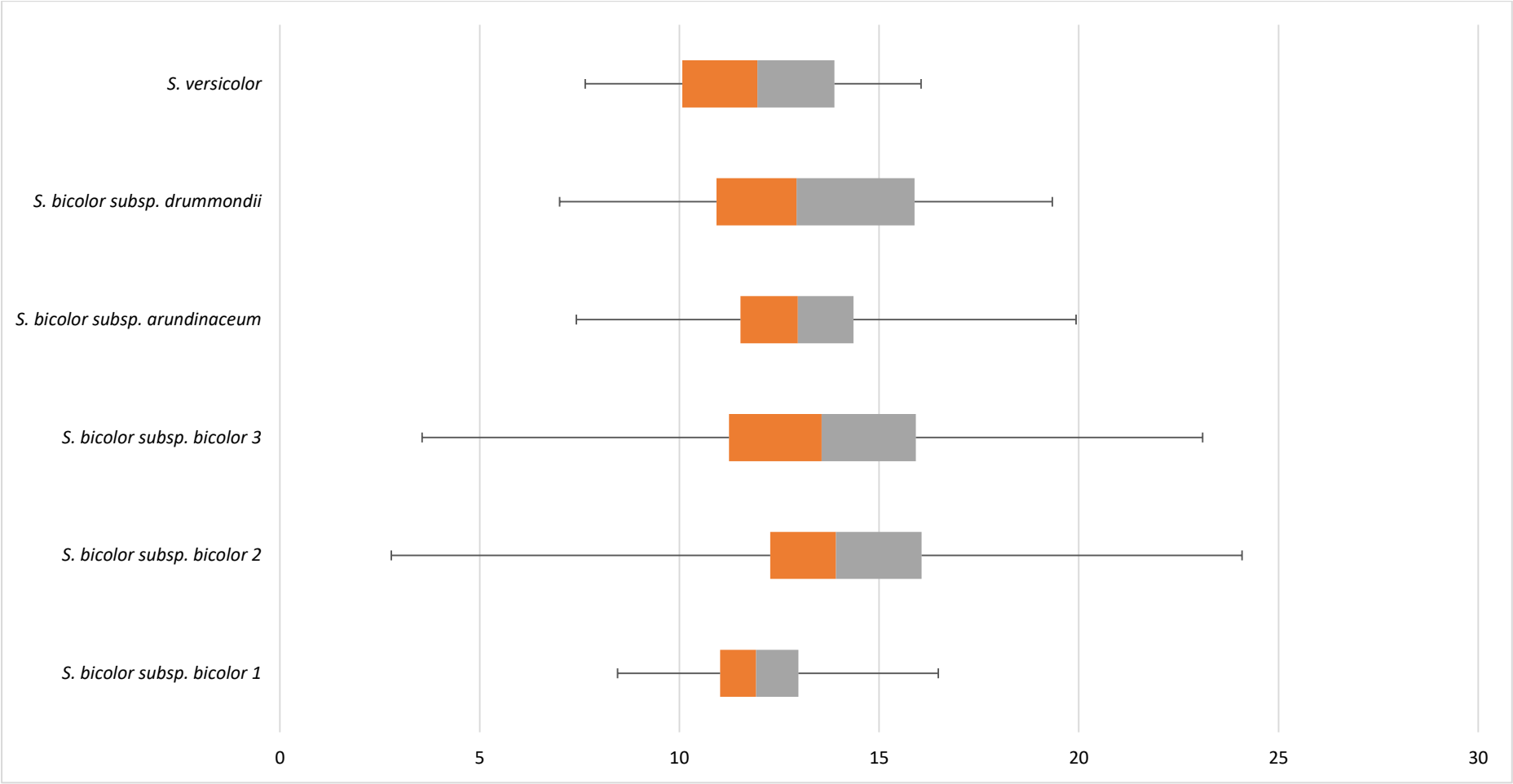

Figure D.12. Phytolith widths of dendritic long cell phytoliths from mature Poaceae inflorescences.

Fabaceae

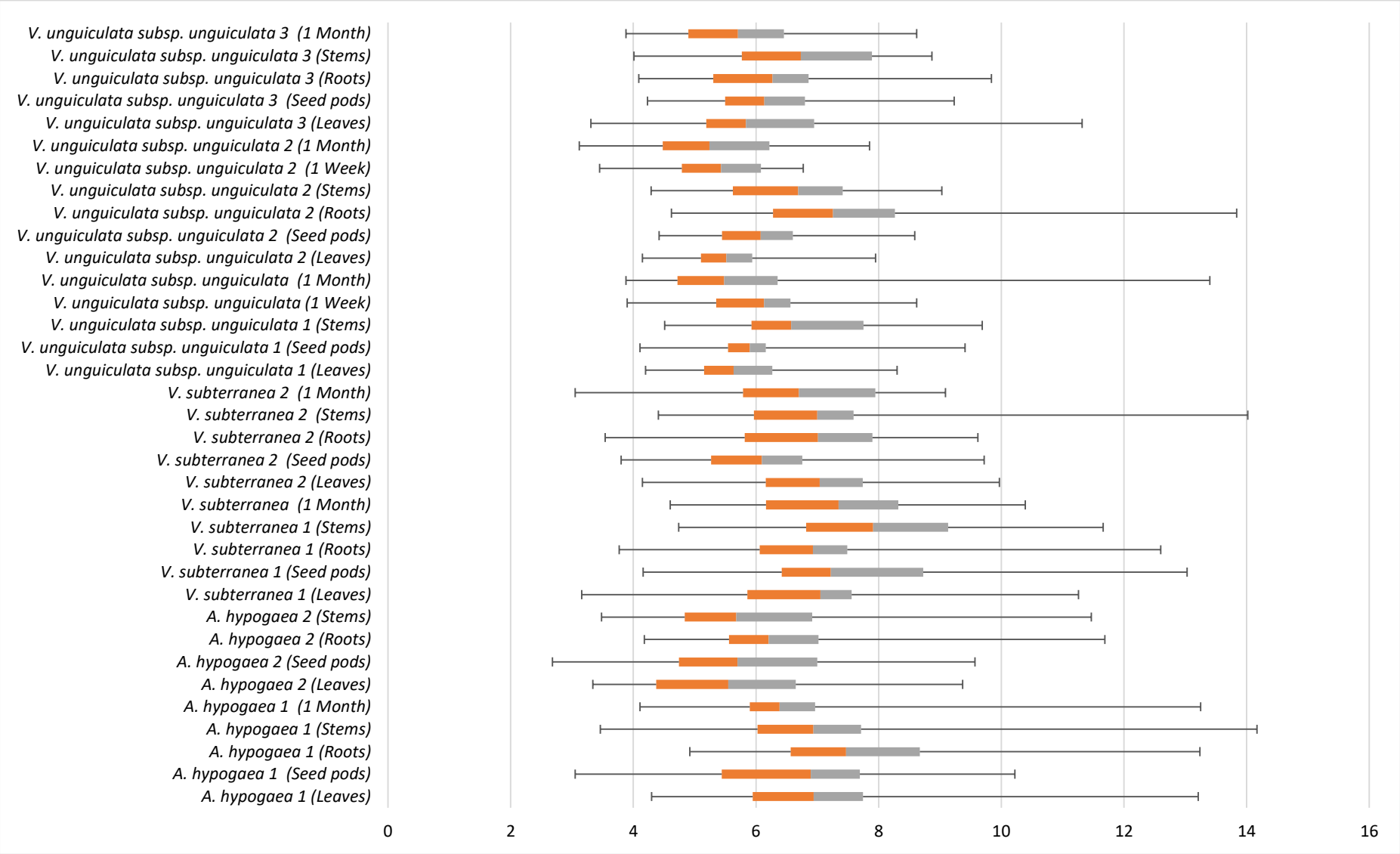

Figure D.13. Phytolith widths of rhomboidal, square or rectangular phytoliths from mature and juvenile Fabaceae.

APPENDIX E: DIAGNOSTIC COUNTS.

Table E.1. Phytoliths from the leaves of mature domesticated Poaceae.

Plant name and variant	Short cell phytoliths (%)	Epidermal long cell phytoliths (%)	Bulliform phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)
E. coracana subsp. coracana 1	69	17,5	1,5	7	0	0,5	4,5
E. coracana subsp. coracana 2	67,5	12	2	14,5	0	2,5	1,5
P. glaucum 1	32	39,5	7	7	1	13,5	-
P. glaucum 2	22	42	9	11	0	16	-
S. bicolor subsp. bicolor 1	57,5	16	1.5	2	3	20	-
S. bicolor subsp. bicolor 2	76,5	9	1	1,5	10	2	-
S. bicolor subsp. bicolor 3	75	15	8,5	1,5	0	0	-
Z. mays 1	49,5	15	6	12,5	2	15	-
Z. mays 2	70,5	2	0	27,5	0	0	-

Table E.2. Short cell phytoliths from the leaves of mature domesticated Poaceae.

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Polylobate 1 (%)	Polylobate 2 (%)	Bilobate (%)	Depressed Saddle (%)	Elongate Saddle (%)
E. coracana* subsp. *coracana 1	-	-	-	-	-	2,5	72,5	25
E. coracana* subsp. *coracana 2	-	-	-	-	-	2,5	70	27,5
P. glaucum 1	71	3,5	1	1,5	0	23	-	-
P. glaucum 2	46	8,5	4	0	0	41,5	-	-
S. bicolor* subsp. *bicolor 1	26,5	-	28	2,5		43	-	-
S. bicolor* subsp. *bicolor 2	29	-	16,5	3		51,5	-	-
S. bicolor* subsp. *bicolor 3	42,5	-	17	2		38,5	-	-
Z. mays 1	46	2,5	2,5	11,5	23,5	14	-	-
Z. mays 2	52	7	9,5	5	2	24,5	-	-

Table E.3. Phytoliths from the inflorescences of mature domesticated Poaceae.

	Short cell phytoliths (%)	Epidermal long cell phytoliths -Plain (%)	Epidermal long cell phytoliths -Dendritic (%)	Epidermal long cell phytoliths -Sinuous (%)	Hair cell phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)	Hair cell clusters (%)	Epidermal cells (%)	Bulliform phytoliths (%)	Stomata phytoliths (%)
E. coracana subsp. coracana 1	55	5,5	-	-	12,5	0	8,5	-	17,5	1	-
E. coracana subsp. coracana 2	59	2	-	-	15,5	1	5,5	-	15,5	1,5	-
P. glaucum 1	46,5	9	-	-	36,5	2	-	4	-	2	-
P. glaucum 2	41,5	5	-	-	45,5	1,5	-	5,5	-	1	-
S. bicolor subsp. bicolor 1	51,5	0	43,5	5	0	0	-	-	-	-	-
S. bicolor subsp. bicolor 2	42	0	53	2,5	0	2,5	-	-	-	-	-
S. bicolor subsp. bicolor 3	44,5	0	46,5	8,5	0	0,5	-	-	-	-	-
Z. mays 1 (cobs)	89	1	-	-	10	-	-	-	-	-	-
Z. mays 2 (cobs)	95,5	2	-	-	2,5	-	-	-	-	-	-
Z. mays 1 (Tassels)	36	5	-	-	52,5	4	-	-	-	2,5	-
Z. mays 2 (Tassels)	17,5	3	-	-	74	4	-	-	-	1	0,5
Z. mays 1 (Husks)	82,5	1,5	-	-	15,5	0,5	-	-	-	-	-
Z. mays 2 (Husks)	73,5	1,5	-	-	20	4,5	-	-	-	0,5	-

Table E.4. Short cell phytoliths from the inflorescences of mature domesticated Poaceae.

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Polylobate (%)	Wavy top rondels (%)	Bilobate (%)	Elongate saddle (%)	Depressed saddle (%)	Ruffle top rondel (%)	Elongate rondel (%)	Round rondel (%)	Saddle like rondel (%)	Irregular rondel (%)	Rondel with one dent (%)
E. coracana subsp. coracana 1	-	-	-	-	-	0,5	19,5	80	-	-	-	-	-	-
E. coracana subsp. coracana 2	-	-	-	-	-	0,5	13	86,5	-	-	-	-	-	-
P. glaucum 1	51	6	8	2,5	-	24	1	-	-	3,5	4	-	-	-
P. glaucum 2	58,5	5	3	1,5	-	22	1,5	-	-	2,5	6	-	-	-
S. bicolor subsp. bicolor 1	-	-	-	-	-	13,5	14	-	-	18	15	20,5	11	8
S. bicolor subsp. bicolor 2	-	-	-	-	-	23,5	5,5	-	-	15	18,5	19,5	8	10
S. bicolor subsp. bicolor 3	-	-	-	-	-	9	7	-	-	26	25	10,5	13	9,5
Z. mays 1 (Cobs)	0,5	-	-	-	5	0,5	-	-	2	33,5	55	-	-	3,5
Z. mays 2 (Cobs)	11	1	4,5	2,5	7,5	18,5	-	-	5	19	18	-	-	13
Z. mays 1 (Tassels)	73	5	2	7	-	13	-	-	-	-	-	-	-	-
Z. mays 2 (Tassels)	63	6	3	3	-	25	-	-	-	-	-	-	-	-
Z. mays 1 (Husks)	60,5	1	2,5	18	-	18	-	-	-	-	-	-	-	-
Z. mays 2 (Husks)	48	0	3	3,5	-	45,5	-	-	-	-	-	-	-	-

Table E.5. Phytoliths from the leaves of mature wild Poaceae.

	Short cell phytoliths (%)	Epidermal long cell phytoliths (%)	Bulliform phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)	Epidermal cells (%)
Cenchrus ciliaris	55	12,5	2,5	22,5	1	4,5	0	2
Digitaria ciliaris	83	0,5	0	9,5	1	1,5	0	4,5
Eleusine coracana subsp. africana	38	8	0,5	49,5	0	0,5	0	3,5
Eleusine indica	39	21,5	0	1	5	0	13,5	20
Eleusine multiflora	57,5	28,5	0,5	1,5	11,5	0	0	0,5
Eleusine tristachya	78	11,5	0	3	4	0	0,5	3
Pennisetum purpureum	40	11,5	0	37,5	5,5	0	0	5,5
Sorghum bicolor subsp. arundinaceum	73	11,5	1	2,5	11	0	0	1
Sorghum bicolor subsp. drummondii	73	9	1	4,5	3	0	0,5	9
Sorghum halepense	77	11	0,5	1,5	4,5	0	0	5,5
Sorghum versicolor	67,5	2,5	1,5	2	0	0	21	5,5

Table E.6. Short cell phytoliths from the leaves of mature wild Poaceae.

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Cross 7 (%)	Polylobate 1 (%)	Polylobate 2 (%)	Bilobate (%)	Depressed Saddle (%)	Elongate Saddle (%)	Round rondel (%)	Elongate Rondel (%)
Cenchrus ciliaris	57	-	1,5	-	1	0,5	40	-	-	-	-
Digitaria ciliaris	2,5	-	-	-	1	-	96,5	-	-	-	-
Eleusine coracana subsp. africana	39	-	6	-	-	-	24	6,5	4,5	13,5	6,5
Eleusine indica	3,5	-	-	-	-	-	2	84,5	10	-	-
Eleusine multiflora	12,5	-	-	-	-	-	20,5	28,5	16	22,5	-
Eleusine tristachya	-	-	-	-	-	-	1	76,5	22,5	-	-
Pennisetum purpureum	51	1	5,5	4	4	2	32,5	-	-	-	-
Sorghum bicolor subsp. arundinaceum	65	-	4,5	-	-	-	30,5	-	-	-	-
Sorghum bicolor subsp. drummondii	32	-	3	-	2	-	63	-	-	-	-
Sorghum halepense	37,5	-	8	-	4,5	0	50	-	-	-	-
Sorghum versicolor	32	-	-	-	17	23,5	27,5	-	-	-	-

Table E.7. Phytoliths from the inflorescences of mature wild Poaceae.

	Short cell phytoliths (%)	Long cell phytoliths-Plain (%)	Long cell phytoliths-Dendritic (%)	Long cell phytoliths-Sinuous (%)	Hair cell phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)	Hair cell clusters (%)	Epidermal cells (%)	Bulliform (%)	Stomata cell phytoliths (%)
Cenchrus ciliaris	43	2	-	-	40	-	-	15	-	-	-
Digitaria ciliaris	86,5	1,5	-	-	10	-	1,5	-	0,5	-	-
Eleusine coracana subsp. africana	58	-	-	-	27,5	-	-	-	13,5	1	-
Eleusine indica	60	22,5	-	-	12	0,5	1	-	2,5	-	1,5
Eleusine multiflora	59	9,5	-	-	29,5	-	-	-	1,5	0,5	-
Eleusine tristachya	90	-	-	-	9,5	-	-	-	0,5	-	-
Pennisetum purpureum	35,5	-	-	4	54,5	-	-	6	-	-	-
Sorghum bicolor subsp. arundinaceum	29,5	-	66	3,5	1	-	-	-	-	-	-
Sorghum bicolor subsp. drummondii	60,5	-	36,5	0,5	2,5	-	-	-	-	-	-
Sorghum halepense	25,5	55,5	-	-	18	-	-	0,5	0,5	-	-
Sorghum versicolor	32,5	-	55	4,5	8	-	-	-	-	-	-

Table E.8. Short cell phytoliths from the inflorescences of mature wild Poaceae.

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Polylobate (%)	Wavy top rondels (%)	Bilobate (%)	Elongate saddle (%)	Depressed saddle (%)	Ruffle top rondel (%)	Elongate rondel (%)	Round rondel (%)	Saddle like rondel (%)	Irregular rondel (%)	Rondel with one dent (%)	Cross rondel (%)
Cenchrus ciliaris	51,5	-	0,5	0,5	-	7,5	3,5	-	-	6	17	-	-	-	13,5
Digitaria ciliaris	71	-	0,5	7	-	21,5	-	-	-	-	-	-	-	-	-
Eleusine coracana subsp. africana	1	-	-	-	-	2	19	78	-	-	-	-	-	-	-
Eleusine indica	0,5	-	-	-	-	4	53	42,5	-	-	-	-	-	-	-
Eleusine multiflora	30,5	-	1	-	-	31	12	17,5	-	3	5	-	-	-	-
Eleusine tristachya	1	-	-	-	-	0,5	24	74,5	-	-	-	-	-	-	-
Pennisetum purpureum	15,5	0,5	6	16,5	-	61,5	-	-	-	-	-	-	-	-	-
Sorghum bicolor subsp. arundinaceum	0,5	-	-	-	-	8,5	19,5	59	-	1,5	8	3	-	-	-
Sorghum bicolor subsp. drummondii	-	-	-	1,5	-	21	24,5	48	-	-	2	3	-	-	-
Sorghum halepense	1	-	0,5	-	-	23	20	28,5	-	1,5	23	2,5	-	-	-
Sorghum versicolor	4	-	1	-	-	22,5	36	25	-	4	6	1,5	-	-	-

Table E.9. Phytoliths observed in juvenile domesticated Poaceae.

	Short cell phytoliths (%)	Epidermal long cell phytoliths (%)	Bulliform phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)	Epidermal cell (%)	Tracheid (%)
E. coracana subsp. coracana 1 (1-2 Weeks)	88,5	0,5	0,5	9	-	-	1	0,5	-
E. coracana subsp. coracana 1 (1 Month)	84,5	5	-	10	-	-	-	0,5	-
E. coracana subsp. coracana 2 (1-2 weeks)	77,5	-	-	11	2,5	-	-	9	-
E. coracana subsp. coracana 2 (1 Month)	82,5	5	-	10,5	0,5	-	-	1,5	-
P. glaucum 1 (1-2 Weeks)	68,5	6,5	8,5	16	-	0,5	-	-	-
P. glaucum 1 (1 Month)	72,5	-	-	27,5	-	-	-	-	-
P. glaucum 2 (1-2 Weeks)	64	4,5	2,5	29	-	-	-	-	-
P. glaucum 2 (1 Month)	61,5	5	-	30	-	-	-	3,5	-
S. bicolor subsp. bicolor 1 (1-2 Weeks)	84,5	1,5	-	9,5	-	-	1	3,5	-
S. bicolor subsp. bicolor 1 (1 Month)	73	11	0,5	4,5	6,5	-	-	4,5	-
S. bicolor subsp. bicolor 2 (1-2 Weeks)	79	19	0,5	1,5	-	-	-	-	-
S. bicolor subsp. bicolor 2 (1 Month)	74,5	1,5	0,5	20,5	0,5	0,5	-	2	-

	Short cell phytoliths (%)	Epidermal long cell phytoliths (%)	Bulliform phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)	Papillae (%)	Hair cell mesophyll (%)	Epidermal cell (%)	Tracheid (%)
S. bicolor subsp. bicolor 3 (1-2 Weeks)	88	-	-	10	1	-	-	1	-
S. bicolor subsp. bicolor 3 (1 Month)	78	13,5	0,5	3	4,5	-	-	0,5	-
Z. mays 1 (1-2 Weeks)	84,5	1	-	13,5	-	-	-	1	-
Z. mays 1 (1 Month)	69,5	11	1	9	-	2	-	-	7,5
Z. mays 2 (1-2 Weeks)	87	-	0,5	9	-	-	-	3,5	-
Z. mays 2 (1 Month)	75	11	-	12	1,5	-	-	0,5	-

Table E.10. Short cell phytoliths observed in juvenile domesticated Poaceae.

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Polylobate 1 (%)	Polylobate 2 (%)	Bilobate (%)	Depressed Saddle (%)	Elongate Saddle (%)
E. coracana subsp. coracana 1 (1-2 Weeks)	19	-	-	-	-	58	19	4
E. coracana subsp. coracana 1 (1 Month)	18,5	-	-	-	1	33,5	38	9
E. coracana subsp. coracana 2 (1-2 weeks)	33,5	-	0,5	-	0,5	52,5	4	9
E. coracana subsp. coracana 2 (1 Month)	17	-	-	-	-	30,5	42,5	10
P. glaucum 1 (1-2 Weeks)	4	-	-	7,5	25	63,5	-	-
P. glaucum 1 (1 Month)	4	-	-	20,5	27	48,5	-	-
P. glaucum 2 (1-2 Weeks)	15,5	0,5	1	12	23	48	-	-
P. glaucum 2 (1 Month)	8,5	-	-	7	6	78,5	-	-
S. bicolor subsp. bicolor 1 (1-2 Weeks)	8	-	0,5	14,5	59	18	-	-
S. bicolor subsp. bicolor 1 (1 Month)	8	1	1	14	51	25	-	-
S. bicolor subsp. bicolor 2 (1-2 Weeks)	15,5	-	-	20	23,5	41	-	-
S. bicolor subsp. bicolor 2 (1 Month)	25,5			11,5	8,5	54,5	-	-
S. bicolor subsp. bicolor 3 (1-2 Weeks)	17	-	-	13	18	52	-	-
S. bicolor subsp. bicolor 3 (1 Month)	38,5	-	0,5	4,5	5	51,5	-	-

Plant name and variant	Cross 1 (%)	Cross 2 (%)	Cross 5/6 (%)	Polylobate 1 (%)	Polylobate 2 (%)	Bilobate (%)	Depressed Saddle (%)	Elongate Saddle (%)
Z. mays 1 (1-2 Weeks)	7	-	-	11	57	25	-	-
Z. mays 1 (1 Month)	3,5	-	0,5	8,5	73	14,5	-	-
Z. mays 2 (1-2 Weeks)	11	1,5	1	12,5	41,5	32,5	-	-
Z. mays 2 (1 Month)	21,5	-	-	22,5	32	24	-	-

Table E.11. Bilobate lobe shapes observed in the leaves and inflorescences of mature domesticated Poaceae.

Lobe shape	E. coracana subsp. coracana 1	E. coracana subsp. coracana 2	P. glaucum 1	P. glaucum 2	S. bicolor subsp. bicolor 1	S. bicolor subsp. bicolor 2	S. bicolor subsp. bicolor 3	Z. mays 1	Z. mays 2
Bifid[2]			X	X	X	X	X	X	X
Bifid and Concave[3]			X		X	X	X	X	
Bifid and Flat			X	X	X	X	X	X	X
Bifid and Protrusion			X		X		X	X	
Bifid and Rounded			X	X	X	X	X	X	X
Concave			X	X	X		X		
Concave and Flat			X	X	X	X	X		
Concave and Protrusion							X		
Concave and Rounded			X	X	X	X	X	X	
Flat			X	X	X	X	X	X	
Flat and Protrusion					X				
Flat and Rounded			X	X	X	X	X	X	X
Protrusion				X					
Protrusion and Rounded				X				X	X
Rounded	X	X	X	X	X	X	X	X	X

[2] Single word descriptions signal that the outer margins of both lobes bear the same shape.
[3] Two word descriptions signal that the outer margins of the lobes are dissimilar. For example, one contains a bifid, while the other is concave.

Table E.12. Bilobate lobe shapes observed in juvenile samples of domesticated Poaceae (1 Month and 1-2 Weeks).

Lobe shape	E. coracana subsp. coracana 1	E. coracana subsp. coracana 2	P. glaucum 1	P. glaucum 2	S. bicolor subsp. bicolor 1	S. bicolor subsp. bicolor 2	S. bicolor subsp. bicolor 3	Z. mays 1	Z. mays 2
Bifid[4]	X	X	X	X	X	X	X	X	X
Bifid and Concave[5]		X	X		X		X	X	
Bifid and Flat	X	X	X	X	X	X	X		X
Bifid and Protrusion					X	X		X	
Bifid and Rounded	X	X	X	X	X	X	X	X	X
Concave				X			X	X	
Concave and Flat	X		X				X		
Concave and Protrusion				X			X	X	
Concave and Rounded	X		X	X	X	X	X	X	
Flat	X		X		X	X		X	
Flat and Protrusion									
Flat and Rounded	X	X	X	X	X	X	X	X	X
Protrusion			X	X	X				
Protrusion and Flat				X					
Protrusion and Rounded					X		X		X
Rounded	X	X	X	X	X	X	X	X	X

[4] Single word descriptions signal that the outer margins of both lobes bear the same shape.
[5] Two word descriptions signal that the outer margins of the lobes are dissimilar. For example, one contains a bifid, while the other is concave.

Table E.13. Bilobate lobe shapes observed in the leaves and inflorescence of wild Poaceae.

Lobe shape	Cenchrus ciliaris	Digitaria ciliaris	Eleusine coracana subsp. africana	Eleusine indica	Eleusine multiflora	Eleusine tristachya	Pennisetum purpureum	Sorghum bicolor subsp. arundinaceum	Sorghum bicolor subsp. drummondii	Sorghum halepense	Sorghum versicolor
Bifid[6]	X	X			X		X		X		X
Bifid and Concave[7]	X								X		X
Bifid and Flat	X	X	X		X		X		X	X	X
Bifid and Protrusion											
Bifid and Rounded	X	X	X		X		X	X	X	X	X
Concave		X					X			X	X
Concave and Flat			X						X		X
Concave and Protrusion										X	X
Concave and Rounded		X	X		X		X		X	X	X
Flat	X	X	X		X		X		X		X
Flat and Protrusion											
Flat and Rounded	X	X	X		X		X	X	X		X

[6] Single word descriptions signal that the outer margins of both lobes bear the same shape.
[7] Two word descriptions signal that the outer margins of the lobes are dissimilar. For example, one contains a bifid, while the other is concave.

Protrusion											
Protrusion and Rounded	X	X	X								X
Rounded	X	X	X		X		X	X	X	X	X

Table E.14. Bilobate variants observed in the leaves of mature domesticated and wild plants.

Plant name and variant	Variant 1	Variant 2	Variant 3	Variant 4
E. coracana* subsp. *coracana 1				
E. coracana* subsp. *coracana 2				
P. glaucum 1		X	X	
P. glaucum 2	X	X	X	X
S. bicolor* subsp. *bicolor 1		X	X	
S. bicolor* subsp. *bicolor 2		X	X	X
S. bicolor* subsp. *bicolor 3		X	X	
Z. mays 1		X	X	
Z. mays 2		X	X	
C. ciliaris		X	X	
D. ciliaris	X	X	X	
E. coracana* subsp. *africana		X	X	
E. indica				
E. multiflora		X	X	
E. tristachya				
P. purpureum		X	X	
S. bicolor* subsp. *arundinaceum		X	X	
S. bicolor* subsp. *drummondii		X	X	
S. halepense		X	X	
S. versicolor	X	X	X	X

Table E.15. Bilobate variants observed in the mature samples of domesticated and wild plants (Inflorescences).

Plant name and variant	Variant 1	Variant 2	Variant 3	Variant 4
E. coracana* subsp. *coracana 1				
E. coracana* subsp. *coracana 2				
P. glaucum 1	X	X	X	X
P. glaucum 2		X	X	
S. bicolor* subsp. *bicolor 1		X	X	
S. bicolor* subsp. *bicolor 2		X	X	
S. bicolor* subsp. *bicolor 3		X	X	
Z. mays 1		X	X	
Z. mays 2		X	X	
C. ciliaris		X	X	
D. ciliaris	X	X	X	
E. coracana* subsp. *africana		X	X	
E. indica				
E. multiflora		X	X	
E. tristachya				
P. purpureum		X	X	
S. bicolor* subsp. *arundinaceum		X	X	
S. bicolor* subsp. *drummondii		X	X	
S. halepense		X	X	
S. versicolor		X	X	

Table E.16. Bilobate variants observed in the juvenile samples of domesticated plants (1 Month).

Plant name and variant	Variant 1	Variant 2	Variant 3	Variant 4
E. coracana subsp. coracana 1		X	X	
E. coracana subsp. coracana 2	X	X	X	X
P. glaucum 1	X	X	X	
P. glaucum 2	X	X	X	X
S. bicolor subsp. bicolor 1		X	X	
S. bicolor subsp. bicolor 2		X	X	
S. bicolor subsp. bicolor 3	X	X	X	
Z. mays 1	X	X	X	X
Z. mays 2	X	X	X	X

Table E.17. Bilobate variants observed in the juvenile samples of domesticated plants (1-2 Weeks).

Plant name and variant	Variant 1	Variant 2	Variant 3	Variant 4
E. coracana subsp. coracana 1	X	X	X	X
E. coracana subsp. coracana 2		X	X	
P. glaucum 1		X	X	
P. glaucum 2	X	X	X	X
S. bicolor subsp. bicolor 1		X	X	X
S. bicolor subsp. bicolor 2		X	X	
S. bicolor subsp. bicolor 3	X	X	X	X
Z. mays 1		X	X	
Z. mays 2		X	X	

Table E.18. Variant 1 cross to bilobate phytolith ratios from Poaceae taxa.

	Ratios
E. coracana subsp. coracana 1	-
E. coracana subsp. coracana 2	-
P. glaucum 1	1:0,3
P. glaucum 2	1:0,9
S. bicolor subsp. bicolor 1	1:1,6
S. bicolor subsp. bicolor 2	1:1,8
S. bicolor subsp. bicolor 3	1:1,2
Z. mays 1	1:0,3
Z. mays 2	1:0,5
C. ciliaris	1:0,7
D. ciliaris	1:38,6
E. coracana subsp. africana	-
E. indica	-
E. multiflora	-
E. tristachya	-
P. purpureum	1:0,6
S. bicolor subsp. arundinaceum	1:0,4
S. bicolor subsp. drummondii	1:1,9
S. halepense	1:1,3
S. versicolor	1:0,9

APPENDIX F: RESULTS OF ANOVA (ANALYSIS OF VARIANCE) CALCULATIONS AT A 95% CONFIDENCE LEVEL

Leaves of domesticated and wild Poaceae (Width)

Table F.1. ANOVA (Analysis of variance) results for the widths of depressed saddle phytoliths from the leaves of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	0,01	0,93942
***E. coracana* subsp. *coracana* 1 (mature) and wild Eleusine taxa**	15,59	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	8,53	0,004035
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	3,27	0,072429
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	8,89	0,00336
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	54	<0,00001
***E. coracana* subsp. *coracana* 2 (mature) and wild Eleusine taxa**	13,41	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	6,37	0,012652
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	2,54	0,113042
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	6,6	0,011181
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	41,59	<0,00001
Wild Eleusine taxa	10,82	<0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 month)**	27,97	<0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 week)**	132,46	<0,00001
***E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *coracana* 2 (1 month)**	5,016	0,026605

Table F.2. ANOVA (Analysis of variance) results for the widths of elongate saddle phytoliths from the leaves of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	5,23	0,023292
E. coracana* subsp. *coracana* 1 (mature), *E. indica*, *E. multiflora* & *E. tristachya	18,86	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	23,77	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	0,95	0,330775
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	18,19	0,000035
E. coracana* subsp. *coracana* 2 (mature), *E. indica*, *E. multiflora* & *E. tristachya	14,17	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	26,96	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	0,88	0,35004
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	1,99	0,160486
E. indica, E. multiflora* & *E. tristachya	25,57	<0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 Month)**	4,94	0,027823
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 week)**	236,91	<0,00001
***E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *coracana* 2 (1 Month)**	2,14	0,145733
***E. coracana* subsp. *coracana* 2 (mature) *E. coracana* subsp. *coracana* 2 (1 week)**	16,56	0,000086
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (juvenile)**	114,62	<0,00001
E. coracana subsp. coracana 2 (mature) & *E. coracana* subsp. *coracana* 2 (juvenile)	8,89	0,000216

Table F.3. ANOVA (Analysis of variance) results for the widths of variant 5/6 cross phytoliths from the leaves of mature domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	44,70	<0,00001
S. bicolor* subsp. *bicolor* 1 & *E. coracana* subsp. *africana	12,72	0,000501
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	3	0,084995
S. bicolor* subsp. *bicolor* 1 & *S. halepense	5,08	0,025714
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	60,48	<0,00001
S. bicolor* subsp. *bicolor* 2 & *E. coracana* subsp. *africana	30,12	<0,00001
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	48,92	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	17,56	0,000048
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	45,12	<0,00001
S. bicolor* subsp. *bicolor* 3 & *E. coracana* subsp. *africana	2,79	0,097341
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	92,74	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	16,53	0,000078
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	213,82	<0,00001
Z. mays* 2 & *E. coracana* subsp. *africana	77,89	<0,00001
Z. mays* 2 & *S. halepense	72,80	<0,00001

Table F.4. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***P. glaucum* 1 (mature) & *P. glaucum* 2 (mature)**	5,42	0,02088
P. glaucum* 1 (mature) & *C. ciliaris	6,16	0,014193
P. glaucum* 1 (mature) & *E. coracana* subsp. *africana	8,07	0,005119
P. glaucum* 1 (mature) & *E. multiflora	0,76	0,386206
P. glaucum* 1 (mature) & *P. purpureum	4	0,47362
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	66,25	<0,00001
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	29,9	<0,00001
***P. glaucum* (mature) 1 & *S. bicolor* subsp. *bicolor* 3 (mature)**	4,19	0,041953
P. glaucum* 1 (mature) & *S. bicolor* subsp. *arundinaceum	90,77	<0,00001
P. glaucum* 1 (mature) & *S. bicolor* subsp. *drummondii	0,06	0,799769
P. glaucum* 1 (mature) & *S. halepense	5,48	0,20591
P. glaucum* 1 (mature) & *S. versicolor	28,47	<0,00001
***P. glaucum* 1 (mature) & *Z. mays* 1**	202,52	<0,00001
***P. glaucum* 1 (mature) & *Z. mays* 2**	147,44	<0,00001
P. glaucum* 2 (mature) & *C. ciliaris	0,37	0,545613
P. glaucum* 2 (mature) & *E. coracana* subsp. *africana	25,64	<0,00001
P. glaucum* 2 (mature) & *E. multiflora	9,64	0,002284
P. glaucum* 2 (mature) & *P. purpureum	17,65	0,000046
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	38,39	<0,00001
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	10,12	0,001699
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	0,11	0,742472
P. glaucum* 2 (mature) & *S. bicolor* subsp. *arundinaceum	62,66	<0,00001
P. glaucum* 2 (mature) & *S. bicolor* subsp. *drummondii	5,65	0,018717
P. glaucum* 2 (mature) & *S. halepense	0,1	0,748684
P. glaucum* 2 (mature) & *S. versicolor	12,98	0,00043
***P. glaucum* 2 (mature) & *Z. mays* 1**	159,24	<0,00001
***P. glaucum* 2 (mature) & *Z. mays* 2**	105,11	<0,00001
***P. glaucum* 1 (mature) & *P. glaucum* 1 (juvenile taxa)**	7,89	0,00527
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 Month)**	11,94	0,000716
***P. glaucum* 1 & *P. glaucum* 1 (1 Week)**	0,81	0,368289
***P. glaucum* 2 (mature) & *P. glaucum* 2 (juvenile taxa)**	40,23	<0,00001
***P. glaucum* 2 & *P. glaucum* 2 (1 Month)**	59,2	<0,00001
***P. glaucum* 2 & *P. glaucum* 2 (1 Week)**	50,6	<0,00001

Table F.5. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
Wild Sorghum taxa	39,63	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature), *S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	23,78	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *C. ciliaris	19,68	0,00018
S. bicolor* subsp. *bicolor* 1 (mature) & *E. coracana* subsp. *africana	90,37	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. multiflora	63,58	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *P. purpureum	77,23	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *arundinaceum	2,37	0,12568
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *drummondii	52,30	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. halepense	24,79	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. versicolor	3,25	0,073256
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 1 (mature)**	44	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 2 (mature)**	11,93	<0,000674
S. bicolor* subsp. *bicolor* 2 (mature) & *C. ciliaris	4,15	0,04349
S. bicolor* subsp. *bicolor* 2 & *E. coracana* subsp. *africana	65,79	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *E. multiflora	38,92	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *P. purpureum	52,44	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *arundinaceum	29,85	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *drummondii	28,57	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. halepense	6,57	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. versicolor	1,23	0,268566
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 1 (mature)**	107,37	<0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 2 (mature)**	57,33	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *C. ciliaris	0,8	0,372824
S. bicolor* subsp. *bicolor* 3 (mature) & *E. coracana* subsp. *africana	24,05	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *E. multiflora	8,35	0,004446
S. bicolor* subsp. *bicolor* 3 (mature) & *P. purpureum	16,15	0,000093
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *arundinaceum	71,01	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *drummondii	4,61	0,033343
S. bicolor* subsp. *bicolor* 3 (mature) & *S. halepense	0,39	0,532159
S. bicolor* subsp. *bicolor* 3 (mature) & *S. versicolor	15,67	0,000117
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 1 (mature)**	169,47	<0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 2 (mature)**	114,80	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (juvenile taxa)**	20,16	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & S. *bicolor* subsp. *bicolor* 1 (1 Month)**	38,39	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (1 Week)**	7,2	0,008288
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (juvenile taxa)**	2,08	0,128304
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Month)**	3,95	0,048827
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Week)**	0,0001	0,990806

***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (juvenile taxa)**	0,09	0,763061
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Month)**	0,2	0,647448
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Week)**	0,12	0,884798

Table F.6. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***Z. mays* 1 (mature) & *Z. mays* 2 (mature)**	13,89	0,00253
Z. mays* 1 (mature) & *C. ciliaris	87,81	<0,00001
Z. mays* 1 (mature) & *E. coracana* subsp. *africana	191,07	<0,00001
Z. mays* 1 (mature) & *E. multiflora	158,70	<0,00001
Z. mays* 1 (mature) & *P. purpureum	174,83	<0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *arundinaceum	19,85	0,000016
Z. mays* 1 (mature) & *S. bicolor* subsp. *drummondii	141,61	<0,00001
Z. mays* 1 (mature) & *S. halepense	100,28	<0,00001
Z. mays* 1 (mature) & *S. versicolor	50,2	<0,00001
Z. mays* 2 (mature) & *C. ciliaris	60,36	<0,00001
Z. mays* 2 (mature) & *E. coracana* subsp. *africana	176,07	<0,00001
Z. mays* 2 (mature) & *E. multiflora	140	<0,00001
Z. mays* 2 (mature) & *P. purpureum	157,36	<0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *arundinaceum	2,68	0,103669
Z. mays* 2 (mature) & *S. bicolor* subsp. *drummondii	119,15	<0,00001
Z. mays* 2 (mature) & *S. halepense	73,7	<0,00001
Z. mays* 2 (mature) & *S. versicolor	24,78	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (juvenile taxa)**	122,92	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Month)**	186,43	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Week)**	82,72	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (juvenile taxa)**	33,36	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Month)**	58,32	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Week)**	22,17	<0,00001

Table F.7. ANOVA (Analysis of variance) results for the widths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***P. glaucum* 1 (mature) & *P. glaucum* 2 (mature)**	0,52	0,471086
P. glaucum* 1 (mature) & *P. purpureum	33,88	<0,00001
P. glaucum* 1 (mature) & *C. ciliaris	1,74	0,189275
P. glaucum* 1 (mature) & *E. coracana* subsp. *africana	23,47	0,45007
P. glaucum* 1 (mature) & *E. multiflora	40,82	<0,00001
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	10,55	0,01362
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	0,24	0,62355
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	4,64	0,32485
P. glaucum* 1 (mature) & *S. bicolor* subsp. *arundinaceum	16,58	0,00076
P. glaucum* 1 (mature) & *S. bicolor* subsp. *drummondii	3,99	0,047479
P. glaucum* 1 (mature) & *S. halepense	3,69	0,056511
P. glaucum* 1 (mature) & *S. versicolor	5,59	0,019385
P. glaucum* 1 (mature) & *E. multiflora, C. ciliaris, P. purpureum, E. coracana* subsp. *africana	11,71	<0,00001
***P. glaucum* 1 (mature) & Wild Sorghums**	25,59	<0,00001
***P. glaucum* 1 (mature) & *Z. mays* 1 (mature)**	138,82	<0,00001
***P. glaucum* 1 (mature) & *Z. mays* 2 (mature)**	160,3	<0,00001
P. glaucum* 2 (mature) & *C. ciliaris	4,09	<0,00001
P. glaucum* 2 (mature) & *E. coracana* subsp. *africana	20,2	0,000014
P. glaucum* 2 (mature) & *E. multiflora	37,67	<0,00001
P. glaucum* 2 (mature) & *P. purpureum	30,6	<0,00001
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	16,64	0,00066
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	1,49	0,223134
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	2,12	0,147345
P. glaucum* 2 (mature) & *S. bicolor* subsp. *arundinaceum	24,21	<0,00001
P. glaucum* 2 (mature) & *S. bicolor* subsp. *drummondii	2,26	0,134156
P. glaucum* 2 (mature) & *S. halepense	1,95	0,164873
P. glaucum* 2 (mature) & *S. versicolor	3,53	0,062327
P. glaucum* 2 (mature) & *E. multiflora, C. ciliaris, P. purpureum, E. coracana* subsp. *africana	12,23	<0,00001
***P. glaucum* 2 (mature) & Wild Sorghums**	24,66	<0,00001
***P. glaucum* 2 (mature) & *Z. mays* 1 (mature)**	190,92	<0,00001
***P. glaucum* 2 (mature) & *Z. mays* 2 (mature)**	220,62	<0,00001
***P. glaucum* 1 (mature) & *P. glaucum* 1 (juvenile taxa)**	0,95	0,388527
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 Month)**	0,74	0,390314
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 week)**	0,87	0,35341
***P. glaucum* 2 (mature) & *P. glaucum* 2 (1 week)**	30,42	<0,00001

Table F.8. ANOVA (Analysis of variance) results for the widths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
WILD SORGHUMS	16,61	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature), *S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	14,99	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *C. ciliaris	2,13	0,146485
S. bicolor* subsp. *bicolor* 1 (mature) & *E. coracana* subsp. *africana	58,31	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. multiflora	82,32	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *P. purpureum	70,62	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *arundinaceum	1,58	0,210648
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *drummondii	21,1	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. halepense	21,93	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. versicolor	25,29	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 1 (mature)**	80,69	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 2 (mature)**	115,97	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *C. ciliaris	0,77	0,38154
S. bicolor* subsp. *bicolor* 2 (mature) & *E. coracana* subsp. *africana	26,88	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *E. multiflora	44,78	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *P. purpureum	37,53	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *arundinaceum	12,85	<0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *drummondii	5,59	0,019376
S. bicolor* subsp. *bicolor* 2 (mature) & *S. halepense	5,34	0,022249
S. bicolor* subsp. *bicolor* 2 (mature) & *S. versicolor	7,47	0,07047
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 1 (mature)**	127,16	<0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 2 (mature)**	175,41	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *C. ciliaris	11,94	0,00717
S. bicolor* subsp. *bicolor* 3 (mature) & *E. coracana* subsp. *africana	13,2	0,000386
S. bicolor* subsp. *bicolor* 3 (mature) & *E. multiflora	29,84	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *P. purpureum	23,13	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *arundinaceum	43,49	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *drummondii	0,21	0,649823
S. bicolor* subsp. *bicolor* 3 (mature) & *S. halepense	0,06	0,803528
S. bicolor* subsp. *bicolor* 3 (mature) & *S. versicolor	0,67	0,412823
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 1 (mature)**	202,38	<0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 2 (mature)**	278,79	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (juvenile taxa)**	13,28	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & S. *bicolor* subsp. *bicolor* 1 (1 Month)**	25,54	<0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (1 Week)**	1,18	0,279999
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (juvenile taxa)**	0,89	0,411575
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Month)**	0,06	0,80623
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Week)**	1,36	0,245801

***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (juvenile taxa)**	5,28	0,005942
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Month)**	8,02	0,00526
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Week)**	0,73	0,394185

Table F.9. ANOVA (Analysis of variance) results for the widths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
***Z. mays* 1 (mature) & *Z. mays* 2 (mature)**	0,91	0,340707
Z. mays* 1 (mature) & *C. ciliaris	69,65	<0,00001
Z. mays* 1 (mature) & *E. coracana* subsp. *africana	176,31	<0,00001
Z. mays* 1 (mature) & *E. multiflora	205,43	<0,00001
Z. mays* 1 (mature) & *P. purpureum	188,71	<0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *arundinaceum	38,18	<0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *drummondii	113,82	<0,00001
Z. mays* 1 (mature) & *S. halepense	119,31	<0,00001
Z. mays* 1 (mature) & *S. versicolor	123,2	<0,00001
Z. mays* 2 (mature) & *C. ciliaris	101,96	<0,00001
Z. mays* 2 (mature) & *E. coracana* subsp. *africana	246,25	<0,00001
Z. mays* 2 (mature) & *E. multiflora	282,1	<0,00001
Z. mays* 2 (mature) & *P. purpureum	256,35	<0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *arundinaceum	59,23	<0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *drummondii	158,03	<0,00001
Z. mays* 2 (mature) & *S. halepense	168,66	<0,00001
Z. mays* 2 (mature) & *S. versicolor	171,86	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (juvenile taxa)**	94,13	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Month)**	172,23	<0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Week)**	42,18	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (juvenile taxa)**	69,58	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Month)**	134,97	<0,00001
***Z. mays* 2 (mature) & *Z. mays* 1 (1 Week)**	12,27	0,000643

Inflorescences of domesticated and wild Poaceae (Width)

Table F.10. ANOVA (Analysis of variance) results for the widths of depressed saddle phytoliths from the inflorescences of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1& 2 (mature)**	12,62	0,000476
***E. coracana* subsp. *coracana* 1 (mature) & wild Eleusine taxa**	52,74	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	2,69	0,103265
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	53,61	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	1,51	0,220844
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	85,3	<0,00001
***E. coracana* subsp. *coracana* 1 (mature) & wild Sorghum taxa**	50,78	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *arundinaceum	24,97	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *drummondii	106,35	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. halepense	33,11	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. versicolor	0,054	0,815938
***E. coracana* subsp. *coracana* 2 (mature) & wild Eleusine taxa**	50,21	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	19,97	0,000016
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	114,22	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	2,24	0,136345
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	42,75	<0,00001
E. coracana* subsp. *africana, E. indica, E. multiflora, E. tristachya	65,4	<0,00001
S. bicolor* subsp. *arundinaceum, S. bicolor* subsp. *drummondii, S. halepense* & *S. versicolor	55,32	<0,00001
***E. coracana* subsp. *coracana* 2 (mature) & wild Sorghum taxa**	95,18	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *arundinaceum	4,4881	0,035802
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *drummondii	162,52	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. halepense	69,88	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. versicolor	9,32	0,002687

Table F.11. ANOVA (Analysis of variance) results for the widths of elongate saddle phytoliths from the inflorescences of domesticated and wild taxa.

Species name	F-ratio	P-value
Wild Eleusine taxa	13,04	<0,00001
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	3,2	0,074991
***E. coracana* subsp. *coracana* 1 & wild Eleusine taxa**	20	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	16,69	0,000072
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	90,51	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	10,77	0,001329
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	2,08	0,151671
E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 1	286,52	<0,00001
E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 2	1,37	0,243699

E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 3	69,2	<0,00001
***E. coracana* subsp. *coracana* 1 (mature) & wild Sorghum taxa**	71,66	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *arundinaceum	25,96	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *drummondii	183,65	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. halepense	27,12	<0,00001
E. coracana* subsp. *coracana* 1 (mature) & S. *versicolor	3,75	0,054681
***E. coracana* subsp. *coracana* 2 (mature) & wild Eleusine taxa**	12,68	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	5,53	0,020004
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	47,99	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	3,36	0,069095
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	0,01	0,935079
E. coracana subsp. coracana 2 *S. bicolor* subsp. *bicolor* 1	312,51	<0,00001
E. coracana subsp. coracana 2 *S. bicolor* subsp. *bicolor* 2	7,1	0,008333
***E. coracana* subsp. *coracana* 2 *S. bicolor* subsp. *bicolor* 3**	89,29	<0,00001
***E. coracana* subsp. *coracana* 2 (mature) & wild Sorghum taxa**	74,45	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *arundinaceum	10,27	0,001653
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *drummondii	195,79	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. halepense	37,46	<0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. versicolor	9,75	0,002162
Wild Sorghum taxa	67,46	<0,00001
***S. bicolor* subsp. bicolor 1, S. *bicolor* subsp. *bicolor* 2, *S. bicolor* subsp. *bicolor* 3**	99,83	<0,00001
S. bicolor* subsp. *bicolor* 1 & *E. indica	435,84	<0,00001
S. bicolor* subsp. *bicolor* 1 & *E. multiflora	167,69	<0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. tristachya	196,6	<0,00001
S. bicolor* subsp. *bicolor* 2 & *E. indica	70,18	<0,00001
S. bicolor* subsp. *bicolor* 2 & *E. multiflora	11,4	0,000969
S. bicolor* subsp. *bicolor* 2 (mature) & *E. tristachya	4,34	0,038941
S. bicolor* subsp. *bicolor* 3 & *E. indica	194,3	<0,00001
S. bicolor* subsp. *bicolor* 3 & *E. multiflora	59,15	<0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *E. tristachya	56,17	<0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	291,02	<0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	0,05	0,819552
S. bicolor* subsp. *bicolor* 1 & *S. halepense	54,74	<0,00001
S. bicolor* subsp. *bicolor* 1 & *S. versicolor	116,75	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *arundinaceum	25,5	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	123,48	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	13,54	0,000326
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	0,594	0,442032
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	109,15	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	36,57	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	1,96	0,163503
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	20,34	0,000013

Table F.12. ANOVA (Analysis of variance) results for the widths of variant 1 cross phytoliths from the inflorescences of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***P. glaucum* 1 & *P. glaucum* 2**	0,07	0,785847
P. glaucum* 1 & *C. ciliaris	5,76	0,017593
P. glaucum* 1 & *D. ciliaris	18,13	0,000036
P. glaucum* 1 & *E. multiflora	4,02	0,046698
P. glaucum* 1 & *P. purpureum	2,21	0,139276
***P. glaucum* 1 & *Z. mays* 1 (husks and male inflorescences)**	390,3	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs, husks and male inflorescences)**	373,39	<0,00001
***P. glaucum* 1 & *Z. mays* 1 (husks)**	715,16	<0,00001
***P. glaucum* 1 & *Z. mays* 1 (male inflorescences)**	523,8	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs)**	284,81	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (husks)**	1074,02	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (male inflorescences)**	130,85	<0,00001
P. glaucum* 2 & *C. ciliaris	4,56	0,034398
P. glaucum* 2 & *D. ciliaris	15,64	0,000119
P. glaucum* 2 & *E. multiflora	3,09	0,081002
P. glaucum* 2 & *P. purpureum	2,70	0,102612
***P. glaucum* 2 & *Z. mays* 1 (husks and male inflorescences)**	363,86	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs, husks and male inflorescences)**	384,20	<0,00001
***P. glaucum* 2 & *Z. mays* 1 (husks)**	693,69	<0,00001
***P. glaucum* 2 & *Z. mays* 1 (male inflorescences)**	506,53	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs)**	271,66	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (husks)**	1050,39	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (male inflorescences)**	124,04	<0,00001
***Z. mays* 1 (husks) & *Z. mays* 2 (husks)**	71,54	<0,00001
***Z. mays* 1 (male inflorescences) & *Z. mays* 2 (male inflorescences)**	98,29	<0,00001
Z. mays* 1 (husks) & *C. ciliaris	368,52	<0,00001
Z. mays* 1 (husks) & *D. ciliaris	329,11	<0,00001
Z. mays* 1 (husks) & *E. multiflora	361,46	<0,00001
Z. mays* 1 (husks) & *P. purpureum	300,98	<0,00001
Z. mays* 1 (male inflorescences) & *C. ciliaris	261,91	<0,00001
Z. mays* 1 (male inflorescences) & *D. ciliaris	227,45	<0,00001
Z. mays* 1 (male inflorescences) & *E. multiflora	257,94	<0,00001
Z. mays* 1 (male inflorescences) & *P. purpureum	225,99	<0,00001
Z. mays* 2 (husks) & *C. ciliaris	551,89	<0,00001
Z. mays* 2 (husks) & *D. ciliaris	511,27	<0,00001
Z. mays* 2 (husks) & *E. multiflora	543,94	<0,00001
Z. mays* 2 (husks) & *P. purpureum	403,09	<0,00001
Z. mays* 2 (male inflorescences) & *C. ciliaris	51,75	<0,00001
Z. mays* 2 (male inflorescences) & *D. ciliaris	35,63	<0,00001
Z. mays* 2 (male inflorescences) & *E. multiflora	52,8	<0,00001
Z. mays* 2 (male inflorescences) & *P. purpureum	65,15	<0,00001
Z. mays* 2 (cobs) & *C. ciliaris	152,02	<0,00001
Z. mays* 2 (cobs) & *D. ciliaris	126,45	<0,00001
Z. mays* 2 (cobs) & *E. multiflora	146,39	<0,00001
Z. mays* 2 (cobs) & *P. purpureum	156,54	<0,00001

Table F.13. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***P. glaucum* 1 & *P. glaucum* 2**	6,063	0,014657
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 1**	181,95	<0,00001
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 2**	93,57	<0,00001
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 3**	198,35	<0,00001
***P. glaucum* 1 & *Z. mays* 1 (husks)**	400,43	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (husks)**	879,718	<0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs)**	288,57	<0,00001
P. glaucum* 1 & *C. ciliaris	1,02	0,313394
P. glaucum* 1 & *D. ciliaris	0,03	0,854231
P. glaucum* 1 & *E. multiflora	18,23	0,000035
P. glaucum* 1 & *P. purpureum	22,49	<0,00001
P. glaucum* 1 & *S. bicolor* subsp. *arundinaceum	6,49	0,011941
P. glaucum* 1 & *S. bicolor* subsp. *drummondii	117,76	<0,00001
P. glaucum* 1 & *S. halepense	46,98	<0,00001
P. glaucum* 1 & *S. versicolor	35,95	<0,00001
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 1**	91,27	<0,00001
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 2**	48,15	<0,00001
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 3**	108,53	<0,00001
***P. glaucum* 2 & *Z. mays* 1 (husks)**	234,96	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (husks)**	636,81	<0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs)**	165,94	<0,00001
P. glaucum* 2 & *C. ciliaris	5,08	0,025901
P. glaucum* 2 & *D. ciliaris	4,31	0,039708
P. glaucum* 2 & *E. multiflora	2,16	0,143313
P. glaucum* 2 & *P. purpureum	30	<0,00001
P. glaucum* 2 & *S. bicolor* subsp. *arundinaceum	13,62	0,000321
P. glaucum* 2 & *S. bicolor* subsp. *drummondii	47,52	<0,00001
P. glaucum* 2 & *S. halepense	13,33	0,000361
P. glaucum* 2 & *S. versicolor	7,63	0,006467

Table F.14. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	3,18	0,04307
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1 (husks)**	34,8	<0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2 (husks)**	297,55	<0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2 (cobs)**	13,86	0,000257
S. bicolor* subsp. *bicolor* 1 & *C. ciliaris	81,24	<0,00001
S. bicolor* subsp. *bicolor* 1 & *D. ciliaris	114,86	<0,00001
S. bicolor* subsp. *bicolor* 1 & *E. multiflora	47,04	<0,00001
S. bicolor* subsp. *bicolor* 1 & *P. purpureum	210,46	<0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	140,16	<0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	1,34	0,248478
S. bicolor* subsp. *bicolor* 1 & *S. halepense	19,73	0,000017
S. bicolor* subsp. *bicolor* 1 & *S. versicolor	32,19	<0,00001
S. bicolor* subsp. *bicolor* 2 & *C. ciliaris	38,2	<0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1 (husks)**	39,22	<0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2 (husks)**	271,02	<0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2 (cobs)**	19,28	0,000018
S. bicolor* subsp. *bicolor* 2 & *D. ciliaris	54,99	<0,00001
S. bicolor* subsp. *bicolor* 2 & *E. multiflora	20,16	<0,00001
S. bicolor* subsp. *bicolor* 2 & *P. purpureum	102,99	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *arundinaceum	67,41	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	0,001	0,980167
S. bicolor* subsp. *bicolor* 2 & *S. halepense	6,86	0,00973
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	12,38	0,000576
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1 (husks)**	17,55	0,000042
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2 (husks)**	236,26	<0,00001
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2 (cobs)**	4,73	0,030796
S. bicolor* subsp. *bicolor* 3 & *C. ciliaris	82,69	<0,00001
S. bicolor* subsp. *bicolor* 3 & *D. ciliaris	120,75	<0,00001
S. bicolor* subsp. *bicolor* 3 & *E. multiflora	55,95	<0,00001
S. bicolor* subsp. *bicolor* 3 & *P. purpureum	206,53	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	140,38	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	4,95	0,027598
S. bicolor* subsp. *bicolor* 3 & *S. halepense	27,62	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	40,91	<0,00001

Table F.15. ANOVA (Analysis of variance) results for the widths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***Z. mays* 1 (husks), *Z. mays* 2 (husks) & *Z. mays* 1 (cobs)**	122,45	<0,00001
***Z. mays* 1 (husks) & *Z. mays* 2 (husks)**	147,14	<0,00001
Z. mays* 1 (husks) & *C. ciliaris	166,39	<0,00001
Z. mays* 1 (husks) & *D. ciliaris	247,91	<0,00001
Z. mays* 1 (husks) & *E. multiflora	139,34	<0,00001
Z. mays* 1 (husks) & *P. purpureum	385,73	<0,00001
Z. mays* 1 (husks) & *S. bicolor* subsp. *arundinaceum	272,39	<0,00001
Z. mays* 1 (husks) & *S. bicolor* subsp. *drummondii	36,72	<0,00001
Z. mays* 1 (husks) & *S. halepense	86,6	<0,00001
Z. mays* 1 (husks) & *S. versicolor	114,48	<0,00001
Z. mays* 2 (husks) & *C. ciliaris	501,23	<0,00001
Z. mays* 2 (husks) & *D. ciliaris	310,86	<0,00001
Z. mays* 2 (husks) & *E. multiflora	369,99	<0,00001
Z. mays* 2 (husks) & *P. purpureum	645,15	<0,00001
Z. mays* 2 (husks) & *S. bicolor* subsp. *arundinaceum	484,98	<0,00001
Z. mays* 2 (husks) & *S. bicolor* subsp. *drummondii	211,57	<0,00001
Z. mays* 2 (husks) & *S. halepense	294,72	<0,00001
Z. mays* 2 (husks) & *S. versicolor	338,42	<0,00001
Z. mays* 2 (cobs) & *C. ciliaris	118,95	<0,00001
Z. mays* 2 (cobs) & *D. ciliaris	176,37	<0,00001
Z. mays* 2 (cobs) & *E. multiflora	92,29	<0,00001
Z. mays* 2 (cobs) & *P. purpureum	284,15	<0,00001
Z. mays* 2 (cobs) & *S. bicolor* subsp. *arundinaceum	197,63	<0,00001
Z. mays* 2 (cobs) & *S. bicolor* subsp. *drummondii	17,37	<0,00001
Z. mays* 2 (cobs) & *S. halepense	52,92	<0,00001
Z. mays* 2 (cobs) & *S. versicolor	72,61	<0,00001

Table F.16. ANOVA (Analysis of variance) results for the widths of dendritic long cell phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	3,07	0,04812
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	6,16	0,013922
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	1,33	0,250843
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	1,74	0,18825
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	0,05	0,828298
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	0,03	0,86243
S. bicolor* subsp. *bicolor* 1 & *S. versicolor	5,07	0,02578
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	3,71	0,055848
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	4,81	0,029775
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	20,88	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	0,6	0,439965
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	1,23	0,26987
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	10,93	0,001187

Table F.17. ANOVA (Analysis of variance) results for the widths of sinuous long cell phytoliths from the inflorescences of domesticated taxa.

Species	**F-ratio**	**P-value**
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	70,33	<0,00001
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	73,3	<0,00001
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	9,05	0,002969
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	104,71	<0,00001

Table F.18. ANOVA (Analysis of variance) results for the widths of elongate rondel phytoliths from the inflorescences of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	2,11	0,122607
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	1,57	0,21206
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	0,55	0,460728
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	4,58	0,03333
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1**	11,38	0,000894
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	63,54	<0,00001
S. bicolor* subsp. *bicolor* 1 & *C. ciliaris	1,90	0,169723
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1**	22,28	<0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	81,25	<0,00001
S. bicolor* subsp. *bicolor* 2 & *C. ciliaris	0,13	0,714138
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1**	8,22	0,004594
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	59,22	<0,00001
S. bicolor* subsp. *bicolor* 3 & *C. ciliaris	4,93	0,27876
***Z. mays* 1 & *Z mays* 2**	28,39	<0,00001
Z. mays* 1 & *C. ciliaris	17,01	0,000062
Z. mays* 2 & *C. ciliaris	48,62	<0,00001

Table F.19. ANOVA (Analysis of variance) results for the widths of variant round rondel phytoliths from the inflorescences of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	2,38	0,093971
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	2,05	0,153476
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	0,47	0,492311
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	4,88	0,028254
S. bicolor* subsp. *bicolor* 1 & *S. halepense	5,75	0,017693
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1**	1,77	0,184341
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	141,92	<0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	1	0,319702
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1**	7,33	0,007367
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	158,66	<0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	0,18	0,668975
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1**	12,56	0,000491
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	179,04	<0,00001
***Z. mays* 1 & *Z. mays* 2**	122,43	<0,00001
Z. mays* 1 & *S. halepense	13,14	0,000396
Z. mays* 2 & *S. halepense	118,38	<0,00001

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Table F.20. ANOVA (Analysis of variance) results for the widths of rhomboidal phytoliths from domesticated Fabaceae.

Species name	F-ratio	P-value
***A. hypogaea* 1 (Phytoliths from all plant sections)**	2,6	0,053237
***A. hypogaea* 2 (Phytoliths from all plant sections)**	2,58	0,054509
***A. hypogaea* (leaves)**	16,53	0,000097
***A. hypogaea* (stems)**	9,78	0,002327
***A. hypogaea* (roots)**	9,04	0,003363
***A. hypogaea* (seed pods)**	4,27	0,041473
***V. subterranea* 1 (Phytoliths from all plant sections)**	5,29	0,001581
***V. subterranea* 2 (Phytoliths from all plant sections)**	4,22	0,006396
***V. subterranea* (seed pods)**	25,34	<0,00001
***V. subterranea* (leaves)**	0,71	0,401805
***V. subterranea* (roots)**	8,81	0,370872
***V. subterranea* (stems)**	8,01	0,005644
***V. unguiculata* subsp. *unguiculata* 1 (Phytoliths from all plant sections)**	14,5	<0,00001
***V. unguiculata* subsp. *unguiculata* 2 (Phytoliths from all plant sections)**	21,15	<0,00001
***V. unguiculata* subsp. *unguiculata* 3 (Phytoliths from all plant sections)**	2,39	0,69579
***V. unguiculata* subsp. *unguiculata* (roots)**	15,07	0,000288
***V. unguiculata* subsp. *unguiculata* (stems)**	0,63	0,536339
***V. unguiculata* subsp. *unguiculata* (seed pods)**	0,29	0,748121
***V. unguiculata* subsp. *unguiculata* (leaves)**	5,21	0,006534
***A. hypogaea* 1 (leaves) & *A. hypogaea* 1 (1 month)**	1,73	0,191536
***A. hypogaea* 1 (stems) & *A. hypogaea* 1 (1 month)**	1,43	0,234098
***A. hypogaea* 1 (seed pods) & *A. hypogaea* 1 (1 month)**	0,03	0,859885
***A. hypogaea* 1 (roots) & *A. hypogaea* 1 (1 month)**	9,4	0,002811
***V. subterranea* 1 (leaves) & *V. subterranea* 1 (1 month)**	2,53	0,114718
***V. subterranea* 1 (stems) & *V. subterranea* 1 (1 month)**	5,19	0,024938
***V. subterranea* 1 (seed pods) & *V. subterranea* 1 (1 month)**	0,22	0,175871
***V. subterranea* 1 (roots) & *V. subterranea* 1 (1 month)**	1,86	0,643453
***V. subterranea* 2 (leaves) & *V. subterranea* 2 (1 month)**	0,98	0,325246
***V. subterranea* 2 (stems) & *V. subterranea* 2 (1 month)**	1,05	0,308887
***V. subterranea* 2 (seed pods) & *V. subterranea* 2 (1 month)**	4,7	0,032638
***V. subterranea* 2 (roots) & *V. subterranea* 2 (1 month)**	0,08	0,783874
***V. unguiculata* subsp. *unguiculata* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	0,001	0,974092
***V. unguiculata* subsp. *unguiculata* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	14,55	0,000239
***V. unguiculata* subsp. *unguiculata* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	1,23	0,26976
***V. unguiculata* subsp. *unguiculata* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (1 week)**	1,47	0,229098
***V. unguiculata* subsp. *unguiculata* 1 (stems) & *V. unguiculata* subsp. *unguiculata* (1 week)**	7,69	0,007061
***V. unguiculata* subsp. *unguiculata* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (1 week)**	0,01	0,922479

***V. unguiculata* subsp. *unguiculata* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	0,84	0,361249
***V. unguiculata* subsp. *unguiculata* 2 (stems) & *V. unguiculata* subsp. *unguiculata* (1 month)**	25,19	<0,00001
***V. unguiculata* subsp. *unguiculata* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	11,63	0,000946
***V. unguiculata* subsp. *unguiculata* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	48,05	<0,00001
***V. unguiculata* subsp. *unguiculata* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (1week)**	2,37	0,127924
***V. unguiculata* subsp. *unguiculata* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (1 week)**	22,67	<0,00001
***V. unguiculata* subsp. *unguiculata* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (1 week)**	13,51	0,000449
***V. unguiculata* subsp. *unguiculata* 2 (roots) & *V. unguiculata* subsp. *unguiculata* (1 week)**	33,97	<0,00001
***V. unguiculata* subsp. *unguiculata* 3 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	3,46	0,06594
***V. unguiculata* subsp. *unguiculata* 3 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	19,3	0,000028
***V. unguiculata* subsp. *unguiculata* 3 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	3,93	0,05022
***V. unguiculata* subsp. *unguiculata* 3 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	5,09	0,026233

Table F.21. ANOVA (Analysis of variance) results for the widths of rhomboidal phytoliths from domesticated Fabaceae.

Species name	F-ratio	P-value
***A. hypogaea* 1 (leaves) & *V. subterranea* 1 (leaves)**	0,7	0,406409
***A. hypogaea* 1 (stems) & *V. subterranea* 1 (stems)**	7,62	0,006869
***A. hypogaea* 1 (roots) & *V. subterranea* 1 (roots)**	2,27	0,135451
***A. hypogaea* 1 (seed pods) & *V. subterranea* 1 (seed pods)**	8,84	0,003705
***A. hypogaea* 1 (leaves) & *V. subterranea* 2 (leaves)**	0,01	0,925571
***A. hypogaea* 1 (stems) & *V. subterranea* 2 (stems)**	0,01	0,914905
***A. hypogaea* 1 (roots) & *V. subterranea* 2 (roots)**	6,56	0,011968
***A. hypogaea* 1 (seed pods) & *V. subterranea* 2 (seed pods)**	2,74	0,10125
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	23,74	< 0,00001
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	0,37	0,544513
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	5,37	0,022539
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	31,03	< 0,00001
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	2,21	0,140101
***A. hypogaea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	0,38	0,537255
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	4,28	0,041088
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	6,34	0,013429
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	0,68	0,413179
***A. hypogaea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	21,19	0,000013
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	0,11	0,745643
***A. hypogaea* 2 (leaves) & *V. subterranea* 1 (leaves)**	11,64	0,00094
***A. hypogaea* 2 (stems) & *V. subterranea* 1 (stems)**	40,22	< 0,00001
***A. hypogaea* 2 (roots) & *V. subterranea* 1 (roots)**	2,26	0,136145
***A. hypogaea* 2 (seed pods) & *V. subterranea* 1 (seed pods)**	26,98	< 0,00001
***A. hypogaea* 2 (leaves) & *V. subterranea* 2 (leaves)**	20,21	0,000019
***A. hypogaea* 2 (stems) & *V. subterranea* 2 (stems)**	11,85	0,00085
***A. hypogaea* 2 (roots) & *V. subterranea* 2 (roots)**	0,57	0,450485
***A. hypogaea* 2 (seed pods) & *V. subterranea* 2 (seed pods)**	0,65	0,42292
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	0,0006	0,980026
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	9,06	0,003329
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	0,07	0,789371
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	0,38	0,540901
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	4,7	0,032608
***A. hypogaea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	5,72	0,01866
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	0,33	0,569147

Species name	F-ratio	P-value
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	2,91	0,0911
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	8,19	0,005148
***A. hypogaea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	1,13	0,291199
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	0,48	0,492238
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	17,58	0,00006
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	15,45	0,000158
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	34,51	< 0,00001
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	24,46	< 0,00001
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	25,17	< 0,00001
***V. subterranea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	0,79	0,376476
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	32,33	< 0,00001
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	3,12	0,080467
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	18,07	0,000049
***V. subterranea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	8,01	0,005654
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	27,79	< 0,00001
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	33,15	< 0,00001
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	0,61	0,436758
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	0,51	0,478571
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	44,5	< 0,00001
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	3,03	0,085125
***V. subterranea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	3,54	0,0629
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	0,13	0,714676
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	7,59	0,006987
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	1,03	0,311657
***V. subterranea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	4,61	0,034344
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	0,0008	0,977304

Leaves of domesticated and wild Poaceae (length)

Table F.22. ANOVA (Analysis of variance) results for the lengths of depressed saddle phytoliths from the leaves of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	1,9	0,169219
***E. coracana* subsp. *coracana* 1 (mature) and wild Eleusine taxa**	18,07	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	24,86	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	5,32	0,022508
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	7,6	0,006583
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	16,07	0,000096
***E. coracana* subsp. *coracana* 2 (mature) and wild Eleusine taxa**	22,72	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	38	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	1,001	0,318653
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	16,01	0,000099
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	27,18	< 0,00001
Wild Eleusine taxa	24,13	< 0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 month)**	11,37	< 0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 week)**	86,15	< 0,00001
***E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *coracana* 2 (1 month)**	23,79	< 0,00001

Table F.23. ANOVA (Analysis of variance) results for the lengths of elongate saddle phytoliths from the leaves of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	0,08	0,784334
E. coracana* subsp. *coracana* 1 (mature), *E. indica*, *E. multiflora* & *E. tristachya	22,7	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	49,02	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	4,85	0,02924
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	11,79	0,000773
E. coracana* subsp. *coracana* 2 (mature), *E. indica*, *E. multiflora* & *E. tristachya	19,56	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	31,78	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	4,63	0,033099
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	10,05	0,001856
E. indica, E. multiflora* & *E. tristachya	27,55	< 0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 Month)**	8,48	0,004138
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (1 week)**	172,42	< 0,00001
***E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *coracana* 2 (1 Month)**	56,71	< 0,00001
***E. coracana* subsp. *coracana* 2 (mature) *E. coracana* subsp. *coracana* 2 (1 week)**	248,97	< 0,00001
***E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *coracana* 1 (juvenile)**	32,5	< 0,00001
E. coracana subsp. coracana 2 (mature) & *E. coracana* subsp. *coracana* 2 (juvenile)	102,22	< 0,00001

Table F.24. ANOVA (Analysis of variance) results for the lengths of variant 5/6 cross phytoliths from the leaves of mature domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	34,08	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. coracana* subsp. *africana	11,7	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	0,06	0,800605
S. bicolor* subsp. *bicolor* 1 & *S. halepense	22,6	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	97,69	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *E. coracana* subsp. *africana	10,37	0,001602
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	54,95	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	19,52	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	84,17	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *E. coracana* subsp. *africana	4,14	0,043767
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	49,91	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	2,7	0,10255
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	242,36	< 0,00001
Z. mays* 2 & *E. coracana* subsp. *africana	83,46	< 0,00001
Z. mays* 2 & *S. halepense	123,65	< 0,00001

Table F.25. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
***P. glaucum* 1 (mature) & *P. glaucum* 2 (mature)**	0,8	0,370807
P. glaucum* 1 (mature) & *D. ciliaris	12,97	0,000431
P. glaucum* 1 (mature) & *C. ciliaris	0,16	0,692971
P. glaucum* 1 (mature) & *E. coracana* subsp. *africana	84,07	< 0,00001
P. glaucum* 1 (mature) & *E. multiflora	218,52	< 0,00001
P. glaucum* 1 (mature) & *P. purpureum	154,3	< 0,00001
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	5,91	0,015961
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	71,81	< 0,00001
***P. glaucum* (mature) 1 & *S. bicolor* subsp. *bicolor* 3 (mature)**	43,73	< 0,00001
P. glaucum* 1 (mature) & *S. bicolor* subsp. *arundinaceum	71,11	< 0,00001
P. glaucum* 1 (mature) & *S. bicolor* subsp. *drummondii	53,44	< 0,00001
P. glaucum* 1 (mature) & *S. halepense	88,88	< 0,00001
P. glaucum* 1 (mature) & *S. versicolor	26,43	< 0,00001
***P. glaucum* 1 (mature) & *Z. mays* 1**	44,44	< 0,00001
***P. glaucum* 1 (mature) & *Z. mays* 2**	35,84	< 0,00001
P. glaucum* 2 (mature) & *D. ciliaris	6,78	0,010172
P. glaucum* 2 (mature) & *C. ciliaris	1,16	0,282438
P. glaucum* 2 (mature) & *E. coracana* subsp. *africana	56,82	< 0,00001
P. glaucum* 2 (mature) & *E. multiflora	155,55	< 0,00001
P. glaucum* 2 (mature) & *P. purpureum	108,88	< 0,00001
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	1,74	0,188181
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	46,54	< 0,00001
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	27,21	< 0,00001
P. glaucum* 2 (mature) & *S. bicolor* subsp. *arundinaceum	46,07	< 0,00001
P. glaucum* 2 (mature) & *S. bicolor* subsp. *drummondii	33,69	< 0,00001
P. glaucum* 2 (mature) & *S. halepense	58,39	< 0,00001
P. glaucum* 2 (mature) & *S. versicolor	16,81	0,000068
***P. glaucum* 2 (mature) & *Z. mays* 1**	50,85	< 0,00001
***P. glaucum* 2 (mature) & *Z. mays* 2**	42,06	< 0,00001
***P. glaucum* 1 (mature) & *P. glaucum* 1 (juvenile taxa)**	9,32	0,000143
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 Month)**	14,75	0,000182
***P. glaucum* 1 & *P. glaucum* 1 (1 Week)**	12,77	0,000504
***P. glaucum* 2 (mature) & *P. glaucum* 2 (juvenile taxa)**	85,15	< 0,00001
***P. glaucum* 2 & *P. glaucum* 2 (1 Month)**	153,62	< 0,00001
***P. glaucum* 2 & *P. glaucum* 2 (1 Week)**	82,27	< 0,00001

Table F.26. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1 (mature), *S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	20,63	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *D. ciliaris	3,53	0,062108
S. bicolor* subsp. *bicolor* 1 (mature) & *C. ciliaris	5,96	0,015812
S. bicolor* subsp. *bicolor* 1 (mature) & *E. coracana* subsp. *africana	60,97	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. multiflora	195,67	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *P. purpureum	129,32	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *arundinaceum	48,56	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *drummondii	32,99	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. halepense	64,92	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. versicolor	13,14	0,000398
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 1 (mature)**	80,08	< 0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 2 (mature)**	68,69	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *D. ciliaris	8,45	0,004211
S. bicolor* subsp. *bicolor* 2 (mature) & *C. ciliaris	58,95	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *E. coracana* subsp. *africana	9,36	0,002634
S. bicolor* subsp. *bicolor* 2 (mature) & *E. multiflora	95,78	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *P. purpureum	48,41	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *arundinaceum	3,45	0,065277
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *drummondii	0,32	0,572863
S. bicolor* subsp. *bicolor* 2 (mature) & *S. halepense	8,86	0,003404
S. bicolor* subsp. *bicolor* 2 (mature) & *S. versicolor	0,43	0,514865
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 1 (mature)**	199,5	< 0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 2 (mature)**	183,49	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *D. ciliaris	2,45	0,119496
S. bicolor* subsp. *bicolor* 3 (mature) & *C. ciliaris	34,84	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *E. coracana* subsp. *africana	15,52	0,000125
S. bicolor* subsp. *bicolor* 3 (mature) & *E. multiflora	97,23	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *P. purpureum	54,78	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *arundinaceum	8,45	0,004202
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *drummondii	3,08	0,081456
S. bicolor* subsp. *bicolor* 3 (mature) & *S. halepense	15,23	0,000144
S. bicolor* subsp. *bicolor* 3 (mature) & *S. versicolor	0,17	0,682228
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 1 (mature)**	154,09	< 0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 2 (mature)**	139,65	< 0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (juvenile taxa)**	6,92	0,001292
***S. bicolor* subsp. *bicolor* 1 (mature) & S. *bicolor* subsp. *bicolor* 1 (1 Month)**	7,93	0,005524
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (1 Week)**	13,07	0,000436
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (juvenile taxa)**	124,09	< 0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Month)**	217,32	< 0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Week)**	128,7	< 0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (juvenile taxa)**	84,75	< 0,00001

***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Month)**	27,76	< 0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Week)**	154,73	< 0,00001

Table F.27. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the leaves of domesticated and wild taxa.

Species	**F-ratio**	**P-value**
***Z. mays* 1 (mature) & *Z. mays* 2 (mature)**	0,48	0,487287
Z. mays* 1 (mature) & D. *ciliaris	65,14	< 0,00001
Z. mays* 1 (mature) & *C. ciliaris	23,64	< 0,00001
Z. mays* 1 (mature) & *E. coracana* subsp. *africana	159,75	< 0,00001
Z. mays* 1 (mature) & *E. multiflora	287,78	< 0,00001
Z. mays* 1 (mature) & *P. purpureum	230,18	< 0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *arundinaceum	146,24	< 0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *drummondii	125,8	< 0,00001
Z. mays* 1 (mature) & *S. halepense	165,47	< 0,00001
Z. mays* 1 (mature) & *S. versicolor	84,52	< 0,00001
Z. mays* 2 (mature) & D. *ciliaris	58,08	< 0,00001
Z. mays* 2 (mature) & *C. ciliaris	18,87	0,000026
Z. mays* 2 (mature) & *E. coracana* subsp. *africana	150,74	< 0,00001
Z. mays* 2 (mature) & *E. multiflora	279,13	< 0,00001
Z. mays* 2 (mature) & *P. purpureum	221,11	< 0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *arundinaceum	137,28	< 0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *drummondii	117,06	< 0,00001
Z. mays* 2 (mature) & *S. halepense	156,39	< 0,00001
Z. mays* 2 (mature) & *S. versicolor	77,04	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (juvenile taxa)**	33,03	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Month)**	66,98	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Week)**	0,52	0,472264
***Z. mays* 2 (mature) & *Z. mays* 2 (juvenile taxa)**	33,64	< 0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Month)**	68,62	< 0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Week)**	0,44	0,506164

Table F.28. ANOVA (Analysis of variance) results for the lengths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
***P. glaucum* 1 (mature) & *P. glaucum* 2 (mature)**	7,01	0,008772
P. glaucum* 1 (mature) & *P. purpureum	86,62	< 0,00001
P. glaucum* 1 (mature) & *C. ciliaris	1,06	0,304825
P. glaucum* 1 (mature) & *E. coracana* subsp. *africana	16,24	0,000089
P. glaucum* 1 (mature) & *E. multiflora	74,84	< 0,00001
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	8,51	0,003934
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	14,17	0,00022
***P. glaucum* 1 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	9,16	0,002795
P. glaucum* 1 (mature) & *S. bicolor* subsp. *arundinaceum	1,77	0,185375
P. glaucum* 1 (mature) & *S. bicolor* subsp. *drummondii	11,35	0,000962
P. glaucum* 1 (mature) & *S. halepense	17,55	0,000048
P. glaucum* 1 (mature) & *S. versicolor	33,79	< 0,00001
***P. glaucum* 1 (mature) & *Z. mays* 1 (mature)**	40,76	< 0,00001
***P. glaucum* 1 (mature) & *Z. mays* 2 (mature)**	109,77	< 0,00001
P. glaucum* 2 (mature) & *C. ciliaris	10,44	0,00152
P. glaucum* 2 (mature) & *E. coracana* subsp. *africana	4,07	0,045545
P. glaucum* 2 (mature) & *E. multiflora	48,38	< 0,00001
P. glaucum* 2 (mature) & *P. purpureum	59,17	< 0,00001
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 1 (mature)**	0,05	0,820965
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (mature)**	1,34	0,247877
***P. glaucum* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	0,12	0,733068
P. glaucum* 2 (mature) & *S. bicolor* subsp. *arundinaceum	0,92	0,338545
P. glaucum* 2 (mature) & *S. bicolor* subsp. *drummondii	1,67	0,19818
P. glaucum* 2 (mature) & *S. halepense	4,46	0,036313
P. glaucum* 2 (mature) & *S. versicolor	15,52	0,000125
***P. glaucum* 2 (mature) & *Z. mays* 1 (mature)**	84,47	< 0,00001
***P. glaucum* 2 (mature) & *Z. mays* 2 (mature)**	186,98	< 0,00001
***P. glaucum* 1 (mature) & *P. glaucum* 1 (juvenile taxa)**	2,48	0,086867
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 Month)**	2,93	0,089377
***P. glaucum* 1 (mature) & *P. glaucum* 1 (1 week)**	3,18	0,077002
***P. glaucum* 2 (mature) & *P. glaucum* 2 (1 week)**	110	< 0,00001

Table F.29. ANOVA (Analysis of variance) results for the lengths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
WILD SORGHUMS	7,72	0,000067
***S. bicolor* subsp. *bicolor* 1 (mature), *S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 3 (mature)**	0,55	0,575624
S. bicolor* subsp. *bicolor* 1 (mature) & *C. ciliaris	12,22	0,000626
S. bicolor* subsp. *bicolor* 1 (mature) & *E. coracana* subsp. *africana	3,59	0,06001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. multiflora	49,4	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *P. purpureum	60,6	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *arundinaceum	1,42	0,235124
S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *drummondii	1,31	0,25385
S. bicolor* subsp. *bicolor* 1 (mature) & *S. halepense	3,97	0,048161
S. bicolor* subsp. *bicolor* 1 (mature) & *S. versicolor	15,1	0,000154
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 1 (mature)**	10,54	0,001509
***S. bicolor* subsp. *bicolor* 1 (mature) & *Z. mays* 2 (mature)**	35,78	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *C. ciliaris	17,24	0,000056
S. bicolor* subsp. *bicolor* 2 (mature) & *E. coracana* subsp. *africana	1,15	0,285251
S. bicolor* subsp. *bicolor* 2 (mature) & *E. multiflora	36,37	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *P. purpureum	46,21	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *arundinaceum	3,9	0,050193
S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *drummondii	0,11	0,739276
S. bicolor* subsp. *bicolor* 2 (mature) & *S. halepense	1,27	0,261497
S. bicolor* subsp. *bicolor* 2 (mature) & *S. versicolor	9,11	0,002987
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 1 (mature)**	106,07	< 0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *Z. mays* 2 (mature)**	221,75	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *C. ciliaris	12,85	0,000457
S. bicolor* subsp. *bicolor* 3 (mature) & *E. coracana* subsp. *africana	3,24	0,073913
S. bicolor* subsp. *bicolor* 3 (mature) & *E. multiflora	48,04	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *P. purpureum	59,15	< 0,00001
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *arundinaceum	1,67	0,198047
S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *drummondii	1,1	0,295875
S. bicolor* subsp. *bicolor* 3 (mature) & *S. halepense	3,58	0,060362
S. bicolor* subsp. *bicolor* 3 (mature) & *S. versicolor	14,37	0,000218
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 1 (mature)**	93,62	< 0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *Z. mays* 2 (mature)**	204,41	< 0,00001
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (juvenile taxa)**	7,11	0,001075
***S. bicolor* subsp. *bicolor* 1 (mature) & S. *bicolor* subsp. *bicolor* 1 (1 Month)**	10,02	0,001878
***S. bicolor* subsp. *bicolor* 1 (mature) & *S. bicolor* subsp. *bicolor* 1 (1 Week)**	9,003	0,003263
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (juvenile taxa)**	16,6	< 0,00001
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Month)**	14,39	0,000216
***S. bicolor* subsp. *bicolor* 2 (mature) & *S. bicolor* subsp. *bicolor* 2 (1 Week)**	31,89	< 0,00001

***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (juvenile taxa)**	19,81	< 0,00001
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Month)**	7,86	0,005743
***S. bicolor* subsp. *bicolor* 3 (mature) & *S. bicolor* subsp. *bicolor* 3 (1 Week)**	34,78	< 0,00001

Table F.30. ANOVA (Analysis of variance) results for the lengths of variant 1 cross phytoliths from the leaves of domesticated and wild taxa.

Species	F-ratio	P-value
***Z. mays* 1 (mature) & *Z. mays* 2 (mature)**	3,06	0,082978
Z. mays* 1 (mature) & *C. ciliaris	16,27	0,000088
Z. mays* 1 (mature) & *E. coracana* subsp. *africana	83,2	< 0,00001
Z. mays* 1 (mature) & *E. multiflora	185,27	< 0,00001
Z. mays* 1 (mature) & *P. purpureum	200,18	< 0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *arundinaceum	45,02	< 0,00001
Z. mays* 1 (mature) & *S. bicolor* subsp. *drummondii	72,65	< 0,00001
Z. mays* 1 (mature) & *S. halepense	88,83	< 0,00001
Z. mays* 1 (mature) & *S. versicolor	116,52	< 0,00001
Z. mays* 2 (mature) & *C. ciliaris	52,97	< 0,00001
Z. mays* 2 (mature) & *E. coracana* subsp. *africana	170,25	< 0,00001
Z. mays* 2 (mature) & *E. multiflora	330,24	< 0,00001
Z. mays* 2 (mature) & *P. purpureum	347,68	< 0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *arundinaceum	111,24	< 0,00001
Z. mays* 2 (mature) & *S. bicolor* subsp. *drummondii	154,31	< 0,00001
Z. mays* 2 (mature) & *S. halepense	183,62	< 0,00001
Z. mays* 2 (mature) & *S. versicolor	221,01	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (juvenile taxa)**	13,38	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Month)**	23,69	< 0,00001
***Z. mays* 1 (mature) & *Z. mays* 1 (1 Week)**	0,3	0,587923
***Z. mays* 2 (mature) & *Z. mays* 2 (juvenile taxa)**	42,57	< 0,00001
***Z. mays* 2 (mature) & *Z. mays* 2 (1 Month)**	66,15	< 0,00001
***Z. mays* 2 (mature) & *Z. mays* 1 (1 Week)**	3,45	0,065472

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Table F.31. ANOVA (Analysis of variance) results for the lengths of depressed saddle phytoliths from the inflorescences of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1& 2 (mature)**	29,85	< 0,00001
***E. coracana* subsp. *coracana* 1 (mature) & wild Eleusine taxa**	45,54	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	50,35	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	144,31	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	3,89	0,050338
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	1,42	0,235645
***E. coracana* subsp. *coracana* 1 (mature) & wild Sorghum taxa**	58,07	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *arundinaceum	97,22	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *drummondii	65,78	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. halepense	32,3	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. versicolor	3,84	0,052042
***E. coracana* subsp. *coracana* 2 (mature) & wild Eleusine taxa**	30,31	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	4,51	0,035374
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	34,9	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	6,22	0,013746
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	29,18	< 0,00001
E. coracana* subsp. *africana, E. indica, E. multiflora, E. tristachya	46,37	< 0,00001
S. bicolor* subsp. *arundinaceum, S. bicolor* subsp. *drummondii, S. halepense* & *S. versicolor	65,44	< 0,00001
***E. coracana* subsp. *coracana* 2 (mature) & wild Sorghum taxa**	68,4	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *arundinaceum	19,02	0,000024
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *drummondii	127,39	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. halepense	83,21	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. versicolor	35,21	< 0,00001

Table F.32. ANOVA (Analysis of variance) results for the lengths of elongate saddle phytoliths from the inflorescences of domesticated and wild taxa.

Species name	F-ratio	P-value
***E. coracana* subsp. *coracana* 1 & 2 (mature)**	1,26	0,26282
***E. coracana* subsp. *coracana* 1 & wild Eleusine taxa**	19,24	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. coracana* subsp. *africana	20,24	0,000014
E. coracana* subsp. *coracana* 1 (mature) & *E. indica	82,33	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *E. multiflora	3,14	0,07886
E. coracana* subsp. *coracana* 1 (mature) & *E. tristachya	0,00	0,97197
E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 1	66,29	< 0,00001
E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 2	56,09	< 0,00001
E. coracana subsp. coracana 1 *S. bicolor* subsp. *bicolor* 3	1,01	0,316383

***E. coracana* subsp. *coracana* 1 (mature) & wild Sorghum taxa**	101,83	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *arundinaceum	65,31	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. bicolor* subsp. *drummondii	266,43	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & *S. halepense	40,46	< 0,00001
E. coracana* subsp. *coracana* 1 (mature) & S. *versicolor	23,86	< 0,00001
***E. coracana* subsp. *coracana* 2 (mature) & wild Eleusine taxa**	14,97	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. coracana* subsp. *africana	10,75	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. indica	52,07	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *E. multiflora	0,75	0,386524
E. coracana* subsp. *coracana* 2 (mature) & *E. tristachya	0,71	0,401321
E. coracana subsp. coracana 2 *S. bicolor* subsp. *bicolor* 1	74,77	< 0,00001
E. coracana subsp. coracana 2 *S. bicolor* subsp. *bicolor* 2	64,31	< 0,00001
***E. coracana* subsp. *coracana* 2 *S. bicolor* subsp. *bicolor* 3**	0,01	0,941971
***E. coracana* subsp. *coracana* 2 (mature) & wild Sorghum taxa**	99,82	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *arundinaceum	42,83	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. bicolor* subsp. *drummondii	259,41	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. halepense	44,54	< 0,00001
E. coracana* subsp. *coracana* 2 (mature) & *S. versicolor	28,09	< 0,00001
Wild Sorghum taxa	95,15	< 0,00001
S. *bicolor* subsp. bicolor 1, S. *bicolor* subsp. *bicolor* 2, *S. bicolor* subsp. *bicolor* 3	36,53	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. coracana* subsp. *africana	89,41	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. indica	170,89	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. multiflora	39,85	< 0,00001
S. bicolor* subsp. *bicolor* 1 (mature) & *E. tristachya	33,73	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. coracana* subsp. *africana	76,52	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *E. indica	145,06	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *E. multiflora	33,29	< 0,00001
S. bicolor* subsp. *bicolor* 2 (mature) & *E. tristachya	28,44	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *E. coracana* subsp. *africana	6,81	0,010021
S. bicolor* subsp. *bicolor* 3 & *E. indica	31,5	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *E. multiflora	0,41	0,525478
S. bicolor* subsp. *bicolor* 3 (mature) & *E. tristachya	0,56	0,457041
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	149,82	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	76,49	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. halepense	0,17	0,681414
S. bicolor* subsp. *bicolor* 1 & *S. versicolor	2,28	0,133083
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *arundinaceum	129,08	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	72,08	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	0,06	0,800927
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	1,68	0,19643
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	27,6	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	196,1	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	31,86	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	20,38	0,000013

Table F.33. ANOVA (Analysis of variance) results for the lengths of variant 1 cross phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***P. glaucum* 1 & *P. glaucum* 2**	0,72	0,397382
P. glaucum* 1 & *C. ciliaris	3,3	0,071146
P. glaucum* 1 & *D. ciliaris	24,44	< 0,00001
P. glaucum* 1 & *E. multiflora	0,61	0,436391
P. glaucum* 1 & *P. purpureum	0,97	0,325424
***P. glaucum* 1 & *Z. mays* 1 (husks and male inflorescences)**	365,92	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs, husks and male inflorescences)**	339,61	< 0,00001
***P. glaucum* 1 & *Z. mays* 1 (husks)**	790,86	< 0,00001
***P. glaucum* 1 & *Z. mays* 1 (male inflorescences)**	350,1	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs)**	218,9	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (husks)**	1049,21	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (male inflorescences)**	147,21	< 0,00001
P. glaucum* 2 & *C. ciliaris	0,98	0,324244
P. glaucum* 2 & *D. ciliaris	15,59	0,000121
P. glaucum* 2 & *E. multiflora	0,002	0,96323
P. glaucum* 2 & *P. purpureum	2,22	0,138769
***P. glaucum* 2 & *Z. mays* 1 (husks and male inflorescences)**	330,43	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs, husks and male inflorescences)**	316,9	< 0,00001
***P. glaucum* 2 & *Z. mays* 1 (husks)**	697,63	< 0,00001
***P. glaucum* 2 & *Z. mays* 1 (male inflorescences)**	303,19	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs)**	182,66	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (husks)**	948,45	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (male inflorescences)**	121,85	< 0,00001
***Z. mays* 1 (husks) & *Z. mays* 2 (husks)**	41,58	< 0,00001
***Z. mays* 1 (male inflorescences) & *Z. mays* 2 (male inflorescences)**	33,38	< 0,00001
Z. mays* 1 (husks) & *C. ciliaris	468,48	< 0,00001
Z. mays* 1 (husks) & *D. ciliaris	347,09	< 0,00001
Z. mays* 1 (husks) & *E. multiflora	473,74	< 0,00001
Z. mays* 1 (husks) & *P. purpureum	361,39	< 0,00001
Z. mays* 1 (male inflorescences) & *C. ciliaris	188,12	< 0,00001
Z. mays* 1 (male inflorescences) & *D. ciliaris	121,3	< 0,00001
Z. mays* 1 (male inflorescences) & *E. multiflora	198,78	< 0,00001
Z. mays* 1 (male inflorescences) & *P. purpureum	158,2	< 0,00001
Z. mays* 2 (husks) & *C. ciliaris	600,91	< 0,00001
Z. mays* 2 (husks) & *D. ciliaris	478,13	< 0,00001
Z. mays* 2 (husks) & *E. multiflora	606,29	< 0,00001
Z. mays* 2 (husks) & *P. purpureum	431,23	< 0,00001
Z. mays* 2 (male inflorescences) & *C. ciliaris	70,25	< 0,00001
Z. mays* 2 (male inflorescences) & *D. ciliaris	33,11	< 0,00001
Z. mays* 2 (male inflorescences) & *E. multiflora	79,49	< 0,00001
Z. mays* 2 (male inflorescences) & *P. purpureum	70,78	< 0,00001
Z. mays* 2 (cobs) & *C. ciliaris	129,53	< 0,00001
Z. mays* 2 (cobs) & *D. ciliaris	75,46	< 0,00001
Z. mays* 2 (cobs) & *E. multiflora	135,15	< 0,00001
Z. mays* 2 (cobs) & *P. purpureum	120,98	< 0,00001

Table F.34. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***P. glaucum* 1 & *P. glaucum* 2**	1,08	0,299582
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 1**	10,41	0,00147
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 2**	4,37	0,037781
***P. glaucum* 1 & *S. bicolor* subsp. *bicolor* 3**	0,79	0,376276
***P. glaucum* 1 & *Z. mays* 1 (husks)**	280,89	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (husks)**	556,69	< 0,00001
***P. glaucum* 1 & *Z. mays* 2 (cobs)**	26,18	< 0,00001
P. glaucum* 1 & *C. ciliaris	20,06	0,000017
P. glaucum* 1 & *D. ciliaris	16,67	0,000073
P. glaucum* 1 & *E. multiflora	1,85	0,175678
P. glaucum* 1 & *P. purpureum	34,19	< 0,00001
P. glaucum* 1 & *S. bicolor* subsp. *arundinaceum	39,36	< 0,00001
P. glaucum* 1 & *S. bicolor* subsp. *drummondii	35,37	< 0,00001
P. glaucum* 1 & *S. halepense	0,0003	0,985554
P. glaucum* 1 & *S. versicolor	1,14	0,286822
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 1**	4,09	0,044371
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 2**	1,02	0,313025
***P. glaucum* 2 & *S. bicolor* subsp. *bicolor* 3**	0,06	0,805098
***P. glaucum* 2 & *Z. mays* 1 (husks)**	307,21	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (husks)**	593,05	< 0,00001
***P. glaucum* 2 & *Z. mays* 2 (cobs)**	36,23	< 0,00001
P. glaucum* 2 & *C. ciliaris	13,49	0,000354
P. glaucum* 2 & *D. ciliaris	9,56	0,002376
P. glaucum* 2 & *E. multiflora	0,25054	0,617437
P. glaucum* 2 & *P. purpureum	23,001	< 0,00001
P. glaucum* 2 & *S. bicolor* subsp. *arundinaceum	28,29	< 0,00001
P. glaucum* 2 & *S. bicolor* subsp. *drummondii	45,39	< 0,00001
P. glaucum* 2 & *S. halepense	0,76	0,384859
P. glaucum* 2 & *S. versicolor	3,88	0,050844

Table F.35. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	2,9	0,05683
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1 (husks)**	427,46	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2 (husks)**	808,43	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2 (cobs)**	71,39	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *C. ciliaris	9,67	0,002311
S. bicolor* subsp. *bicolor* 1 & *D. ciliaris	3,41	0,066731
S. bicolor* subsp. *bicolor* 1 & *E. multiflora	1,32	0,252353
S. bicolor* subsp. *bicolor* 1 & *P. purpureum	15,98	0,0001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	23,62	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	97,25	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. halepense	8,68	0,003748

S. bicolor* subsp. *bicolor* 1 & *S. versicolor	19,32	0,000021
S. bicolor* subsp. *bicolor* 2 & *C. ciliaris	9,83	0,002137
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1 (husks)**	350,34	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2 (husks)**	664,26	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2 (cobs)**	50,09	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *D. ciliaris	5,34	0,022265
S. bicolor* subsp. *bicolor* 2 & *E. multiflora	0,1	0,751757
S. bicolor* subsp. *bicolor* 2 & *P. purpureum	16,66	0,000073
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *arundinaceum	22,36	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	61,85	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	3,22	0,074585
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	8,83	0,003442
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1 (husks)**	338,17	< 0,00001
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2 (husks)**	664,58	< 0,00001
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2 (cobs)**	38,92	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *C. ciliaris	20,85	0,000012
S. bicolor* subsp. *bicolor* 3 & *D. ciliaris	14,77	0,00018
S. bicolor* subsp. *bicolor* 3 & *E. multiflora	0,6	0,4399
S. bicolor* subsp. *bicolor* 3 & *P. purpureum	34,94	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	41,93	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	55,02	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	0,6	0,439749
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	4,17	0,042822

Table F.36. ANOVA (Analysis of variance) results for the lengths of bilobate phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***Z. mays* 1 (husks), *Z. mays* 2 (husks) & *Z. mays* 2 (cobs)**	143,1	< 0,00001
***Z. mays* 1 (husks) & *Z. mays* 2 (husks)**	26,74	< 0,00001
Z. mays* 1 (husks) & *C. ciliaris	194,36	< 0,00001
Z. mays* 1 (husks) & *D. ciliaris	285,23	< 0,00001
Z. mays* 1 (husks) & *E. multiflora	197,59	< 0,00001
Z. mays* 1 (husks) & *P. purpureum	339,11	< 0,00001
Z. mays* 1 (husks) & *S. bicolor* subsp. *arundinaceum	300,71	< 0,00001
Z. mays* 1 (husks) & *S. bicolor* subsp. *drummondii	71,29	< 0,00001
Z. mays* 1 (husks) & *S. halepense	179,99	< 0,00001
Z. mays* 1 (husks) & *S. versicolor	163,93	< 0,00001
Z. mays* 2 (husks) & *C. ciliaris	356,67	< 0,00001
Z. mays* 2 (husks) & *D. ciliaris	533,76	< 0,00001
Z. mays* 2 (husks) & *E. multiflora	384,54	< 0,00001
Z. mays* 2 (husks) & *P. purpureum	620,08	< 0,00001
Z. mays* 2 (husks) & *S. bicolor* subsp. *arundinaceum	538,78	< 0,00001
Z. mays* 2 (husks) & *S. bicolor* subsp. *drummondii	187,9	< 0,00001
Z. mays* 2 (husks) & *S. halepense	367,02	< 0,00001
Z. mays* 2 (husks) & *S. versicolor	346,83	< 0,00001
Z. mays* 2 (cobs) & *C. ciliaris	50,95	< 0,00001
Z. mays* 2 (cobs) & *D. ciliaris	61,37	< 0,00001
Z. mays* 2 (cobs) & *E. multiflora	27,35	< 0,00001
Z. mays* 2 (cobs) & *P. purpureum	88,17	< 0,00001
Z. mays* 2 (cobs) & *S. bicolor* subsp. *arundinaceum	86,66	< 0,00001
Z. mays* 2 (cobs) & *S. bicolor* subsp. *drummondii	1,18	0,278492
Z. mays* 2 (cobs) & *S. halepense	17,81	0,000042
Z. mays* 2 (cobs) & *S. versicolor	11,39	0,000942

Table F.37. ANOVA (Analysis of variance) results for the lengths of dendritic long cell phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	14,02	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	0,62	0,432942
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	16,49	0,00007
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	24,79	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	94,02	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *drummondii	88,57	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. versicolor	118,77	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *arundinaceum	114,64	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *drummondii	106,68	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. versicolor	142,5	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *arundinaceum	42,6	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. bicolor* subsp. *drummondii	41,21	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. versicolor	60,34	< 0,00001

Table F.38. ANOVA (Analysis of variance) results for the lengths of sinuous long cell phytoliths from the inflorescences of domesticated taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	9,49	0,000101
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	4,1	0,04423
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	23,36	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	4,59	0,033454

Table F.39. ANOVA (Analysis of variance) results for the lengths of elongate rondel phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	8,83	0,000187
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	17,99	0,000034
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	3,82	0,052169
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	5,01	0,026384
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1**	18,77	< 0,00001
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	177,27	< 0,00001
S. bicolor* subsp. *bicolor* 1 & *C. ciliaris	36,25	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1**	65,7	< 0,00001
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	288,71	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *C. ciliaris	7,62	0,006517
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1**	36,57	< 0,00001
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	222,92	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *C. ciliaris	19,66	0,000018
***Z. mays* 1 & *Z mays* 2**	72,25	< 0,00001
Z. mays* 1 & *C. ciliaris	70,87	< 0,00001
Z. mays* 2 & *C. ciliaris	221,03	< 0,00001

Table F.40. ANOVA (Analysis of variance) results for the lengths of variant round rondel phytoliths from the inflorescences of domesticated and wild taxa.

Species	F-ratio	P-value
***S. bicolor* subsp. *bicolor* 1, *S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	4,51	0,011767
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 2**	4,07	0,045056
***S. bicolor* subsp. *bicolor* 2 & *S. bicolor* subsp. *bicolor* 3**	0,72	0,395832
***S. bicolor* subsp. *bicolor* 1 & *S. bicolor* subsp. *bicolor* 3**	9,34	0,002548
S. bicolor* subsp. *bicolor* 1 & *S. halepense	15,1	0,000153
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 1**	0,16	0,691192
***S. bicolor* subsp. *bicolor* 1 & *Z. mays* 2**	121,49	< 0,00001
S. bicolor* subsp. *bicolor* 2 & *S. halepense	3,28	0,072198
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 1**	6,23	0,013397
***S. bicolor* subsp. *bicolor* 2 & *Z. mays* 2**	147,79	< 0,00001
S. bicolor* subsp. *bicolor* 3 & *S. halepense	1,42	0,23486
***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 1**	13,27	0,000345

***S. bicolor* subsp. *bicolor* 3 & *Z. mays* 2**	176,95	< 0,00001
***Z. mays* 1 & *Z. mays* 2**	123,5	< 0,00001
Z. mays* 1 & *S. halepense	21,54	< 0,00001
Z. mays* 2 & *S. halepense	128,65	< 0,00001

Domesticated Fabaceae

Table F.41. ANOVA (Analysis of variance) results for the lengths of rhomboidal phytoliths from domesticated Fabaceae.

Species name	F-ratio	P-value
***A. hypogaea* 1 (Phytoliths from all plant sections)**	1,98	0,118368
***A. hypogaea* 2 (Phytoliths from all plant sections)**	14,36	< 0,00001
***A. hypogaea* (leaves)**	7,36	0,007896
***A. hypogaea* (stems)**	1,2	0,275275
***A. hypogaea* (roots)**	2,99	0,087161
***A. hypogaea* (seed pods)**	0,04	0,843158
***V. subterranea* 1 (Phytoliths from all plant sections)**	3,09	0,028359
***V. subterranea* 2 (Phytoliths from all plant sections)**	11,86	< 0,00001
***V. subterranea* (seed pods)**	16,15	0,000115
***V. subterranea* (leaves)**	1,37	0,244942
***V. subterranea* (roots)**	1,44	0,233035
***V. subterranea* (stems)**	2,74	0,100815
***V. unguiculata* subsp. *unguiculata* 1 (Phytoliths from all plant sections)**	26,62	< 0,00001
***V. unguiculata* subsp. *unguiculata* 2 (Phytoliths from all plant sections)**	23,98	< 0,00001
***V. unguiculata* subsp. *unguiculata* 3 (Phytoliths from all plant sections)**	17,23	< 0,00001
***V. unguiculata* subsp. *unguiculata* (roots)**	2,43	0,12244
***V. unguiculata* subsp. *unguiculata* (stems)**	2,92	0,057005
***V. unguiculata* subsp. *unguiculata* (seed pods)**	14,97	< ,00001
***V. unguiculata* subsp. *unguiculata* (leaves)**	8,13	0,000446
***A. hypogaea* 1 (leaves) & *A. hypogaea* 1 (1 month)**	7,43	0,007605
***A. hypogaea* 1 (stems) & *A. hypogaea* 1 (1 month)**	11,14	0,001196
***A. hypogaea* 1 (seed pods) & *A. hypogaea* 1 (1 month)**	17,99	0,00005
***A. hypogaea* 1 (roots) & *A. hypogaea* 1 (1 month)**	21,05	0,000013
***V. subterranea* 1 (leaves) & *V. subterranea* 1 (1 month)**	7,34	0,007966
***V. subterranea* 1 (stems) & *V. subterranea* 1 (1 month)**	10,23	0,001863
***V. subterranea* 1 (seed pods) & *V. subterranea* 1 (1 month)**	0,0002	0,989709
***V. subterranea* 1 (roots) & *V. subterranea* 1 (1 month)**	2,23	0,138691
***V. subterranea* 2 (leaves) & *V. subterranea* 2 (1 month)**	1,76	0,187597
***V. subterranea* 2 (stems) & *V. subterranea* 2 (1 month)**	0,91	0,343432
***V. subterranea* 2 (seed pods) & *V. subterranea* 2 (1 month)**	23,83	< 0,00001
***V. subterranea* 2 (roots) & *V. subterranea* 2 (1 month)**	0,007	0,934916
***V. unguiculata* subsp. *unguiculata* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	3,18	0,0776
***V. unguiculata* subsp. *unguiculata* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	34,93	< 0,00001

***V. unguiculata* subsp. *unguiculata* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (1 month)**	0,12	0,734202
***V. unguiculata* subsp. *unguiculata* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (1 week)**	0,39	0,535589
***V. unguiculata* subsp. *unguiculata* 1 (stems) & *V. unguiculata* subsp. *unguiculata* (1 week)**	8,55	0,004592
***V. unguiculata* subsp. *unguiculata* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (1 week)**	6,59	0,012312
***V. unguiculata* subsp. *unguiculata* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	0,05	0,827483
***V. unguiculata* subsp. *unguiculata* 2 (stems) & *V. unguiculata* subsp. *unguiculata* (1 month)**	29,3	< 0,00001
***V. unguiculata* subsp. *unguiculata* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	0,08	0,779457
***V. unguiculata* subsp. *unguiculata* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (1 month)**	36,59	< 0,00001
***V. unguiculata* subsp. *unguiculata* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (1week)**	0,07	0,790794
***V. unguiculata* subsp. *unguiculata* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (1 week)**	19,38	0,000036
***V. unguiculata* subsp. *unguiculata* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (1 week)**	0,03	0,850699
***V. unguiculata* subsp. *unguiculata* 2 (roots) & *V. unguiculata* subsp. *unguiculata* (1 week)**	23,5	< 0,00001
***V. unguiculata* subsp. *unguiculata* 3 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	33,81	< 0,00001
***V. unguiculata* subsp. *unguiculata* 3 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	72,96	< 0,00001
***V. unguiculata* subsp. *unguiculata* 3 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	27,55	< 0,00001
***V. unguiculata* subsp. *unguiculata* 3 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (1 month)**	122,51	< 0,00001

Table F.42. ANOVA (Analysis of variance) results for the lengths of rhomboidal phytoliths from domesticated Fabaceae.

Species name	F-ratio	P-value
***A. hypogaea* 1 (leaves) & *V. subterranea* 1 (leaves)**	3,79	0,054547
***A. hypogaea* 1 (stems) & *V. subterranea* 1 (stems)**	3,03	0,084849
***A. hypogaea* 1 (roots) & *V. subterranea* 1 (roots)**	1,56	0,214285
***A. hypogaea* 1 (seed pods) & *V. subterranea* 1 (seed pods)**	4,25	0,041876
***A. hypogaea* 1 (leaves) & *V. subterranea* 2 (leaves)**	0,87	0,353628
***A. hypogaea* 1 (stems) & *V. subterranea* 2 (stems)**	0,01	0,93786
***A. hypogaea* 1 (roots) & *V. subterranea* 2 (roots)**	6,09	0,015342
***A. hypogaea* 1 (seed pods) & *V. subterranea* 2 (seed pods)**	36,57	< 0,00001
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	9,07	0,003312
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	0,37	0,545113
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	47,93	< 0,00001
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	7,18	0,008633

Species name	F-ratio	P-value
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	7,36	0,007888
***A. hypogaea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	2,85	0,094284
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	14,76	0,000217
***A. hypogaea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	0,07	0,787918
***A. hypogaea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	5,84	0,017519
***A. hypogaea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	11,32	0,001097
***A. hypogaea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	1,68	0,197374
***A. hypogaea* 2 (leaves) & *V. subterranea* 1 (leaves)**	21,86	0,002129
***A. hypogaea* 2 (stems) & *V. subterranea* 1 (stems)**	0,24	0,624411
***A. hypogaea* 2 (roots) & *V. subterranea* 1 (roots)**	9,96	< 0,00001
***A. hypogaea* 2 (seed pods) & *V. subterranea* 1 (seed pods)**	3,41	0,067878
***A. hypogaea* 2 (leaves) & *V. subterranea* 2 (leaves)**	15	0,000194
***A. hypogaea* 2 (stems) & *V. subterranea* 2 (stems)**	1,04	0,309276
***A. hypogaea* 2 (roots) & *V. subterranea* 2 (roots)**	21,49	0,000011
***A. hypogaea* 2 (seed pods) & *V. subterranea* 2 (seed pods)**	28,12	< 0,00001
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	0,004	0,948858
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	0,32	0,31885
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	36,8	< 0,00001
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	0,08	0,77483
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	2,57	0,112144
***A. hypogaea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	0,01	0,932847
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	11,7	0,000913
***A. hypogaea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	10,18	0,001911
***A. hypogaea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	1,4	0,239654
***A. hypogaea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	3,12	0,080311
***A. hypogaea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	1,37	0,245134
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	27,44	< 0,00001
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	1,39	0,241474
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	24,56	< 0,00001
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	23,3	< 0,00001

Species name	F-ratio	P-value
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	1,64	0,202689
***V. subterranea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	8,99	0,003444
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	3,26	0,074227
***V. subterranea* 1 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	3,32	0,07022
***V. subterranea* 1 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	0,63	0,430791
***V. subterranea* 1 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	23,46	< 0,00001
***V. subterranea* 1 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	0,5	0,483192
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 1 (leaves)**	19,64	0,000024
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 1 (stems)**	0,28	0,600667
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 1 (seed pods)**	1,21	0,274159
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 2 (leaves)**	15,95	0,000126
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 2 (stems)**	6,97	0,009642
***V. subterranea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 2 (roots)**	18,58	0,000039
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 2 (seed pods)**	4,76	0,031592
***V. subterranea* 2 (leaves) & *V. unguiculata* subsp. *unguiculata* 3 (leaves)**	0,52	0,473427
***V. subterranea* 2 (stems) & *V. unguiculata* subsp. *unguiculata* 3 (stems)**	5,45	0,021571
***V. subterranea* 2 (roots) & *V. unguiculata* subsp. *unguiculata* 3 (roots)**	41,07	< 0,00001
***V. subterranea* 2 (seed pods) & *V. unguiculata* subsp. *unguiculata* 3 (seed pods)**	20,66	0,000016

APPENDIX G: ELEUSINE CORACANA SUBSP. CORACANA TABLES

Measurements of mature and juvenile Eleusine coracana subsp. coracana phytoliths

Table G.1. Length of mature *Eleusine coracana* subsp. *coracana* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (Inflorescence)	14,08	6,45	10,5699
Elongate saddle (Inflorescence)	14,29	5,4	9,5375
Depressed saddle (Leaf)	14	5,35	9,5409
Elongate saddle (Leaf)	14,25	8,78	11,1641

Table G.2. Width of mature *Eleusine coracana* subsp. *coracana* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (Inflorescence)	14,29	5,4	9,5375
Elongate saddle (Inflorescence)	10,97	5,43	7,9823
Depressed saddle (Leaf)	12,32	5,78	8,532
Elongate saddle (Leaf)	10,28	4,3	7,3016

Table G.3. Length of mature *Eleusine coracana* subsp. *coracana* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (Inflorescence)	13,45	5,35	9,3843
Elongate saddle (Inflorescence)	14,53	9,19	11,704
Depressed saddle (Leaf)	13,08	5,75	9,2413
Elongate saddle (Leaf)	14,6	7,72	11,116

Table G.4. Width of mature *Eleusine coracana* subsp. *coracana* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (Inflorescence)	13,11	5,51	8,8282
Elongate saddle (Inflorescence)	11,26	4,53	7,6631
Depressed saddle (Leaf)	11,82	4,99	8,5157
Elongate saddle (Leaf)	12,25	4,38	7,7259

Table G.5. Length of juvenile *Eleusine coracana* subsp. *coracana* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (1 Month)	14,91	7,97	10,4378
Elongate saddle (1 Month)	17,16	8,95	11,8836
Bilobates (1 Month)	26,81	14,03	19,9176
Variant 1 crosses (1 Month)	19,33	9,37	14,498
Depressed saddle (1-2 Weeks)	14,42	10,69	12,5976
Elongate saddle (1-2 Weeks)	17,72	11,76	14,5528
Bilobates (1-2 Weeks)	30,35	18,52	23,3152
Variant 1 crosses (1-2 Weeks)	19,96	11,67	16,4964

Table G.6. Width of juvenile *Eleusine coracana* subsp. *coracana* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (1 Month)	12,67	6,28	9,8012
Elongate saddle (1 Month)	10,48	5,45	7,7154
Bilobates (1 Month)	13,09	5,19	8,468
Variant 1 crosses (1 Month)	13,36	6,16	9,919
Depressed saddle (1-2 Weeks)	16,04	9,66	12,2792
Elongate saddle (1-2 Weeks)	14,7	8,29	11,1832
Bilobates (1-2 Weeks)	13,65	7,45	10,2192
Variant 1 crosses (1-2 Weeks)	14,64	8,71	11,602

Table G.7. Length of juvenile *Eleusine coracana* subsp. *coracana* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (1 Month)	14,17	7,23	10,54
Elongate saddle (1 Month)	20,04	9,12	12,767
Bilobates (1 Month)	28,26	16,33	21,2278
Variant 1 crosses (1 Month)	19,83	11,05	14,613
Depressed saddle (1-2 Weeks)	NA	NA	NA
Elongate saddle (1-2 Weeks)	NA	NA	NA
Bilobates (1-2 Weeks)	27,85	17,25	22,9492
Variant 1 crosses (1-2 Weeks)	25,28	11,57	17,4228

Table G.8. Width of juvenile *Eleusine coracana* subsp. *coracana* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (1 Month)	13,33	6,6	9,1456
Elongate saddle (1 Month)	11,7	5,47	8,1062
Bilobates (1 Month)	13,42	7,07	10,0142
Variant 1 crosses (1 Month)	15,04	8,22	10,6786
Depressed saddle (1-2 Weeks)	NA	NA	NA
Elongate saddle (1-2 Weeks)	NA	NA	NA
Bilobates (1-2 Weeks)	14,69	8,2	11,5672
Variant 1 crosses (1-2 Weeks)	18,59	8,92	12,3736

Phytoliths sizes of mature and juvenile specimens[8]

Table G.9. Mature *Eleusine coracana* subsp. *coracana* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddles (Inflorescence)	3	88	9	0	0
Elongate saddles (Inflorescence)	20	80	0	0	0
Depressed saddles (Leaf)	10	84	6	0	0
Elongate saddles (Leaf)	33	67	0	0	0

[8] Extra small- smaller than 6,87 µm;
Small- 6,87-11,4 µm;
Medium- 11,45-15,98 µm;
Large- 16,03-20,56 µm;
Extra Large- 20,61-25,19 µm.

Table G.10. Mature *Eleusine coracana* subsp. *coracana* 2 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddles (Inflorescence)	8	90	2	0	0
Elongate saddles (Inflorescence)	32	68	0	0	0
Depressed saddles (Leaf)	19	79	2	0	0
Elongate saddles (Leaf)	29	70	1	0	0

Table G.11. Phytolith sizes for juvenile *Eleusine coracana* subsp. *coracana* 1 specimens.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddle (1 Month)	1	40	9	0	0
Elongate saddle (1 Month)	17	33	0	0	0
Bilobates (1 Month)	8	39	3	0	0
Variant 1 crosses (1 Month)	1	38	11	0	0
Depressed saddle (1-2 Weeks)	0	11	13	1	0
Elongate saddle (1-2 Weeks)	0	14	11	0	0
Bilobates (1-2 Weeks)	0	20	5	0	0
Variant 1 crosses (1-2 Weeks)	0	12	13	0	0

Table G.12. Phytolith sizes for juvenile *Eleusine coracana* subsp. *coracana* 2 specimens.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddle (1 Month)	2	44	4	0	0
Elongate saddle (1 Month)	10	39	1	0	0
Bilobates (1 Month)	0	41	9	0	0
Variant 1 crosses (1 Month)	0	39	11	0	0
Depressed saddle (1-2 Weeks)	NA	NA	NA	NA	NA
Elongate saddle (1-2 Weeks)	NA	NA	NA	NA	NA
Bilobates (1-2 Weeks)	0	10	15	0	0
Variant 1 crosses (1-2 Weeks)	0	8	15	2	0

APPENDIX H: PENNISETUM GLAUCUM TABLES

Measurements of mature and juvenile Pennisetum glaucum phytoliths

Table H.1. Length of mature *Pennisetum glaucum* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (Inflorescence)	23,64	9,78	16,07
Variant 1 crosses (Inflorescence)	18,02	6,08	10,3181
Bilobates (Leaf)	30,06	12,35	20,6224
Variant 1 crosses (Leaf)	21,22	9,73	14,6242

Table H.2. Width of mature *Pennisetum glaucum* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (Inflorescence)	12,11	5,1	8,0428
Variant 1 crosses (Inflorescence)	12,38	4,2	8,247
Bilobates (Leaf)	15,54	5,39	9,2638
Variant 1 crosses (Leaf)	15,61	7,69	11,0646

Table H.3. Length of mature *Pennisetum glaucum* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (Inflorescence)	25,12	10,61	15,6332
Variant 1 crosses (Inflorescence)	17,44	6,33	10,5964
Variant 5/6 crosses (Inflorescence)	19	8,61	13,03589
Bilobates (Leaf)	29,36	12,39	20,2126
Variant 1 crosses (Leaf)	20,69	8,82	13,705

Table H.4. Width of mature *Pennisetum glaucum* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (Inflorescence)	17,43	4,66	8,7132
Variant 1 crosses (Inflorescence)	12,77	5,59	8,3106
Variant 5/6 crosses (Inflorescence)	15,12	6,87	10,12357
Bilobates (Leaf)	15,2	5,33	9,8885
Variant 1 crosses (Leaf)	14,15	7,54	10,8921

Table H.5. Length of juvenile *Pennisetum glaucum* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	40,71	14,12	23,0494
Variant 1 crosses (1 Month)	19,72	10,98	15,58731
Variant 1 polylobates (1 Month)	41,39	17,47	29,1834
Variant 2 polylobates (1 Month)	49,68	24,09	35,7752
Bilobates (1-2 Weeks)	36,1	14,3	23,4976
Variant 1 crosses (1-2 Weeks)	24,88	11,07	15,7092
Variant 1 polylobates (1-2 Weeks)	33,76	19,78	25,6168
Variant 2 polylobates (1-2 Weeks)	44,08	21,29	32,6952

Table H.6. Width of juvenile *Pennisetum glaucum* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	11,68	4,43	8,1298
Variant 1 crosses (1 Month)	14,48	6,82	10,71577
Variant 1 polylobates (1 Month)	12,15	5,09	8,5946
Variant 2 polylobates (1 Month)	12,34	5,25	8,494
Bilobates (1-2 Weeks)	12,27	6,45	9,6516
Variant 1 crosses (1-2 Weeks)	16,79	8,8	11,4492
Variant 1 polylobates (1-2 Weeks)	16,82	4,94	10,27
Variant 2 polylobates (1-2 Weeks)	13,32	5,8	9,232

Table H.7. Length of juvenile *Pennisetum glaucum* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	46,48	20,57	29,8932
Bilobates (1-2 Weeks)	40,33	21,97	27,7788
Variant 1 crosses (1-2 Weeks)	26,08	14,75	19,26
Variant 1 polylobates (1-2 Weeks)	41,06	18,11	28,572
Variant 2 polylobates (1-2 Weeks)	42,9	22,57	34,816

Table H.8. Width of juvenile *Pennisetum glaucum* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	19,39	7,68	12,7176
Bilobates (1-2 Weeks)	16,89	9,84	12,804
Variant 1 crosses (1-2 Weeks)	18,6	9,76	13,0768
Variant 1 polylobates (1-2 Weeks)	14,99	7,66	11,4752
Variant 2 polylobates (1-2 Weeks)	14,02	6,9	10,1452

Phytoliths sizes of mature and juvenile specimens[9]

Table H.9. Mature *Pennisetum glaucum* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (Inflorescence)	24	73	3	0	0
Variant 1 crosses (Inflorescence)	23	73	4	0	0
Bilobates (Leaf)	9	74	17	0	0
Variant 1 crosses (Leaf)	0	60	40	0	0

Table H.10. Mature *Pennisetum glaucum* 2 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (Inflorescence)	17	74	7	2	0
Variant 1 crosses (inflorescence)	22	73	5	0	0
Variant 5/6 crosses (Inflorescence)	0	42	14	0	0
Bilobates (Leaf)	3	78	19	0	0
Variant 1 crosses (Leaf)	0	61	39	0	0

[9] Extra small- smaller than 6,87 µm;
Small- 6,87-11,4 µm;
Medium- 11,45-15,98 µm;
Large- 16,03-20,56 µm;
Extra Large- 20,61-25,19 µm.

Table H.11. Phytolith sizes for juvenile *Pennisetum glaucum* 1 specimens.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	14	34	2	0	0
Variant 1 crosses (1 Month)	1	13	12	0	0
Variant 1 polylobates (1 Month)	7	40	3	0	0
Variant 2 polylobates (1 Month)	6	42	2	0	0
Bilobates (1-2 Weeks)	1	19	5	0	0
Variant 1 crosses (1-2 Weeks)	0	15	8	2	0
Variant 1 polylobates (1-2 Weeks)	4	13	7	1	0
Variant 2 polylobates (1-2 Weeks)	2	21	2	0	0

Table H.12. Phytolith sizes for juvenile *Pennisetum glaucum* 2 specimens.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	0	20	24	6	0
Bilobates (1-2 Weeks)	0	6	18	1	0
Variant 1 crosses (1-2 Weeks)	0	5	16	4	0
Variant 1 polylobates (1-2 Weeks)	0	10	15	0	0
Variant 2 polylobates (1-2 Weeks)	0	19	6	0	0

APPENDIX I: SORGHUM BICOLOR SUBSP. BICOLOR TABLES

Measurements of mature and juvenile Sorghum bicolor subsp. bicolor specimens

Table I.1. Length of mature *Sorghum bicolor* subsp. *bicolor* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Rondels with one dent (Inflorescence)	17,11	9,82	13,03
Saddle like rondels (Inflorescence)	17,91	9,25	13
Bilobates (Inflorescence)	22,22	9,83	14,88
Elongate rondels (Inflorescence)	21,03	7,33	14,83
Irregular rondels (Inflorescence)	17,84	7,75	13,19
Round rondels (Inflorescence)	17,01	6,06	12,84
Elongate saddles (Inflorescence)	17,86	9,08	13,66
Dendritic long cells (Inflorescence)	77,27	14,14	36,66
Sinuous long cells (Inflorescence)	94,29	20,48	39,99
Bilobates (Leaf)	26,25	14,53	19,6379
Variant 1 crosses (Leaf)	20,98	9,81	13,6325
Variant 5/6 crosses (Leaf)	19,25	9,19	12,9373

Table I.2. Width of mature *Sorghum bicolor* subsp. *bicolor* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Rondels with one dent (Inflorescence)	15,33	7,88	11,23
Saddle like rondels (Inflorescence)	15,38	7,79	11,58
Bilobates (Inflorescence)	18,47	6,86	11,75
Elongate rondels (Inflorescence)	12,11	3,72	8,51
Irregular rondels (Inflorescence)	14,62	6,02	10,34
Round rondels (Inflorescence)	15,57	5,92	11,2
Elongate saddles (Inflorescence)	14,91	5,87	11,49
Dendritic long cells (Inflorescence)	27,03	6,8	13,13
Sinuous long cells (Inflorescence)	16,48	8,45	12,1
Bilobates (Leaf)	17,89	8,14	11,6588
Variant 1 crosses (Leaf)	18,15	8,42	11,90133
Variant 5/6 crosses (Leaf)	17,43	6,31	10,6488

Table I.3. Length of mature *Sorghum bicolor* subsp. *bicolo*r 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Rondels with one dent (Inflorescence)	18,55	7,22	12,23
Saddle like rondels (Inflorescence)	17,95	8,85	12,67
Bilobates (Inflorescence)	26,82	10,3	15,22
Elongate rondels (Inflorescence)	18,7	9,81	13,62
Irregular rondels (Inflorescence)	18,51	7,71	12,53
Round rondels (Inflorescence)	18,63	7,63	12,23
Elongate saddles (Inflorescence)	17,23	8,29	11,69
Dendritic long cells (Inflorescence)	81,81	16,42	35,3
Sinuous long cells (Inflorescence)	96,85	18,86	44,75
Bilobates (Leaf)	23,24	12,22	17,4008
Variant 1 crosses (Leaf)	20,94	7,94	13,3291
Variant 5/6 crosses (Leaf)	17,55	8,47	13,0007

Table I.4. Width of mature *Sorghum bicolor* subsp. *bicolor* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Rondels with one dent (Inflorescence)	16,98	6,59	10,18
Saddle like rondels (Inflorescence)	17,84	6,19	11,6
Bilobates (Inflorescence)	18,51	6,19	11,3
Elongate rondels (Inflorescence)	12,3	4,63	8,21
Irregular rondels (Inflorescence)	17,13	5,73	9,74
Round rondels (Inflorescence)	14,58	6,07	10,82
Elongate saddles (Inflorescence)	14,94	6,49	9,68
Dendritic long cells (Inflorescence)	24,09	2,79	14,27
Sinuous long cells (Inflorescence)	22,17	10,41	14,6
Bilobates (Leaf)	15,28	6,95	10,6843
Variant 1 crosses (Leaf)	15,34	7,51	11,1882
Variant 5/6 crosses (Leaf)	16,1	6,61	11,0692

Table I.5. Length of mature *Sorghum bicolor* subsp. *bicolor* 3 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Rondels with one dent (Inflorescence)	16,62	8,4	12,34
Saddle like rondels (Inflorescence)	17,58	7,51	12,49
Bilobates (Inflorescence)	22,65	9,07	15,73
Elongate rondels (Inflorescence)	20,95	11,4	14,25
Irregular rondels (Inflorescence)	17,87	8,02	12,55
Round rondels (Inflorescence)	16,58	7,52	11,98
Elongate saddles (Inflorescence)	17,23	8,29	11,69
Dendritic long cells (Inflorescence)	83,94	21,67	43,88
Sinuous long cells (Inflorescence)	111,38	27,13	49,72
Bilobates (Leaf)	26,59	11,98	17,9385
Variant 1 crosses (Leaf)	20,57	9,18	13,5958
Variant 5/6 crosses (Leaf)	16,92	8,26	11,2154

Table I.6. Width of mature *Sorghum bicolor* subsp. *bicolor* 3 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Rondels with one dent (Inflorescence)	17,47	7,02	11,01
Saddle like rondels (Inflorescence)	16,58	6,85	11,67
Bilobates (Inflorescence)	18,87	6,55	12,23
Elongate rondels (Inflorescence)	12,24	5,62	8,69
Irregular rondels (Inflorescence)	15,56	5,48	9,98
Round rondels (Inflorescence)	15,06	7	10,63
Elongate saddles (Inflorescence)	14,94	6,49	9,68
Dendritic long cells (Inflorescence)	23,1	3,56	13,66
Sinuous long cells (Inflorescence)	18,76	7,63	11,37
Bilobates (Leaf)	16,5	6,17	9,8047
Variant 1 crosses (Leaf)	14,86	7,94	10,5789
Variant 5/6 crosses (Leaf)	12,96	5,65	8,9969

Table I.7. Length of juvenile *Sorghum bicolor* subsp. *bicolor* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	36,2	11,91	21,2886
Variant 1 crosses (1 Month)	21,39	9,93	14,9772
Variant 1 polylobates (1 Month)	45,89	11,73	26,1238
Variant 2 polylobates (1 Month)	61,04	18,19	29,531
Bilobates (1-2 Weeks)	36,99	14,22	22,2524
Variant 1 crosses (1-2 Weeks)	18,94	11,71	15,1032
Variant 1 polylobates (1-2 Weeks)	33,51	18,87	25,1428
Variant 2 polylobates (1-2 Weeks)	37,1	18,81	28,0448

Table I.8. Width of juvenile *Sorghum bicolor* subsp. *bicolor* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	15,61	6,24	9,3998
Variant 1 crosses (1 Month)	17,01	6,33	10,1514
Variant 1 polylobates (1 Month)	14,81	5,74	9,8066
Variant 2 polylobates (1 Month)	15,34	5,63	9,1014
Bilobates (1-2 Weeks)	15,9	6,66	10,3636
Variant 1 crosses (1-2 Weeks)	17,09	8,93	11,4488
Variant 1 polylobates (1-2 Weeks)	13,53	8,11	10,9432
Variant 2 polylobates (1-2 Weeks)	15,09	7,49	10,048

Table I.9. Length of juvenile *Sorghum bicolor* subsp. *bicolor* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	34,69	17,08	25,3804
Variant 1 crosses (1 Month)	23,09	9,42	14,9888
Variant 1 polylobates (1 Month)	41,82	14,7	28,9662
Variant 2 polylobates (1 Month)	54,72	18,12	35,99171
Bilobates (1-2 Weeks)	30,12	18,4	23,6012
Variant 1 crosses (1-2 Weeks)	19,72	13,04	16,1752
Variant 1 polylobates (1-2 Weeks)	43,06	17,56	25,9888
Variant 2 polylobates (1-2 Weeks)	38,03	24,31	30,6288

Table I.10. Width of juvenile *Sorghum bicolor* subsp. *bicolor* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	15,39	6,78	11,305
Variant 1 crosses (1 Month)	15,36	7,71	11,2624
Variant 1 polylobates (1 Month)	16,88	8,64	11,4104
Variant 2 polylobates (1 Month)	13,85	8,61	10,95143
Bilobates (1-2 Weeks)	16,08	7,46	10,6888
Variant 1 crosses (1-2 Weeks)	17,3	7,91	10,7032
Variant 1 polylobates (1-2 Weeks)	15,47	6,25	10,2116
Variant 2 polylobates (1-2 Weeks)	12,88	7,75	10,136

Table I.11. Length of juvenile *Sorghum bicolor* subsp. *bicolor* 3 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	29,18	13,72	20,5738
Variant 1 crosses (1 Month)	17,62	9,66	14,6146
Variant 1 polylobates (1 Month)	37,48	15,62	21,7122
Variant 2 polylobates (1 Month)	34,72	18,01	24,7408
Bilobates (1-2 Weeks)	45,1	17,96	28,6268
Variant 1 crosses (1-2 Weeks)	20,13	10,9	16,5872
Variant 1 polylobates (1-2 Weeks)	46,21	20,52	30,19
Variant 2 polylobates (1-2 Weeks)	49,78	21,88	31,7904

Table I.12. Width of juvenile *Sorghum bicolor* subsp. *bicolor* 3 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width
Bilobates (1 Month)	12,57	6,26	9,6688
Variant 1 crosses (1 Month)	13,01	7,51	9,891
Variant 1 polylobates (1 Month)	13,29	6,87	9,8856
Variant 2 polylobates (1 Month)	13,47	5,96	8,9276
Bilobates (1-2 Weeks)	14,4	6,63	9,6836
Variant 1 crosses (1-2 Weeks)	13,9	7,36	10,8532
Variant 1 polylobates (1-2 Weeks)	16,01	8,39	10,7924
Variant 2 polylobates (1-2 Weeks)	13,51	6,58	10,0388

Phytoliths sizes of mature and juvenile specimens[10]

Table I.13. Mature *Sorghum bicolor* subsp. *bicolor* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Rondels with one dent (Inflorescence)	0	58	42	0	0
Saddle like rondels (Inflorescence)	0	46	54	0	0
Bilobates (Inflorescence)	1	43	52	4	0
Elongate rondels (Inflorescence)	22	77	1	0	0
Irregular rondels (Inflorescence)	2	84	14	0	0
Round rondels (Inflorescence)	1	51	48	0	0
Elongate saddles (Inflorescence)	0	58	42	0	0
Bilobates (Leaf)	0	50	46	4	0
Variant 1 crosses (Leaf)	0	38	60	2	0
Variant 5/6 crosses (Leaf)	0	18	79	3	0

[10] Extra small- smaller than 6,87 µm;
Small- 6,87-11,4 µm;
Medium- 11,45-15,98 µm;
Large- 16,03-20,56 µm;
Extra Large- 20,61-25,19 µm.

Table I.14. Mature *Sorghum bicolor* subsp. *bicolor* 2 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Rondels with one dent (Inflorescence)	1	75	23	1	0
Saddle like rondels (Inflorescence)	1	49	48	2	0
Bilobates (Inflorescence)	5	48	41	6	0
Elongate rondels (Inflorescence)	23	73	4	0	0
Irregular rondels (Inflorescence)	5	80	14	1	0
Round rondels (Inflorescence)	3	55	42	0	0
Elongate saddles (Inflorescence)	14	76	10	0	0
Bilobates (Leaf)	0	68	32	0	0
Variant 1 crosses (Leaf)	0	55	45	0	0
Variant 5/6 crosses (Leaf)	1	55	43	1	0

Table I.15. Mature *Sorghum bicolor* subsp. *bicolor* 3 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Rondels with one dent (Inflorescence)	0	63	34	3	0
Saddle like rondels (Inflorescence)	1	41	57	1	0
Bilobates (Inflorescence)	1	37	54	8	0
Elongate rondels (Inflorescence)	13	79	8	0	0
Irregular rondels (Inflorescence)	7	71	22	0	0
Round rondels (Inflorescence)	0	72	28	0	0
Elongate saddles (Inflorescence)	2	79	19	0	0
Bilobates (Leaf)	4	94	2	0	0
Variant 1 crosses (Leaf)	0	72	28	0	0
Variant 5/6 crosses (Leaf)	6	87	7	0	0

Table I.16. Juvenile *Sorghum bicolor* subsp. *bicolor* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	4	38	8	0	0
Variant 1 crosses (1 Month)	2	36	11	1	0
Variant 1 polylobates (1 Month)	4	34	12	0	0
Variant 2 polylobates (1 Month)	7	34	9	0	0
Bilobates (1-2 Weeks)	1	19	5	0	0
Variant 1 crosses (1-2 Weeks)	0	14	10	1	0
Variant 1 polylobates (1-2 Weeks)	0	15	10	0	0
Variant 2 polylobates (1-2 Weeks)	0	23	2	0	0

Table I.17. Juvenile *Sorghum bicolor* subsp. *bicolor* 2 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	1	22	27	0	0
Variant 1 crosses (1 Month)	0	32	18	0	0
Variant 1 polylobates (1 Month)	1	27	21	1	0
Variant 2 polylobates (1 Month)	1	20	14	0	0
Bilobates (1-2 Weeks)	17	7	1	0	0
Variant 1 crosses (1-2 Weeks)	0	18	6	1	0
Variant 1 polylobates (1-2 Weeks)	1	16	8	0	0
Variant 2 polylobates (1-2 Weeks)	0	18	7	0	0

Table I.18. Juvenile *Sorghum bicolor* subsp. *bicolor* 3 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	4	38	8	0	0
Variant 1 crosses (1 Month)	0	44	6	0	0
Variant 1 polylobates (1 Month)	0	45	5	0	0
Variant 2 polylobates (1 Month)	5	42	3	0	0
Bilobates (1-2 Weeks)	2	17	6	0	0
Variant 1 crosses (1-2 Weeks)	0	16	9	0	0
Variant 1 polylobates (1-2 Weeks)	0	16	8	1	0
Variant 2 polylobates (1-2 Weeks)	1	18	6	0	0

APPENDIX J: ZEA MAYS TABLES

Measurements of mature and juvenile Zea mays specimens

Table J.1. Length of mature *Zea mays* 1 leaf phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates	38,73	14,89	24,0046
Variant 1 crosses	24,68	11,41	14,6503
Variant 1 polylobates	33,63	15,37	23,9503
Variant 2 polylobates	41,35	15,77	27,9906

Table J.2. Width of mature *Zea mays* 1 leaf phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates	19,59	6,25	13,929
Variant 1 crosses	22,75	9,63	14,6503
Variant 1 polylobates	19,33	7,93	14,8516
Variant 2 polylobates	19,59	9,58	14,5245

Table J.3. Length of mature *Zea mays* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Elongate rondels (Cob)	23,15	10,8	16,3471
Round rondels (Cob)	17,25	8,76	12,9393
Variant 1 crosses (Male inflorescence)	26,42	11,43	17,2398
Bilobates (Husks)	36,19	15,7	24,5279
Variant 1 crosses (Husks)	27,56	13,79	20,1974

Table J.4. Width of mature *Zea mays* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Elongate rondels (Cob)	14,25	5,39	9,4604
Round rondels (Cob)	15,28	6,63	11,53
Variant 1 crosses (Male inflorescence)	21,95	9,86	14,8611
Bilobates (Husks)	19,48	9,08	13,6763
Variant 1 crosses (Husks)	22,53	10,84	16,0162

Table J.5. Length of mature *Zea mays* 2 leaf phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates	35,45	15,06	23,61
Variant 1 crosses	25,48	11,14	18,46
Variant 5/6 crosses	22,18	9,22	15,89

Table J.6. Width of mature *Zea mays* 2 leaf phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates	19,6	8,65	12,69
Variant 1 crosses	20,76	10,36	14,97
Variant 5/6 crosses	20,14	8,73	12,9

Table J.7. Length of mature *Zea mays* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Elongate rondels (Cob)	28,61	12,35	19,92
Round rondels (Cob)	26,5	9,51	16,89
Bilobates (Cob)	29,21	11,77	18,44
Rondels with one dent (Cob)	23,44	10,29	16,58
Variant 1 crosses (Cob)	26,39	10,99	16,26
Variant 5/6 crosses (Cob)	18,05	11,69	15,55
Variant 1 crosses (Male inflorescence)	23,09	9,2	14,8192
Bilobates (Husks)	35,67	18,27	27,4183
Variant 1 crosses (Husks)	36,96	16,82	22,8971

Table J.8. Width of mature *Zea mays* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Elongate rondels (Cob)	19,81	5,15	11,62
Round rondels (Cob)	21,69	9,69	15,23
Bilobates (Cob)	19,34	7,75	13
Rondels with one dent (Cob)	21,27	7,43	13,3
Variant 1 crosses (Cob)	17,96	8,8	13,28
Variant 5/6 crosses (Cob)	17,84	8,74	13,35
Variant 1 crosses (Male inflorescence)	17,82	5,46	11,5339
Bilobates (Husks)	29,37	12,41	18,4245
Variant 1 crosses (Husks)	29,79	13,81	19,2111

Table J.9. Length of juvenile *Zea mays* 1 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	26,62	13,35	18,911
Variant 1 crosses (1 Month)	19,17	9,33	14,8292
Variant 2 polylobates (1 Month)	40,14	19,19	27,7806
Bilobates (1-2 Weeks)	31,6	15,14	23,3476
Variant 1 crosses (1-2 Weeks)	22,13	9,99	17,4272
Variant 1 polylobates (1-2 Weeks)	44,24	18,77	28,9432
Variant 2 polylobates (1-2 Weeks)	43,22	24,9	34,0096

Table J.10. Width of juvenile *Zea mays* 1 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	13,53	5,78	8,4438
Variant 1 crosses (1 Month)	16,53	6,47	9,4586
Variant 2 polylobates (1 Month)	10,86	5,06	7,9748
Bilobates (1-2 Weeks)	12,3	6,41	8,9484
Variant 1 crosses (1-2 Weeks)	15,18	8,15	11,1296
Variant 1 polylobates (1-2 Weeks)	12,73	6,25	9,0208
Variant 2 polylobates (1-2 Weeks)	11,55	5,79	8,8384

Table J.11. Length of juvenile *Zea mays* 2 phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (1 Month)	25,29	13,73	18,4396
Variant 1 crosses (1 Month)	21,38	9,52	14,9082
Variant 1 polylobates (1 Month)	35,14	14,54	20,8652
Variant 2 polylobates (1 Month)	32,49	19,4	25,4218
Bilobates (1-2 Weeks)	34,95	16,01	24,242
Variant 1 crosses (1-2 Weeks)	22,97	13,45	19,5172
Variant 1 polylobates (1-2 Weeks)	35,17	18,66	29,0324
Variant 2 polylobates (1-2 Weeks)	42,96	23,12	32,2892

Table J.12. Width of juvenile *Zea mays* 2 phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (1 Month)	14,09	6,64	10,092
Variant 1 crosses (1 Month)	14,23	7,49	10,8528
Variant 1 polylobates (1 Month)	13,47	7,94	10,5814
Variant 2 polylobates (1 Month)	13,51	7,21	9,8984
Bilobates (1-2 Weeks)	15,49	6,75	10,5556
Variant 1 crosses (1-2 Weeks)	16,42	10,39	13,2872
Variant 1 polylobates (1-2 Weeks)	15,15	7,95	10,558
Variant 2 polylobates (1-2 Weeks)	14,57	7,22	10,372

Phytoliths sizes of mature and juvenile specimens[11]

Table J.13. Mature *Zea mays* 1 leaf phytolith sizes.

	Extra Small	Small	Medium	Large	Extra large
Bilobates	1	14	65	20	0
Variant 1 crosses	0	10	63	25	2
Variant 1 polylobates	0	5	68	27	0
Variant 2 polylobates	0	5	70	25	0

Table J.14. Mature *Zea mays* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra large
Elongate rondels (Cob)	14	65	21	0	0
Round rondels (Cob)	1	43	56	0	0
Variant 1 crosses (Male inflorescence)	0	4	68	25	3
Bilobates (Husks)	0	18	67	15	0
Variant 1 crosses (Husks)	0	3	45	48	4

Table J.15. Mature *Zea mays* 2 leaf phytolith sizes.

	Extra Small	Small	Medium	Large	Extra large
Bilobates	0	28	68	4	0
Variant 1 crosses	0	6	61	32	1
Variant 5/6 crosses	0	3	47	46	4

[11] Extra small- smaller than 6,87 µm;
Small- 6,87-11,4 µm;
Medium- 11,45-15,98 µm;
Large- 16,03-20,56 µm;
Extra Large- 20,61-25,19 µm.

Table J.16. Mature *Zea mays* 2 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra large	Double Extra Large
Elongate rondels (Cob)	8	45	36	11	0	0
Round rondels (Cob)	0	8	51	39	2	0
Bilobates (Cob)	0	26	61	13	0	0
Rondels with one dent (Cob)	0	28	52	19	1	0
Variant 1 crosses (Cob)	0	11	45	5	0	0
Variant 5/6 crosses (Cob)	0	7	20	5	0	0
Variant 1 crosses (Male inflorescence)	1	52	40	7	0	0
Bilobates (Husks)	0	0	23	56	17	4
Variant 1 crosses (Husks)	0	0	12	61	23	4

Table J.17. Juvenile *Zea mays* 1 phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	7	41	2	0	0
Variant 1 crosses (1 Month)	2	43	4	1	0
Variant 2 polylobates (1 Month)	9	41	0	0	0
Bilobates (1-2 Weeks)	3	21	1	0	0
Variant 1 crosses (1-2 Weeks)	0	15	10	0	0
Variant 1 polylobates (1-2 Weeks)	3	20	2	0	0
Variant 2 polylobates (1-2 Weeks)	2	22	1	0	0

Table J.18. Juvenile *Zea mays* 2 leaf phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (1 Month)	1	36	13	0	0
Variant 1 crosses (1 Month)	0	30	20	0	0
Variant 1 polylobates (1 Month)	0	35	15	0	0
Variant 2 polylobates (1 Month)	0	44	6	0	0
Bilobates (1-2 Weeks)	1	17	7	0	0
Variant 1 crosses (1-2 Weeks)	0	5	18	2	0
Variant 1 polylobates (1-2 Weeks)	0	19	6	0	0
Variant 2 polylobates (1-2 Weeks)	0	11	14	0	0

APPENDIX K: WILD TAXA TABLES

Measurements of mature specimens[12]

Table K.1. Length of mature *Cenchrus ciliaris* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Variant 1 crosses (Inflorescence)	15,59	7,72	10,9792
Cross to rondels (Inflorescence)	13,35	7,29	10,4428
Bilobates (Inflorescence)	16,92	10,56	13,46536
Elongate rondels (Inflorescence)	19,61	8,59	12,7068
Bilobates (Leaf)	29,4	15,7	20,8308
Variant 1 crosses (Leaf)	23,49	10,18	15,099

Table K.2. Width of mature *Cenchrus ciliaris* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Variant 1 crosses (Inflorescence)	13,14	6,52	8,905
Cross to rondels (Inflorescence)	19,63	6,97	9,4014
Bilobates (Inflorescence)	9,92	4,25	7,717857
Elongate rondels (Inflorescence)	10,99	5,7	8,119
Bilobates (Leaf)	13,67	7	10,0778
Variant 1 crosses (Leaf)	14,89	8,25	11,4488

[12] Extra small- smaller than 6,87 µm;
Small- 6,87-11,4 µm;
Medium- 11,45-15,98 µm;
Large- 16,03-20,56 µm;
Extra Large- 20,61-25,19 µm.

Table K.3. Mature *Cenchrus ciliaris* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Variant 1 crosses (Inflorescence)	5	23	0	0	0
Cross to rondels (Inflorescence)	3	43	4	0	0
Bilobates (Inflorescence)	6	44	0	0	0
Elongate rondels (Inflorescence)	0	47	3	0	0
Bilobates (Leaf)	0	37	13	0	0
Variant 1 crosses (Leaf)	0	23	27	0	0

Table K.4. Length of mature *Digitaria ciliaris* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Variant 1 crosses (Inflorescence)	16,85	7,83	12,1508
Bilobates (Inflorescence)	18,86	10,05	14,1912
Bilobates (Leaf)	28,49	13,2	18,712

Table K.5. Width of mature *Digitaria ciliaris* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Variant 1 crosses (Inflorescence)	12,33	6,48	9,3854
Bilobates (Inflorescence)	11,9	5,91	7,9946
Bilobates (Leaf)	11,36	4,92	7,8734

Table K.6. Mature *Digitaria ciliaris* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Variant 1 crosses (Inflorescence)	10	39	1	0	0
Bilobates (Inflorescence)	1	45	4	0	0
Bilobates (Leaf)	12	38	0	0	0

Table K.7. Length of mature *Eleusine coracana* subsp. *africana* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (Inflorescence)	13,9	6,25	8,7998
Elongate saddle (Inflorescence)	15,38	7,53	10,8886
Bilobates (Leaf)	23,53	12,04	16,1958
Variant 1 crosses (Leaf)	17,69	8,65	12,9152
Variant 5/6 crosses (Leaf)	17,26	8,22	11,86316
Depressed saddles (Leaf)	14,07	7,68	10,8338
Round rondels (Leaf)	14,47	7,53	10,5998
Elongate rondels (Leaf)	17,05	8,36	12,696

Table K.8. Width of mature *Eleusine coracana* subsp. *africana* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (Inflorescence)	12,14	4,72	8,4116
Elongate saddle (Inflorescence)	10,41	4,6	7,13
Bilobates (Leaf)	13,66	5,69	8,361
Variant 1 crosses (Leaf)	13,92	7,85	9,745
Variant 5/6 crosses (Leaf)	14,5	6,58	9,461316
Depressed saddles (Leaf)	12,81	6,88	9,1958
Round rondels (Leaf)	12,88	6,58	9,2508
Elongate rondels (Leaf)	10,72	4,94	7,8136

Table K.9. Mature *Eleusine coracana* subsp. *africana* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddle (Inflorescence)	5	43	2	0	0
Elongate saddle (Inflorescence)	24	26	0	0	0
Bilobates (Leaf)	6	43	1	0	0
Variant 1 crosses (Leaf)	0	47	3	0	0
Variant 5/6 crosses (Leaf)	1	34	3	0	0
Depressed saddles (Leaf)	1	46	3	0	0
Round rondels (Leaf)	2	43	5	0	0
Elongate rondels (Leaf)	13	37	0	0	0

Table K.10. Length of mature *Eleusine indica* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddles (Inflorescence)	9,86	5,85	7,904
Elongate saddles (Inflorescence)	12,41	7,99	10,0678
Depressed saddles (Leaf)	10,47	7,54	9,0136
Elongate saddles (leaf)	12,87	7,6	9,8736

Table K.11. Width of mature *Eleusine indica* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddles (Inflorescence)	9,98	5,57	7,2264
Elongate saddles (Inflorescence)	7,8	5,11	6,279
Depressed saddles (Leaf)	12,85	6,49	8,9512
Elongate saddles (leaf)	8,88	4,79	6,4706

Table K.12. Mature *Eleusine indica* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddles (Inflorescence)	19	31	0	0	0
Elongate saddles (Inflorescence)	42	8	0	0	0
Depressed saddles (Leaf)	2	43	5	0	0
Elongate saddles (leaf)	34	16	0	0	0

Table K.13. Length of mature *Eleusine multiflora* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Variant 1 crosses (Inflorescence)	17,32	7,54	10,615
Bilobates (Inflorescence)	22,89	11,7	15,3746
Elongate saddles (Inflorescence)	14,93	9,14	11,45323
Depressed saddle (Inflorescence)	14,98	7,75	10,0744
Variant 1 crosses (Leaf)	15,17	7,71	11,156
Bilobates (Leaf)	17,4	9,43	13,8244
Depressed saddle (Leaf)	12,16	7,41	10,2134
Round rondel (leaf)	14,34	7,93	10,8962
Elongate saddles (Leaf)	17,77	8,02	11,7044

Table K.14. Width of mature *Eleusine multiflora* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Variant 1 crosses (Inflorescence)	14,27	5,5	8,8186
Bilobates (Inflorescence)	14,02	5,82	9,245
Elongate saddles (Inflorescence)	10,74	4,69	7,15871
Depressed saddle (Inflorescence)	15,62	6,12	9,1494
Variant 1 crosses (Leaf)	11,95	6,47	9,278
Bilobates (Leaf)	11,19	6,82	9,0006
Depressed saddle (Leaf)	12,82	7,02	9,204
Round rondel (leaf)	13,23	7,68	10,0352
Elongate saddles (Leaf)	10,09	4,25	7,4864

Table K.15. Mature *Eleusine multiflora* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Variant 1 crosses (Inflorescence)	5	42	3	0	0
Bilobates (Inflorescence)	3	42	5	0	0
Elongate saddles (Inflorescence)	12	19	0	0	0
Depressed saddle (Inflorescence)	2	45	3	0	0
Variant 1 crosses (Leaf)	1	47	2	0	0
Bilobates (Leaf)	1	49	0	0	0
Depressed saddle (Leaf)	0	48	2	0	0
Round rondel (leaf)	0	44	6	0	0
Elongate saddles (Leaf)	16	34	0	0	0

Table K.16. Length of mature *Eleusine tristachya* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddles (Inflorescence)	14,23	7,76	10,8656
Elongate saddles (Inflorescence)	15,36	8,56	11,9198
Depressed saddles (Leaf)	13,58	7,68	10,5558
Elongate saddles (Leaf)	16,48	8,88	11,8792

Table K.17. Width of mature *Eleusine tristachya* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddles (Inflorescence)	13,99	7,76	11,2084
Elongate saddles (Inflorescence)	11,36	5,24	7,6816
Depressed saddles (Leaf)	15,15	7,7	10,4094
Elongate saddles (Leaf)	11,01	5,99	8,0788

Table K.18. Mature *Eleusine tristachya* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddles (Inflorescence)	0	28	22	0	0
Elongate saddles (Inflorescence)	11	39	0	0	0
Depressed saddles (Leaf)	0	37	13	0	0
Elongate saddles (Leaf)	8	42	0	0	0

Table K.19. Length of mature *Pennisetum purpureum* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Variant 1 crosses (Inflorescence)	14,05	6,76	9,868571
Variant 1 polylobates (Inflorescence)	19,47	12,3	15,38963
Bilobates (Inflorescence)	16,67	10,86	13,4698
Bilobates (Leaf)	18,68	10,86	14,7374
Variant 1 crosses (Leaf)	14,64	7,48	10,8206

Table K.20. Width of mature *Pennisetum purpureum* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Variant 1 crosses (Inflorescence)	10,82	5,31	7,739286
Variant 1 polylobates (Inflorescence)	9,23	5,16	7,110741
Bilobates (Inflorescence)	9,15	4,96	6,9098
Bilobates (Leaf)	12,27	5,67	8,6346
Variant 1 crosses (Leaf)	13,18	6,51	9,3542

Table K.21. Mature *Pennisetum purpureum* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Variant 1 crosses (Inflorescence)	8	20	0	0	0
Variant 1 polylobates (Inflorescence)	12	15	0	0	0
Bilobates (Inflorescence)	25	25	0	0	0
Bilobates (Leaf)	8	40	2	0	0
Variant 1 crosses (Leaf)	2	43	5	0	0

Table K.22. Length of mature *Sorghum bicolor* subsp. *arundinaceum* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (Inflorescence)	18,91	9,83	12,9539
Depressed saddle (Inflorescence)	11,15	5,52	8,2328
Elongate saddle (Inflorescence)	13,45	7,41	10,084
Dendritic long cells (Variant 2) (Inflorescence)	83,15	31,95	58,7246
Variant 1 crosses (Leaf)	20,37	9,56	14,0718
Bilobates (Leaf)	20,87	12,35	16,7136

Table K.23. Width of mature *Sorghum bicolor* subsp. *arundinaceum* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (Inflorescence)	10,59	5,36	7,363659
Depressed saddle (Inflorescence)	11,79	5,96	8,298
Elongate saddle (Inflorescence)	10,09	4,78	6,9598
Dendritic long cells (Variant 2) (Inflorescence)	19,93	7,42	13,2438
Variant 1 crosses (Leaf)	16,47	8,64	12,2644
Bilobates (Leaf)	14,93	9,14	12,1762

Table K.24. Mature *Sorghum bicolor* subsp. *arundinaceum* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (Inflorescence)	14	27	0	0	0
Depressed saddle (Inflorescence)	8	40	2	0	0
Elongate saddle (Inflorescence)	25	25	0	0	0
Variant 1 crosses (Leaf)	0	15	34	1	0
Bilobates (Leaf)	0	12	38	0	0

Table K.25. Length of mature *Sorghum bicolor* subsp. *drummondii* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (Inflorescence)	26,62	14,06	19,0718
Depressed saddle (Inflorescence)	19,73	8,2	12,9596
Elongate saddle (Inflorescence)	22,56	10,29	16,6902
Dendritic long cells (Variant 2) (Inflorescence)	91,4	26,7	59,3506
Bilobates (Leaf)	22,42	12,48	17,1872
Variant 1 crosses (Leaf)	19,4	9,49	13,201

Table K.26. Width of mature *Sorghum bicolor* subsp. *drummondii* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (Inflorescence)	16,66	7,61	11,3112
Depressed saddle (Inflorescence)	17,26	7,87	12,4352
Elongate saddle (Inflorescence)	16,08	6,19	11,5632
Dendritic long cells (Variant 2) (Inflorescence)	19,34	7	13,026
Bilobates (Leaf)	12,42	5,84	9,1844
Variant 1 crosses (Leaf)	14,61	7,63	10,458

Table K.27. Mature *Sorghum bicolor* subsp. *drummondii* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (Inflorescence)	0	27	22	1	0
Depressed saddle (Inflorescence)	0	15	33	2	0
Elongate saddle (Inflorescence)	1	22	26	1	0
Bilobates (Leaf)	3	44	3	0	0
Variant 1 crosses (Leaf)	0	35	15	0	0

Table K.28. Length of mature *Sorghum halepense* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Bilobates (Inflorescence)	22,65	9,79	16,0612
Round rondel (Inflorescence)	15,69	7,49	11,5952
Depressed saddle (Inflorescence)	16,84	7,22	12,1846
Elongate saddle (Inflorescence)	18,91	9,61	13,5314
Bilobates (Leaf)	19,84	13,16	16,3302
Variant 1 crosses (Leaf)	17,52	10,07	12,9136
Variant 5/6 crosses (Leaf)	14,9	8,76	11,6622

Table K.29. Width of mature *Sorghum halepense* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Bilobates (Inflorescence)	13,36	6,05	10,0764
Round rondel (Inflorescence)	14,01	7,29	10,5028
Depressed saddle (Inflorescence)	15,3	7,97	11,0662
Elongate saddle (Inflorescence)	14,14	6,26	9,2626
Bilobates (Leaf)	12,77	6,33	9,9816
Variant 1 crosses (Leaf)	14,42	7,36	10,5182
Variant 5/6 crosses (Leaf)	14	6,75	9,991

Table K.30. Mature *Sorghum halepense* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Bilobates (Inflorescence)	1	35	14	0	0
Round rondel (Inflorescence)	0	37	13	0	0
Depressed saddle (Inflorescence)	0	30	20	0	0
Elongate saddle (Inflorescence)	5	40	5	0	0
Bilobates (Leaf)	1	44	5	0	0
Variant 1 crosses (Leaf)	0	39	11	0	0
Variant 5/6 crosses (Leaf)	1	44	5	0	0

Table K.31. Length of mature *Sorghum versicolor* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Depressed saddle (Inflorescence)	15,08	7,88	11,0818
Bilobates (Inflorescence)	22,51	13,47	16,5748
Elongate saddles (Inflorescence)	17,64	8,35	13,1794
Dendritic long cells (Variant 2) (Inflorescence)	94,86	36,42	61,767
Bilobates (Leaf)	25,64	12,43	17,721
Variant 1 crosses (Leaf)	17,04	7,96	12,1702
Polylobate 1 (Leaf)	25,45	11,18	17,397
Polylobate 2 (Leaf)	28,79	11,75	20,8432

Table K.32. Width of mature *Sorghum versicolor* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Depressed saddle (Inflorescence)	13,92	6,22	9,5956
Bilobates (Inflorescence)	12,76	6,84	9,7006
Elongate saddles (Inflorescence)	13,34	5,88	8,418
Dendritic long cells (Variant 2) (Inflorescence)	16,05	7,64	11,9686
Bilobates (Leaf)	14,48	7,29	11,0154
Variant 1 crosses (Leaf)	14,11	6,99	10,3696
Polylobate 1 (Leaf)	14,32	5,83	9,8924
Polylobate 2 (Leaf)	13,47	7,24	10,2216

Table K.33. Mature *Sorghum versicolor* phytolith sizes.

	Extra Small	Small	Medium	Large	Extra Large
Depressed saddle (Inflorescence)	1	43	6	0	0
Bilobates (Inflorescence)	1	40	9	0	0
Elongate saddles (Inflorescence)	7	41	2	0	0
Bilobates (Leaf)	0	31	19	0	0
Variant 1 crosses (Leaf)	0	41	9	0	0
Polylobate 1 (Leaf)	2	41	7	0	0
Polylobate 2 (Leaf)	0	40	10	0	0

APPENDIX L: FABACEAE TABLES

Table L.1. Diagnostic counts for *Arachis hypogaea*.

	Rhomboidal/square/rectangular phytoliths (%)	Epidermal cell phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)
Arachis hypogaea 1 leaves	67,5	18,5	13	1
Arachis hypogaea 1 stems	62,5	23	14,5	0
Arachis hypogaea 1 seed pods	92,5	7	0,5	0
Arachis hypogaea 1 roots	58	40	2	0
Arachis hypogaea 2 leaves	84,5	12	3,5	0
Arachis hypogaea 2 stems	70,5	26,5	3	0
Arachis hypogaea 2 seed pods	68	21	10,5	0,5
Arachis hypogaea 2 roots	64	36	0	0

Table L.2. Length of mature *Arachis hypogaea* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Arachis hypogaea 1 leaves	13,67	5,21	9,3788
Arachis hypogaea 1 stems	16,05	6,11	9,6258
Arachis hypogaea 1 seed pods	14,07	5,68	10,035
Arachis hypogaea 1 roots	18,63	6,74	10,4364
Arachis hypogaea 2 leaves	13,89	4,92	8,1828
Arachis hypogaea 2 stems	15,01	5,65	10,1264
Arachis hypogaea 2 seed pods	17,28	5,98	10,0306
Arachis hypogaea 2 roots	16,22	6,67	11,3328

Table L.3. Width of mature *Arachis hypogaea* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Arachis hypogaea 1 leaves	13,21	4,3	7,0726
Arachis hypogaea 1 stems	14,17	3,46	7,043
Arachis hypogaea 1 seed pods	10,22	3,05	6,6858
Arachis hypogaea 1 roots	13,24	4,92	7,6646
Arachis hypogaea 2 leaves	9,37	3,34	5,712
Arachis hypogaea 2 stems	11,47	3,48	5,9514
Arachis hypogaea 2 seed pods	9,57	2,68	5,9888
Arachis hypogaea 2 roots	11,69	4,18	6,5984

Table L.4. Diagnostic counts for *Vigna subterranea*.

	Rhomboidal/square/rectangular phytoliths (%)	Epidermal cell phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)
Vigna subterranea 1 leaves	72	27,5	0,5	0
Vigna subterranea 1 stems	59	41	0	0
Vigna subterranea 1 seed pods	96	4	0	0
Vigna subterranea 1 roots	73	27	0	0
Vigna subterranea 2 leaves	64	35,5	0,5	0
Vigna subterranea 2 stems	72,5	27,5	0	0
Vigna subterranea 2 seed pods	97	3	0	0
Vigna subterranea 2 roots	60	40	0	0

Table L.5. Length of mature *Vigna subterranea* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Vigna subterranea 1 leaves	15,52	6,59	10,2412
Vigna subterranea 1 stems	15,11	6,8	10,3406
Vigna subterranea 1 seed pods	16,41	6,41	9,171
Vigna subterranea 1 roots	18,3	5,31	9,7932
Vigna subterranea 2 leaves	15,3	5,91	9,7616
Vigna subterranea 2 stems	15,78	5,61	9,6596
Vigna subterranea 2 seed pods	12,86	5,62	7,7774
Vigna subterranea 2 roots	14,94	6,22	9,2634

Table L.6. Width of *Vigna subterranea* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Vigna subterranea 1 leaves	11,26	3,16	6,7928
Vigna subterranea 1 stems	11,66	4,74	7,9902
Vigna subterranea 1 seed pods	13,03	4,16	7,7404
Vigna subterranea 1 roots	12,6	3,77	7,1338
Vigna subterranea 2 leaves	9,97	4,15	7,043
Vigna subterranea 2 stems	14,02	4,41	7,0804
Vigna subterranea 2 seed pods	9,72	3,8	6,1852
Vigna subterranea 2 roots	9,62	3,54	6,8442

Table L.7. Diagnostic count for mature *Vigna unguiculata* subsp. *unguiculata*.

	Rhomboidal/square/rectangular phytoliths (%)	Epidermal cell phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)
Vigna unguiculata subsp. unguiculata 1 leaves	98,5	0	1,5	0
Vigna unguiculata subsp. unguiculata 1 stems	38,5	61,5	0	0
Vigna unguiculata subsp. unguiculata 1 seed pods	44	56	0	0
Vigna unguiculata subsp. unguiculata 1 roots	-	-	-	-
Vigna unguiculata subsp. unguiculata 2 leaves	94	0	5	1
Vigna unguiculata subsp. unguiculata 2 stems	28	69,5	2,5	0
Vigna unguiculata subsp. unguiculata 2 seed pods	48,5	51,5	0	0
Vigna unguiculata subsp. unguiculata 2 roots	56,5	43	0,5	0
Vigna unguiculata subsp. unguiculata 3 leaves	95,5	0	2	2,5
Vigna unguiculata subsp. unguiculata 3 stems	48	50	1,5	0,5
Vigna unguiculata subsp. unguiculata 3 seed pods	43,5	55,5	1	0
Vigna unguiculata subsp. unguiculata 3 roots	61	38	1	0

Table L.8. Length of mature *Vigna unguiculata* subsp. *unguiculata* phytoliths.

	Maximum length (µm)	Minimum length (µm)	Average length (µm)
Vigna unguiculata subsp. unguiculata 1 leaves	12,19	5,72	8,2076
Vigna unguiculata subsp. unguiculata 1 stems	15,96	6,06	9,8778
Vigna unguiculata subsp. unguiculata 1 seed pods	11,5	4,96	7,4608
Vigna unguiculata subsp. unguiculata 1 roots	-	-	-
Vigna unguiculata subsp. unguiculata 2 leaves	14,1	5,09	8,2976
Vigna unguiculata subsp. unguiculata 2 stems	17,23	6,29	10,9354
Vigna unguiculata subsp. unguiculata 2 seed pods	13,89	5,73	8,4892
Vigna unguiculata subsp. unguiculata 2 roots	17,98	6,3	11,3778
Vigna unguiculata subsp. unguiculata 3 leaves	13,93	5,61	9,4902
Vigna unguiculata subsp. unguiculata 3 stems	15,88	7,43	10,6632
Vigna unguiculata subsp. unguiculata 3 seed pods	14,35	6,04	9,4646
Vigna unguiculata subsp. unguiculata 3 roots	17,47	7,44	12,2292

Table L.9. Width of mature *Vigna unguiculata* subsp. *unguiculata* phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Vigna unguiculata subsp. unguiculata 1 leaves	8,3	4,2	5,7184
Vigna unguiculata subsp. unguiculata 1 stems	9,69	4,51	6,8478
Vigna unguiculata subsp. unguiculata 1 seed pods	9,41	4,11	6,0244
Vigna unguiculata subsp. unguiculata 1 roots	-	-	-
Vigna unguiculata subsp. unguiculata 2 leaves	7,95	4,15	5,5598
Vigna unguiculata subsp. unguiculata 2 stems	9,03	4,29	6,5778
Vigna unguiculata subsp. unguiculata 2 seed pods	8,59	4,42	6,1044
Vigna unguiculata subsp. unguiculata 2 roots	13,84	4,62	7,4472
Vigna unguiculata subsp. unguiculata 3 leaves	11,32	3,31	6,2422
Vigna unguiculata subsp. unguiculata 3 stems	8,87	4,01	6,7844
Vigna unguiculata subsp. unguiculata 3 seed pods	9,23	4,23	6,1786
Vigna unguiculata subsp. unguiculata 3 roots	9,84	4,09	6,273

Table L.10. Length of juvenile Fabaceae domesticate phytoliths.

	Maximum Length (µm)	Minimum length (µm)	Average length (µm)
Arachis hypogaea 1 (1-2 Weeks)	NA	NA	NA
Arachis hypogaea 1 (1 Month)	16,53	5,9	8,189
Arachis hypogaea 2 (1-2 Weeks)	NA	NA	NA
Arachis hypogaea 2 (1 Month)	12,42	4,92	7,9262
Vigna subterranea 1 (1-2 Weeks)	NA	NA	NA
Vigna subterranea 1 (1 Month)	13,62	5,88	9,1662
Vigna subterranea 2 (1-2 Weeks)	NA	NA	NA
Vigna subterranea 2 (1 Month)	15,54	6,58	9,2932
Vigna unguiculata subsp. unguiculata 1 (1-2 Weeks)	13,8	5,8	8,4708
Vigna unguiculata subsp. unguiculata 1 (1 Month)	14,75	4,64	7,5756
Vigna unguiculata subsp. unguiculata 2 (1-2 Weeks)	13,32	5,87	8,4096
Vigna unguiculata subsp. unguiculata 2 (1 Month)	14,16	4,48	8,3814
Vigna unguiculata subsp. unguiculata 3 (1-2 Weeks)	NA	NA	NA
Vigna unguiculata subsp. unguiculata 3 (1 Month)	12,21	5,15	7,4678

Table L.11. Width of juvenile Fabaceae domesticate phytoliths.

	Maximum width (µm)	Minimum width (µm)	Average width (µm)
Arachis hypogaea 1 (1-2 Weeks)	NA	NA	NA
Arachis hypogaea 1 (1 Month)	13,25	4,11	6,626
Arachis hypogaea 2 (1-2 Weeks)	NA	NA	NA
Arachis hypogaea 2 (1 Month)	12	2,97	6,0618
Vigna subterranea 1 (1-2 Weeks)	NA	NA	NA
Vigna subterranea 1 (1 Month)	10,39	4,6	7,2868
Vigna subterranea 2 (1-2 Weeks)	NA	NA	NA
Vigna subterranea 2 (1 Month)	9,09	3,05	6,7654
Vigna unguiculata subsp. unguiculata 1 (1-2 Weeks)	8,62	3,9	5,9996
Vigna unguiculata subsp. unguiculata 1 (1 Month)	13,4	3,88	5,7268
Vigna unguiculata subsp. unguiculata 2 (1-2 Weeks)	3,45	6,77	5,2436
Vigna unguiculata subsp. unguiculata 2 (1 Month)	7,85	3,12	5,3786
Vigna unguiculata subsp. unguiculata 3 (1-2 Weeks)	NA	NA	NA
Vigna unguiculata subsp. unguiculata 3 (1 Month)	8,62	3,88	5,7436

Table L.12. Diagnostic counts for juvenile Fabaceae domesticates.

	Rhomboidal/square/rectangular phytoliths (%)	Epidermal cell phytoliths (%)	Hair cell phytoliths (%)	Stomata phytoliths (%)
Arachis hypogaea 1 (1-2 Weeks)	82,5	11,5	2	4
Arachis hypogaea 1 (1 Month)	95,5	1,5	3	0
Arachis hypogaea 2 (1-2 Weeks)	96,5	1	2,5	0
Arachis hypogaea 2 (1 Month)	93,5	2,5	4	0
Vigna subterranea 1 (1-2 Weeks)	94,5	5	0,5	0
Vigna subterranea 1 (1 Month)	76	19	5	0
Vigna subterranea 2 (1-2 Weeks)	74,5	23,5	2	0
Vigna subterranea 2 (1 Month)	70,5	27,5	2	0
Vigna unguiculata subsp. unguiculata 1 (1-2 Weeks)	88,5	10,5	1	0
Vigna unguiculata subsp. unguiculata 1 (1 Month)	90	6	3	1
Vigna unguiculata subsp. unguiculata 2 (1-2 Weeks)	76,5	21	2	0,5
Vigna unguiculata subsp. unguiculata 2 (1 Month)	94	3	3	0
Vigna unguiculata subsp. unguiculata 3 (1-2 Weeks)	62,5	21,5	13	3
Vigna unguiculata subsp. unguiculata 3 (1 Month)	93,5	0	3,5	3

APPENDIX M: RAINFALL AND TEMPERATURES

Table M.1. Time periods when Poaceae domesticates were cultivated.

Species	Season 1: (Oct 2012-Jan 2013)	Season 2: (Dec 2014- Mar 2015)	Season 3: (Oct 2015- Feb 2016)
E. coracana subsp. coracana 1 (Mature)			X
E. coracana subsp. coracana 1 (Juvenile: 1 Week)			X
E. coracana subsp. coracana 1 (Juvenile: 1 Month)			X
E. coracana subsp. coracana 2 (Mature)			X
E. coracana subsp. coracana 2 (Juvenile: 1 Week)			X
E. coracana subsp. coracana 2 (Juvenile: 1 Month)			X
P. glaucum 1 (Mature)		X	
P. glaucum 1 (Juvenile: 1 Week)			X
P. glaucum 1 (Juvenile: 1 Month)			X
P. glaucum 2 (Mature)			X
P. glaucum 2 (Juvenile: 1 Week)			X
P. glaucum 2 (Juvenile: 1 Month)			X
S. bicolor subsp. bicolor 1 (Mature)	X		
S. bicolor subsp. bicolor 1 (Juvenile: 1 Week)			X
S. bicolor subsp. bicolor 1 (Juvenile: 1 Month)			X
S. bicolor subsp. bicolor 2 (Mature)		X	
S. bicolor subsp. bicolor 2 (Juvenile: 1 Week)			X
S. bicolor subsp. bicolor 2 (Juvenile: 1 Month)			X
S. bicolor subsp. bicolor 3 (Mature)			X
S. bicolor subsp. bicolor 3 (Juvenile: 1 Week)			X
S. bicolor subsp. bicolor 3 (Juvenile: 1 Month)			X
Z. mays 1 (Mature)	X		
Z. mays 1 (Juvenile: 1 Week)			X

Z. mays 1 (Juvenile: 1 Month)			X
Z. mays 2 (Mature)		X	
Z. mays 2 (Juvenile: 1 Week)			X
Z. mays 2 (Juvenile: 1 Month)			X

Table M.2. Time periods when Fabaceae domesticates were cultivated.

Species	**Season 1: (Oct 2012-Jan 2013)**	**Season 2: (Dec 2014- Mar 2015)**	**Season 3: (Oct 2015- Feb 2016)**
A. hypogaea 1 (Mature)	X		
A. hypogaea 1 (Juvenile: 1 Week)			X
A. hypogaea 1 (Juvenile: 1 Month)			X
A. hypogaea 2 (Mature)			X
A. hypogaea 2 (Juvenile: 1 Week)			X
A. hypogaea 2 (Juvenile: 1 Month)			X
V. subterranea 1 (Mature)	X		
V. subterranea 1 (Juvenile: 1 Week)			X
V. subterranea 1 (Juvenile: 1 Month)			X
V. subterranea 2 (Mature)		X	
V. subterranea 2 (Juvenile: 1 Week)			X
V. subterranea 2 (Juvenile: 1 Month)			X
V. unguiculata 1 (Mature)		X	
V. unguiculata 1 (Juvenile: 1 Week)			X
V. unguiculata 1 (Juvenile: 1 Month)		X	
V. unguiculata 2 (Mature)		X	
V. unguiculata 2 (Juvenile: 1 Week)			X
V. unguiculata 2 (Juvenile: 1 Month)		X	
V. unguiculata 3 (Mature)		X	
V. unguiculata 3 (Juvenile: 1 Week)			X
V. unguiculata 3 (Juvenile: 1 Month)		X	

Table M.3. Rainfall (mm) at Bokoni Farmscapes experimental garden during the period that crops were cultivated (2012).

Day of the month	SEP	OCT	NOV	DEC
1	-	-	-	16
2	-	-	-	4
3	-	-	-	2
4	-	-	-	-
5	-	-	-	2
6	20	-	1	-
7	85	-	-	-
8	37	-	26	-
9	-	-	4	-
10	-	-	-	14
11	-	-	-	-
12	-	60	-	-
13	-	18	-	-
14	-	1,5	-	-
15	2	-	-	-
16	1	-	5	-
17	-	48	2	41
18	-	-	12	-
19	-	-	-	-
20	-	8	-	21
21	-	2	-	
22	-	-	15	
23	-	-	-	100
24	-	1	60	
25	-	-	15	
26	-	5	-	
27	-	-	-	
28	-	-	-	
29	-	-	-	
30	-	-	-	
31	-	-	-	6
Total rainfall	145	143,5	140	206

Table M.4. Rainfall (mm) at Bokoni farmscapes experimental garden during the period that crops were cultivated (2013).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3	1	11	-	-	-	-	-	-	-	-	11
2	-	-	12	5	-	-	-	-	-	-	-	-
3	-	-	32	30	-	-	-	-	-	-	-	10
4	-	-	-	-	-	-	-	-	-	-	-	10
5	-	18	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	2
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	7	-	-	-	-	-	-	18	-	-
9	-	16	-	-	-	-	-	-	-	-	-	2
10	-	5	12	-	-	-	-	3	-	-	-	30
11	39	-	-	-	-	-	-	-	-	19	11	34
12	1	-	-	-	-	-	-	-	-	-	-	8
13	-	12	-	16	-	-	-	-	-	-	4	28
14	-	-	-	1	-	-	-	-	-	-	10	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	7	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	7	-	-	-	-	-	-	-	-	-	-	28
19	15	-	-	-	-	-	-	-	-	30	-	4
20	24	-	-	26	-	-	-	-	-	12	-	-
21	12	-	-	34	-	-	-	-	-	23	36	-
22	-	-	-	-	-	-	-	-	-	16	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	5	-	-	-	-	-	-	2	-	-
27	-	-	-	-	-	-	-	-	-	28	-	12
28	-	-	4	-	-	-	-	-	-	11	28	-
29	-	-	-	-	-	-	-	-	-	18	46	-
30	-	-	-	-	-	-	-	-	16	8	-	10
31	18	-	-	-	-	-	-	-	-	11	-	8
Total rainfall	126	52	83	112	0	0	0	3	16	196	135	197

Table M.5. Rainfall (mm) at Bokoni farmscapes experimental garden during the period that crops were cultivated (2014).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	-	-	-	-	-	-	-	-	-	17	17,5
2	-	-	8	-	-	-	-	-	-	-	-	-
3	-	5	10	2	-	-	-	-	-	-	1	-
4	-	-	30	-	-	-	-	-	-	2	5	-
5	-	-	70	-	-	-	-	-	-	-	-	-
6	-	-	38	-	-	-	-	-	-	-	-	34
7	-	22	35	-	-	-	-	-	-	-	-	15
8	-	-	-	-	-	-	-	-	-	-	6	-
9	-	-	18	3	-	-	-	-	-	-	-	12
10	5,5	-	4	-	-	-	-	-	-	-	-	-
11	5	-	1	-	-	-	-	-	-	-	15	5
12	40	-	-	-	-	-	-	-	-	-	5,5	28
13	-	-	6	-	-	-	-	-	-	-	-	5
14	7	2	2	-	-	-	-	-	-	2	-	-
15	-	-	-	-	-	-	-	-	-	-	12	-
16	-	-	-	2	-	-	-	-	-		3	-
17	-	-	-	3	-	-	-	-	-	7	7	12
18	-	-	1	-	-	-	-	-	-	-	12	1
19	-	-	10	-	-	-	-	-	-	-	-	4
20	16	-	-	-	-	-	-	2	-	-	-	36
21	-	-	-	-	-	-	-	-	-	-	-	3
22	-	-	-	-	-	-	-	-	-	4	-	-
23	-	-	-	1	-	-	-	-	-	1	-	3
24	-	6,5	-	-	-	-	-	-	-	6	-	3
25	26	-	-	-	-	-	-	-	-	15	3	-
26	-	-	-	-	-	-	-	-	-	-	25	-
27	2	-	-	-	-	-	-	-	-	-	3,5	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	5	4	-
31	5	-	14	-	-	-	-	-	-	6	-	-
Total rainfall	106,5	35,5	247	11	0	0	0	2	0	48	119	178,5

Table M.6. Rainfall (mm) at Bokoni farmscapes experimental garden during the period that crops were cultivated (2015).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	9	-	-	-	-	-	-	-	-	-	-	5
2	-	8	-	-	-	-	-	-	-	-	-	-
3	-	18	-	-	-	-	-	-	-	-	-	2
4	14	-	-	-	-	-	-	-	-	-	-	22
5	-	-	-	-	-	-	-	-	5	-	-	10
6	55	-	-	-	-	-	-	-	19	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	36	-	12	-	-	-	-	-	-	-	28
9	-	7	-	15	-	-	-	-	-	-	-	-
10	-	-	-		-	-	-	-	-	-	-	-
11	-	-	-	10	-	-	-	-	-	-	-	-
12	-	-	-	-	1,5	-	-	-	-	-	-	16
13	-	-	-	-	-	-	-	-	-	-	-	10
14	-	-	-	-	-	-	-	-	-	-	8	17
15	2	-	-	-	-	-	-	-	-	4	7	20
16	-	-	5	-	-	-	-	-	-	4	-	-
17	3	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	2	-
19	-	-	-	-	-	-	-	-	-	15	7	-
20	-	-	5	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	14	-
22	4	-	-	-	-	-	-	-		3	-	-
23	-	-	18	18	-	-	-	-	8	-	-	-
24	-	-	-	-	-	-	-	-	13	8	-	6
25	-	24	-	-	-	-	-	-	-	40	-	9
26	-	-	-	-	-	-	-	-	-		16	38
27	-	-	-	60	-	-	-	-	-	14	-	-
28	-	-	2	-	-	-	-	-	-	-	-	-
29	-	-	9	-	-	-	-	-	-	-	-	-
30	28	17	25	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
Total rainfall	115	110	64	115	0	1,5	0	0	45	88	54	183

Table M.7. Rainfall (mm) at Bokoni farmscapes experimental garden during the period that crops were cultivated (2016).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN
1	-	-	-	-	-	-
2	5	-	-	-	-	-
3	-	-	-	-	-	-
4	-	9	-	-	-	-
5	-	10	-	-	-	-
6	-	-	-	5	-	-
7	-	-	-	3	-	-
8	10	-	-	-	-	-
9	24	-	14	-	-	-
10	4	-	12	-	-	-
11	15	12	20	-	-	-
12	4	-	22	-	-	-
13	5	-	-	-	-	3
14	7	-	-	-	-	-
15	-	-	5	-	-	-
16	3	4	3	-	-	-
17	-	-	5	-	-	-
18	-	-	6	-	-	-
19	-	31	-	15	-	-
20	-	-	36	-	-	-
21	-	-	-	-	-	-
22	-	34	-	-	-	-
23	3	-	-	-	-	-
24	-	-	-	-	-	-
25	-	30	-	-	-	-
26	24	-	-	-	8	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
Total rainfall	104	130	123	23	8	3

Table M.8. Rainfall (mm) data from the Belfast weather station (2012) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	0.2	0.2	-	-	-	-	-	-	-	-	2.8
2	9.2	-	0.2	-	-	-	-	-	-	-	-	0.2
3	2.6	-	-	-	-	-	-	-	-	-	-	2.6
4	-	-	-	-	-	-	-	-	-	-	-	2.4
5	50.8	-	-	-	-	-	-	-	17	-	-	8
6	11.6	10.4	-	0.2	-	-	-	-	80.8	-	0.6	0.6
7	0.2	1.6	18	-	0.2	-	-	-	24.4	-	12.2	-
8	17	-	0.4	-	-	-	-	0.2	2.4	-	15.2	0.2
9	0.6	-	8	-	-	-	0.2	-	-	-	-	19.6
10	14.4	22.8	0.2	-	-	-	-	-	-	-	5.2	0.2
11	-	2.4	19.4	-	0.2	-	-	-	-	67.2	-	3.2
12	-	-	1.2	-	-	-	-	-	-	26.2	-	-
13	0.8	-	-	0.2	-	-	-	-	1.4	5.8	-	-
14	6	-	-	-	-	-	-	-	3.4	0.2	4	3.2
15	-	-	-	-	-	-	-	-	0.6	-	4.6	3.2
16	8	-	15.4	-	-	-	-	-	-	47.2	3.4	13.8
17	19.4	-	-	-	-	-	-	-	-	3	14.2	0.4
18	4.4	2.8	-	4.4	-	-	-	-	-	-	0.6	8.6
19	-	4.2	-	-	-	-	-	-	-	8.4	-	-
20	-	5.8	0.2	0.4	-	-	-	-	-	0.8	-	-
21	-	-	-	5.8	-	-	-	-	-	0.2	7.8	-
22	2.8	-	0.2	-	0.2	0.4	-	-	-	-	-	-
23	15.4	0.8	-	34.4	-	-	-	-	-	0.8	87	-
24	0.6	0.2	-	5.4	-	-	-	-	-	-	26.6	0.2
25	-	0.2	-	-	-	-	-	-	-	3.4	-	52.2
26	-	-	-	0.2	-	-	-	-	-	-	-	8.2
27	0.2	0.2	-	-	-	-	-	-	-	0.8	-	3
28	4	0.2	1.2	-	-	-	-	-	-	0.2	-	5.8
29	5.4	-	11.6	-	-	-	-	-	-	-	2	3.8
30	-	-	30.6	-	-	-	-	-	-	-	6.2	-
31	-	-	1.6	-	-	-	-	-	-	-	-	3.6
Total rainfall	173.4	51.8	108.4	51	0.6	0.4	0.2	0.2	130.0	164.2	189.6	145.8

Table M.9. Rainfall (mm) data from the Belfast weather station (2013) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	25.2	0.2	10.8	-	-	-	-	0.2	-	-	-	-
2	-	0.2	8.6	7.6	-	-	-	-	-	-	5.2	12.2
3	-	0.6	-	26	-	-	-	0.2	-	-	-	13
4	-	25.2	0.2	-	-	-	-	-	-	-	-	-
5	0.2	0.2	3.4	-	-	-	-	-	-	-	-	4.4
6	0.2	-	0.4	-	-	-	-	-	-	-	-	0.6
7	-	7.2	2	-	-	-	0.2	-	-	30.6	-	-
8	-	1.2	0.2	-	-	-	-	-	-	0.2	-	3.6
9	-	1.2	1.2	-	-	-	-	3.6	-	-	0.2	8.8
10	52.4	0.4	0.4	2	-	-	-	0.2	-	3	-	33.4
11	1.6	-	-	-	4.6	-	-	-	-	-	-	19
12	1	0.8	-	4	-	-	-	-	-	-	-	9.6
13	-	0.2	0.2	-	-	-	-	-	0.2	-	-	3.4
14	1.8	13.2	0.2	0.4	0.2	-	-	-	-	-	-	-
15	12.4	-	11.6	0.2	-	-	-	-	-	-	-	-
16	0.2	-	-	-	-	-	-	-	-	-	-	-
17	22.4	-	-	-	-	-	-	-	-	-	1.4	14
18	34.4	0.2	0.2	-	0.2	-	-	-	-	7.4	-	6.4
19	25	-	-	28.2	-	-	-	-	-	23.4	-	3.4
20	6.8	-	0.4	28.8	-	-	-	-	-	29	28.8	0.2
21	-	12.2	-	0.2	-	-	-	-	0.4	14.6	0.6	-
22	-	0.2	0.2	-	-	-	-	-	0.2	-	3	-
23	-	0.2	-	0.2	-	-	0.2	-	-	-	0.2	-
24	-	-	16.8	0.2	-	-	-	-	-	-	-	-
25	-	0.2	0.8	-	-	-	-	-	-	0.4	7.8	-
26	-	1.6	-	0.2	-	-	-	-	-	15.4	4	-
27	7.2	0.2	2.6	0.2	-	-	-	-	-	20.8	16.2	-
28	-	31.2	1.4	-	-	-	-	-	0.4	56.2	41.4	-
29	-	-	7.4	-	-	-	-	-	19	0.8	0.4	-
30	1	-	-	0.2	-	-	0.2	-	0.2	10.4	23.2	-
31	-	-	-	-	-	-	-	-	-	13.6	-	-
Total rainfall	191.8	96.6	69.0	98.4	5	0	0.6	4.2	20.4	225.8	132.4	132.0

Table M.10. Rainfall (mm) data from the Belfast weather station (2014) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	-	12.2	-	-	-	-	-	-	-	-	-
2	-	2.4	16.6	3.2	-	-	-	-	-	-	3	-
3	-	-	10	-	-	-	-	-	-	4	3.8	-
4	-	0.2	23.8	8.4	-	-	-	-	-	-	-	-
5	-	-	98.2	-	-	-	-	-	-	-	-	6.8
6	-	7.6	15	-	-	-	-	-	-	-	-	45
7	-	0.8	1.6	0.2	-	-	-	-	-	-	7.4	3.4
8	-	0.6	3.8	1.2	-	-	-	-	-	-	6	8.8
9	-	-	0.6	2.4	-	-	-	-	-	0.2	0.2	-
10	11	0.2	10.6	2.6	-	-	-	-	-	-	3.2	30
11	0.2	-	2.2	-	-	-	-	-	-	-	1.2	6
12	-	-	1.6	0.2	-	-	-	-	-	-	0.2	-
13	-	-	7	-	-	-	-	0.2	-	1.2	-	-
14	-	0.2	0.2	2.4	-	-	-	-	-	-	-	-
15	2.4	-	0.2	-	-	-	-	0.8	-	-	5.8	18
16	-	-	-	5.4	-	-	-	1.2	-	1.4	15.8	5
17	0.2	0.2	1	0.2	-	0.2	-	0.2	-	0.4	6.2	0.8
18	-	0.2	2	-	-	-	-	-	-	-	0.2	0.4
19	43.2	-	0.2	-	-	-	-	-	-	-	-	34
20	-	6.4	-	-	-	-	-	-	-	-	0.6	0.2
21	-	1.8	-	-	0.2	-	-	-	-	19	2.2	-
22	-	0.4	-	-	-	-	-	-	-	1.4	3.8	1.6
23	-	-	0.2	0.8	-	-	-	-	-	4	1.8	0.8
24	21.4	0.4	-	-	-	-	-	-	-	3	9.4	-
25	0.4	2.6	0.4	-	-	-	-	-	-	3.4	3.4	-
26	1.4	0.2	-	-	-	-	-	-	-	0.2	13	9.8
27	0.8	5.6	10.8	-	-	-	-	-	-	-	-	9.6
28	0.4	-	-	-	-	-	0.2	-	-	-	-	59
29	4.2	-	-	-	-	-	0.2	-	3	3	24.6	-
30	1.2	-	2.6	-	-	-	-	-	-	-	19.4	-
31	1.2	-	4	-	-	-	-	-	-	17	-	2.4
Total rainfall	88.0	29.8	224.8	27	0.2	0.2	0.4	2.4	3	58.2	131.2	241.6

Table M.11. Rainfall (mm) data from the Belfast weather station (2015) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	19.6	4.6	5.4	-	-	0.2	-	-	-	1.8	-	-
2	-	12.2	0.2	0.2	-	0.2	-	-	-	-	-	0.8
3	4.2	-	-	2.4	-	-	-	-	0.8	-	-	37.6
4	-	0.8	-	3.4	--	-	-	-	8.6	-	-	1
5	5	0.8	-	-	-	-	-	-	16.2	-	-	1.4
6	2.8	-	0.2	-	0.2	-	-	-	-	-	-	-
7	-	7.2	6.6	11	-	-	-	-	-	0.2	-	5.2
8	0.2	-	1.6	29.8	-	-	-	-	0.6	-	-	-
9	-	0.6	-	-	-	-	-	-	-	-	-	-
10	0.2	6.6	-	0.2	0.2	-	-	-	-	-	-	-
11	-	0.2	-	-	-	1	-	-	-	-	-	0.6
12	0.2	-	-	0.2	-	-	-	-	-	-	-	7
13	1	-	6	0.2	0.2	-	-	-	0.2	-	5.4	-
14	0.6	4.4	-	-	-	-	-	-	-	10.4	5.8	35
15	-	0.4	-	-	-	-	-	-	-	1.4	1.2	-
16	2.8	0.2	7.6	-	-	-	-	-	-	2.6	2.8	-
17	-	-	14.6	-	-	-	-	-	-	0.2	1.8	-
18	-	-	-	1.6	-	-	-	-	-	-	5.8	-
19	-	-	3.6	0.2	-	-	-	-	-	-	-	-
20	-	0.2	0.2	-	-	0.2	-	-	-	-	-	9.4
21	1	-	4.4	-	-	-	-	-	-	7.6	-	-
22	12	-	35.6	21.6	-	-	-	13.8	4.2	-	-	-
23	0.2	0.2	-	3.8	-	-	-	0.2	9.8	0.2	-	-
24	-	5.4	-	9.2	-	-	6.8	-	0.2	21	-	-
25	6.6	0.6	-	-	-	-	-	-	-	-	-	1.2
26	-	-	-	-	-	-	-	-	-	5.2	-	61
27	15	-	1.6	9.6	-	-	-	-	-	-	-	0.2
28	0.2	15	3.8	-	-	-	-	-	-	-	-	0.2
29	41.2	-	1	-	-	-	-	-	-	-	-	-
30	3.4	-	27	-	-	-	-	-	-	-	-	-
31	3	-	-	-	-	-	-	-	-	-	-	-
Total rainfall	119.2	59.4	119.4	93.4	0.6	1.6	6.8	14	40.6	50.6	22.8	160.6

Table M.12. Rainfall (mm) data from the Belfast weather station (2016) (data from the South African Weather Service).

Day of the month	JAN	FEB
1	10.6	-
2	-	-
3	-	22.2
4	-	12
5	-	2.8
6	-	1.4
7	9	3.4
8	17.8	5.4
9	10.2	23.8
10	6	7
11	-	-
12	9	-
13	9.2	-
14	-	0.6
15	7.6	-
16	0.6	1.8
17	-	-
18	-	12.6
19	6.8	-
20	-	11.2
21	-	5.2
22	6	1.4
23	-	0.2
24	2.2	20.8
25	5.2	8
26	-	12.2
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
Total rainfall	100.2	152.0

Table M.13. Daily maximum temperature (ºC) data from the Belfast weather station (2012) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	24.4	25.1	23.1	14.6	25.8	17.7	21.6	18.5	27.1	26.1	14.8	16.7
2	25.7	24.1	21.9	16.5	23.8	19.7	21.4	19.6	19.8	28.9	17.8	18.9
3	27.3	25.2	24.1	17.3	25.9	15.9	21.4	21.2	12.5	28.5	-	-
4	26.4	25.6	27.2	21.4	26	18.9	20.1	22.3	21.2	31.2	-	-
5	27.6	23.5	25.1	19.2	27.6	18.7	19.6	22.6	11.2	29.1	-	-
6	25.6	22.8	20.1	18.3	26.2	17.2	20.6	19.5	10.5	29.5	-	22.2
7	23.3	25.5	23.6	19.8	22.7	16.6	20.3	6.7	11.1	29.7	-	-
8	25.4	27	24.1	21.6	19.9	18.3	18.4	10.5	16.3	20.5	-	27.2
9	23.8	23.9	25.8	21.2	21.9	10.4	17.9	15.9	19.9	23.8	-	25.2
10	23	25.4	26.5	20.7	22.2	12.2	18.7	18.1	23.5	22.1	-	20.1
11	24.9	22.6	21.6	19.2	18.9	13.9	18.9	21.6	21	23.2	24.4	-
12	25.8	23.9	23.2	19.9	20	18.4	16	12.9	23.5	14.2	-	17.3
13	25.7	23.4	24	16.4	19.4	17.4	15.6	17.5	24.7	18.9	-	-
14	20.6	24.5	23.2	18.5	20.4	14.3	17.2	21.5	15.2	20.2	-	-
15	20.9	25.9	20.9	20.4	19.6	14.4	12.8	23.4	10.3	23.3	24.8	-
16	18.6	27.6	18.8	19.8	18.8	16.5	15.4	23	12.8	24.8	26.6	-
17	15.4	28	23.4	21.3	19.6	15.3	15.6	11.2	17.6	22.4	28.7	-
18	14.9	24	23.2	20.7	20.3	18.9	15.3	19	22.2	24	-	21.7
19	19.4	20.3	21.5	20	20.8	16.8	18.8	21.4	25.3	26.7	-	-
20	20.8	24.4	22.5	21.3	20	18.6	18.5	26.5	25.5	18.9	27.9	25.2
21	24.8	25.1	23.3	20.6	17.5	14	20.8	26	25.1	18.2	27.9	-
22	22.9	26.3	24.3	19.1	17.5	15.5	20.1	25.1	22.3	24.2	21	25.6
23	21.4	28.4	22.9	16.3	17.4	19.2	20	26.7	24	15.5	24.9	-
24	22.5	23.6	21.2	12.5	22	16.3	17.6	28	24.3	11.6	18.7	-
25	20.8	26.3	22.2	16.8	19.4	14.1	18.4	27.3	22.2	17.8	21.9	27.6
26	20.8	25.5	24.9	19.6	22	16.6	19.1	27.1	23.9	22.5	23.2	23.4
27	22.8	23.3	24.8	21	17.5	19.3	19.7	23.4	28	21.3	20.7	-
28	24.5	24.3	20.3	23.1	17	20.1	18.7	23.9	26.1	21.6	23.2	27
29	23.1	23.7	17	23.6	18.3	20.9	16	25.8	21.1	21.7	-	-
30	25.2	-	22.4	24.5	18.6	22	17.9	26	24.2	23.3	23.1	28.3
31	23.6	-	20.3	-	15.6	-	17.5	25.7	-	17.5	-	23.1
Average maximum temperature	23	24.8	22.8	19.5	20.7	16.9	18.4	21.2	20.4	22.6	23.1	23.3

Table M.14. Daily maximum temperature (ºC) data from the Belfast weather station (2013) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	22.2	18.3	25.3	20.8	24.4	24.4	-	-	-	22.6	22.6
2	-	25.2	18.2	27.4	22.1	21.7	22.1	-	20.9	-	15.5	22.2
3	-	27.4	21.5	18.7	22.6	21.9	25.3	-	-	24.3	18.6	22
4	-	26.8	22.9	9.7	20.7	21.8	15.9	-	-	26.9	23	23.8
5	-	18.2	25.1	22.5	17.3	21.6	20.4	-	20.3	30.8	25.3	18.6
6	-	23	28.2	23.5	17.4	20.4	14.6	-	12.9	19	25.8	17.5
7	-	27.4	25.7	28.8	9.7	25.6	23.3	23.5	23.5	22.1	21.8	19.5
8	-	30.9	23.5	26.7	20.1	20.8	-	-	25.2	19.5	25.8	21.3
9	-	27.3	-	-	20.6	9	12.1	-	28.1	23	24.8	23
10	-	24.7	18.4	28	19	9.2	-	-	30	23.7	20.9	15.1
11	23.9	24.8	20.4	12	17.9	-	15.5	-	26.6	26	20.8	20.3
12	19.1	24.7	20.7	21.9	19.4	-	-	-	22.4	27.7	-	23.1
13	20.2	25.8	17.5	21.3	19.3	-	-	-	30.6	24.2	-	22.2
14	24.5	31.9	21.7	22	20.2	20.9	-	-	-	15.6	-	25.2
15	20.8	27.3	22.7	26.7	19.9	20.9	-	-	-	21.3	26.4	26.3
16	20	24	26.8	28.5	20.2	17.5	-	-	-	25.7	25	23.8
17	24.4	25.5	26.7	29.6	26.2	15.1	-	-	30.2	24.5	26.2	22.9
18	24.5	29.2	24.5	27.5	20.2	17	-	-	27.4	24	26.8	20.1
19	19.1	31.5	26.1	-	20.2	19.5	-	18.7	28.1	13.6	24	18
20	17	31.9	27.2	17.3	19.1	19.3	-	22	27.6	11.9	24.9	22
21	-	28.9	20.3	17.2	12.1	20.6	-	20.8	-	15	16.4	25.1
22	-	25.9	25.8	25.3	28.3	21	-	19.3	-	9.8	18	25.5
23	-	28.1	30	-	20.7	19.8	-	-	-	15.3	24.8	-
24	27.9	24.9	28.8	-	18.5	22.5	-	20.9	-	18.5	20.5	-
25	29.2	22.8	22.9	-	21.8	24.8	-	17.2	-	20.7	22.7	-
26	23.8	25.5	22.9	20.2	21.2	20.6	-	21.2	-	21.3	23.8	-
27	26.4	27.4	20.8	20.4	21.3	22.6	-	22.6	-	21.5	21.6	-
28	23.3	27.3	24.7	26.7	22.4	15.9	-	22.7	-	17.8	14.2	-
29	22	-	24.4	12.1	16.4	20.9	-	-	-	19.9	17	-
30	24.2	-	23.3	21.3	21.1	22.8	-	-	-	22.7	23.6	-
31	25.5	-	20.9	-	23.8	-	-	-	-	22.8	-	-
Average maximum temperature	23.1	26.4	23.4	22.4	20	19.9	19.3	20.9	25.3	21.0	22.3	21.8

Table M.15. Daily maximum temperature (ºC) data from the Belfast weather station (2014) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	25.2	23.7	21.8	22.7	22	16.9	18.2	16.9	20.9	21.4	22.4
2	-	24.8	19.8	22.8	24.4	21.3	16.6	19	17.2	19.8	22	22.6
3	-	20.6	17.5	23.5	24.1	20.9	15.6	18.9	17.2	18.4	22.2	25.1
4	-	24.5	20.9	18.3	22.4	19.9	16.1	17.6	18.7	18	20.5	26.5
5	-	25.7	18.7	20.8	23	19.4	17.2	20.3	18.7	22	24.7	28.7
6	-	21.9	22.1	18.9	14.1	8.6	18.4	22	22.6	24.8	22.3	23.9
7	-	21.2	19.9	18	19.5	12.9	16.7	20.7	24.2	25	23.2	21.4
8	22.5	25.6	21.6	17.4	19.6	17.6	9.3	15.1	27	26.5	21.7	23.2
9	22.9	23.1	22.7	15.8	20.1	18.4	11.1	18.2	26.2	29.3	25.9	17.3
10	23.9	22.2	16.5	16.7	21.3	17.5	10.9	17.4	28	16.1	24.6	21.7
11	23.9	25.5	19	17.1	19.7	15.7	13.5	16.7	26.6	20.2	14.1	24
12	23.1	24.7	20.8	17.7	18.7	17	14.3	16.2	28.5	27.1	20.7	20.2
13	26.8	22.5	15.7	19.6	19.9	16.7	16.6	19.3	26.3	28.1	23	19.7
14	21.1	21.5	15.1	18	19.9	16.3	16.6	21.8	28.3	25.4	25.3	23.3
15	25.4	20.3	22.9	19.4	19.7	19.6	15.8	22	28.6	21.7	22.4	24.2
16	25.1	22.8	24.8	12.9	20.8	19	17.2	12.4	26.5	20.2	15.5	15.4
17	24.3	21.4	23.6	16.8	20.3	16.4	18.6	14.2	28.6	15.8	9.9	16.5
18	24.1	26.5	23.1	19.6	14.8	18.4	20.2	18.7	27.9	19.4	16.8	22
19	24.2	24.1	23	21.3	17	15.8	17.1	21.5	25.3	24.9	19.5	22.5
20	23.6	24.3	25.4	22.6	16.1	16.2	16.8	23.6	12.5	26.2	22.7	26.1
21	22.3	20	19.9	22.8	17.8	17.9	15.4	23.4	21.7	25.5	24.3	26.6
22	23.4	20.3	21.6	20.2	16.9	19	15.9	16.6	21.3	22.3	25.3	25.1
23	24.1	24.5	25.1	20.3	19.6	18.8	18.6	16.8	24.5	23.9	20.7	24.6
24	23.7	23.4	20.9	20	22.5	19.9	19.7	17	24.4	26.7	24.1	26.3
25	24.8	22.7	22.9	19.6	21.8	17.7	19.8	19.4	26.4	22.6	23.1	27.1
26	18.7	19.8	24.3	19.3	22.4	18.3	19.3	22.5	27.4	12.5	23.9	24.8
27	19.3	22	22.6	21	22.2	19.6	18.3	22.5	28.2	20.1	19.7	21
28	20.8	24.4	17.5	18.7	19.8	16.3	18.4	24.3	19.7	23.8	24.7	22.5
29	23	-	21.2	22	21	17.3	11.8	10.9	22.1	26.2	21.2	17.9
30	24.8	-	22.4	23.7	22.1	17.6	15.8	15.2	24.8	28.6	22	23.3
31	22	-	20.4	-	22	-	17.5	16.4	-	24.9	-	21.3
Average maximum temperature	23.2	23.1	21.1	19.6	20.2	17.7	16.3	18.7	23.9	22.8	21.6	22.8

Table M.16. Daily maximum temperature (ºC) data from the Belfast weather station (2015) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	20.2	23.6	21.9	23.4	21.2	18.7	16.2	15.8	23.9	25.5	29.2	-
2	25.2	22.8	16.6	23.1	20.9	16.9	17.6	17.5	25.4	23.9	25.5	28.9
3	26.1	24.9	19	23.1	22.7	17.3	17.9	18	12.5	26.2	16.3	22.8
4	26.3	24.2	23.2	18.6	23.6	14.1	17.4	19.5	11.4	28.8	16.3	25.8
5	26.4	26.2	26.2	22	22	12.5	19.5	21	11.2	30	21.6	28.2
6	24.9	25.7	22.4	16	24.7	12.1	18.9	19.5	14.1	28.5	25	27.8
7	23	27	23.2	18.7	17.1	14.1	13.8	19.9	21.3	28.6	26.7	29.5
8	24.5	26	22.9	16.3	18.7	15.5	14.9	22.3	24.7	29.4	28.7	23.7
9	24.2	26.9	21.3	17.3	20.8	17.6	17.5	21.5	24.7	29.1	30.9	26.5
10	24.1	28.5	25.5	18	20.8	14.2	16.9	16.7	28.9	26.7	31.2	28.9
11	24.1	26.9	22.6	19.5	19.2	15.6	13.7	14.8	28.6	28.5	31.8	28.4
12	21.8	25.3	20.9	19.8	18.4	15.6	18.1	16.5	21	26.3	31.3	26.2
13	26.5	26.4	24.9	20.1	19.5	17.5	21.1	21.3	12.4	30.1	29.4	26.4
14	20.7	24	22.4	22.6	23.8	19.4	15.7	23.2	22.1	26.3	21.9	20.1
15	23	18.5	25	23	24.5	20.5	19.1	22.8	24.1	21.9	25.7	21.7
16	24.1	19.1	25.2	21.4	24.6	19.5	22.7	23.9	27.5	16.5	14.6	23.6
17	17.3	20.9	23.9	18.2	18.6	11.5	-	23.5	27.2	15.9	19.3	19.5
18	19.9	26.1	22.3	18.9	22.6	17	19.1	23.4	24.4	24	22	27.1
19	21.3	27.1	21.4	18	23.2	16.4	20.3	24.1	20.8	25.8	22.1	28.6
20	21.8	26.2	25.4	19.5	21.9	14.3	21.1	22	21.9	22.6	16.9	27.5
21	24.7	28.1	23.1	21.3	22.9	16.1	19.6	24.4	21.9	25.8	-	27.3
22	23.7	21.8	22.2	18.7	14.7	16.9	14.4	26.2	25.9	18	-	28
23	25.8	24.9	23.2	20.9	18.9	17	-	24.1	28.3	23.7	-	25.7
24	25.2	25.3	24.7	20	22	17.6	11.1	25	28.2	25.8	-	28.1
25	24.8	22.9	25.5	21.3	21.1	18.9	17.7	24.6	28.3	25.8	-	23.5
26	26.3	25.8	22.3	22.7	23.1	12.4	12.4	24.8	27.5	23.8	-	19.5
27	27.6	23.5	24.3	21.7	22.2	15.8	15.4	24.4	27.8	19.2	-	25.1
28	21.3	19.7	23	22	21	16.1	16.3	25	29.1	21.2	-	26.3
29	20.8	-	18.7	22.5	22.9	17.2	19.2	25.7	28.6	20.1	-	26.3
30	22.1	-	20.9	22.9	23.6	15.1	20.3	26.1	27.1	23.2	-	23.6
31	24.1	-	19.9	-	23.1	-	12.3	25.2	-	29.2	-	25.1
Average maximum temperature	23.6	24.6	22.7	20.4	21.4	16.1	17.2	22	23.4	24.9	24.3	25.7

Table M.17. Daily maximum temperature (ºC) data from the Belfast weather station (2016) (data from the South African Weather Service).

Day of the month	JAN	FEB
1	26.1	24
2	24.7	27.6
3	24.1	28.5
4	26.2	25
5	28.3	18
6	31.1	22.8
7	32.1	26.6
8	20.6	24.1
9	22	24.3
10	24.3	23.5
11	22.6	26.7
12	21.9	26.5
13	24.2	29
14	20	25.5
15	21.1	28.4
16	18.6	27.2
17	19.5	25
18	19.9	25.6
19	23.4	27.2
20	22.8	29.5
21	21.5	26.1
22	22.2	20.2
23	23.8	20.2
24	23.8	26.1
25	25.2	25.4
26	20.9	21.9
27	27.1	16.7
28	25.4	21.1
29	23.8	23.9
30	25.2	-
31	25.2	-
Average maximum temperature	23.8	24.7

Table M.18. Daily minimum temperature (ºC) data from the Belfast weather station (2012) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	12.7	7.4	12.9	8.5	9.2	2	3.1	-0.6	8.7	5.1	4.6	12.7
2	12.6	12	11.8	7.2	9.6	4.7	3.6	-3	6.7	8.2	5.5	13.4
3	11.3	10.3	9.8	4.9	8.6	2.7	2.5	0.9	10.3	9.4	-	-
4	13.9	13	12.5	3.1	7.9	1.1	1.5	3	7.9	11	-	-
5	10.4	14.9	12.8	6.2	9.7	2.5	3.9	4.9	8.2	13.2	-	-
6	11.7	14.9	13.3	6.2	10.8	3.4	0.8	3	4.7	11.2	-	13.8
7	14.3	13.6	12.4	2.9	9.5	0.9	5.1	-0.8	5.7	9.1	-	-
8	13	15.8	11.4	6.1	8.2	4.4	6.1	1.4	6.5	11.2	-	14.5
9	13.9	16.1	11.4	8.3	6.8	0	5.8	0.8	5.2	12.7	-	13.4
10	13.1	13.9	13.2	2.8	5.6	-2	1.9	-0.1	9	13.6	-	12.9
11	13.3	14	11.8	2.5	8.9	-3	1.9	4.2	8.5	11	12.5	-
12	15.4	11.8	10.7	7.1	4.3	-1.3	5.3	-0.9	5.8	11.4	-	10.5
13	15	14.4	11.2	4.4	4.9	-1.6	3.1	-2	6.9	11.5	-	-
14	14.3	14.4	11.7	0.3	6.5	3.3	3	-0.7	7.7	11.3	-	-
15	10.2	11.7	10.8	3.9	4.3	0.8	-0.9	6.1	7.6	9.5	10.9	-
16	10.4	13	11.2	8.8	5.1	1.5	0.1	4.6	6.7	12.1	12.5	-
17	13.5	14.6	11.9	6	2.2	2.8	-2.2	5.7	5.3	10.4	14.1	-
18	12.7	15.2	10.9	7.8	3.7	3.7	1.1	5.2	5.9	13.2	-	13.2
19	11.7	15.2	12.3	8.2	3.6	4.5	-1.1	1.3	10.3	12.3	-	-
20	11	14.2	11.8	6.5	4.5	2.6	1.7	7.7	9.9	13.6	15.6	13.6
21	11.4	13.6	10.2	5.9	2.7	6.1	3.7	8.5	10.6	11.2	13.6	-
22	13.9	15.2	9.3	8.1	1.2	5.1	2.7	10.3	11.9	11	12.9	11.5
23	15.3	14.4	11.5	7.2	3.6	6.5	3.9	10.9	10.9	9.4	12.1	-
24	15.1	11.6	9.8	8.4	4.1	2.2	3	10.8	6.1	8.8	14.4	-
25	12.1	13.1	9.9	8.9	4.7	0	2.2	10.7	8.7	7.9	11.9	14.3
26	12.1	15.1	8.4	8.2	-0.9	-2.5	0.8	10.4	6.3	9.8	10.2	14.4
27	11.1	12.2	10.4	8	5.9	-0.2	0.8	7.1	9.5	12	11.3	-
28	8.8	10.6	10.8	8.4	6.3	-2.6	2.4	6.8	10	11.3	11.1	15.4
29	13.2	9.6	11.2	10.4	2.1	2.9	1.3	7	3.1	12.7	-	-
30	10.7	-	10.5	8.9	2.1	2.1	1.8	8.5	2	11.1	13.4	15.1
31	12.3	-	9.9	-	5	-	2.9	8	-	6.7	-	15.8
Average minimum temperature	12.6	13.3	11.2	6.5	5.5	1.8	2.3	4.5	7.6	10.7	11.7	13.6

Table M.19. Daily minimum temperature (ºC) data from the Belfast weather station (2013) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	14.1	12.5	14.9	6.5	8.7	3.4	-	-	-	9.7	11.5
2	-	12.6	12.2	12.9	5.6	10	5.5	-	-2.1	-	7.3	13.2
3	-	12.2	11.6	9.7	5.5	8.1	6.1	-	-	7.5	7	14
4	-	14.1	10.9	7.5	5.9	5.9	4.9	-	-	7.3	7	13.8
5	-	11.7	10.1	5	4	4.2	8.7	-	6.5	8.7	8.4	11.5
6	-	14.1	11.9	4.3	1.9	2.9	2.1	-	6.3	12.6	9.9	10.7
7	-	12.9	14.2	6	0.9	3.6	3.7	21.8	5.7	6.5	12.2	9.6
8	-	15.1	12.9	7.7	0.8	6.7	-	-	6.6	6.7	9.7	11.8
9	-	15.6	-	-	1.5	4.7	4.8	-	12.1	6.8	9.8	14
10	-	15.9	12.5	9.2	7.1	5.5	-	-	8.7	10.2	11.5	12.3
11	14.7	15.5	11.9	8.2	5.6	-	15.2	-	10.9	6.5	9.7	12.1
12	13.4	14.1	12.4	7.3	4	-	-	-	8.6	10.6	-	10.1
13	12.4	16.5	10.3	10.1	3	-	-	-	8.4	6.9	-	11.9
14	14.7	16.1	13.2	9.5	3.6	8.4	-	-	-	3.9	-	11.4
15	15.8	16.5	6.5	10.5	3.4	6.6	-	-	-	6	15.6	16.3
16	15.3	14.5	10.3	9.4	4	1.7	-	-	-	5.4	14	14.4
17	14.5	16.2	11.8	13.7	5.2	-1.5	-	-	13	11.1	14.1	11.7
18	16.3	15.4	14.2	11.3	10.2	-0.7	-	-	9.4	9.5	10.4	12
19	14.3	15.4	12.2	-	3.3	2.8	-	8.2	10	8	12.5	11
20	13.9	17.5	12.7	8.1	1.9	0.9	-	7.5	10.8	7.7	12.7	11.3
21	-	13.8	12.2	9.3	6.6	0	-	5.4	-	8.9	9.9	8.7
22	-	13.5	12.8	6.9	5.6	-1	-	4.3	-	6.5	9.7	13
23	-	11	8.8	-	4.6	1.4	-	-	-	6.2	11	-
24	14	14.8	12.4	-	6.7	-3.1	-	2.7	-	6.5	12.2	-
25	12.7	13.6	11.9	-	5	2.8	-	7.4	-	5.5	12.2	-
26	13.7	11.7	13.4	5.6	6.1	4.5	-	6.3	-	10.6	9.9	-
27	15	12.5	12.9	9.8	4.4	3.9	-	4.7	-	9.1	11.7	-
28	14.9	11.8	11.2	11.9	7.7	1.4	-	6.6	-	8.3	10.2	-
29	14.1	-	13	9.2	4.2	4.9	-	-	-	4.9	10.2	-
30	13.9	-	14.8	17.2	6.8	5.1	-	-	-	9.8	11.1	-
31	14.4	-	15.1	-	4.5	-	-	-	-	10.7	-	-
Average minimum temperature	14.3	14.2	12.1	9.4	4.7	3.6	6.0	7.5	8.2	7.9	10.7	12.1

Table M.20. Daily minimum temperature (ºC) data from the Belfast weather station (2014) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-	14.3	12.4	9.5	4.8	6.2	2	4.7	-0.7	4.8	12.2	10.6
2	-	16.7	14	11.2	6.5	4.2	-2.5	0.9	-0.9	5.9	10.7	9
3	-	13.6	14.9	11.4	6.5	4.4	-0.7	1.4	-1.6	5.1	13.3	6.7
4	-	13.6	14.7	11.2	6.6	3	0.3	1.5	-0.6	5.1	12.1	10.4
5	-	13.5	15.1	11	6.9	2.6	5.3	1.6	-0.5	3.3	7.6	12.3
6	-	15.5	14.3	8.6	8.3	-3.1	4.9	4.4	2.7	4.5	10.8	9.8
7	-	14.6	14.4	7.8	7	-3.7	3.1	6.4	4.8	6.6	9.5	10.5
8	14.2	13.4	14.7	7	3.6	-3.1	-1.5	6.3	5.3	8.1	10.3	10.8
9	13.9	13.8	14.8	9.7	3.5	-1	-4.2	5.9	5.5	11.1	13.4	11.8
10	15.7	12.6	13.3	7.3	5.3	0	-4.6	5.5	7.1	9.5	14.1	11.4
11	13.9	11	13.6	8.7	4	0.9	-5	6.8	6.3	9.6	12.7	14.1
12	14.9	11.9	15.5	8.9	0.3	-1.4	-1	5.4	7	10.3	12.6	13.3
13	12.3	13.3	9.4	7.4	3.1	-2.8	-0.7	1.6	9.9	12.1	14.2	12.8
14	12.4	14.1	9.5	8.5	1.5	-3.1	-1.4	4.2	7	10.2	13.2	12.2
15	14.5	13.3	8.7	6	4.3	4.8	3.1	3.9	4.1	10.3	12.3	13
16	13.9	11.7	10.9	8.9	6.5	-0.3	0.9	8.7	8.9	10.9	8.9	12
17	12.3	10.8	13	6.9	3.6	1.4	2.4	5.5	7.6	5.3	7.1	11.7
18	10.3	8.9	14.6	8.2	7.1	3.8	5	4.2	9.1	3.2	6.1	13.3
19	12.9	10.5	15.1	5.9	3.8	-0.1	4.3	5.3	8.9	2.3	5.8	14.4
20	11.5	12.8	13.9	7.4	1.4	-3.7	-0.4	6.4	7	6.6	9.8	12.7
21	13.2	14.4	12.4	-	4.2	-2.4	-0.7	7.9	7.3	7.4	10.5	11.9
22	11.3	14.1	12.4	7.6	4.9	-1.6	-1.3	2.7	8.7	9.2	10.6	15
23	12.1	13.7	8.7	6.6	5.1	-1.8	2.2	-0.2	6	8.9	10.5	14.9
24	14.1	12.8	12.7	6.5	2.3	-1.5	1.5	1.5	8.1	10.8	8.7	15.2
25	13.3	12.4	10.8	1.6	2.3	0.8	1.4	-1.2	6.6	9.7	11.3	14.8
26	13.5	12.8	9.1	1.3	2.7	2.4	3.6	-0.2	8.5	9.6	11.1	15.8
27	14	9.5	11.2	6	3.8	3.2	1.2	2.7	11.4	8.7	11.9	14.6
28	14.6	11.4	11.2	4.3	5.6	4.8	3.9	6.8	11.6	7.1	12.8	14.4
29	15.5	-	10	5.7	4.2	2.5	1.4	-0.7	10.7	8.7	12.4	13.1
30	14.5	-	9.9	4.3	3.3	3.1	-2.6	-5.8	7.2	9.9	8.7	9.8
31	15.6	-	10.5	-	6	-	0.7	-1.9	-	12.6	-	12.7
Average minimum temperature	13.5	12.9	12.4	7.4	4.5	0.6	0.7	3.3	6.1	8	10.8	12.4

Table M.21. Daily minimum temperature (ºC) data from the Belfast weather station (2015) (data from the South African Weather Service).

Day of the month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	12	14.7	11.7	8.3	1.6	4	0.9	-4.5	8.3	9.7	14.4	-
2	12.4	14.9	10.2	8.7	3.9	6	2.1	-2.5	6.1	7.3	8.1	15.5
3	13.6	13.7	7.1	8.2	2.3	7.5	1.8	-1	7.1	6	5.6	14
4	11.5	14.7	5.6	11.7	5.6	2.9	0.1	0.5	5.6	10.2	4	12
5	13.8	12.5	8.8	10.3	5.7	-0.7	1.1	3.7	7.2	9.2	3.4	11
6	15	14.1	12.2	10.9	6.5	-1	1.6	-0.5	6.8	10.3	4	15.1
7	15.6	12.7	10.1	10.7	9.8	-2	2.7	1.3	6.4	10.7	6.6	14.6
8	15.2	12.9	11.7	10.8	7.6	-2	1.6	2.7	8.4	14	9.8	13.8
9	14.1	16	10.3	8.2	6.7	-1.1	1.1	2.6	11.2	11	12.3	13.6
10	14.7	15.2	9.1	6.5	6.6	1.4	3.5	2.6	13.6	9.4	13.6	14.3
11	14.1	13.7	10.2	5.9	7.7	-1.8	1.6	3.7	9.8	11.8	13.1	14.8
12	11.8	13	12	9	6.4	4.5	4.5	2.7	9.2	12.1	14.6	14.8
13	14	13.8	11.4	8.9	7	0.7	2.4	5.9	7.2	9.9	14.3	14.5
14	14.9	14.7	13.1	7.3	4.7	0.3	6.3	1.9	6	14.2	13.2	13.3
15	14.2	12.7	12.6	9.2	4.2	-0.4	1.9	7.2	5.6	12.9	12.9	12.7
16	13.2	11.6	12.2	8.4	6.5	-2.3	2.8	5	11.6	9.3	9.7	14
17	11.5	11.2	11.9	9.8	8.1	1.2	-	4.5	12.6	8.8	8.6	15.4
18	11	12.1	11.8	9.8	5.8	-2.4	-3	3.3	10.3	7.8	10.9	14.2
19	12.5	11.6	13.3	11.3	5.7	-1.7	1.2	5.8	9.8	8.4	11.1	12.1
20	11	14.2	11.5	9.6	5.5	2.9	2.7	8.6	10.8	8.1	10.5	14.1
21	11	11.5	13.5	6.6	4	-0.6	4.9	6.1	10.5	6.9	-	13.6
22	11.7	13.3	12.5	8.6	6.3	-0.4	5.7	8.7	12.2	10.8	-	14.9
23	12.3	11.4	12.9	6.2	5.3	-0.7	-	9.1	11.9	9.1	-	14.2
24	9.2	10.5	10.2	10.7	3.2	0	7.6	8.7	12.3	9.5	-	14.4
25	9.9	13.8	11.6	7.7	3.8	1.2	0.7	6.3	12.1	11.2	-	15.9
26	12.5	11.8	12.1	6.6	4.1	5.9	-1.6	7	10.1	11.6	-	12.1
27	14.5	12.5	10.8	6.1	4.8	5.5	-0.7	7.7	8	11.2	-	11.7
28	14.6	12.9	11.5	6.9	4.4	4.2	-1	8.6	13.7	8.2	-	12.7
29	14.4	-	12.6	6.5	3.1	3.1	1.7	9.1	14.6	7.1	-	13.3
30	14	-	11.3	7.1	3.7	4.1	2.4	8.9	11.4	7.8	-	11.7
31	11.1	-	12.6	-	4.5	-	-0.7	7.7	-	9.7	-	12.9
Average minimum temperature	12.9	13.1	11.2	8.6	5.3	1.3	1.9	4.6	9.7	9.8	10.0	13.7

Table M.22. Daily minimum temperature (ºC) data from the Belfast weather station (2016) (data from the South African Weather Service).

Day of the month	JAN	FEB
1	14.1	12.2
2	15.2	11.1
3	13.7	13.6
4	10.3	14.1
5	11.1	11.8
6	12.1	11.8
7	14.2	14
8	13.6	14.3
9	12.5	12.9
10	12.8	11.6
11	13.4	11.4
12	12.8	16.1
13	11.2	13.2
14	14.1	14.6
15	13.9	13.3
16	13.2	14.9
17	10.9	15.5
18	9.6	15.1
19	9.5	15.1
20	13.5	16
21	13	15.5
22	14.2	14.6
23	14.2	14.5
24	14.7	14
25	14.6	15.3
26	13.8	15.3
27	12.7	13
28	13.9	11.5
29	14.1	13.3
30	12.6	-
31	11.9	-
Average minimum temperature	12.9	13.8

Table M.23. Mean monthly rainfall (mm) data from the Belfast weather station (data from the South African Weather Service).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Total rainfall 2012	173.4	51.8	108.4	51	0.6	0.4	0.2	0.2	130.0	164.2	189.6	145.8
Total rainfall 2013	191.8	96.6	69.0	98.4	5	0	0.6	4.2	20.4	225.8	132.4	132.0
Total rainfall 2014	88.0	29.8	224.8	27	0.2	0.2	0.4	2.4	3	58.2	131.2	241.6
Total rainfall 2015	119.2	59.4	119.4	93.4	0.6	1.6	6.8	14	40.6	50.6	22.8	160.6
Total rainfall 2016	100.2	152.0	-	-	-	-	-	-	-	-	-	-

Table M.24. Mean monthly maximum temperature (ºC) data from the Belfast weather station (data from the South African Weather Service).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average maximum Temperature 2012	23	24.8	22.8	19.5	20.7	16.9	18.4	21.2	20.4	22.6	23.1	23.3
Average maximum Temperature 2013	23.1	26.4	23.4	22.4	20	19.9	19.3	20.9	25.3	21.0	22.3	21.8
Average maximum Temperature 2014	23.2	23.1	21.1	19.6	20.2	17.7	16.3	18.7	23.9	22.8	21.6	22.8
Average maximum Temperature 2015	23.6	24.6	22.7	20.4	21.4	16.1	17.2	22	23.4	24.9	24.3	25.7
Average maximum temperature 2016	23.8	24.7	-	-	-	-	-	-	-	-	-	-

Table M.25. Mean monthly minimum temperature (ºC) data from the Belfast weather station (data from the South African Weather Service).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average minimum Temperature 2012	12.6	13.3	11.2	6.5	5.5	1.8	2.3	4.5	7.6	10.7	11.7	13.6
Average minimum Temperature 2013	14.3	14.2	12.1	9.4	4.7	3.6	6.0	7.5	8.2	7.9	10.7	12.1
Average minimum Temperature 2014	13.5	12.9	12.4	7.4	4.5	0.6	0.7	3.3	6.1	8	10.8	12.4
Average minimum Temperature 2015	12.9	13.1	11.2	8.6	5.3	1.3	1.9	4.6	9.7	9.8	10.0	13.7
Average minimum temperature 2016	12.9	13.8	-	-	-	-	-	-	-	-	-	-

APPENDIX N: BIOMES OF SOUTH AFRICA

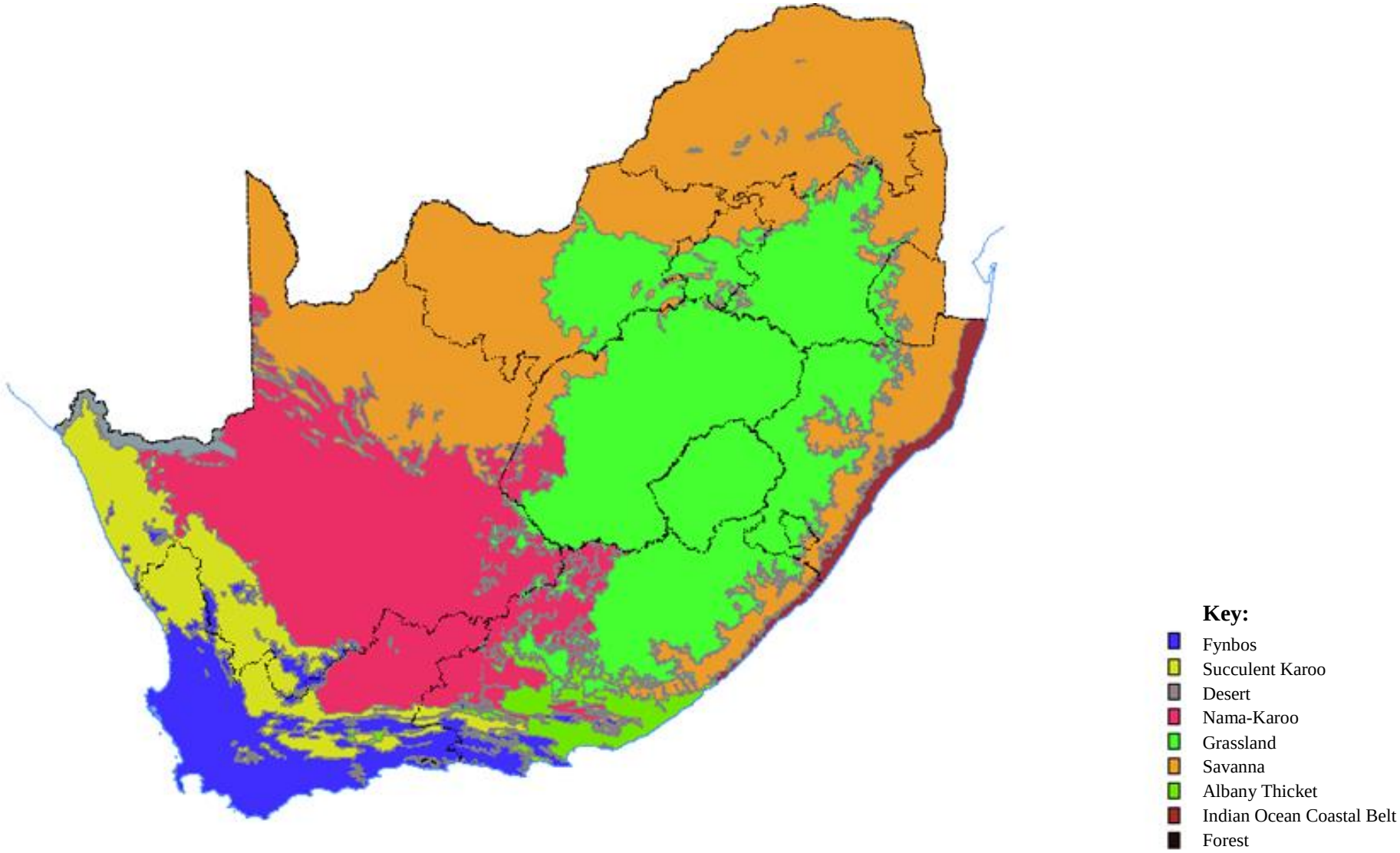

Figure N.1. Map indicating the biomes present in South Africa (after Mucina & Rutherford 2006).

APPENDIX O: IMAGES

Pictures of domesticated taxa

Figure O.1. Examples of domesticated plants: (A) Mature specimens of *S. bicolor* subsp. *bicolor*. (B) Specimens of *E. coracana* subsp. *coracana* before seeds are formed. (C) Specimens of *E. coracana* subsp. *coracana* with seeds. (D) Mature specimens of *P. glaucum.*

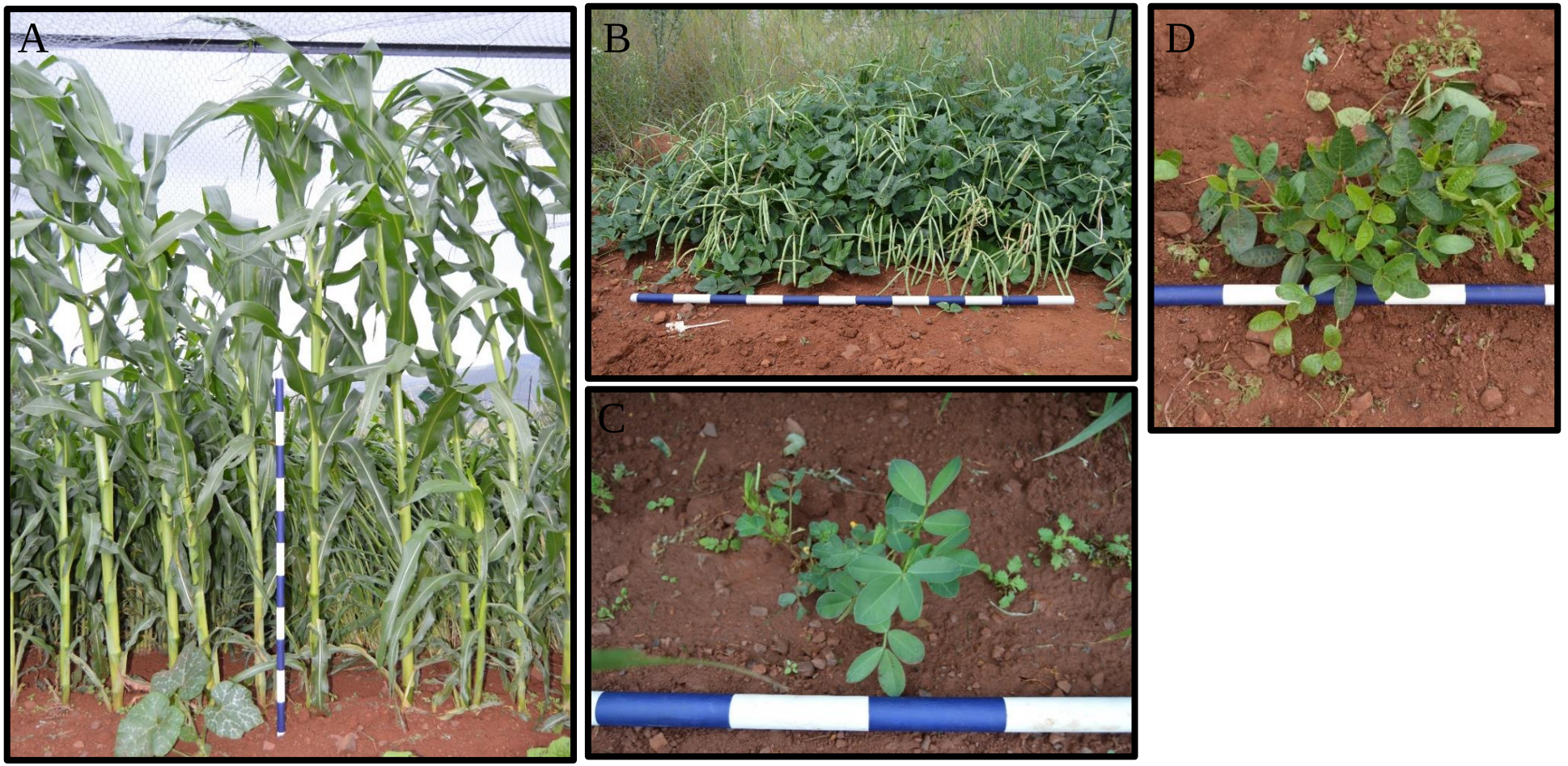

Figure O.2. Examples of domesticated plants: (A) Mature specimens of *Z. mays*. (B) Mature specimens of *V. unguiculata* subsp. *unguiculata*. (C) Mature specimens of *A. hypogaea*. (D) Mature specimens of *V. subterranea.*

Domesticated taxa

Eleusine coracana subsp. coracana 1 and 2

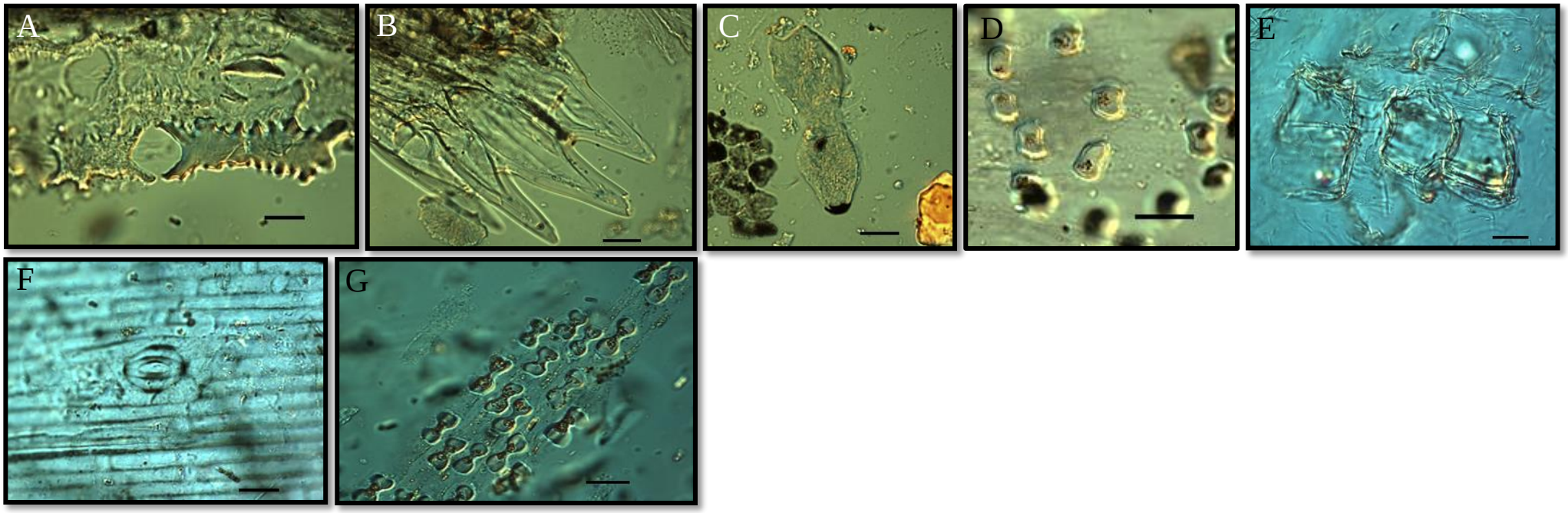

Figure O.3. (A) Stomata and epidermal long cell phytoliths from *E. coracana* subsp. *coracana* inflorescences. (B) Hair cell phytoliths from mature *E. coracana* subsp. *coracana* inflorescences. (C) Hair cell mesophyll from *E. coracana* subsp. *coracana* inflorescences. (D) Depressed and elongate saddles from mature *E. coracana* subsp. *coracana* inflorescences. (E) Epidermal cell phytoliths from mature *E. coracana* subsp. *coracana* stems. (F) Stomata phytoliths from mature *E. coracana* subsp. *coracana* stems. (G) Bilobate phytoliths from juvenile (1 month) *E. coracana* subsp. *coracana* specimens (Scale 20 µm).

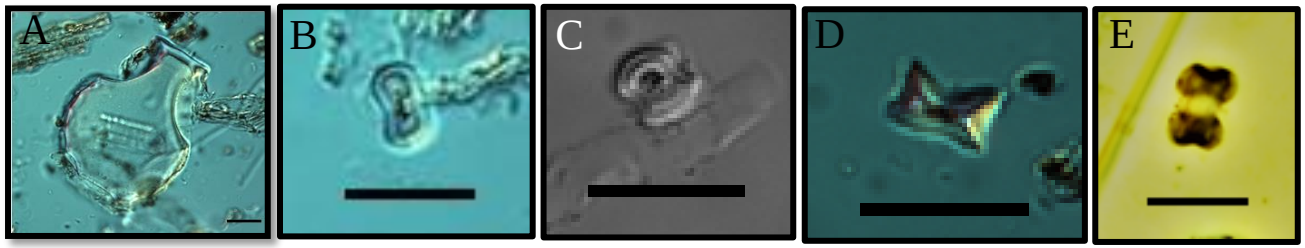

Figure O.4. (A) Bulliform phytolith from mature *E. coracana* subsp. *coracana* leaves. (B-D) Depressed and elongate saddles from mature *E. coracana* subsp. *coracana* leaves. (L) Cross 1 phytolith from juvenile (1-2 weeks) *E. coracana* subsp. *coracana* specimens (Scale 20 µm).

Pennisetum glaucum 1 and 2

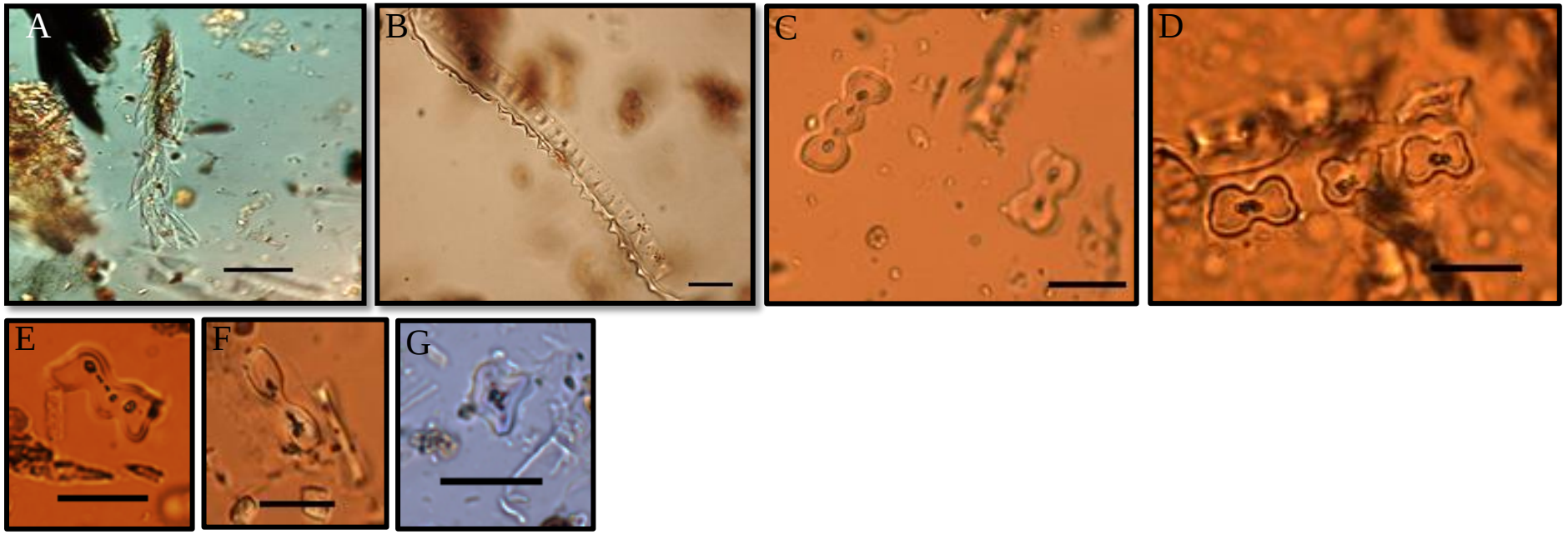

Figure O.5. (A) Hair cell clusters from *P. glaucum* inflorescences. (B) Unknown phytolith from mature *P. glaucum* roots. (C-E) Polylobate, cross 1 and bilobate phytoliths from juvenile (1-2 weeks) *P. glaucum* samples. (F-G) Cross 1 and bilobate phytoliths from mature *P. glaucum* leaves (Scale 20 µm).

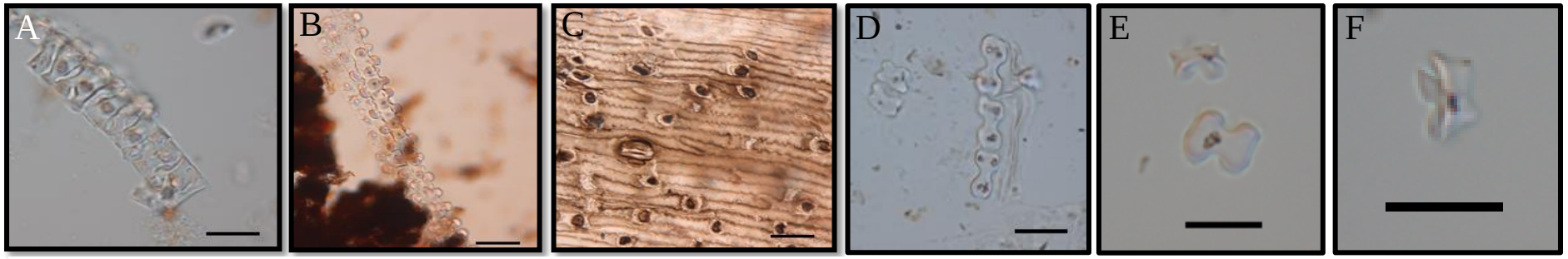

Figure O.6. (A-B) Unknown phytoliths from mature *S. bicolor* subsp. *bicolor* roots. (C) Stomata and other phytoliths from mature *S. bicolor* subsp. *bicolor* stems. (D-F) Cross 1 and bilobate phytoliths from mature *S. bicolor* subsp. *bicolor* leaves (Scale 20 µm).

Sorghum bicolor subsp. bicolor 1-3

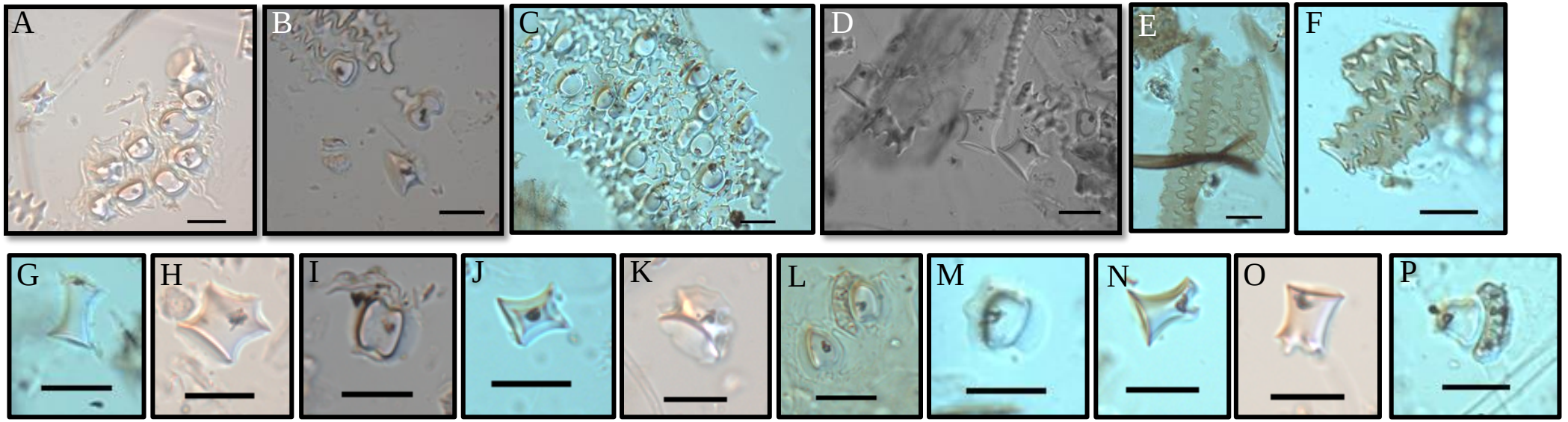

Figure O.7. (A-B) Saddle and bilobate phytoliths from *S. bicolor* subsp. *bicolor* inflorescences. (C) Rondel phytoliths from *S. bicolor* subsp. *bicolor* inflorescences. (D) Rondel phytoliths from *S. bicolor* subsp. *bicolor* inflorescences. (E-F) Long cell phytoliths from mature *S. bicolor* subsp. *bicolor* inflorescences. (G-P) Rondel and saddle and from mature *S. bicolor* subsp. *bicolor* inflorescences (Scale 20 µm).

Figure O.8. (A) Bilobate phytoliths from juvenile (1-2 weeks) *S. bicolor* subsp. *bicolor* specimens. (B)Bilobate phytolith from juvenile (1-2 weeks) *S. bicolor* subsp. *bicolor* samples. (C-D) Bilobate, polylobate and cross phytoliths from juvenile (1 month) *S. bicolor* subsp. *bicolor* samples (Scale 20 µm).

Zea mays 1 and 2

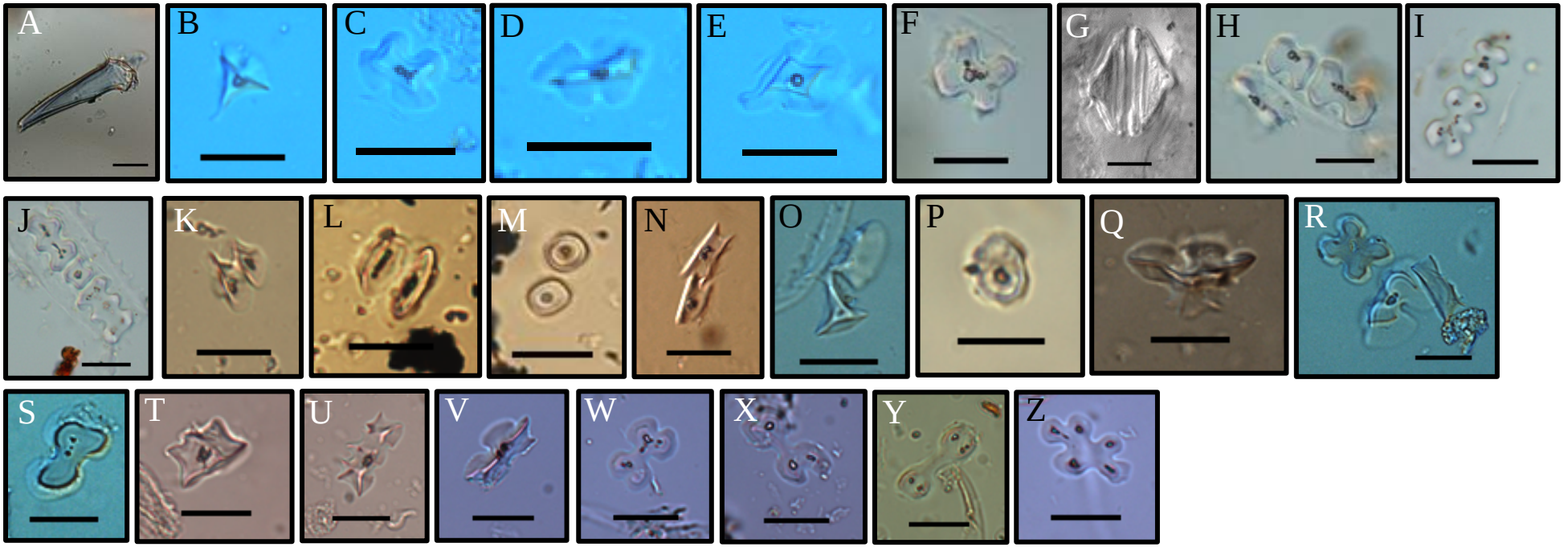

Figure O.9. (A) Hair cell phytoliths from mature *Z. mays* leaves. (B-F) Cross phytoliths from mature *Z. mays* leaves. (G) Stomata phytoliths from mature *Z. mays* leaves. (H-I) Polylobate, bilobate and cross 1 phytoliths from mature *Z. mays* leaves. (K-P) Rondel phytoliths from mature *Z. mays* cobs. (Q-Z) Cross, bilobate and polylobate phytoliths from *Z. mays* husks (Scale 20 µm).

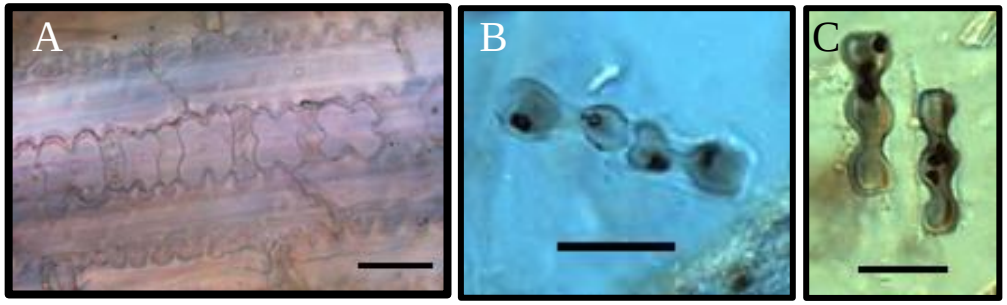

Figure O.10. (A) Variant 1 crosses from juvenile (1-2 weeks) *Z. mays* specimens. (B-C) Polylobate and bilobate phytoliths from juvenile (1-2 weeks) *Z. mays* samples (Scale 20 µm).

Arachis hypogaea 1 and 2, Vigna subterranea 1 and 2, Vigna unguiculata subsp. unguiculata 1 - 3

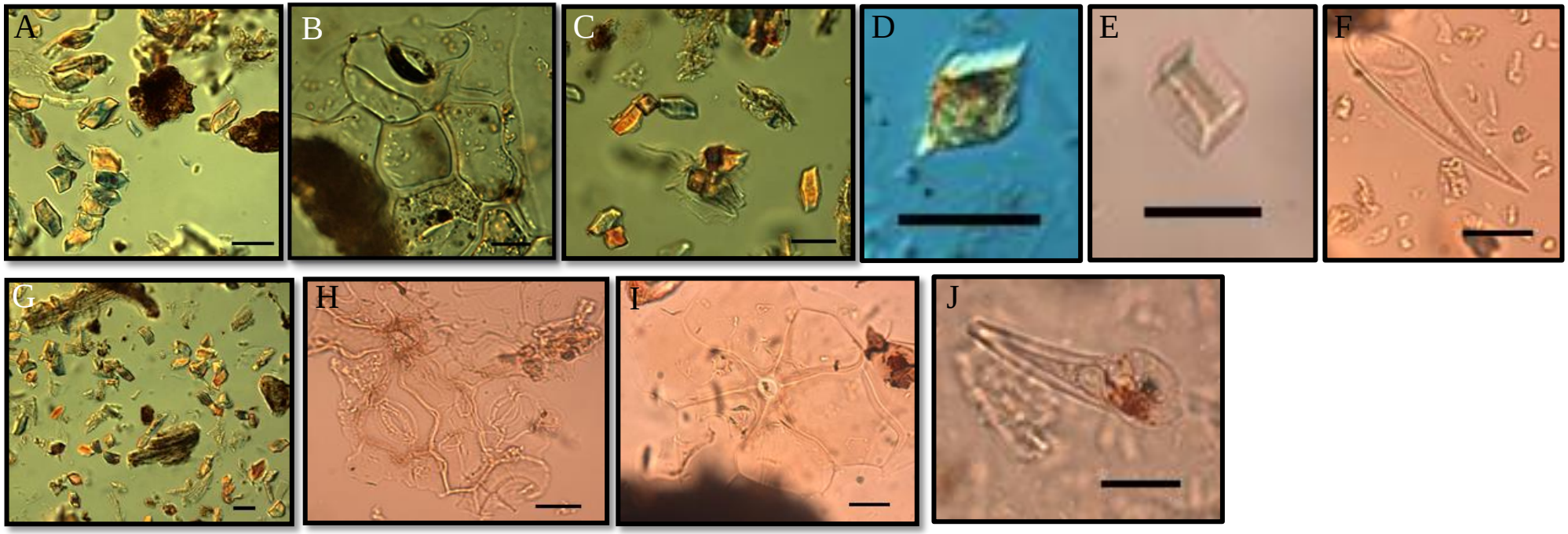

Figure O.11. (A) Six-sided phytoliths from mature *A. hypogaea*. (B) Stomata phytoliths from mature *V. subterranea.* (C) Six-sided phytoliths from mature *V. subterranea.* (D-F) Six-sided and hair cell phytoliths from *V. subterranea*. (G) Six-sided phytoliths from mature *V. unguiculata* subsp. *unguiculata*. (H) Stomata phytoliths from mature *V. unguiculata* subsp. *unguiculata.* (I) Trichome base from mature *V. unguiculata* subsp. *unguiculata*. (J) Hair cell phytoliths from mature *V. unguiculata* subsp. *unguiculata* (Scale 20 µm).

Wild taxa

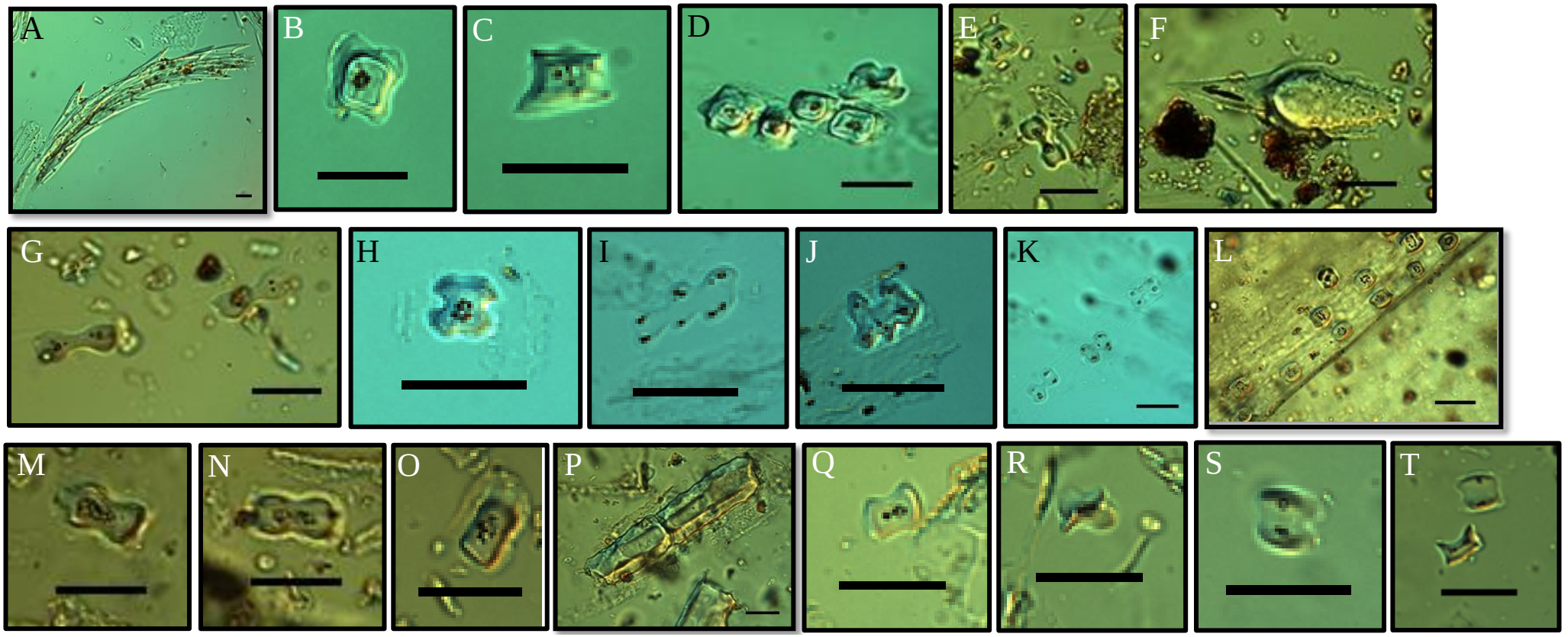

Figure O.12. (A) Hair cell cluster from mature *C. ciliaris* inflorescences. (B-D) Cross-rondel phytoliths from *C. ciliaris* inflorescences. (E-F) Cross 1, bilobate and hair cell phytoliths from *C. ciliaris* leaves. (G-H) Bilobate and cross 1 phytoliths from *D. ciliaris* leaves. (I-K) Polylobate phytolith from *D. ciliaris* inflorescences. Polylobate, cross 1 and bilobate phytoliths from *D. ciliaris* inflorescences. (L) Depressed saddles from mature *E. coracana* subsp. *africana* leaves and inflorescences. (M-O) Bilobate and saddle phytoliths from *E. coracana* subsp. *africana* leaves and inflorescences. (P) Hair cell mesophyll phytoliths from mature *E. indica* leaves. (Q-T) Depressed and elongate saddle phytoliths from *E. indica* leaves and inflorescences (Scale 20 µm).

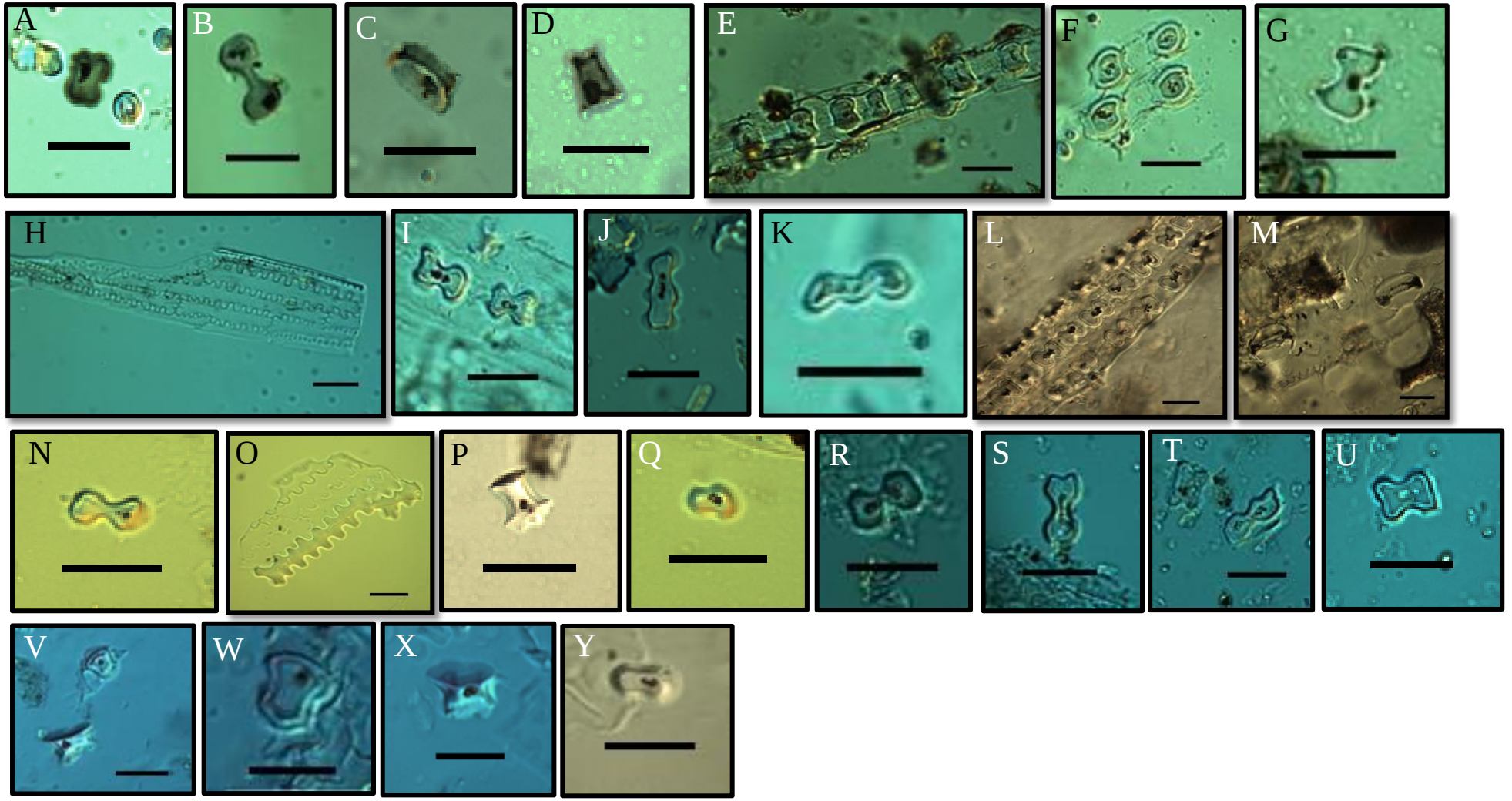

Figure O.13. (A-B) Bilobate and cross 1 phytoliths from *E. multiflora* leaves. (C-D) Rondel phytoliths from *E. multiflora* inflorescences. (E) Depressed and elongate saddle phytoliths from mature *E. tristachya* leaves and inflorescences. (F-G) Saddle and bilobate phytoliths from *E. tristachya* leaves and inflorescences. (H) Sinuous long cell phytoliths from mature *P. purpureum* inflorescences. (I-K) Bilobate, cross 1 and polylobate phytoliths from *P. purpureum* leaves and inflorescences. (L) Bilobate and cross 1 phytoliths from mature *S. bicolor* subsp. *arundinaceum* leaves. (M) Stomata phytoliths from mature *S. bicolor* subsp. *arundinaceum* leaves. (N) Bilobate phytolith from *S. bicolor* subsp. *arundinaceum* leaves. (O) Sinuous long cell phytoliths from mature *S. bicolor* subsp. *arundinaceum* inflorescences. (P-Q) Rondel and saddle elongate saddle phytoliths from *S. bicolor* subsp. *arundinaceum* inflorescences. (R-U) Bilobate, cross 1 and polylobate phytoliths from *S. bicolor* subsp. *drummondii* leaves. (V-Y) Depressed and elongate saddles from *S. bicolor* subsp. *drummondii* inflorescences (Scale 20 µm).

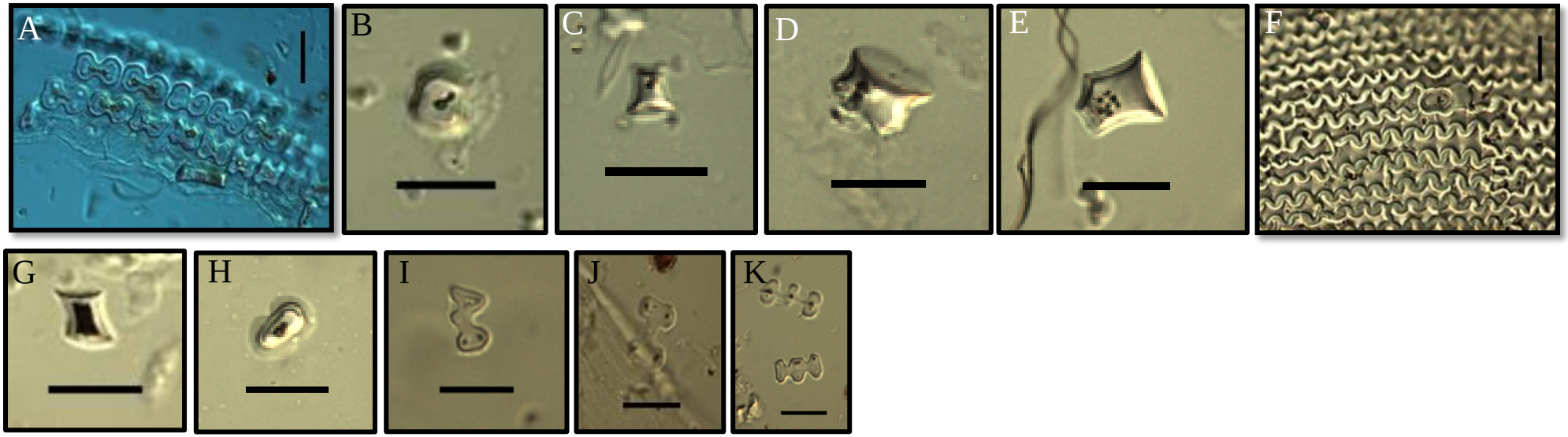

Figure O.14. (A) Bilobate and cross 1 phytoliths from mature *S. halepense* leaves. (B-D) Saddle and rondel phytoliths from *S. halepense* inflorescences. (E) Rondel phytolith from *S. halepense* inflorescences. (F) Dendritic long cell phytoliths from mature *S. versicolor* inflorescences. (G-H) Rondel and bilobate phytoliths from *S. versicolor* inflorescences. (I-K) Bilobate and polylobate phytoliths from *S. versicolor* leaves (Scale 20 µm).

APPENDIX P: MEASURED PHYTOLITHS

Table P.1. Types and number of phytoliths measured to obtain statistically relevant data for domesticated plants.

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
Eleusine coracana subsp. *coracana* 1	Leaf	Depressed saddle	16	100	1,77	1,3312	1,54
		Elongate saddle	13	100	0,99	0,9948	1,08
	Inflorescence	Depressed saddle	12	100	1,97	1,4018	1,42
		Elongate saddle	11	100	1,39	1,1807	1,21
	Juvenile: 1-2 Weeks	Variant 1 crosses	12	25	2,26	-	-
		Bilobates	14	25	2,16	-	-
		Depressed saddles	16	25	3,56	1,8855	1,53
		Elongate saddles	13	25	2,44	1,561	1,4
	Juvenile: 1 Month	Variant 1 crosses	20	50	2,88	-	-
		Bilobates	26	50	2,8	-	-
		Depressed saddles	17	50	2,22	1,4893	1,54
		Elongate saddles	20	50	1,49	1,2221	1,94
Eleusine coracana subsp. *coracana* 2	Leaf	Depressed saddles	26	100	2,82	1,6782	1,53
		Elongate saddles	27	100	2,45	1,5667	1,38
	Inflorescence	Depressed saddles	18	100	2,02	1,4213	1,64
		Elongate saddles	20	100	1,79	1,3364	1,4
	Juvenile: 1-2 Weeks	Variant 1 crosses	20	25	4,5	-	-
		Bilobates	15	25	2,88	-	-
		Elongate saddles	7	18	0,88	0,936	2,44
	Juvenile: 1 Month	Variant 1 crosses	10	50	1,73	-	-
		Bilobates	14	50	2	-	-
		Depressed saddles	18	50	2,27	1,508	1,15
		Elongate saddles	19	50	1,85	1,3598	2,14

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
Pennisetum glaucum 1	Leaf	Bilobates	30	100	3,85	1,9609	3,02
		Variant 1 crosses	17	100	3,08	1,7547	2,59
	Inflorescence	Bilobates	25	100	2,43	1,558	2,95
		Variant 1 crosses	27	100	2,71	1,6348	2,22
	Juvenile: 1-2 Weeks	Bilobates	22	25	3,36	1,74	5,34
		Variant 1 polylobates	25	25	3,25	-	-
		Variant 2 Polylobates	25	25	3,04	-	-
		Variant 1 crosses	24	25	4,77	2,18	2,43
	Juvenile: 1 Month	Bilobates	31	50	3,07	1,75	4,66
		Variant 1 polylobates	23	50	2,58	-	-
		Variant 2 Polylobates	20	50	2,16	-	-
Pennisetum glaucum 2	Leaf	Bilobates	23	100	3,35	1,8305	3,42
		Variant 1 crosses	15	100	2,63	1,6211	2,32
	Inflorescence	Bilobates	44	100	4,99	2,2328	2,99
		Variant 1 crosses	27	100	2,79	1,6709	2,41
		Variant 5/6 crosses	22	56	3,43	-	-
	Juvenile: 1-2 Weeks	Bilobates	14	25	3,88	1,84	4,8
		Variant 1 polylobates	25	25	4,9	-	-
		Variant 2 Polylobates	25	25	3,82	-	-
		Variant 1 crosses	21	25	5,24	2,29	3,22
	Juvenile: 1 Month	Bilobates	28	50	6,84	2,62	6,15
Sorghum bicolor subsp. *bicolor* 1	Leaf	Bilobates	16	100	1,38	2,1938	2,69
		Variant 1 crosses	7	100	3,3	1,8153	2,21
		Variant 5/6 crosses	20	100	3,42	1,8501	1,63
	Inflorescence	Saddle-like rondels	15	100	3,05	-	-
		Bilobates	25	100	5,4	2,2663	2,24
		Elongate rondels	31	100	3,34	1,8275	2,13

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Irregular rondels	18	100	2,93	-	-
		Round rondels	17	100	3,14	1,771	1,97
		Rondels with one dent	13	100	2,47	-	-
		Elongate saddles	15	100	2,9	1,7037	1,78
		Sinuous long cells	11	100	2,27	1,5063	14,47
		Dendritic long cells	42	100	10,89	3,3	12,58
	Juvenile: 1-2 Weeks	Bilobates	25	25	4,02	2,01	4,87
		Variant 1 polylobates	14	25	2,38	-	-
		Variant 2 polylobates	15	25	2,28	-	-
		Variant 1 crosses	15	25	2,96	1,72	2,13
	Juvenile: 1 Month	Bilobates	28	50	3,66	1,92	4,47
		Variant 1 polylobates	25	50	3,6	-	-
		Variant 2 polylobates	39	50	4,8	-	-
		Variant 1 crosses	33	50	5,18	2,28	2,89
Sorghum bicolor subsp. *bicolor* 2	Leaf	Bilobates	17	100	2,9	1,7042	2,3
		Variant 1 crosses	17	100	3,24	1,8008	2,27
		Variant 5/6 crosses	14	100	2,47	1,5732	1,9
	Inflorescence	Saddle-like rondels	25	100	4,98	-	-
		Bilobates	46	100	8,91	2,9845	2,82
		Elongate rondels	24	100	2,45	1,5647	1,93
		Irregular rondels	25	100	3,48	-	-
		Round rondels	23	100	3,96	1,9899	2,24
		Rondels with one dent	23	100	3,36	-	-
		Elongate saddles	24	100	3,31	1,5647	1,93

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Sinuous long cells	20	100	6,26	2,5014	18,52
		Dendritic long cells	34	100	10,37	3,2208	11,77
	Juvenile: 1-2 Weeks	Bilobates	21	25	3,39	1,89	2,97
		Variant 1 polylobates	25	25	3,92	-	-
		Variant 2 polylobates	16	25	2,49	-	-
		Variant 1 crosses	25	25	4,35	2,09	2,19
	Juvenile: 1 Month	Bilobates	18	50	3,96	1,99	2,35
		Variant 1 polylobates	14	50	3,31	-	-
		Variant 2 polylobates	22	35	1,99	-	-
		Variant 1 crosses	13	50	2,62	1,62	2,98
Sorghum bicolor subsp. *bicolor* 3	Leaf	Bilobates	18	100	3,14	1,7707	2,7
		Variant 1 crosses	22	100	2,01	1,417	2,2
		Variant 5/6 crosses	12	100	2,16	1,4682	1,66
	Inflorescence	Saddle-like rondels	23	100	4,71	-	-
		Bilobates	29	100	6,41	2,5326	2,47
		Elongate rondels	23	100	2,61	1,616	2,09
		Irregular rondels	31	100	4,67	-	-
		Round rondels	21	100	3,51	1,8732	1,99
		Rondels with one dent	20	100	3,56	-	-
		Elongate saddles	20	100	2,76	1,6611	1,88
		Sinuous long cells	19	100	3,74	1,9343	13,99
		Dendritic long cells	39	100	10,81	3,288	12,57
	Juvenile: 1-2 Weeks	Bilobates	25	25	3,53	1,88	6,75
		Variant 1 polylobates	25	25	4,31	-	-
		Variant 2 polylobates	25	25	3,84	-	-

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Variant 1 crosses	13	25	2,27	1,51	2,52
	Juvenile: 1 Month	Bilobates	18	50	2,52	1,59	3,23
		Variant 1 polylobates	14	50	2,02	-	-
		Variant 2 polylobates	22	50	2,56	-	-
		Variant 1 crosses	13	50	1,88	1,3715	1,87
Zea mays 1	Leaf	Bilobates	24	100	6,9	2,6271	4,07
		Variant 1 crosses	19	100	6,18	2,4866	2,85
		Variant 1 polylobates	14	100	4,43	-	-
		Variant 2 polylobates	16	100	5,13	-	-
	Cobs	Elongate rondels	34	100	4,55	2,1339	2,76
		Round rondels	15	100	2,89	1,7007	1,73
		Rondels with one dent	10	23	1,78	-	-
	Tassels	Variant 1 crosses	17	100	5,68	2,3831	2,96
	Husks	Bilobates	20	100	5,5	2,3448	4,09
		Variant 1 crosses	15	100	5,77	2,0416	2,82
		Variant 5/6 crosses	11	23	4,01	-	-
	Juvenile: 1-2 Weeks	Bilobates	19	25	2,27	2,16	4,09
		Variant 1 polylobates	25	25	3,07	-	-
		Variant 2 polylobates	18	25	2,12	-	-
		Variant 1 crosses	25	25	4,65	1.51	2,86
	Juvenile: 1 Month	Bilobates	22	50	2,3	1,8	2,35
		Variant 1 crosses	24	50	3,26	1.52	2,27
		Variant 1 polylobates	27	50	1,56	-	-
Zea mays 2	Leaf	Bilobates	17	100	4,12	2,0307	3,97
		Variant 1 crosses	15	100	4,9	2,2143	2,59

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Variant 5/6 crosses	20	100	4,98	2,2319	2,5
	Cobs	Elongate rondels	58	100	11,82	3,4384	3,17
		Round rondels	24	100	8,32	2,884	3,11
		Rondels with one dent	32	100	8,5	-	-
		Variant 1 crosses	18	59	4,67	2,1248	2,83
		Bilobates	24	100	6,09	2,4672	3,58
		Variant 5/6 crosses	22	32	5,8	-	-
	Tassels	Variant 1 crosses	28	100	5,58	2,3631	2,97
	Husks	Bilobates	19	100	9,82	3,1344	3,8
		Variant 1 crosses	16	100	8,52	2,9189	3,18
	Juvenile: 1-2 Weeks	Bilobates	25	25	4,08	1,84	5,24
		Variant 1 polylobates			4,22	-	-
		Variant 2 polylobates	19	25	3,01	-	-
		Variant 1 crosses	13	25	3,39	2.02	2,29
	Juvenile: 1 Month	Bilobates	22	50	3,33	1,65	2,72
		Variant 1 crosses	16	50	2,73	1.83	2,37
		Variant 1 polylobates	13	50	2,17	-	-
		Variant 2 polylobates	14	50	1,95	-	-

Table P.2. Types and number of phytoliths measured to obtain statistically relevant data for wild taxa.

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
Cenchrus ciliaris	Leaf	Bilobates	41	50	3,06	1,75	3,07
		Variant 1 crosses	23	50	2,32	1,5246	2,81
	Inflorescence	Bilobates	18	28	1,62	1,2732	1,65
		Variant 1 crosses	34	50	2,16	1,4705	1,82
		Cross-rondels	27	50	3,59	-	-
		Elongate rondels	15	50	1,5	1,2038	1,84
Digitaria ciliaris	Leaf	Bilobates	24	50	2,21	1,49	3,13
	Inflorescence	Bilobates	21	50	2	1,4148	1,95
		Variant 1 crosses	14	50	1,8	1,3407	1,96
Eleusine coracana subsp. *africana*	Leaf	Variant 5/6 crosses	16	38	2,07	1,4373	1,7
		Variant 1 crosses	19	50	1,25	1,1173	2,14
		Round rondels	19	50	2,4	-	-
		Bilobates	23	50	2,39	1,5466	2,22
		Elongate rondels	23	50	2,14	-	-
		Depressed saddles	13	50	1,62	1,2723	1,41
	Inflorescence	Elongate saddles	21	50	1,56	1,2509	1,51
		Depressed saddles	23	50	2,42	1,5559	1,48
Eleusine indica	Leaf	Elongate saddles	15	50	0,93	0,9619	1,02
		Depressed saddles	15	50	1,82	1,3506	0,69
	Inflorescence	Elongate saddles	7	50	0,41	0,6409	1,1
		Depressed saddles	10	50	0,74	0,8589	0,94
Eleusine multiflora	Leaf	Elongate saddles	19	50	1,61	1,2697	1,92
		Depressed saddles	12	50	1,54	1,2393	1,1
		Bilobates	12	50	1,47	1,2104	1,66
		Variant 1 crosses	13	50	1,65	1,2857	1,63

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Round rondels	9	50	1,36	-	-
	Inflorescence	Depressed saddles	22	50	2,79	1,6704	1,51
		Elongate saddles	24	31	1,81	1,3454	1,42
		Variant 1 crosses	24	50	2,78	1,6663	2,14
		Bilobates	24	50	3,08	1,755	2,96
Eleusine tristachya	Leaf	Depressed saddles	19	50	2,99	1,7296	1,29
		Elongate saddles	14	50	1,34	1,159	1,41
	Inflorescence	Depressed saddles	14	50	2,61	1,6141	1,46
		Elongate saddles	18	50	1,57	1,2518	1,63
Pennisetum purpureum	Leaf	Bilobates	20	50	2,2	1,4828	2,02
		Variant 1 crosses	19	50	2,47	1,5723	1,81
		Variant 5/6 crosses	7	20	0,77	-	-
	Inflorescence	Variant 1 polylobate	15	27	1,15	-	-
		Bilobates	12	50	0,84	0,9176	1,54
		Variant 1 crosses	23	28	2,08	1,4448	1,74
Sorghum bicolor subsp. *arundinaceum*	Leaf	Variant 1 crosses	11	50	2,52	1,5877	1,96
		Bilobates	8	50	1,64	1,2805	1,76
	Inflorescence	Depressed saddles	22	50	2,22	1,4916	1,26
		Elongate saddles	17	50	1,24	1,113	1,49
		Bilobates	15	41	1,17	1,0838	1,86
		Dendritic long cells	29	50	7,59	2,7557	14,2
Sorghum bicolor subsp. *drummondii*	Leaf	Bilobates	17	50	2,06	1,4358	1,93
		Variant 1 crosses	19	50	3,05	1,7475	2,11
	Inflorescence	Depressed saddles	17	50	3,9	1,9947	2,16
		Elongate saddles	21	50	4,21	2,0526	2,39
		Bilobates	22	50	4,23	2,0564	2,85

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z scores	Standard deviation (width)	Standard deviation (length)
		Dendritic long cells	45	50	11,41	3,3781	16,3
Sorghum halepense	Leaf	Bilobates	12	50	1,7	1,304	1,53
		Variant 1 crosses	12	50	1,92	1,384	1,81
		Variant 5/6 crosses	11	50	1,67	1,2904	1,38
	Inflorescence	Round rondels	14	50	2,24	1,4962	1,56
		Depressed saddles	17	50	3,13	1,7705	2,01
		Elongate saddles	26	50	3,27	1,8077	1,89
		Bilobates	26	50	3,96	1,9894	2,48
Sorghum versicolor	Leaf	Bilobates	17	50	3,08	1,7555	3,68
		Variant 1 crosses	18	50	2,91	1,5756	2,11
		Variant 1 polylobates	18	50	2,56	-	-
		Variant 2 polylobates	13	50	1,98	-	-
	Inflorescence	Bilobates	20	50	2,79	1,671	2,22
		Depressed saddles	17	50	2,27	1,5099	1,67
		Elongate saddles	22	50	2,28	1,5099	1,96
		Dendritic long cells	22	50	4,59	2,1415	14,65

Table P.3. Types and number of phytoliths measured to obtain statistically relevant data for Fabaceae.

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z score	Standard deviation (width)	Standard deviation (length)
Arachis hypogaea 1	Roots	Rhomboidal	35	50	3,08	1,7549	2,72
	Stems	Rhomboidal	45	50	3,4	1,8452	2,16
	Seed pods	Rhomboidal	45	50	3,05	1,7456	2,21
	Leaves	Rhomboidal	41	50	3,1	1,77987	2,22
	Juvenile: 1-2 Weeks	Rhomboidal	-	-	-	-	-
	Juvenile: 1 Month	Rhomboidal	46	50	2,66	1,6313	2,15
Arachis hypogaea 2	Roots	Rhomboidal	48	50	3,2	1,7918	2,46
	Stems	Rhomboidal	50	50	2,7	1,64	2,4

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z score	Standard deviation (width)	Standard deviation (length)
	Seed pods	Rhomboidal	48	50	2,6	1,626	2,63
	Leaves	Rhomboidal	49	50	2,42	1,579	2,19
	Juvenile: 1-2 Weeks	Rhomboidal	-	-	-	-	-
	Juvenile: 1 Month	Rhomboidal	-	-	-	-	-
Vigna subterranea 1	Roots	Rhomboidal	41	50	3,14	1,5741	2,72
	Stems	Rhomboidal	26	50	2,48	1,7711	1,94
	Seed pods	Rhomboidal	36	50	3,24	1,8005	1,98
	Leaves	Rhomboidal	36	50	2,53	1,5891	2,21
	Juvenile: 1-2 Weeks	Rhomboidal	-	-	-	-	-
	Juvenile: 1 Month	Rhomboidal	29	50	2,29	1,514	1,73
Vigna subterranea 2	Roots	Rhomboidal	29	50	2,05	1,4325	1,98
	Stems	Rhomboidal	36	50	2,69	1,6399	2,16
	Seed pods	Rhomboidal	27	50	1,53	1,2373	1,45
	Leaves	Rhomboidal	25	50	1,89	1,3744	1,87
	Juvenile: 1-2 Weeks	Rhomboidal	-	-	-	-	-
	Juvenile: 1 Month	Rhomboidal	30	50	2,05	1,4327	1,65
Vigna unguiculata subsp. *unguiculata* 1	Roots	Rhomboidal	-	-	-	-	-
	Stems	Rhomboidal	25	50	1,75	1,3218	1,99
	Seed pods	Rhomboidal	20	50	1,02	1,012	1,43
	Leaves	Rhomboidal	16	50	0,76	0,8702	1,62
	Juvenile: 1-2 Weeks	Rhomboidal	22	25	1,18	16,62	1,92
	Juvenile: 1 Month	Rhomboidal	6	50	2,57	1,6033	1,91
Vigna unguiculata subsp. *unguiculata* 2	Roots	Rhomboidal	37	50	3,08	1,7563	2,85
	Stems	Rhomboidal	23	50	1,49	1,219	2,64
	Seed pods	Rhomboidal	16	50	0,9	0,9473	1,8
	Leaves	Rhomboidal	13	50	0,58	0,7635	1,8
	Juvenile: 1-2 Weeks	Rhomboidal	23	25	0,95	0,97	1,55

Plant species	Plant sections	Phytolith type	Number of phytoliths needed	Number of phytoliths measured	Z score	Standard deviation (width)	Standard deviation (length)
	Juvenile: 1 Month	Rhomboidal	32	50	1,37	1,17	2,04
Vigna unguiculata subsp. *unguiculata* 3	Roots	Rhomboidal	25	50	1,49	1,2435	2,61
	Stems	Rhomboidal	23	50	1,55	1,2208	2,13
	Seed pods	Rhomboidal	20	50	1,15	1,0707	2,19
	Leaves	Rhomboidal	40	50	2,33	1,5276	1,9
	Juvenile: 1-2 Weeks	Rhomboidal	-	-	-	-	-
	Juvenile: 1 Month	Rhomboidal	26	50	1,26	1,6313	1,56