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Towards sustainability of harvesting the medicinal plant pelargonium sidoides DC. (GERANIACEAE)

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2012-03-05
http://hdl.handle.net/10539/11387

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ABSTRACT

Pelargonium sidoides has been used for centuries in traditional medicine in Lesotho and South Africa as well as globally in modern medicine. Consequently *P. sidoides* tubers have been wild-harvested extensively in Eastern Cape and Lesotho to meet the growing trade demand. In recent years, the number of plant gatherers intending to supply markets and generate incomes have increased. Tubers are targeted because they contain medicinal properties. The medicinal compounds in the tubers are thought to be highly correlated with colour, with their concentration increasing as the colour develops towards dark-red. Dark-red coloured tubers seem to be preferred by the Pelargonium industry and are considered to be mature. Repeated harvesting of *P. sidoides* plants from the wild has been reported to result in localized population declines. This is exercabated by harvesting methods currently used which involve entire removal of the plant and not filling up harvest holes to safeguard tuber remnants left in the soil. Although various studies have investigated the impacts of such harvesting operations on *P. sidoides* wild populations, these studies have not provided information on tuber recovery rate and suitable recommendations to ensure sustainable harvest of *P. sidoides* from the wild. Therefore this study investigated (i) rate of tuber recovery in *P. sidoides* plants, (ii) impacts of wild harvest on its tuber recovery and (iii) made recommendations on sustainable harvest options for the species. The investigations were made using linear and non-linear regression models and ANOVA. Comparisons were done for "lowveld" (Eastern Cape) and "highveld" (Lesotho and Free-State) vegetation regions.

The rate of *P. sidoides* tuber recovery was measured by tuber recovery colour and biomass in previously wild-harvested sites. Tuber regrowth rate in cultivated sites was also investigated in the same manner to determine prospects for cultivation. Time since last harvest was found to affect tuber recovery colour and biomass. As time since last harvest increased in the "lowveld" and "highveld" vegetation regions, tuber recovery colour and biomass also increased (lowveld- r^2= 0.63, $P < 0.05$, d.f = 7 and highveld- r^2= 0.55, $P < 0.05$, d.f = 5). In cultivated sites, only tuber regrowth using biomass was found to increase positively with time when study sites from the "lowveld" and "highveld" vegetation regions were combined (r^2= 0.68, $P < 0.03$, d.f = 8).

P. sidoides tuber recovery size was found to be smaller in previously wild-harvested sites compared to tuber size in unharvested control sites in the "lowveld" and "highveld" vegetation regions (lowveld- $F_{11,95}$= 9.7226, $P < 0.001$, highveld- $F_{23,99}$= 7.0519, $P < 0.001$). Cultivated plants also had more tuber regrowth size than tuber recovery size of previously wild-harvested sites showing that cultivation can be a viable option to produce the resource and contribute to the conservation of the wild resource.

To ascertain under which scenarios *P. sidoides* can be harvested sustainably in the wild, factors which affect sustainable harvesting of *P. sidoides* such as effects of depth of harvest hole, mother tuber size (biomass), canopy area and altitude on tuber recovery biomass, tuber recovery colour and number of stems/plant were explored. Although results that were obtained varied, filling harvest holes with soil post-harvest increased tuber recovery biomass meaning that this factor can be included in *P. sidoides* harvesting guidelines. Furthermore, tuber and tuber recovery biomass tended to increase with an increase in canopy area suggesting that canopy size can be used as a surrogate for tuber size (tuber recovery biomass r^2= 0.81, $P < 0.05$, df = 7, tuber biomass- r^2= 0.57, $P < 0.05$, df = 7).

The findings of this study revealed that tuber recovery colour and biomass in previously wild-harvested sites increased positively with time. *P. sidoides* plants were found to require ≥8 years for tuber recovery to develop the dark-red colouration and ≥10-15 years for previously wild-harvested plants to reach pre-harvest biomass. Furthermore, tuber recovery size in previously wild-harvested sites was found to be smaller compared to tuber size in unharvested sites even after 8 years since last harvest suggesting that tuber recovery size has not reached pre-harvest size after this period. Hence this confirms that even a single return harvest event within a 10 to 15 post harvest period can negatively affect wild populations of *P. sidoides*. This period is however too long for a sustainable Pelargonium industry thus questioning wild harvest as a viable methodology without rigorous ongoing monitoring and management of wild harvest sites. This is despite training on sustainable harvest, such as harvest methods provided by the Pelargonium industry. Conversely, prospects for cultivation as a viable alternative to wild harvest seem promising since cultivated plants only required ≥9 years to attain similar biomass to that of unharvested wild plants. Given that it is unclear what the Pelargonium industry considers as commercially acceptable for *P. sidoides* tuber characteristics, the tuber regrowth rate of ≥8years in cultivation may be shortened to meet trade specifications.

The study also showed that for sustainable wild harvest of *P. sidoides*, harvest operations should entail effective closure of harvest holes with soil to ensure the survival of tuber remnants. Additionally, plants with bigger canopies may be targeted when harvesting *P. sidoides* in previously wild-harvested and new harvest areas. It must be noted though that a thorough investigation is needed to ascertain whether canopy size can be confidently used as surrogate for tuber size. Therefore further research into sustainable harvest methods for *P. sidoides* is recommended, and direct longer term monitoring of selected sites would be useful. More research is also needed on tuber colour development in cultivated plants and what constitutes commercially harvestable tubers.