they were usually recording different light intensities, resulting in a hopelessly wide scatter of points on the 'calibration curve'.

The next technique tried was that of taking sets of readings in different but steady light intensities, with a range of incorporated resistances from 10,000 to the minimum resistance possible for each set. It was suggested that by plotting a series of these curves on normal, logarithmic or log log graph paper that calibration values could be read off, but this proved to be impossible.

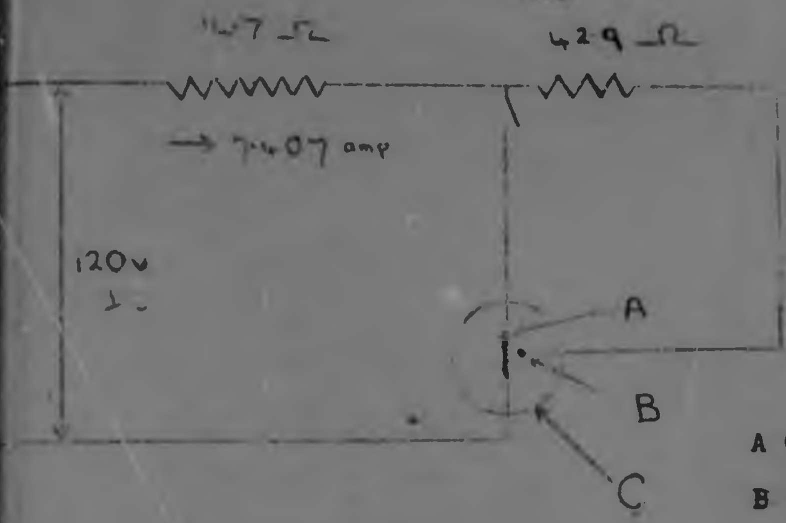
The technique finally used involved the use of the 'Inverse Square'. This law states that the intensity of light from a point source is inversely proportional to the square of the distance from the source,

$$\text{i.e.,} \quad I = k/d^2.$$

This principle was utilised by placing the receptor cell far enough away from a point source of light so that the intensity was less than 250 foot candles and could be measured on the meter scale. As 'd' was known 'k' could be calculated. This was done for several distances before the cell was so close to the light that a known resistance had to be incorporated to bring the readings on scale. As the cell was then moved closer to the light source, with the resistance in circuit, a scale reading was recorded for which the true value of 'I' could later be calculated.

This technique was first used with an ordinary light globe in a darkroom, but it was found to be very difficult to obtain an accurate measurement of 'd' from the diffuse light centre of the globe, the error being increasingly important as 'd' decreased.

To overcome this difficulty the calibrations were finally performed using a 100 candlepower Ediswan Pointolite, a special lamp giving a point source of light from a ball of approximately 2mm across. The circuit used for the operation of the pointolite was as follows:-



A Coil for striking arc

B Point source

C Globe confines

The apparatus was operated in a closed darkroom with blackened walls so that reflected light could not effect the measurements. In each run a minimum of seven readings were taken at intensities of less than 250 foot candles in order to obtain a reliable estimate of 'k'. In the first set of five runs resistances of 1,000 and 2,000 ohms were placed in circuit as these resistances had been used in field measurements. It was then decided to use 1,300 ohms in field measurements and another set of five runs was made with this resistance in circuit.

The calibration curves with the three resistances in circuit are given in figure 16.

The relationships between the two sets of readings were later checked by measuring a number of light intensities with 2,000 (or 1,000) ohms in circuit and also taking reading with 1,300 ohms in circuit on each occasion. The relationships between these pairs of readings were the same as can be read off the curves in figure 16.

Conclusion

Of the various approaches used in the calibration of a photometer with resistances in circuit the only satisfactory method was found to be by the utilisation of the Inverse Square Law.

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APPENDIX - PART THREE

A CHECK ON THE NEED FOR DAILY WASHING OF ATMOMETERS

Matheson (1937) stated that daily washing of atmometers would be required under highveld conditions, but reference to overseas literature from Fuller (1911) to Cooper (1961) indicates that weekly washing and reading are the accepted rule. As daily reading was not practicable at Frankenwald for the investigations outlined in Chapter III, it was decided to check on the need for daily washing. A preliminary trial carried on for 10 days with only two atmometers, one washed and one unwashed, showed no difference, so a more detailed trial was set up on the 13th November, 1961.

Methods

Six atmometers equipped with Livingstone-Thone valves were used, three which were left unwashed over the whole period and three which were washed after each days exposure on the roof of the Botany Department. Due to unavoidable absences at Frankenwald and over some week-ends daily washing was not possible on all occasions, and so on the day before these breaks the atmometers were placed in a closed room for the two or three day period, and the three atmometers concerned were washed as usual at the end of the break. Hence in table A18 wherever the mean readings for each group of three atmometers are given for a period of two or more days this exposure was in the closed room, where the dirt deposited on the cups over this time was less than that deposited by one day's exposure on the roof.

Results

Table A18 gives the mean values for the evaporation losses from both the washed and unwashed atmometers for each of the readings made over the 44 day period.

Discussion and Conclusions

Despite the fact that at the end of the experiment the unwashed atmometers were somewhat discoloured by the fall of dust and the splashing of dirt by rain, and had a growth of green algae on the under surfaces of the cups, there was no difference between the readings of the washed and unwashed atmometers. From this it is concluded that under the conditions of this experiment daily washing of atmometers is not required.

As the atmometers at Frankenwald never became as dirty as the unwashed atmometers in this experiment, and as overseas workers have not found daily washing to be necessary, it is concluded that the cleaning and washing procedure described in chapter III were fully adequate for the investigations carried out.

TABLE A18

ATMOMETER WASHING TRIAL - COMMENCED 13TH NOVEMBER 1961

Mean loss of water in ccs from three atmometers in each treatment

Days exposed	Washed	Unwashed
1	27cc	26cc
1	28	29
1	18	18
3	72	72
3	69	71
1	15	15
3	44	47
1	14	13
3	59	58
1	43	46
1	23	23
1	17	17
1	32	32
1	28	28
2	36	37
1	34	34
1	37	38
1	68	69
1	30	26
1	52	53
1	76	78
1	32	32
2	63	63
[illegible]	30	31
2	42	41
1	38	38
1	75	75
5	168	167
1	42	42

APPENDIX - PART FOUR

CALIBRATION OF SOIL POINT CONES AS ATMOMETERS.

The results obtained by using soil point cones as atmometers are given in chapter III(b). This section describes the experiments carried out to justify this usage of soil points.

Soil point cones are hollow pieces of porous porclain with an upper cylindrical portion, stoppered by a rubber bung, and a lower conical portion, the total height of the point being 7.5 cm. Each point is waterproofed over the outside edge except for an absorbing zone of 12 sq. cm of uncoated porclain which is located on the conical portion. Detailed descriptions of points can be found in Livingstone (1931), and one of the points is illustrated in plate 13. The points were designed to measure the 'water-supplying power of the soil' by the absorption taking place through the porous band when points are placed in the ground.

The points were used as atmometers by filling them with a convenient amount of water, 5 cc from a pipette, and then standing them up in the soil with the unglazed portion just above ground level. The remaining water after evaporation had proceeded for a known amount of time was then measured in a 10 ml. measuring cylinder, graduated to 0.1 ml. Distilled water was used in all the investigations. The 10 ml measuring cylinder used in some of the experiments was later found to have an error of 0.1 ml at 5.0 ml. Hence one or two values of 5.1 cc were recorded when the points were emptied immediately after filling. As is customary with evaporimeters the results are expressed in cc rather than ml.

Several difficulties arose when trying to use points as atmometers and these have been grouped under the following headings.

(1) It became obvious that it was necessary to pre-soak the points, as otherwise most of the 5.0 cc added was used in

wetting the porous material. This meant that the points had to be pre-soaked for any trial carried out, and investigations carried out to find the time of pre-soaking required.

(2) When the usual rubber bung was pushed home after the point had been filled a considerable amount of exudate appeared on the outside of the porous band due to increased interior pressure. Obviously this loss had to be avoided.

(3) As there was a decrease in pressure head in the point as evaporation proceeded through the porous band, it was necessary to establish whether the height of the water in the point affected the resultant evaporation rate.

(4) It was finally necessary to establish whether the evaporation rate as recorded from points had a consistent relationship with evaporation as recorded by Piche or Livingstone atmometers under the same conditions.

In the series of experiments designed to answer the above questions the standard error (S.E.) the mean of the replicates is given, being $\pm s/\sqrt{n}$, where 's' is the standard deviation, $\sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$, and 'n' the number of replicates.

(1) Pre-soaking requirement of points

Sixteen points were left to dry out overnight, after which four points were soaked with water for 3 hours, four for 1 hour, four for 10 minutes and four were left unsoaked, the periods of soaking ending simultaneously. The points were then quickly emptied out and were re-filled in a given order with 5 cc of water, and were closed by bungs with breather tubes (discussed in the next section). After 10 minutes the points were emptied out in the order in which they were filled, and the residue measured. The points were then left to dry in the open sun for two hours, and the experiment was then repeated. Later work shows the evaporation from a ten minutes exposure ina closed room would be negligible.

The results for the two runs of this experiment are given in table A19, run 'A' being the first test, and run 'B' the second.

TABLE A19

RESIDUE AFTER DIFFERENT TIMES OF PRE-SOAKING - 1.

Residue in cc

Time of soaking	Run 'A' Residue	S.E.	Run 'B' Residue	S.E.
3 hours	5.1	± .04	5.0	±.01
1 hour	5.0	.00	5.0	.00
10 minutes	5.0	.04	5.0	.04
unsoaked	1.5	.05	2.5	.08

The results clearly show that if points are to be used as atmometers that a period of pre-soaking, which can be as little as 10 minutes, is required. The comparison of the readings from unsoaked points indicates that some water is retained in points even after two hours sun drying.

Although 10 minutes is a convenient time of pre-soaking in the field, a similar experiment to that already described was carried out on sixteen air dry points four of which were soaked for each of 10, 5 and 1 minutes, with an unsoaked control. The results of the two runs carried out are given in table A20.

TABLE A20

RESIDUE AFTER DIFFERENT TIMES OF PRE-SOAKING - 2.

Residue in cc

Time of soaking	Run 'A' Residue	S.E.	Run 'B' Residue	S.E.
10 minutes	5.0	± .02	5.1	± .03
5 minutes	5.0	.00	4.8	.05
1 minute	4.1	.22	4.1	.22
unsoaked	1.9	.07	1.7	.19

As five minutes appeared to be borderline for full soaking requirements, 10 minutes was used in all the field work.

A further seven points fitted with breather tubes were allowed to evaporate until the average water content was 1.4 cc. The points were then emptied, immediately re-filled with water, left for a brief period in a closed room and were finally emptied and the residue measured. A set of points that had been pre-soaked with 5.0 cc were similarly treated, the residue for both sets being given in table A21 for the two runs carried out.

TABLE A21

EFFECT OF TWO TREATMENTS OF PRE-SOAKING POINTS

Residue in cc

Treatment	Run 'A' Residue	Run 'A' S.E.	Run 'B' Residue	Run 'B' S.E.
Points fully pre-soaked	5.0	± .03	5.1	±.04
Points that evaporated to 1.4 cc	5.0	± .04	5.1	±.03

These results indicated that points which had evaporated three-quaters of their water could be emptied out and refilled with another 5.0 cc for a second run without another period of pre-soaking being required.

Again, if the points which were re-filled with 5 cc after having only 1.4 cc of water had not retained the full 5.0 cc on emptying, this would have meant that some of the previous evaporation was from the water equivalent to that held in the pre-soaking, as well as from the addition of 5 cc.

When the residue from a point is measured a small amount of water is held in the inside of the tip by capillary action. An attempt was made to measure this amount by drying the tip of a freshly emptied point with a weighed wedge of filter paper, and then quickly measuring the gain in weight on an automatic balance. This was done on two occasions for a set of 10 points, with the filter paper being left in position for 30 seconds.

The mean weight gain for each paper used in each point for the two runs was:- Run A 0.109 cc; Run B 0.112 cc

Although the weight gain would vary with the length of time the paper was left in the point, these results give an indication of the amount of water involved. In field use this amount of 0.1 cc is compensated for in that an equivalent amount of water would be left in the point when it is emptied after pre-soaking as would be left when the residue is emptied after an actual run.

(2) Exudation trials

As mentioned before it was noticed that when the points were closed by fitting rubber stoppers there was an immediate exudation from the porous band, presumeably due to increased pressure inside the point.

To overcome this each stopper was fitted with a ╮ shaped breather tube identical to that used in the Livingstone atmometer, and shown in plate 13. To illustrate the effectiveness of these tubes six pre-soaked points were filled with 5.0 cc of water and fitted with normal stoppers, while another six were filled and closed with stoppers fitted with breather tubes. On a second run the stoppers and points were interchanged.

After each point was stoppered a piece of weighed cotton wool was used to wipe off any exudate appearing, several weighings being taken while exudation was taking place. The amount of weight gain of the wool would not equal the total moisture loss by exudation, as evaporation would have taken place from the cotton wool even though the weighings were done on an automatic balance. The mean weight gain of wool wiping the points with the normal stoppers was 0.273 gm (S.E. ± 0.04) and 0.002 gm (S.E. ± 0.0006) for those fitted with the breather tube. The students 't' test showed differences to be significant at 0.01.

To further illustrate the exudation losses resulting from the use of air-tight stoppers eight pre-soaked points were filled with 5.0 cc of water and were closed with normal stoppers, while seven other points were closed by stoppers fitted with breather tubes. The points were left in a room till exudation had ceased, and the residual water was measured. The mean residual water content was 4.7 cc (S.E. ± 0.05), for the closed points, and 5.0 (S.E. ± 0.03) for those fitted with tubes.

The following tests were carried out to demonstrate the effect that fitting of breather tubes would have on field measurements. Six een pre-soaked points were filled with 5.0 cc of water, and eight closed with normal stoppers and eight with stoppers with breather tubes. They were then left to evaporate in a closed room in run 'A' and exposed to sun and wind in run 'B'. The results of both runs are given in table A22.

TABLE A22

THE EFFECT OF BREATHER TUBES

Treatment	Mean water loss (cc) Run A	Mean water loss (cc) Run B	Evap. rate (cc/hour) Run A	Evap. rate (cc/hour) Run B
Points closed	1.0 (± .08)	3.3 (± .14)	0.33	1.10
Points with tubes	0.8 (± .08)	2.9 (± .10)	0.27	0.97

These tests described have shown that it is necessary to fit stoppers with breather tubes to avoid an initial loss of approximately 0.3 cc of water.

(3) Variation in 'evaporation rate' with a varying water level.

As previously mentioned it was necessary to establish whether there was any variation in evaporation rate as the water level fell in the points.

This was initially checked by leaving 15 points out in the sun and progressively removing lots of five and measuring the residue after one, two, and three hours. By subtracting the readings obtained it was possible to find the evaporation rate for each hour as the water level fell in the points. These evaporation rates were found to have a constant ratio with evaporation as measured by Piche evaporimeters placed alongside the points, so demonstrating that the reduction in water level does not effect the evaporation rate of points. However the following technique demonstrates this point better as it allows for statistical analysis.

15 pre-soaked points were divided into three groups of five points and were filled with 5.0, 4.0 and 3.0 cc of water.

The points were exposed for a given time and the water losses from two runs of this type are given in table A23.

TABLE A23

TOTAL WATER LOSSES FROM POINTS FILLED WITH DIFFERENT QUANTITIES OF WATER (cc)

Treatment	Run A	Run B
Points filled with 5cc	1.6 (± .03)	1.8 (± .06)
Points filled with 4cc	1.5 (.04)	1.8 (.08)
Points filled with 3cc	1.5 (.08)	1.7 (.06)

Analysis of variance showed that the difference between the evaporation rates was not significant. From this it is concluded that [illegible] action in water of points during evaporation will have no significant effect upon the evaporation rate recorded.

(4) Comparison of points with other atmometers

The final stage in these investigations was to compare the evaporation rates recorded from points with those recorded by standard atmometers. The comparison had to be made with Piche atmometers (evaporimeters) as no Livingstone atmometers were available.

In a first series of trials seven pre-soaked points were exposed in the sun with two Piche atmometers alongside, while seven other points were exposed in a room with two atmometers alongside. The instruments could then be compared under two conditions. In the second series of trials five points were placed in a room, five were exposed to wind and [illegible] and five exposed to wind only. However as only four Piche atmometers were available duplicate Piche readings could be made in only one of these positions. The evaporation rates for both instruments are given in table A24, together with the Piche evaporation divided by the point evaporation expressed as a percentage.

TABLE A24

EVAPORATION RATES FOR POINTS AND PICHE ATMOMETERS

(A) Readings made under two different conditions

	In sun & wind	In room
Run 1 (over 4 hours)		
Point evap. (cc/hr.)	.45	.23
Piche evap. (cc/hr.)	.38	.19
Piche/point x 100.	85%	83%
Run 2 (over 4 hours)		
Point evap. (cc/hr.)	.95	.30
Piche evap. (cc/hr.)	.63	.20
Piche/point x 100	66%	66%
Run 3 (over 4 hours)		
Point evap. (cc/hr.)	.93	.27
Piche evap. (cc/hr.)	.65	.18
Piche/point x 100.	70%	67%

(B) Readings made under three different conditions

	In sun & wind	In wind	In room
Run 1 (Over 5 hours)			
Point evap. (cc/hr.)	.59	.50	.21
Piche evap. (cc/hr.)	.46	.38	.13
Piche/point x 100.	78%	76%	62%
Run 2 (over 4 hours)			
Point evap. (cc/hr.)	.83	.65	.26
Piche evap. (cc/hr.)	reading lost	.57	.20
Piche/point x 100.	-	88%	77%
Run 3 (over 4 hours)			
Point evap. (cc/hr.)	.78	.45	.20
Piche evap. (cc/hr.)	.63	.40	reading lost
Piche/point x 100.	81%	89%	-
Run 4 (over 5 hours)			
Point evap. (cc/hr.)	.91	.65	.25
Piche evap. (cc/hr.)	.75	.58	.18
Piche/point x 100.	83%	89%	72%

The limiting factor, especially in the second series of measurements, is in the Piche atmometer measurements, for a difference of 0.1 cc in the atmometer reading can raise or lower the Piche/point percentage by 5 - 10%.

As a result of these tests, carried out over a range of Piche evaporation rates varying from .13 cc/hr. to .75 cc/hr. it is concluded that the ratio of Piche to point evaporation remains within a range of 0.60 to 0.90. Hence point evaporation rates would have an equally consistent ratio to

Livingstone atmometer evaporation rates (Matheson, 1937).

Conclusions

Tests carried out have shown that soil point cones can be satisfactorily used as ground level atmometers, provided that points are pre-soaked and the stoppers fitted with breather tubes. The 'evaporation rate' as measured by points had a reasonably constant ratio with the evaporation rate from Piche atmometers when compared over a wide range of conditions.

APPENDIX - PART FIVE

CALIBRATION OF GYPSUM BLOCK RESISTANCE UNITS

As noted in chapter III it had been decided when the blocks were originally installed to use the calibration curve drawn up by Jansen (1959b), and used by Leigh (1960), but as the 1961/1962 season progressed, it was found that the soil moisture values obtained were far too low.

This could have been due to two causes:-

(i) The soil type in the seasonal burn experiment studied by Jansen was different from the soils in experiment T6B.

(ii) The calibration technique used by Jansen was unsatisfactory.

The soil from the seasonal burn experiment held slightly less water than some T6B soils, as Jansen (personal communication) found the wilting point was 3.4% by the sunflower technique, whereas the corresponding values for the R and T soils were 3.0 and 5.6%. Of greater importance were the errors inherent in the calibration technique used by Jansen, and these were associated with the problems involved in adding or removing water evenly through a soil block with the resistance units embedded in it. These errors in calibration resulted in such anomalies as recorded by Jansen (1959a) where November 1959 is recorded as a month of 'high rainfalls' with a fall of 1.56" on the 10th. Yet moisture data for the 11th shows a range at 3" depth of from 3.2% to 5.9% and at 6" depth of from 2.2% to 5.1%, although the wilting point of the soil was 3.4%

The following technique was adopted to overcome the problem of ensuring a uniform moisture content throughout the soil block during calibration.

Plastic pots holding 3,000 gm of soil were filled with soil moistened to just below sticky point, and the soil was pressed down in the pots. Four gypsum blocks were set in each pot, two being approximately two inches below the soil surface, and two being two inches from the base of a six inch pot. The pots were then sown with barley and the surface was covered by washed river sand that had been retained by a 10 mesh seive. Thermometers were placed in some of the pots so that the resistance readings obtained could be corrected for temperature.

The pots were left in a greenhouse for a period of at least one month, by which time the barley was six to nine inches high. The pots were watered back to field capacity by weighing, and so the growing barley underwent several wetting and drying cycles during this time. A typical pot with barley is shown in plate 20. The pots then were brought back to above field capacity and left to dry out; block resistances, soil temperatures and pot weights being measured each day. This was done until the barley was wilting badly and then the soil was again brought back to field capacity and the process repeated. Small samples of barley were removed at intervals and checked for moisture content. At the end of the last drying cycle the barley shoots were cut off at soil level and weighed before and after oven drying at 50°C. The sand was removed from the top of the pot and the soil block shaken out onto a tray. The soil mass was then smashed apart, the resistance units removed and the total weight and moisture content of the soil determined. It was then possible to calculate the soil moisture percentage at each weighing during the drying cycle, and so to draw up the calibration curves for the R, E, H and T topsoils and the R and T subsoils. The curves for the purple veld (T) soils are given in figure 17.

The following points were taken into consideration during the calibrations:-

(1) As the moisture content of the barley in the fresh and wilted states was known, it was possible to check whether loss of water from the barley would be a significant portion of the loss in weight during drying cycles. However in all

BETWEEN PAGE 228 and 229 SEE 35mm FICHE

reached before permanent writing took place.

cases this involved a maximum error of 0.1% soil moisture.

(2) The coarse sand on top of the soil almost eliminated surface evaporation, hence all water loss was through the barley. At the same time the sand did not retain significant amounts of water at tensions lower than field capacity. A sample placed on a Haines' apparatus gave the following moisture contents with increasing tensions:-

Tension (cm)	0	1.0	2.5	5.0	7.5	10.0	20.0	30.0	60.0	100.0
Moisture content%	27.6	26.4	23.3	18.2	6.0	5.1	4.2	4.0	3.4	2.1

From this it is assumed that at the higher tensions involved in the calibration curves the water content of the sand need not be considered.

(3) When the soil mass was finally removed from the pots it was found that in all cases the barley roots had penetrated right throughout the block. Again in all cases the resistance units were very firmly embedded in the dry soil with very good soil to block contact.

(4) Although the soil was sieved to ⅛" before filling the pots it is considered that this would not limit the accuracy of the calibration technique in view of the work carried out by Elrick and Tanner (1955).

(5) This technique, although not as desireable as that of calibration in pressure membranes, is similar to that described and considered satisfactory by Aitchison et al (1951) who grew sunflowers in smaller pots containing 1,000 gm of soil in which the resistance blocks were installed. Having the larger soil to plant ratio as described, however, reduced possible errors by avoiding calculation of the rate of loss of water present in the plant tissues. In view of the work of Ursic (1961) it is also likely that the use of barley rather than sunflowers would enable a higher tension to be reached before permanent wilting took place.

The Errors in the Block Calibration and pF curves

As all the gypsum blocks were of the same type, and were manufactured under the same conditions, they would have a similar moisture tension relationship, and so this relationship can be used to evaluate the errors involved in the preparation of the soil moisture tension and pF curves.

If any resistance is taken on the calibration curves, such as 1×10^6 ohms, the soil moisture percentage can be read off, e.g. for the T subsoil. Turning to the pF curve for the T subsoil the pF corresponding to the original resistance can then be determined, and this pF value should be the same for all soils at any given resistance. If this is done for the R and T topsoils and subsoils (the only soils with pF curves) at say 1.0×10^6 and 1.0×10^4 ohms, the following pF values are obtained:-

Resistance	T topsoil	R topsoil	T subsoil	R subsoil
1.0×10^6 ohms	4.6	4.7	4.3	4.3
1.0×10^4 ohms	4.0	4.0	3.7	4.0

In view of the methods used to determine both sets of curves, this range of values can be considered as satisfactory.

APPENDIX - PART SIX

Germination Inhibitors: A Check on the Inhibiting Action of the 1:20 root extract of *Trachypogon spicatus* sampled on the 8/11/1961.

In chapter V it was shown that all the extracts prepared from roots and soils collected on the 8/11/1961 showed no inhibitory effect except for the 1:20 root extract of Trachypogon which completely inhibited germination.

The following steps were taken to try and account for this inhibition.

(1) The previous results were checked by testing the control, the Trachypogon 1:20 root extract, the Trachypogon 1:5 root extract and the 1:5 extract diluted to 1:20. The tests were carried out in the usual manner with four petri dishes, each with 50 seeds, for each solution. The mean control germination was 91%, the 1:20 extract 0%, the 1:5 extract 88%, and the 1:5 diluted to 1:20 91%.

(2) Second extracts were prepared from the root samples used to give the first extracts and these were tested in the same manner. The mean control germination was 90%, the 1:5 extract 93%, the 1:5 diluted to 1:20 82% and the 1:20 extract 90%. This showed that all the inhibitor was removed on the first soaking.

(3) The original extracts used in (1) were used to wet filter paper on which 25 pre-germinated Eragrostis seeds were placed. The seedlings were allowed to develop for three days after which they were removed and the root and shoot length measured. This test was carried out in duplicate and the results are presented in table A25.

TABLE A25

EFFECT OF EXTRACTS ON SEEDLING DEVELOPMENT

Solution	Test A Root(mm)	Test A Shoot(mm)	Test B Root(mm)	Test B Shoot(mm)
Control (water)	10.5	7.0	9.7	3.5
1:20 extract	1.8	1.7	1.8	1.8
1:5 extract	9.6	5.6	8.2	5.7
1:5 diluted to 1:20	7.9	4.6	8.6	6.0

Although low seedling numbers were used the growth inhibiting character of the 1:20 extract was clearly shown.

(4) The 1:20 extract had been stored in a brown bottle and the 1:5 extract in a clear bottle, so part of the 1:20 extract was exposed to light for several days in case the corresponding activity in the 1:5 bottle had been destroyed by light. The exposed solution gave a germination of 1% on two lots of 50 seeds, and the solution in the dark bottle again gave no germination. This light exposure was more severe than that given to the 1:5 solution, so it was concluded that storage of the 1:5 extract in a clear bottle had not effected or destroyed an inhibitor present in the 1:20 extract.

(5) As the author had washed out the beakers used in the extractions with detergent it was assumed that dirty glassware was not the cause of the inhibition. The suggestion was made that the detergent may have been responsible, but shaking of the 1:20 extract produced no 'froth', and shaking of known detergent concentrations showed that the extract must therefore have been more dilute than 1:1,000 detergent solution. The germination percentage of 100 Eragrostis seeds in solutions of known detergent strength was 24% for a 1:10 detergent, 90% for a 1:100 detergent and 96% for a 1:1,000 detergent. Therefore detergent could not have been responsible for the inhibition.

(6) Further field samples of roots of purple veld grasses were taken on the 20th November. Roots were removed from six individual Trachypogon tussocks, and were tested seperately,

and bulk samp[illegible] re taken from six Elyonurus argente[illegible]s and six Tristachya nisrida tussocks, all extracts being from 1 part roots to 10 of water. The extracts were tested on 2 petri dishes, each with 50 Eragrostis seeds, and the germination percentages obtained were as follows:-

Species:	Con.	Tras1	Tras2	Tras3	Tras4	Tras5	Tras6	Ela	Tris
Germ. %	93	90	88	92	91	92	93	85	95

Further field samples were taken on the 29th November and seperate 1:20 and 1:5 extracts were prepared from the bulked roots of six Trachypogon, six Elyonurus, six Tristachya and six Digitaria tricholaenoides (1:20 only), and the results of testing on two petri dishes, each with 50 Eragrostis seeds are given in table A26.

TABLE A26

EFFECT OF ROOT EXTRACTS ON GERMINATION OF ERAGROSTIS CURVULA

(control germination 88%)

Species	Dilution 1:20	1:5
Trachypogon spicatus	88	87
Elyonurus argenteus	80	87
Tristachya hispida	85	92
Digitaria tricholaenoides	87	(insufficient roots)

These tests established that there was no great variation between extracts from individual Trachypogon plants (as isolated roots from a single active plant could have been caught up in the original 1:20 extract) and that roots of the other dominant purple veld grasses had noinhibitor [illegible]. Hence, considering also the tests of purple veld dicotyledons, purple veld mulch and living leaf material mentioned in chapter V, it is suggested that the inhibiting action of the original 1:20 extract was not the result of any appreciable inhibiting activity in the field.

(7) As noted in table 29 in chapter [illegible] the pH of the 1:20 extract concerned was 2.2, a value much lower than for the other extracts, yet, from the work of Leigh (1960), [illegible]

low enough to be the sure and sole cause of the complete inhibition. Studies by Lawson (personal communication) had also linked acidity with inhibition as exhibited by Trachypogon extracts.

A sample of the 1:20 extract was brought back to pH 6.0, and when tested on two petri dishes, each with 50 Eragrostis seeds, gave a germination percentage of 55%, but following seedling growth was very slow.

The remaining 1:20 extract was found to be still effective after three weeks of standing. Seeds that had been kept moist with the extract while under test for two or three weeks failed to germinate after they had been washed with water and been placed on filter paper moistened by water.

Conclusions

(1) The inhibition of the original 1:20 Trachypogon spicatus root extract was not a general property of purple veld plants or soil at this period.

(2) The inhibition was to an appreciable extent caused by the low pH of the extract.

(3) The 'inhibitor' was either a substance present in or on plant roots in very isolated cases, or else was present on the equipment used for preparation and was not removed by washing in detergent, yet dissolved into the extract on standing.

APPENDIX - PART SEVEN

CLIMATIC CONDITIONS IN THE 1961/1962 GROWING SEASON

As many of the observations in this thesis must be considered in relation to the climatic conditions prevailing during the 1961/1962 growing season, these conditions are briefly summarised in table A27, where the rainfall and the mean % relative humidity, and the mean maximum and minimum temperatures for each month are given. The average monthly rainfalls are also tabulated, the values being obtained from 28 years of recording at Frankenwald. The daily rainfall pattern is graphed at the base of figure , showing that the heavy rainfalls in October, and to a lesser extent in March, were at the end of the month.

In table A28a the probabilities of receiving various amounts of monthly rainfall at Frankenwald have been given and in table [illegible] the percentage of months in years prior to 1961/1962 with rainfall greater and less than the corresponding months in 1961/1962. Although the probability figures are only based on 27 years of observations it is considered that, under highveld conditions, they give a reasonably accurate picture of rainfall expectancies.

The rainfall in 1961/1962 was good, though below average in November and December, was poor in January, February and part of March, but was heavy in late March and April. Thus mid-summer was a period of severe moisture stress to plants as a result of high day and night temperatures combined with low rainfall. October was also a month of high evaporative stress as a result of high air temperature and low humidity acting with the windier conditions prevailing before the opening rains.

The probability values given in table A28 emphasise that the mid-season of 1961/1962 was exceptionally dry and it may well have been the most severe over the 28 years of recording. The break at the end of summer came too late for growth to be greatly raaewed, owing to the onset of cooler weather.

TABLE 128

RAINFALL FREQUENCIES - FRANKENWALD RESEARCH STATION

(a) Probabilities of receiving monthly amounts of rainfall within the ranges indicated

Rainfall Group (ins.)

Month	0	0 - 0.99	1.00-1.99	2.00-2.99	3.00-3.99	4.00-5.99	over 6.00
August	59	30	11	-	-	-	-
Sept.	14	57	14	7	4	4	-
Oct.	-	25	32	18	14	7	4
Nov.	-	7	3	11	24	31	24
Dec.	-	-	14	4	21	27	34
Jan.	-	-	10	24	17	21	28
Feb.	-	7	-	28	14	34	17
Mar.	-	10	7	28	24	21	10
Apr.	3	35	21	24	10	7	-
May	4	5[illegible]	28	4	3	3	-
June	54	36	7	3	-	-	-
July	56	33	7	4	-	-	-

(b) Percentage of years prior to 1961/1962 with rainfall greater than, or equal to and lass than 1961/1962

Month of year

	1961 S	O	N	D	1962 J.	F	M	A	M	J	J	A
% years with above 1961/62 rainfall	70	59	82	75	100	96	29	25	96	46	46	42
% years equal to or below 1961/62 rainfall	30	41	18	25	-	4	71	75	4	54	54	58

TABLE A27

CLIMATIC DATA - FRANKENWALD RESEARCH STATION - 1961/1962

Characteristic	S	O	N	D	J	F	M	A	M	J	J	A	Total
Av. monthly rainfall (ins.) (28 years)	0.90	2.13	4.96	5.02	4.6[illegible]	4.23	3.33	1.75	0.95	0.31	0.28	0.30	28.77
Monthly rainfall (ins.) Sept. '61 - Aug. '62.	0.16	1.73	2.98	3.44	1.09	0.92	4.01	2.48	-	0.03	-	-	16.84
Monthly % relative humidity Sept. '61 - Aug. '62.	52	40	52	58	48	47	41	42	24	15	14	N.A.	
Monthly maximum temperature Sept. '61 - Aug. '62.	26	29	25	25	28	28	26	22	21	21	20	N.A.	
Monthly minmum temperature Sept. '61 - Aug. '62.	8	8	12	11	14	12	11	6	3	-1	0	N.A.	

(N.A. = Not available)

APPENDIX - PART EIGHT

Plates 1 to 21, illustrating various aspects of the results presented in this thesis.

Plate 1. The 1960 (R) plot. The tall growth of *Conyza ambigua* can be seen and also tussocks of *Eragrostis curvula* with matt growth of *Cynodon dactylon*.

Plate 2. A closer view of the R plot, showing Cynodon growth below Conyza plants; also much bare ground.

Plate 3. A close-up of the R stand, showing the absence of litter as compared with plates 4 and 8. Young Hyparrhenia plants are indicated by "H", and prostrate <u>Acanthospermum xanthoides</u> plants by "A".

Plate 4. Part of the Cynodon dominated portion of the 1957 (E) plot, with numerous plants of <u>Gnapthalium luteo-album</u> and virtually no bare ground.

Plate 5. Looking accross Eragrostis in the 1957 and 1958 plots, with one of the scattered but well developed Hyparrhenia hirta plants in the foreground. The bare intertussock areas cannot be seen in this photograph.

Plate 6. The Hyparrhenia dominated portion of the 1951 (H) plot showing the height of past and present seed heads of Hyparrhenia and associated ruderals.

Plate 7. Looking accross the purple veld (T) plot; note the short dense growth and the complete absence of ruderals as compared with the nearby T6B plots.

Plate 8. A closer view of the short purple veld grassland shown in plate 7, to be compared with the height of the vegetation shown in the previous plates.

Plate 9. Looking down the S.E. boundary of T68 with the ends of the plots on the right, and the yearly mown boundary in the centre and left.

Plate 10. A mounted Livingstone atmometer. The mercury in the rain-proof Livingstone-Thone valve rests on the lower cotton wool plug, yet allows water movement upwards.

Plate 11. An atmometer operating in a Cynodon dominated portion of the E plot with thick *Gnapthalium luteo-album* and an Eragrostis tussock on the right.

Plate 12. One of the cleared areas used in the studies of aerial evaporative power.

Plate 13. A Soil Point Cone operating in the E stand as an evaporimeter. Note the breather tube and the porous band marked by the letter 'P', also the bare ground surface with Cynodon actively invading from the right.

Plate 14. One of the denuded quadrats laid out in Hyparrhenia after ploughing, hoeing and levelling. The adjacent cropped lands can just be distinguished on the other side of a fence.

Plate 45. A clump of *Fimbristylis* sp. (marked 'F') on a bare patch of the R plot. The exposure meter is two inches high.

Plate 46. The seedling growth of [illegible] under four light intensities. Each small square on the graph paper is one-tenth of an inch. 5% should be 3% as in the text.

Plate 17. Hyparrhenia near the denuded quadrats (just visible at the rear) in March 1962; note the complete absence of new seed heads. There are almost no ruderals in this stand as compared with the Hyparrhenia shown in plate 6.

Plate 18. Hyparrhenia at the edge of a road about 25 yards away from the area shown in plate 17, the two photographs being taken on the same day. Not- the thick crop of seed heads.

Plate 19. An earthenware plate packed with cattle dung showing Cynodon seedlings growing from seeds contained in the dung.

Plate 20. Barley (*Hordeum vulgare*) growing in one of the pots used for the calibration of gypsum blocks. Leads to the buried blocks and a thermometer can be seen.

Plate 21. The influence of grazing: the purple veld areas on the left have been ungrazed for many years and are degenerate with an apparent invasion of Hyparrhenia, and there are many ruderals in inter-tussock areas. The overgrazed unit (O.G.) on the right is devoid of ruderals, and ruderals in the protected area have been grazed by animals leaning over and through the fence.

1956: Cynodon often very thick, fair to poor condition; Eragr-
ostis poor, almost all dead in dense Cynodon areas; approx.

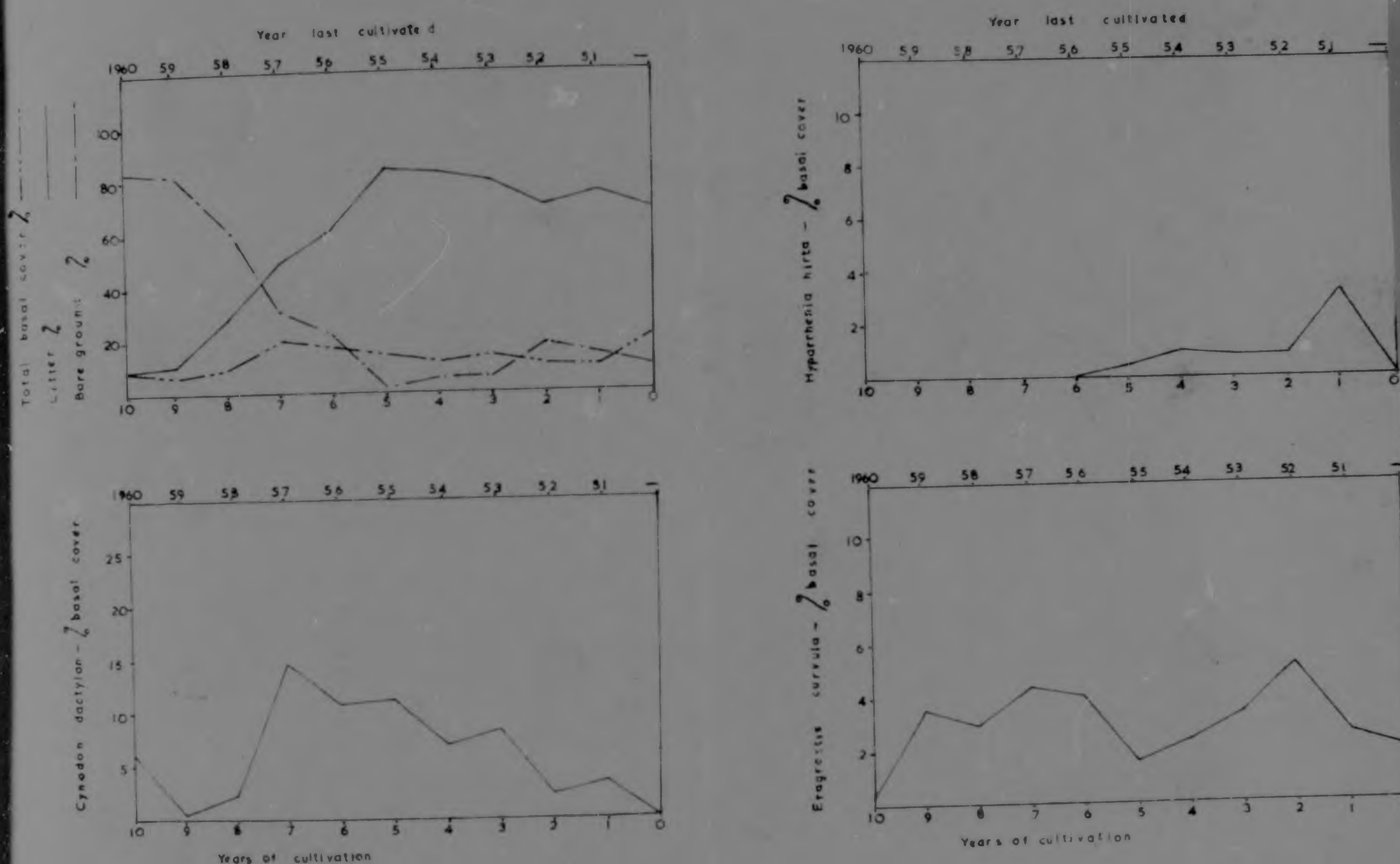
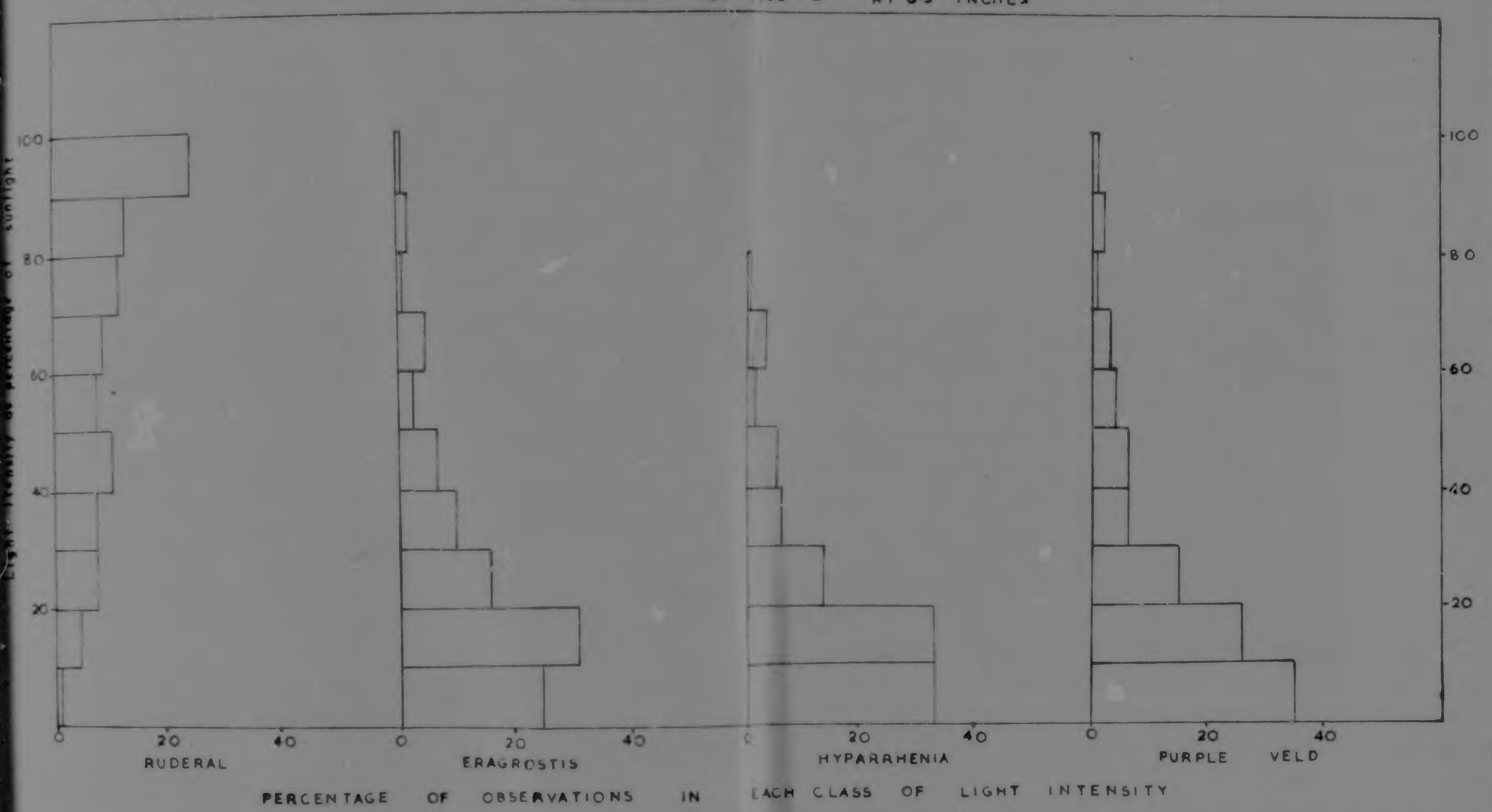


FIG I BOTANICAL ANALYSIS — EXPERIMENT T6B 1961—1962

and 15 which also illustrate various features of the plots.

(3) The shading effect of the tall species could severely

FIG 2 DISTRIBUTION OF LIGHT INTENSITY IN FOUR STAGES OF SECONDARY SUCCESSION 1961 - 1962 - AT 0·5 INCHES

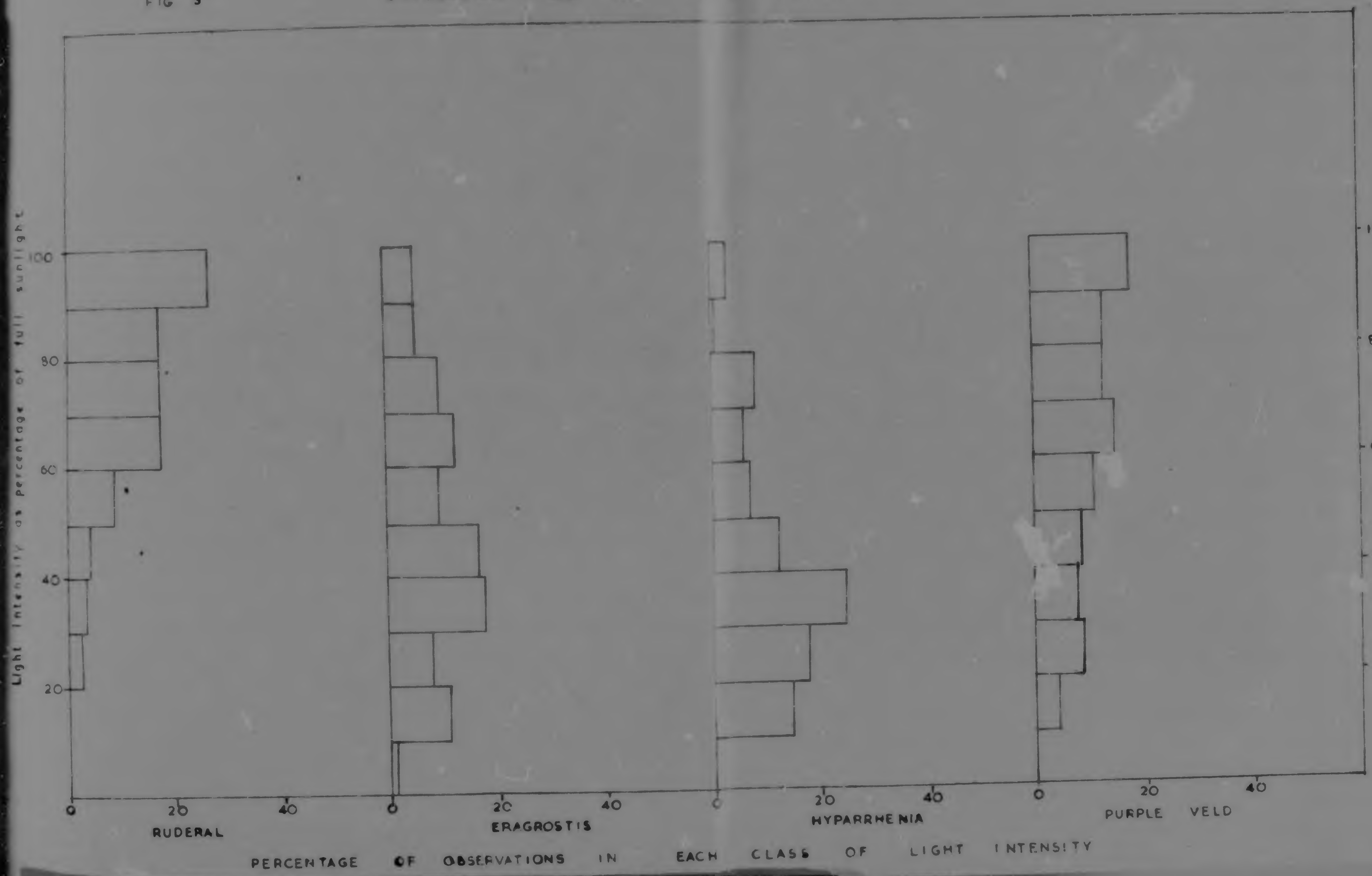


be competing. For this reason it is suggested that any further studies of light intensity in relation to secondary succession be based on detailed analyses of light intensity within various species interactions as they occur in the field.

(3) The shading effect of the tall species could severely

FIG 3

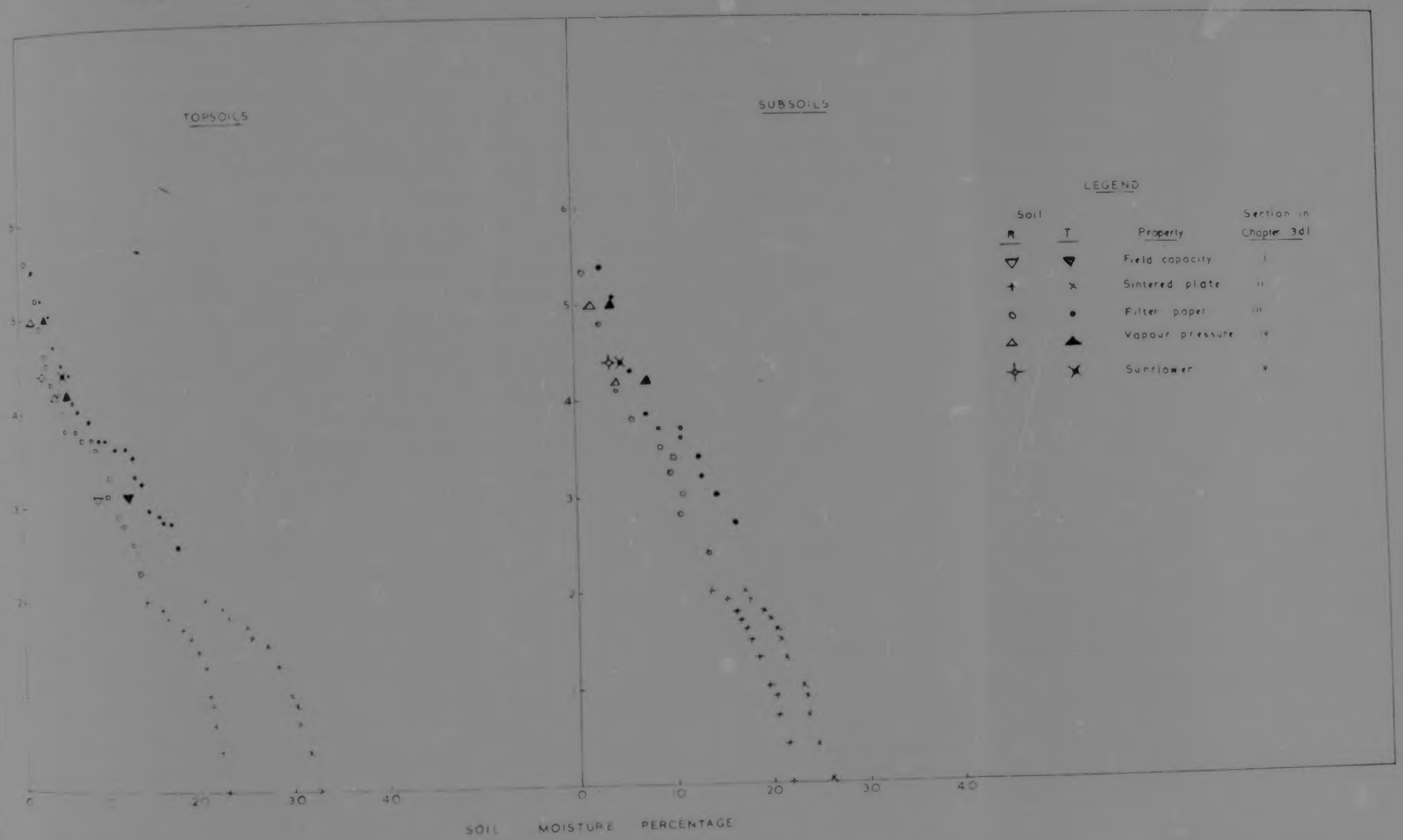
DISTRIBUTION OF LIGHT INTENSITY IN FOUR STAGES OF SECONDARY SUCCESSION 1961 — 1962 — AT 4 INCHES



be based on detailed analyses of light intensity within various species interactions as they occur in the field.

...n a vacuum desiccator. Measurements in triplicate were made at

FIG 5 MOISTURE CHARACTERISTIC — R and T SOILS



iii Mechanical analyses

Mechanical analyses of the soils described in part ii above, and also of the R and T subsoils were carried out by African

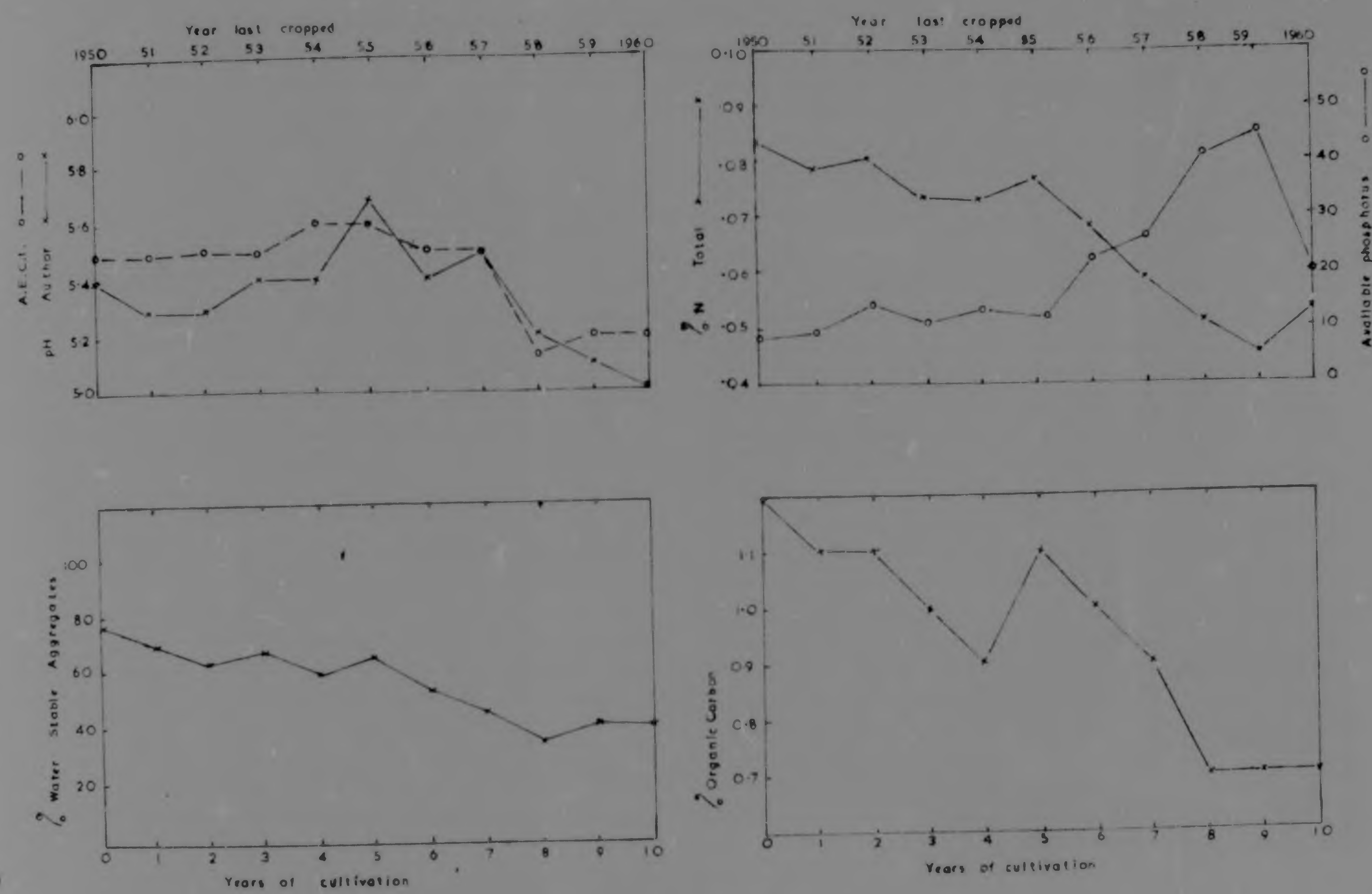
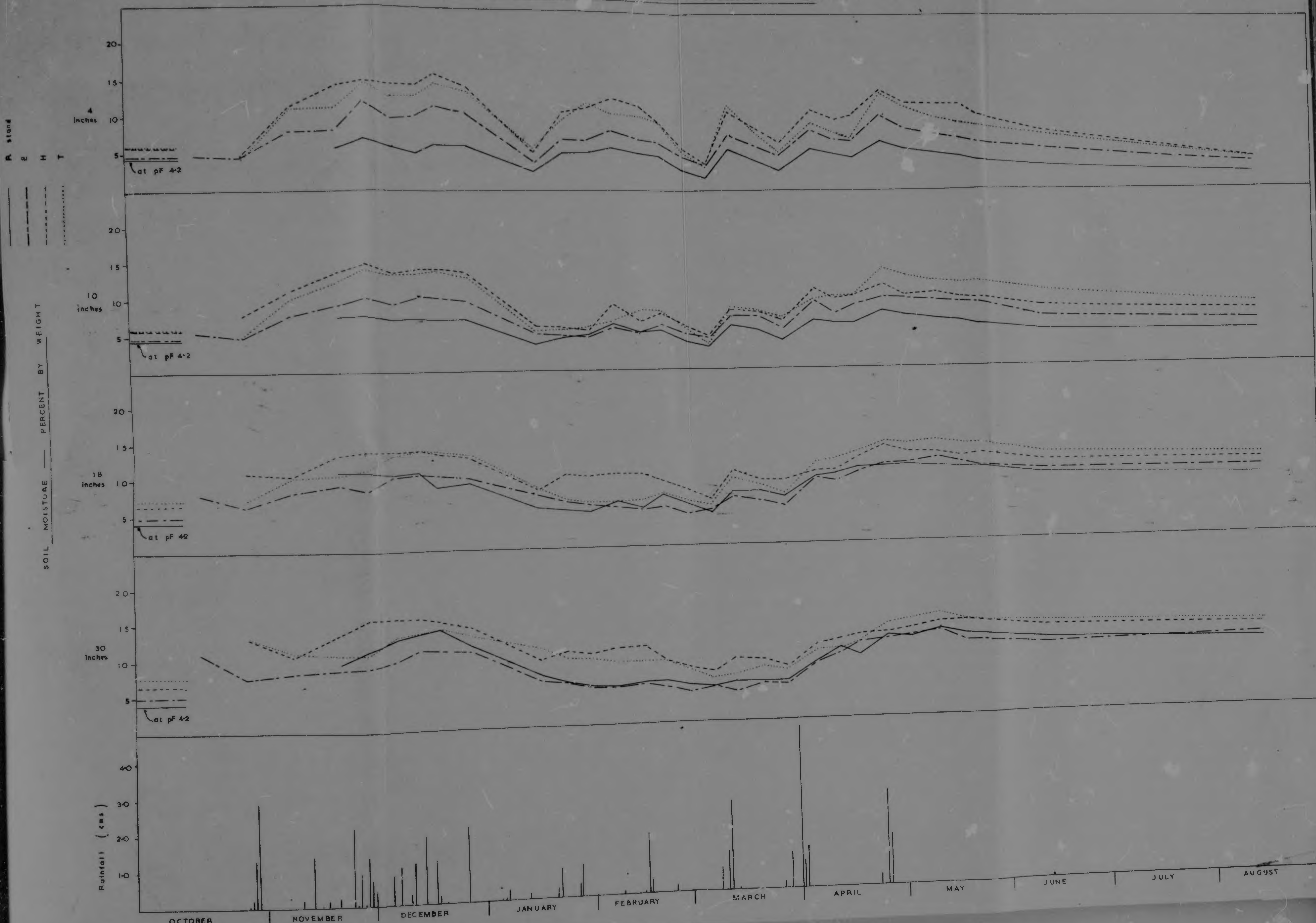
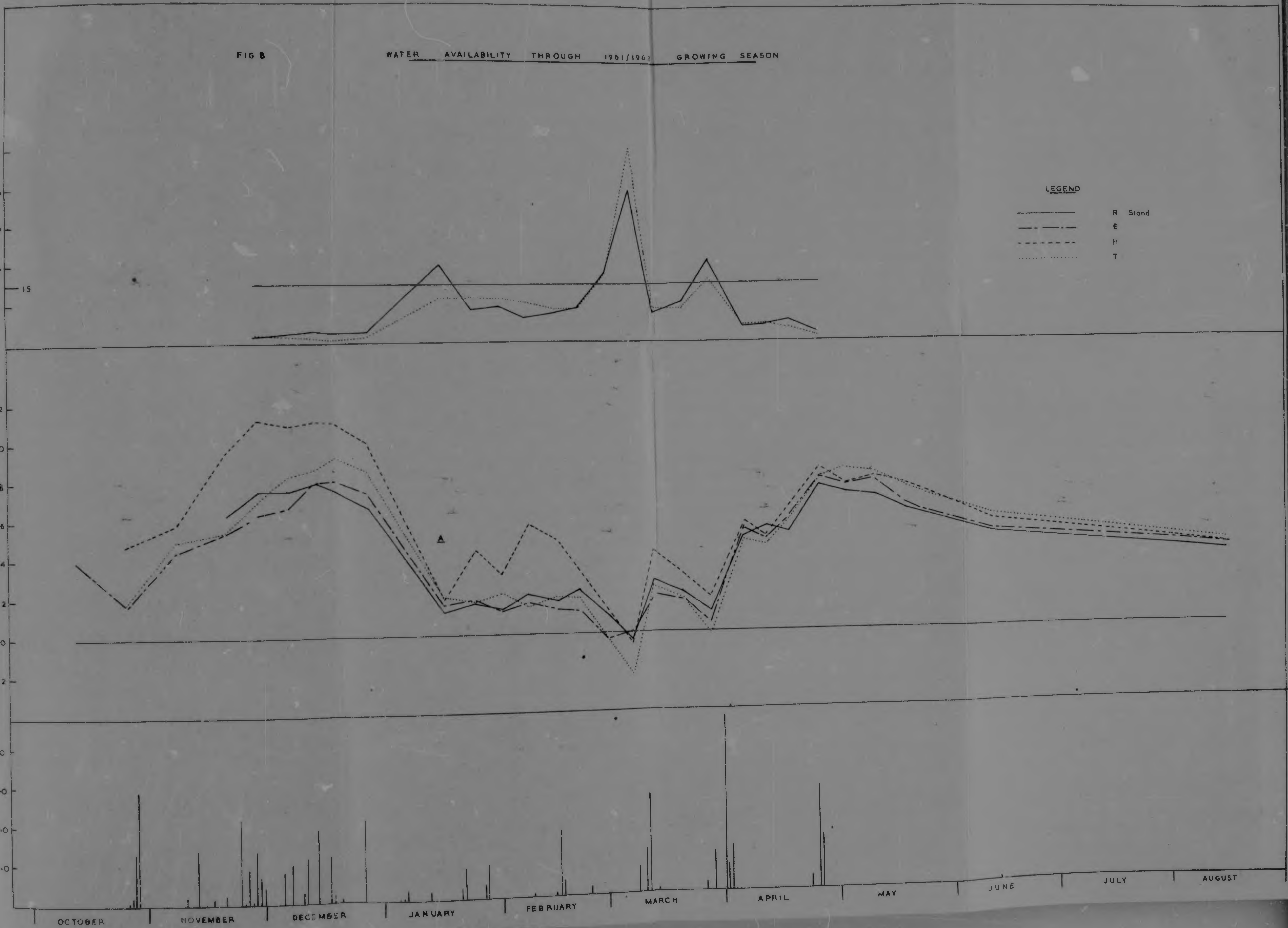


FIG 6 SOIL ANALYSES — EXPERIMENT T68 — 1961

FIG 7 SOIL MOISTURE UNDER FOUR STAGES OF SECONDARY SUCCESSION 1961 / 1962



drainage, yet some of the soil moisture measurements were made only 24 hours or less after rain. The moisture content of the bulk density samples, determined gravimetrically not long after rain (table 19), was above 15% for the T and H stands whereas



drainage, yet some of the soil moisture measurements were made only 24 hours or less after rain. The moisture content of the bulk density samples, determined gravimetrically not long after rain (table 19), was above 15% for the T and H stands whereas

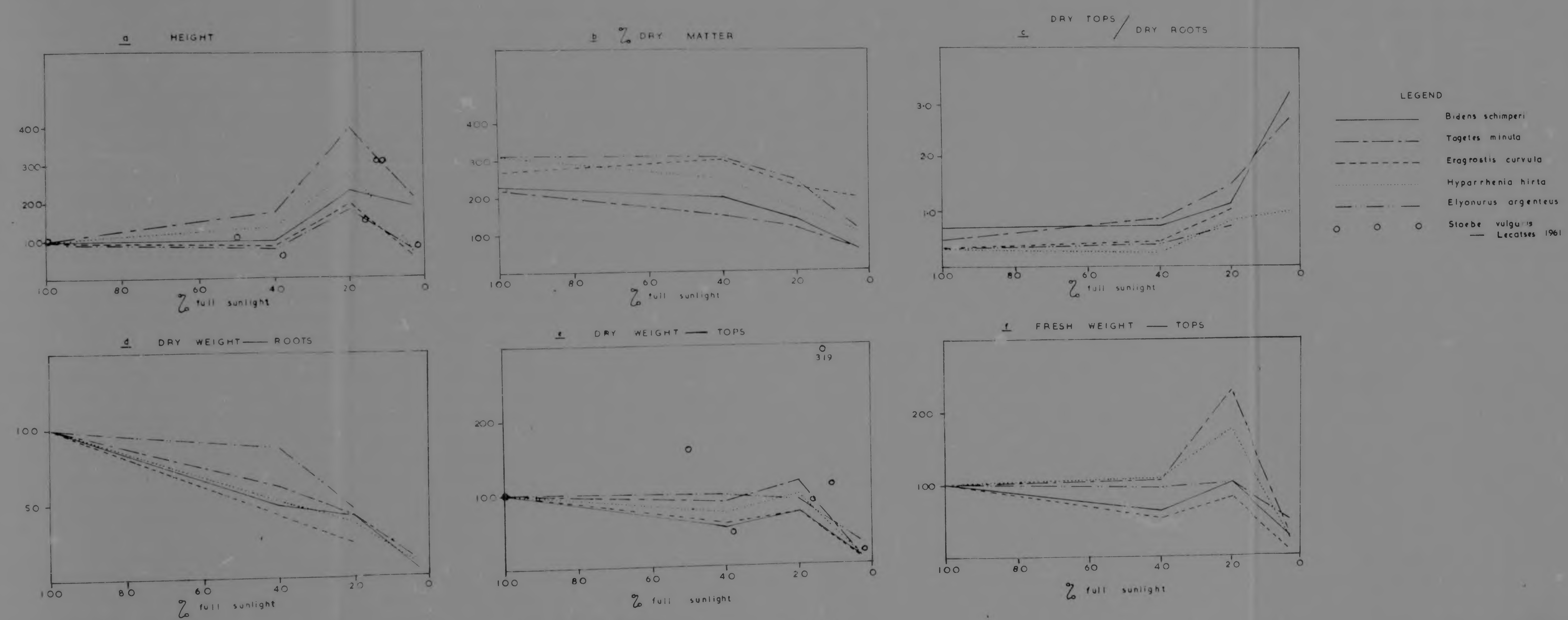
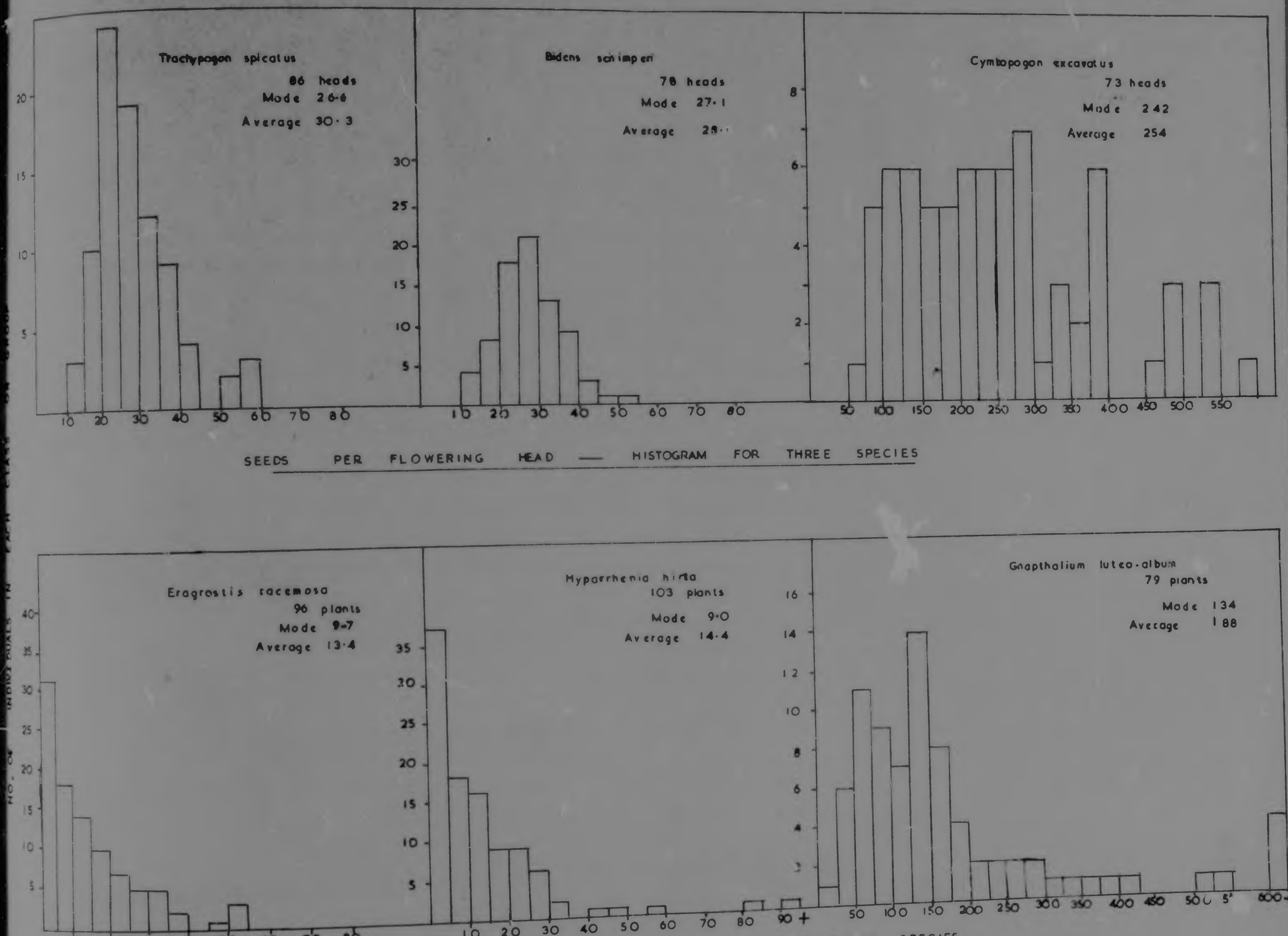


FIG 12 SEEDLING GROWTH UNDER DIFFERENT LIGHT INTENSITIES

(Full sunlight as 100 in a, d, e and f)

(2) All the species showed the same reactions to varying

FIG 13

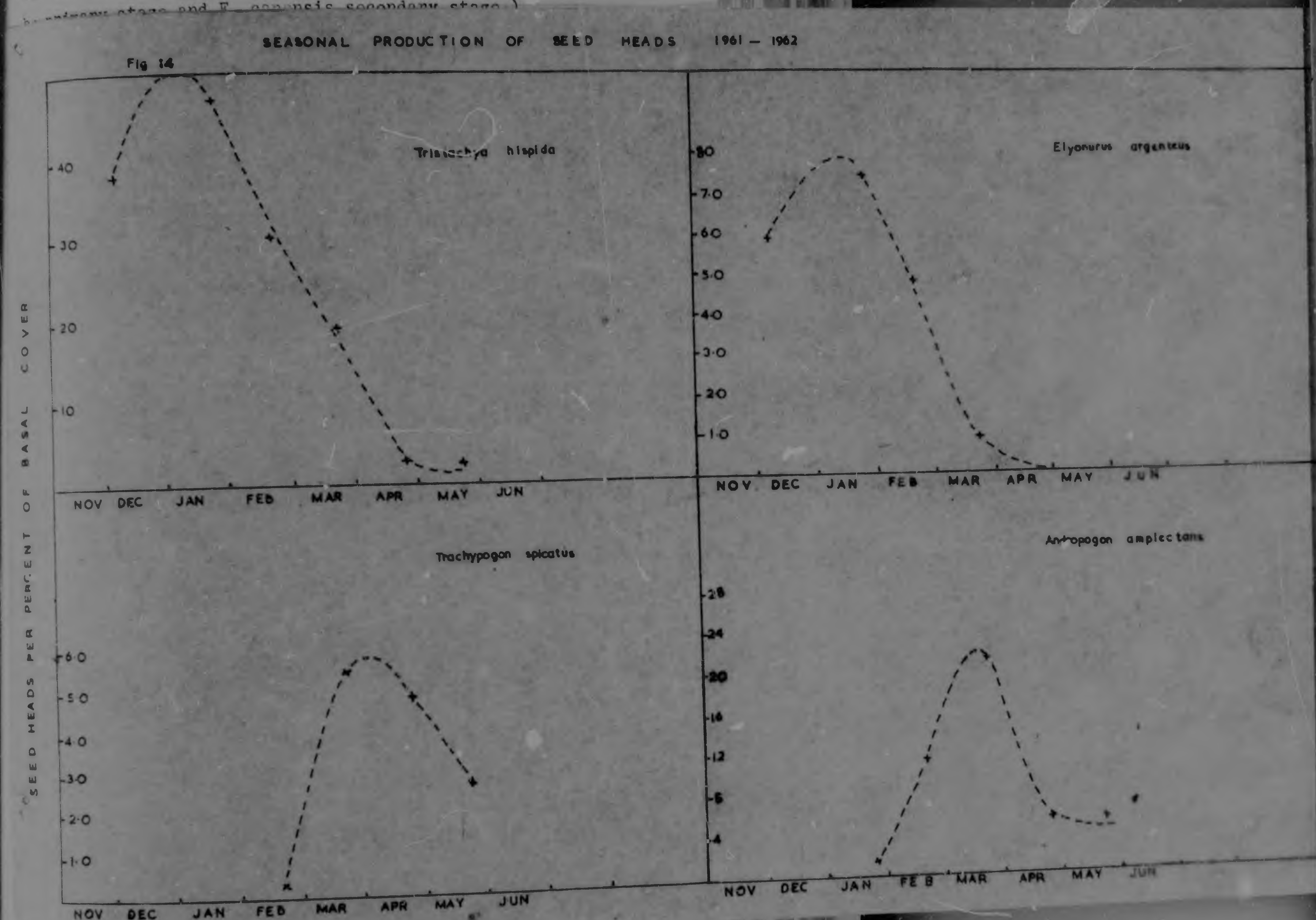


SEEDS PER FLOWERING HEAD — HISTOGRAM FOR THREE SPECIES

FLOWERING HEADS PER PLANT — HISTOGRAM FOR THREE SPECIES

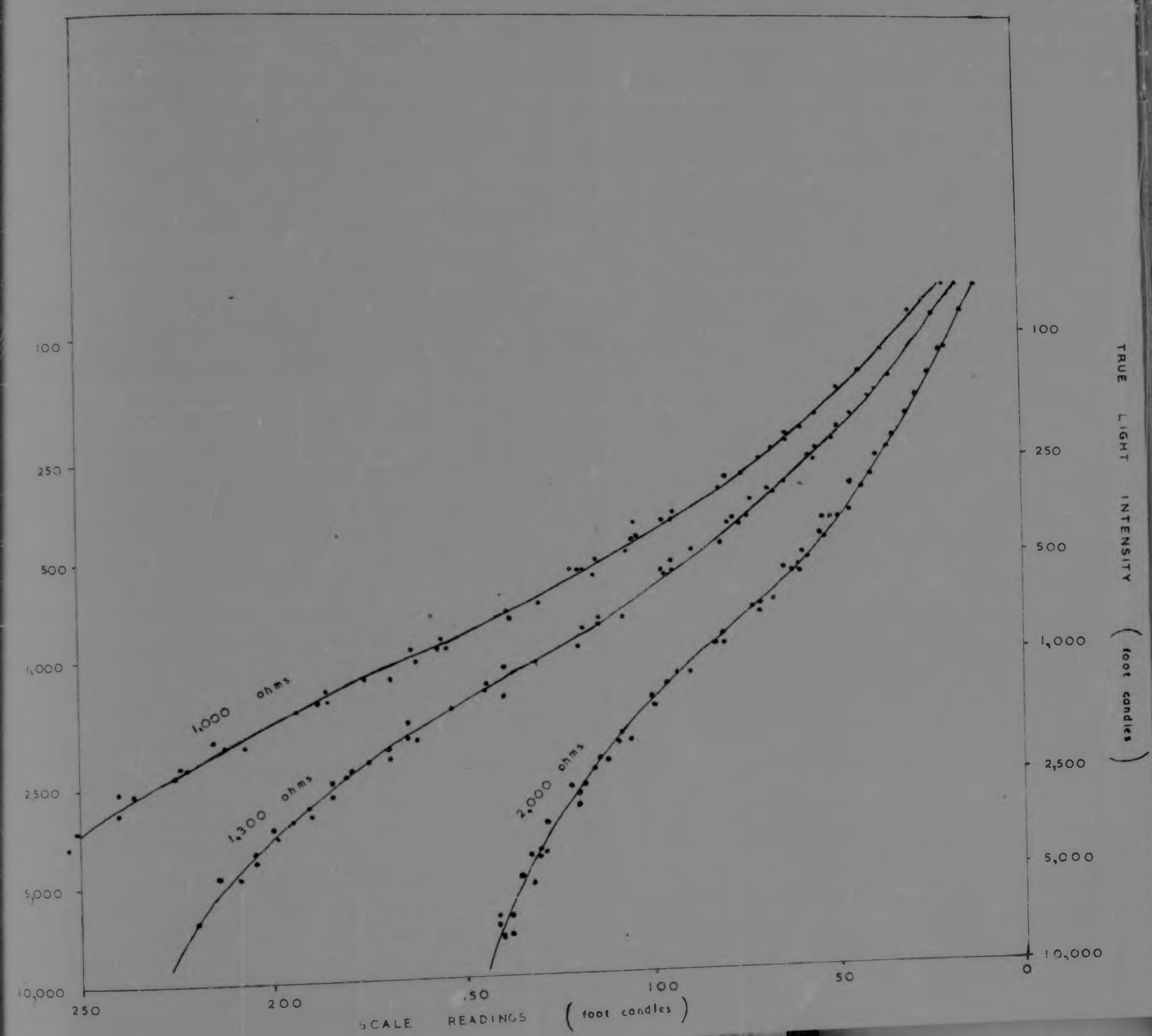
able extent independent of density, and Harper (personal communication) stressed the importance of determining output of seeds from stands. However Salisbury (1942) held that

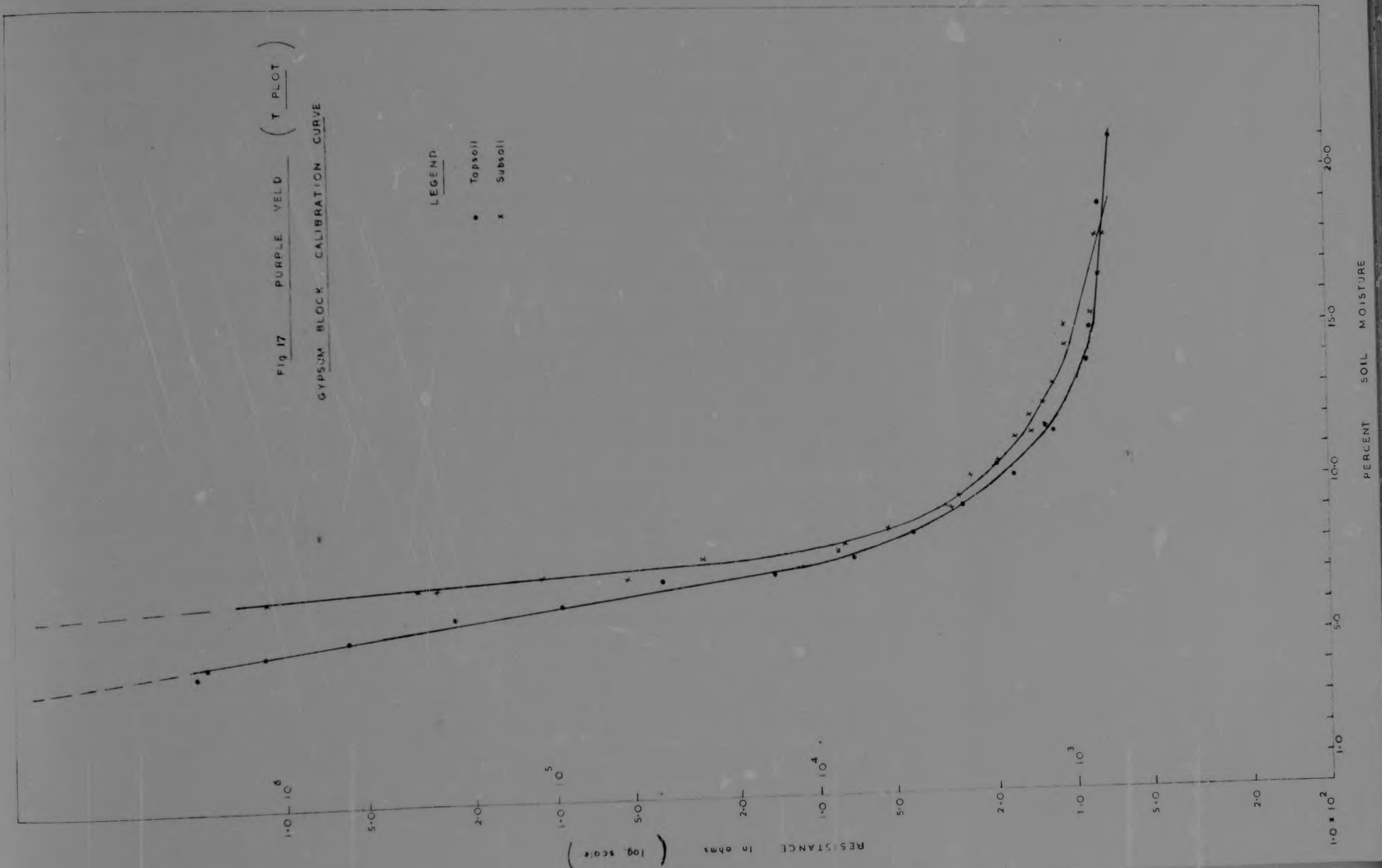
(In the calculations given above E. racemosa is considered to be primary stage and E. capensis secondary stage.)



results presented in this section show a clear trend towards a reduction in seed output as succession advances. The seed output from a stand of purple veld species has been shown to be particularly low. The results from this section will be referred to later in this thesis.

FIG 16 PHOTOMETER CALIBRATION CURVES — Resistances in circuit





reached before permanent wilting took place.