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Studies on the regeneration of perennial weeds in the glasshouse

II. Tropical species

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Contents

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II. Tropical species

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1. SUMMARY

Some aspects of the growth and regeneration of rhizomes of four species of tropical perennial grass weeds in the glasshouse, are described and previous work on their regeneration is reviewed.

Rhizomes of Cynodon dactylon (L) Pers. grew most rapidly from March to June irrespective of whether they were planted in September, December, March or June. After twelve months growth most rhizome was produced by plants established in December. Planting in March, however, gave rise to the greatest number of regenerating fragments. Two-node fragments which were prepared and tested in September regenerated better than those tested in December, March or June. Regeneration was less dependent upon age than upon season.

Rhizome fragments of Digitaria scalarum (Schweinf.) Chiov. prepared from the apical region failed to grow. Fragments taken from other positions showed little difference in their capacity to regenerate. One-node fragments were less able to regenerate than two-node fragments. Regeneration and growth of two-node fragments was unequally distributed between the nodes; the distal bud was dominant over the proximal bud. This dominant pattern was reduced when fragments were exposed to light on the surface of moist fibre-glass as opposed to being buried in soil. Most rhizome growth of D. scalarum resulted from planting in December. Regeneration of two-node fragments was much more dependent upon season than on age of material, being good in summer but poor during the winter months.

Preliminary studies of Imperata cylindrica (L.) Beauv. showed that apical fragments (9 cm long) generally regenerated much better than did sub-apical fragments of comparable size. Regeneration was best in summer but regeneration in the winter was improved by keeping the stock plants at 10°C rather than at 21°C. Light was found to be an important requirement for the regrowth of apical fragments. Season had a greater effect on regeneration than did age of material. Both regeneration and rhizome growth were at a maximum in the summer months.

Patterns of rhizome growth and regeneration of Sorghum halepense (L.) Pers. were similar to those of C. dactylon. Age, however, had the greatest influence on regeneration, which improved as the material matured. Plants established in December produced more rhizome and a greater number of regenerating fragments (two-node) than did March, June or September plantings.

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2. GENERAL INTRODUCTION

Perennial weeds are even more of a threat to agriculture in the tropics than they are in temperate regions. Many of these weeds are grasses. Cultural methods are seldom effective in suppressing such plants so that the use of chemicals offers the most likely promise of worthwhile control. At the Weed Research Organization several tropical grass species are now being used routinely in evaluation studies of new herbicides. This forms part of the Organization's work on behalf of developing countries.

Efficient testing of new herbicides for their ability to control perennial weeds depends initially on suitable techniques being available for propagating the weeds and growing them on in a predictable manner. Hence the need for the studies reported here, the aims of which are similar to those described in a previous report (Henson, 1969).

Four species were studied, namely: Cynodon dactylon (L) Pers., Digitaria scalarum (Schweinf.) Chiov., Imperata cylindrica (L) Beauv. and Sorghum halepense (L) Pers. These rhizomatous grasses were chosen for their general importance as weeds throughout the tropics and sub-tropics. Of these, C. dactylon, I. cylindrica and S. halepense were considered by Holm (1969) to be three of the world's ten worst weeds. Both C. dactylon and S. halepense are found throughout practically the whole of the tropics and sub-tropics as agricultural weeds. S. halepense is also a problem in the southern states of the U.S.A. (Stamper, 1967). I. cylindrica is also very widespread but does not occur as a weed in Central or in South America. It is however, particularly serious in the Far East. D. scalarum is mainly a problem in East Africa (Edwards and Bogdan, 1951; Ivens, 1967).

Despite a wealth of information and much experimental work directed towards the effective control of these plants, there has been little investigation into their growth reproduction or autecology. S. halepense (Johnsongrass) is the exception and its growth has been extensively studied in the U.S.A.

All the species spread and can reproduce by their underground rhizome systems. Both C. dactylon and D. scalarum can also reproduce by overground stolons which adds appreciably to the difficulties of control. Seed is also a major means of spread with S. halepense (Stamper, 1967). The importance of seed in determining the distribution of the other species is less well known although all have been found to produce some viable seed.

Finally, apart from their role as weeds the plants have some minor productive function; e.g. as pasture grasses, and such uses have in several instances encouraged their spread and establishment as severe crop competitors.

3. CYNODON DACTYLON (L) PERS.

3.i. Introduction

There appears to be little work yet published on the autecology of this grass. It is, however, known to be a very variable species and there have been several records of the occurrence of sub-specific types.

Rochecouste (1962) has isolated and studied four bio-types of the species in Mauritius. Two of these bio-types were triploids and two were tertraploids; the growth patterns of which differed. The triploids, established from single-node rhizome fragments, started to form new rhizome in May (the start of the dry season), while the tertraploids only began to initiate rhizome in September (the start of the wet season). The bio-types differed also in their stolon and rhizome diameters and in tiller and root production, but no significant differences in the rhizome dry weight of the bio-types could be found. The carbohydrate content of the rhizome was found to vary seasonally being at a maximum in August and a minimum in December. All the bio-types had similar fluctuations in reserves for the majority of the year.

Clones of C. dactylon maintained at WRO have also shown large differences in the amount of rhizome they can produce.

In Rochecouste's study there were no differences in regenerative ability between bio-types. Single-node fragments were found to germinate over a period of up to 115 days in the glasshouse. During the first ten weeks of this period the percentage of buds germinating increased linearly with time.

Physiological variation between bio-types has also been established; bio-types have been found to differ in their calcium requirements (Ramakrishnan and Singh, 1966).

The maximum depth at which rhizomes of C. dactylon can survive and from which shoots can emerge was found by Pop-antoski (1954) to be 40 cm.

Thomas (1969) has studied the resistance of rhizomes to water loss. He found that rhizome fragments failed to regenerate once dried to 50% of their original weight. This represents a high tolerance to desiccation as the rhizomes initially contained as much as 41.2% dry matter. Buds thus were able to survive until the rhizome moisture content had fallen to about 10% of the original total weight. No buds survived, however, when rhizomes were stored in air-dried soil for seven days; a treatment presumably resulting in water loss beyond the critical level.

This short review represents the extent of knowledge about the growth and regeneration of C. dactylon as far as it can be traced. The work described below was confined to a study of the growth of the rhizome, its relation to aerial shoot growth and the regenerative ability of the rhizome as influenced by age and by season.

3.ii. Effects of season and plant age on rhizome production and reproductive potential

Methods

For this experiment plants were established by planting pre-sprouted one-node fragments of rhizome, centrally, one per pot, into 22 cm diameter plastic pots containing John Innes potting compost no. 2. The rhizome used was obtained from stock plants originally derived from the Sudan. The material was clonal. Pre-sprouting was achieved by laying the prepared fragments onto the surface of moist fibre-glass matting; a technique described by Thomas (1967). Approximately 10-14 days were required for roots and a shoot to develop to a stage suitable for planting.

Plants were established at four times during the months of September and December in 1967 and March and June in 1968.

The plants were grown throughout in a heated glasshouse at W.R.O. at a temperature of around 21°C. From mid-September to mid-April the day length was extended to 18 h /day with a low density of 80 watt "daylight" fluorescent tubes. For the rest of the year plants received natural daylight.

The plants were kept well watered and at seven day intervals during the summer and 14 day intervals during the winter a liquid fertilizer with an N.P.K. ratio of 8.5.3. was applied.

Due to the luxuriant production of aerial shoots the foliage had to be trimmed during the summer. This helped to reduce mutual shading and avoided rooting of the stolons into adjacent pots. All the foliage removed was weighed and the results added onto the final shoot weights.

The plants, initially placed in a fully randomised block, were re-randomised at intervals to reduce "edge" effects on growth.

The plants were assessed after three, six, nine and 12 months of growth. There were thus 16 treatments with three replicate pots per treatment. During the assessments the following direct data were obtained:

1) fresh weight of aerial shoots;

2) fresh weight of rhizome including ascending below-ground shoots;

3) length of rhizome including ascending below-ground shoots;

4) number of clearly distinguishable nodes;

5) number of two-node fragments considered suitable as material for propagation.

The following data were then derived by calculation:

1) fresh weight of rhizome per cm length;

2) mean length of main internodes;

3) rhizome/aerial shoot fresh weight ratio.

Before recording weights of rhizomes, the rhizomes were trimmed of roots, washed of soil and carefully wiped free of surplus moisture.

Two-node fragments of the rhizomes were prepared and placed on moist fibre-glass in the dark at a temperature of 23°C to regenerate. The fragments were examined after ten days and the production of shoots and roots noted. A fragment was classed as having regenerated if it possessed at least one healthy root and a shoot.

Results

The results may be considered under two heads; (1) rhizome growth and (2) regeneration of rhizome fragments. Both are pertinent to the determination of plant reproductive potential. Data of rhizome and aerial shoot growth are presented in Table I. The various measures of rhizome growth (length, weight and node number) show similar variations both with age of plant and with time of planting. Thus rhizome

Table I

Rhizome and aerial shoot productivity of C. dactylon
(data are means of three plants)

Month of planting	Plant age in months	Month of assessment	Rhizome length (cm/plt)	Rhizome fresh weight (g/plt)	Aerial shoot fresh weight (g/plt)	Number of distinct nodes on rhizome (per plant)	Rhizome fresh weight per cm length (mg)	Mean length of rhizome per node (cm)	Rhizome/shoot fresh weight ratio	Rhizome as a % by weight of rhizome plus aerial shoot
Sept. 1967	3	Dec.	17	1	55	6	53	3.0	0.02	2.2
	6	March	167	8	178	46	47	3.6	0.04	4.3
	9	June	1311	68	267	415	52	3.2	0.26	20.3
	12	Sept.	1819	92	329	682	51	2.7	0.28	21.8
Dec. 1967	3	March	107	4	37	21	37	5.2	0.11	9.8
	6	June	1589	78	227	371	49	4.3	0.35	25.6
	9	Sept.	2871	137	288	714	48	4.0	0.48	32.2
	12	Dec.	2047	88	358	683	43	3.0	0.24	19.7
March 1968	3	June	911	45	149	189	49	4.8	0.30	23.2
	6	Sept.	1155	44	190	511	38	2.3	0.23	18.8
	9	Dec.	1273	45	256	440	35	2.9	0.18	14.9
	12	March	1759	70	388	511	40	3.4	0.18	15.3
June 1968	3	Sept.	500	22	164	126	45	4.0	0.14	11.8
	6	Dec.	661	29	264	219	44	3.0	0.11	9.9
	9	March	696	33	449	187	48	3.7	0.07	6.8
	12	June	1386	74	476	385	53	3.6	0.16	13.5

increased most rapidly with plants established in December. June-planted plants yielded the least rhizome. Most growth of rhizome occurred during the months March to June, irrespective of the time of planting (Table II).

Growth of aerial shoots, upon which the growth of the rhizome is largely dependent, proved to be most rapid for June-established plants. The rhizome/aerial shoot ratio changed little during the life of these plants, in contrast to the December and September plantings where the ratio generally increased with age, and to the March planting where it decreased with age. Low rhizome/aerial shoot ratios early in the life of the plants indicates a delay in the initiation of rhizome and it is probable that rhizomes were formed much later on plants established in September than they were on plants established at the other times.

In some instances a decline in the amount of rhizome occurred. Where the reduction in fresh weight was much greater than the reduction in length or in node number, as with December-planted material during the 9-12 month stage, a reduction in rhizome reserves must have occurred.

There was little consistent variation in the weight of rhizome per cm of length or in the length of the internodes, nor did the regenerative capacity of fragments (see below) appear related to these parameters. The gross bulk of rhizome available to the bud was thus of little importance in influencing its regrowth.

The number of fragments subjectively assessed as suitable for regeneration depended upon the total node number and upon the habit of the rhizome system. Immature apices and mature nodes at which buds had sprouted were discarded. Thus the more branched the rhizome system the fewer the number of nodes available for propagation. The number of fragments, expressed as a percentage of the maximum possible, was gradually reduced as the plants aged, being 68% for three month old plants and 36% for twelve month old plants. However, the actual number of fragments obtained steadily increased with age (Fig. 1a) due to the extensive growth of the rhizomes.

Regeneration of fragments was generally related to season. More regeneration occurred during summer (June and September) than during winter (December and March) although this was altered to some extent by the maturity of the plants (Fig. 1c). The maximum number of regenerating fragments was obtained from March-planted material (Fig. 1b).

In all cases fragments regenerated firstly by the growth of a bud into a shoot followed by roots which were initiated at the base of the new shoot. Most regeneration occurred soon after the commencement of incubation; after ten days there was little further development from remaining fragments. Those fragments not growing either remained dormant or decayed.

3.iii. Conclusions

Earlier work has established that there exists a number of distinct races of C. dactylon in nature which vary in such ways, as response to climate and requirements for soil calcium which are likely to affect their competitiveness and hence importance as weeds in specific situations. Studies have so far indicated that fragments of rhizome possess a great potential for survival being able, for instance to regrow even after deep burial or desiccation. The several aspects of rhizome

Fig. 1 Reproductive potential of Rhizome of Cynodon dactylon

a. Number of fragments selected as suitable for regenerating

b. Number of fragments regenerating roots and shoots within ten days

c. Percentage of fragments regenerating roots and shoots within ten days

Time of planting:

Sept.

Dec.

March

June

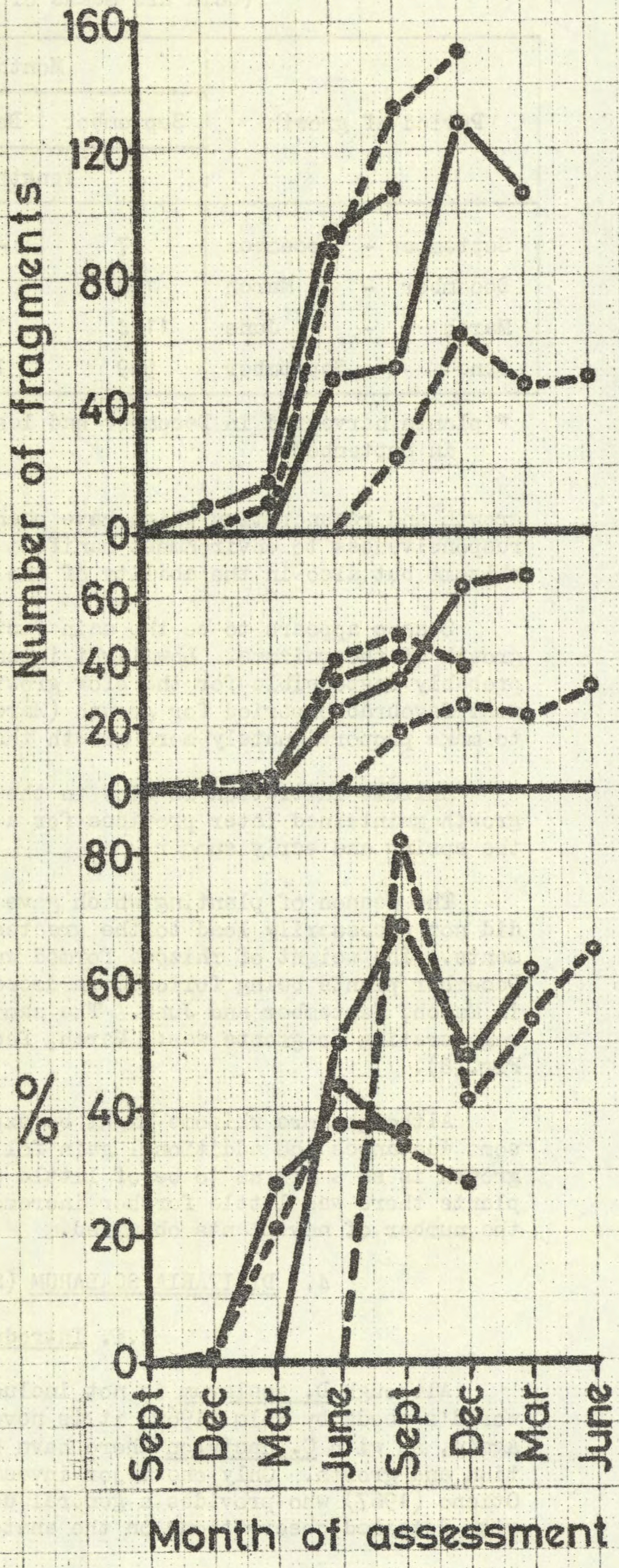

Table II

Increments in rhizome length of C. dactylon
during three-monthly periods of growth

(data are means of three plants)

Period of growth	Month of planting				Total
	September	December	March	June	
	length in cm/plant				
September - December	17	-825*	118	161	-529*
December - March	150	107	486	36	779
March - June	1144	1482	911	689	4226
June - September	509	1282	244	500	2535

* plants harvested in December had less rhizome than those harvested in September

growth and regeneration which have been studied here suggest a responsiveness to environment manifest not only in the growth of the rhizome but also in the ability of the prepared fragments to regrow.

Season appears to be the main factor influencing the rate of growth of the rhizome. Low light intensities of the winter months are probably responsible for the slow growth during this period. During the most favourable period for growth (March-June) the older plants are able to make proportionately more growth than are the younger plants.

Rhizome initiation is slow in the winter months but the aerial growth maintained later provides for a rapid increase in rhizome during the spring and early summer.

The season of planting which gave the greatest quantity of rhizome did not necessarily lead to the greatest numbers of regenerating fragments. The weight of rhizome formed was greatest on the whole with December plants being followed in decreasing order by plants established in March, September and June. The same order for the number of regenerating fragments was: March, December, June and September (see Fig. 8).

Although more rhizome might be expected the older the plant, in some instances the additional gain following a further three months growth is so small as to be of little effect. Thus for March-planted plants there was little further increment after nine months growth in the number of new plants obtained.

4. DIGITARIA SCALARUM (SCHWEINF.) CHIOV.

4.i. Introduction

Although D. scalarum is not included in the "top ten" of the world's weeds by Holm (1969) it is nevertheless an important problem. Again, as with C. dactylon there have been few studies on its regeneration and growth. Only one major investigation can be traced. This was by Otieno (1967) who provides a general description of the rhizomes together with detailed observations on the anatomy of the rhizomes, roots, stems and leaves. He found the rhizomes to have lignified epidermal cells which enable them to resist desiccation for long periods. Any small part of the rhizome which includes a node can sprout and establish new plants in the tropical environment.

At W.R.O. three experimental studies of D. scalarum were made, the results of which are reported here. The first had the object of determining the relative ability of various parts of the rhizome to regenerate. Secondly the interaction of the incubation environment with the manifestation of apical dominance in two-node fragments was investigated. Thirdly a study of the effects of season and plant age was made.

4.ii. Effects of fragment size and origin on regeneration

Methods

This experiment compared the regeneration and growth of one and two-node rhizome fragments taken from various positions in relation to the apex, along the rhizome. The rhizome material used was clonal and was originally obtained from Tanzania. Fragments were taken from eight positions along the rhizome corresponding to the first 15 nodes plus the apex; the first fragment (position 1) containing the apex and the first distinguishable node. The first one-node fragment consisted solely of the apex while subsequent fragments were prepared from every other node so that they were of comparable status to the series of two-node fragments.

The fragments were planted singly in 7.5 cm diameter pots, 1.3 cm deep in a light sandly loam soil of pH 7.2. The pots were placed in a glasshouse with a temperature maintained at 22-28°C and with a high relative humidity.

The treatments were replicated ten times and the pots randomised within ten blocks. The experiment was terminated 25 days after planting.

Results

The main results are presented in Table III and the growth of shoots measured at 11, 18 and 25 days after planting is shown graphically in Fig. 2.

The size of fragment had the greatest effect on the percentage regeneration. One-node fragments were less capable of regenerating than two-node fragments.

Of the two-node fragments which regenerated, 67% produced a shoot from both nodes. Growth was channelled into one node only. The shoot at this node (designated the primary shoot) emerged earlier (Fig. 2) and grew almost three times the length of the other (secondary) shoot. The mean lengths per shoot are shown in Table IV. Shoots produced from one-node fragments were thus approximately equal in length to the mean lengths of the shoots on two-node fragments. When assessed by total length however shoots on one-node fragments attained only 37% of the total length of shoots on two-node fragments. Thus although individual shoot lengths on one and two-node fragments were similar the lesser number of shoots produced on one-node fragments reduced their total length.

Fragment origin affected both regeneration and mean shoot length. Fragments obtained from apical regions of the rhizome showed reduced

Fig. 2 Growth of shoots on regenerating rhizome fragments of Digitaria scalarum, 11, 18 and 25 days after planting

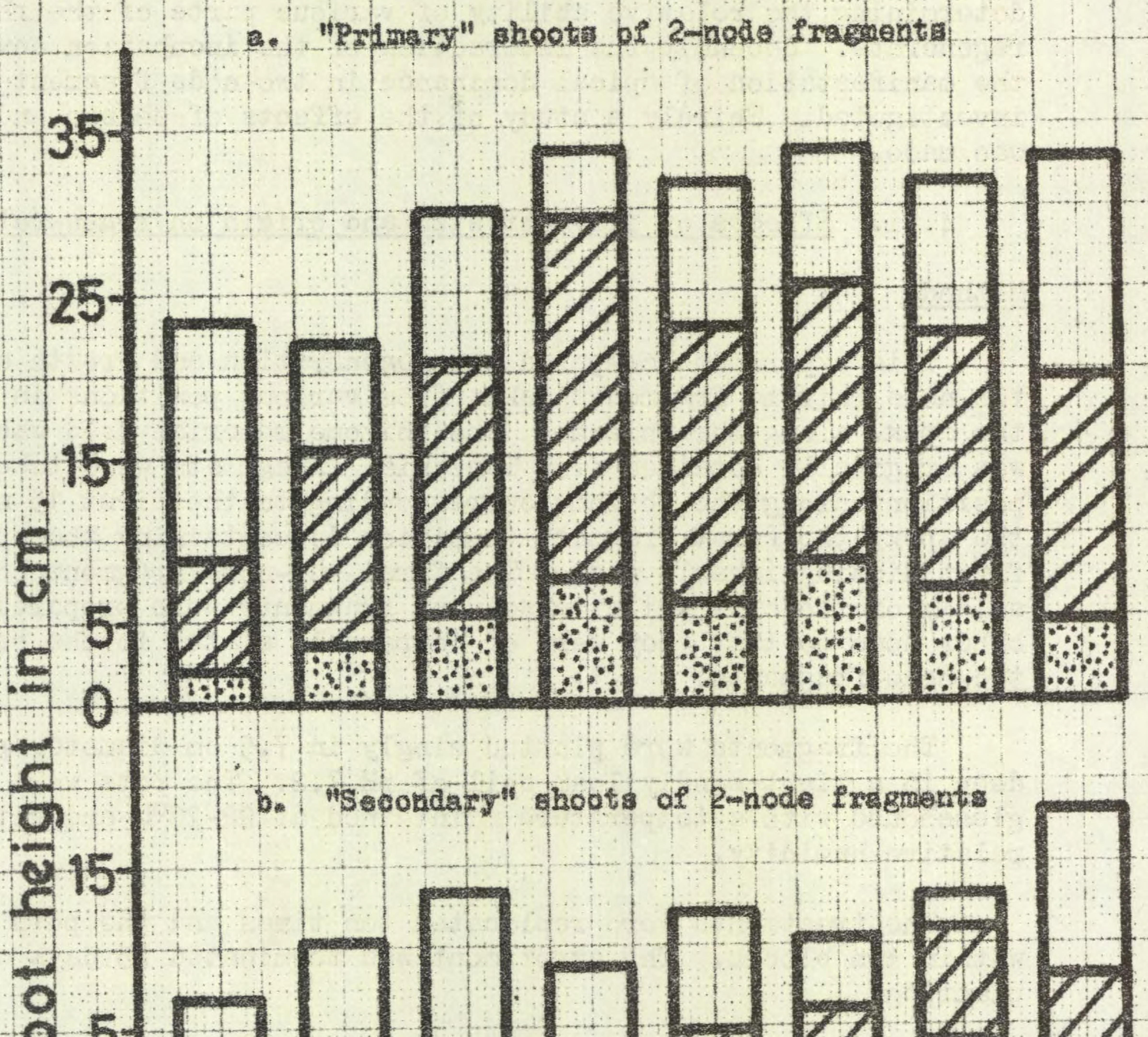

Table III

The effect of fragment size and origin on shoot production and growth of Digitaria scalarum

-	Position from apex	% of nodes producing shoots 25 days from planting	Mean length per growing shoot 25 days from planting (cm)	Mean shoot length per fragment 25 days from planting (cm)
≠ Primary shoots on two-node fragments	1	10	23.0	2.3/
	2	90	22.1	23.4
	3	100	30.0	30.0
	4	100	33.6	33.6
	5	100	31.3	31.3
	6	100	33.2	33.2
	7	100	31.9	31.9
	8	100	32.9	32.9
≠ Secondary shoots on two-node fragments	1	10	7.0	0.7*
	2	60	10.3	6.2
	3	70	13.4	9.4
	4	100	8.7	8.7
	5	70	12.1	8.5
	6	70	10.1	7.1
	7	70	13.1	9.2
	8	20	18.5	3.7
Shoots on one-node fragments	1	0	0	0 /
	2	0	0	0
	3	40	20.2	8.1
	4	70	24.5	17.2
	5	90	13.1	20.8
	6	80	25.6	20.5
	7	80	21.8	17.4
	8	100	19.5	19.5

/ L.S.D. = 6.1 cm (P = 0.05)
≠ see text
* not significant

Table IV

The effect of fragment size on shoot length

Fragment size	Shoot type	Mean length per shoot (cm)	% of total for 2-node fragment
2-node	Primary	31.2	73.2
	Secondary	11.4	26.7
	Mean	21.3	50.0
1-node		24.1	56.5

survival, and mean shoot length tended to decrease. All one-node fragments taken from positions 1 and 2 died, as did 90% of the two-node fragments which contained the apex. The percentage of one-node fragments regenerating gradually increased with distance from the apex until the 8th and 9th nodes (position 5) after which there was little change. With two-node fragments a similar effect occurred but the depressant effect of proximity to the apex was less marked.

Mean length of primary shoots on two-node fragments was also reduced by proximity to the apex. This effect was most marked at 18 days from planting, when a similar relationship held for both the secondary shoots and for the shoots on one-node fragments. At 25 days from planting differences were less marked.

4.iii. Apical dominance in rhizome fragments and modification therof by the incubation environment

Methods

The degree of dominance and the position of the dominant bud (node) on rhizome fragments was to be determined. The effect of the incubation environment on the expression of dominance was measured through the provision of two contrasting environments. One, two and three-node rhizome fragments were taken at random from healthy stock plants. Apical fragments were discarded. The prepared fragments were either:

i) laid on the surface of moist fibre-glass matting, exposed to light in the glasshouse, or

ii) planted 1.3 cm deep in a light sandy laom soil contained in tin-plate boxes 15.3 x 12.5 x 6.3 cm deep.

Fragments were grouped into five replicates with each replicate containing a total of 12 nodes, (i.e. twelve one-node, six two-node or four three-node fragments). With soil planted fragments, one replicate was planted per box.

Both boxes and matting were placed in a glasshouse at 22-28°C with a high relative humidity.

Subsequently the fragments were examined and the shoot and root production at each node was recorded separately. All fragments on fibre-glass were recorded after ten days. Fragments planted in soil were recorded after 10, 17 and 24 days from planting.

Nodes were counted as having regenerated if a healthy shoot had developed. The count thus included nodes which had not developed roots. A fragment was counted as having regenerated if one healthy shoot and some accompanying root had formed.

Results

The percentage regeneration of both fragments and nodes is shown in Table V. There was little difference between soil and fibre-glass or between fragment sizes in the percentage of regenerating fragments.

The percentage of regenerating nodes declined as fragment size increased and was lower with two and three-node fragments when planted in soil than when laid on fibre-glass. This was mainly due to a reduction in the proportion of proximal nodes which regenerated. In soil over twice as many distal as proximal nodes regenerated with both two and three node fragments, while such differences were either absent

Table V

The percentage of regenerating nodes and fragments of D. scalarum in two contrasting environments

(means of five replicates)

	Soil					Fibre-glass surface				
	i	ii	iii	iv	v	i	ii	iii	iv	v
One-node fragments	96	-	-	96	96	93	-	-	93	93
Two-node fragments	69	-	33	51	97	83	-	90	88	100
Three-node fragments	87	58	33	59	100	100	55	70	75	100

i Distal nodes
ii Central nodes
iii Proximal nodes
iv All nodes
v Fragments

or reduced with fragments laid on fibre-glass where distal and proximal nodes regenerated equally well.

In terms of freshweight, the growth of both shoots and roots was unevenly distributed between the nodes of the two and three-node fragments (Table VI). This occurred both with soil and fibre-glass, with the distal node being favoured.

The proximal node of two-node fragments contributed 52% of the total shoot number produced on fibre-glass, but only 40% of the total shoot freshweight. Likewise, the proximal node of the three-node fragments on fibre-glass formed 31% of shoot numbers but only 14% of shoot weights.

The distal node thus contributed the greater percentage of shoot and root freshweight produced by the rhizome fragment. One-node fragments (growth all "distal") in soil produced 348 mg of shoots per node and 46 mg of roots per node, while two node fragments (growth both "distal" and "proximal") produced only 162 mg of shoots per node and 24 mg of roots per node.

The rate of freshweight increment of distal shoots was also greater than that of proximal shoots. From the 10th to the 14th day from planting distal shoots increased 4.7 - 5.2 times in freshweight. The corresponding rates of increase for proximal shoots were less than 2 times. The size of fragment did not affect growth increment rate.

Initial growth at the nodes led to a depletion of reserves within the rhizome. Such depletion continued gradually throughout the 24 days of the experiment. All three sizes of fragment underwent a similar rate of depletion despite differences in shoot and root growth. By the 24th day a mean 38% (range: 34 - 48%) reduction in initial freshweight had occurred.

Table VI

Shoot and root freshweight distribution between nodes of two and three-node rhizome fragments of <u>D. scalarum</u>

			Shoots		Roots	
			Two-node fragments	Three-node fragments	Two-node fragments	Three-node fragments
Fibre-glass (10 days growth)	Mean freshweight per replicate in g		0.57	0.78	0.16	0.14
	% of total weight	Distal node	60	66	66	64
		Central node	-	20	-	16
		Proximal node	40	14	34	20
Soil (10 days growth)	Mean freshweight per replicate in g		0.91	0.69	0.13	0.31
	% of total weight	Distal node	45	57	62	23
		Central node	-	14	-	6
		Proximal node	55	29	38	71
Soil (17 days growth)	Mean freshweight per replicate in g		1.66	1.66	0.22	0.27
	% of total weight	Distal node	70	70	57	52
		Central node	-	5	-	28
		Proximal node	30	25	43	20
Soil (24 days growth)	Mean freshweight per replicate in g		1.94	3.21	0.28	0.43
	% of total weight	Distal node	100	65	100	19
		Central node	-	35	-	81
		Proximal node	0	0	0	0

4.iv. Effects of season and plant age on rhizome production and reproductive potential

Methods

These were as previously described for C. dactylon.

Results

Assessments of rhizome length, fresh weight and node number provided similar indications of a growth pattern under the influence of both plant age and season (Table VII). The amount of rhizome on the plant increased with age; December-planted material giving rise to the steepest increment gradients. The oldest plants, however, showed a slight decline in the amount of rhizome. Reductions in rhizome occurred during the winter months.

The most favourable period for growth of rhizome was during June to September (Table VIII) except for material actually planted in June. This produced most growth in the last few months (March to June) of its twelve-month life.

There were no great or consistent differences in the weight per cm length or in the length of rhizome available per node.

The amount of aerial shoot growth increased steadily with age. Although both aerial shoot weight and rhizome weight tended to increase together there was some tendency for the rhizome/aerial shoot weight ratio to increase with plant age.

The proportion of growth (excluding the roots) in the form of rhizome was low by comparison to C. dactylon. As seen in Table VIII it varied from as little as 0.7% to 11.0%. The planting time means were: March, 8.9%; December, 8.4%; June, 5.8%; September, 3.5%.

The number of fragments obtained from the plants was generally proportional to the total length of rhizome. The greatest number of fragments were obtained from twleve-month old plants with the exception of March-planted material which showed a marked decline by comparison with the nine-month plants (Fig. 3a).

The regeneration of fragments was largely dependent on the time of year of harvest (Figs. 3b and 3c). The influence of the age of the material was thus small. The winter months proved unfavourable for regeneration. The condition of the material was responsible for these variations in regenerative capacity as the incubation environment used was standard throughout the year.

4.v. Conclusions

Rhizome fragments of D. scalarum are capable of rapidly regenerating under favourable environmental conditions. Except for the apex and adjoining nodes, fragments taken from any position along the rhizome will regrow. Fragments taken from the tip of the rhizome are slender and the apex itself is not a food storage site. Reserves there are inadequate to support growth. There is also a slight fall off in regeneration of fragments 14-16 nodes behind the apex which may be due to decreased fragment size (i.e. reduced internode length in this region) or to its greater maturity.

Table VII

Rhizome and aerial shoot productivity of <u>D. scalarum</u>
(data are means of three plants)

Month of planting	Plant age in months	Month of assess-ment	Rhizome length (cm/plt)	Rhizome fresh weight (g/plt)	Aerial shoot fresh weight (g/plt)	Number of distinct nodes on rhizome (per plant)	Rhizome fresh weight per cm length (mg)	Mean length of rhizome per node (cm)	Rhizome/shoot fresh weight ratio	Rhizome as a % by weight of rhizome plus aerial shoot
Sept. 1967	3	Dec.	3	1	22	1	40	1.9	.005	4.4
	6	March	24	1	154	21	41	1.2	.007	0.7
	9	June	316	17	419	215	54	1.5	.041	3.9
	12	Sept.	715	27	527	565	38	1.3	.051	4.9
Dec. 1967	3	March	24	1	23	9	37	2.8	.039	4.2
	6	June	747	40	361	347	54	2.2	.111	10.0
	9	Sept.	1681	65	530	1056	38	1.6	.122	10.9
	12	Dec.	1491	51	558	904	34	1.6	.091	8.4
March 1968	3	June	292	18	205	139	61	2.1	.087	8.1
	6	Sept.	800	43	349	487	54	1.6	.123	11.0
	9	Dec.	909	35	378	690	38	1.3	.092	8.5
	12	March	897	40	463	649	44	1.4	.086	8.0
June 1968	3	Sept.	377	18	260	223	48	1.7	.069	6.5
	6	Dec.	199	7	235	118	36	1.7	.031	2.9
	9	March	279	12	248	128	44	2.2	.050	4.6
	12	June	952	55	546	464	58	2.1	.101	9.2

Fig. 3. Reproductive potential of rhizome of **Digitaria scalarum**

a. Number of fragments selected as suitable for regenerating

b. Number of fragments regenerating roots and shoots within ten days

c. Percentage of fragments regenerating roots and shoots within ten days

Time of planting:

Sept. ●———●

Dec. ●– – –●

March ○———○

June ○– – –○

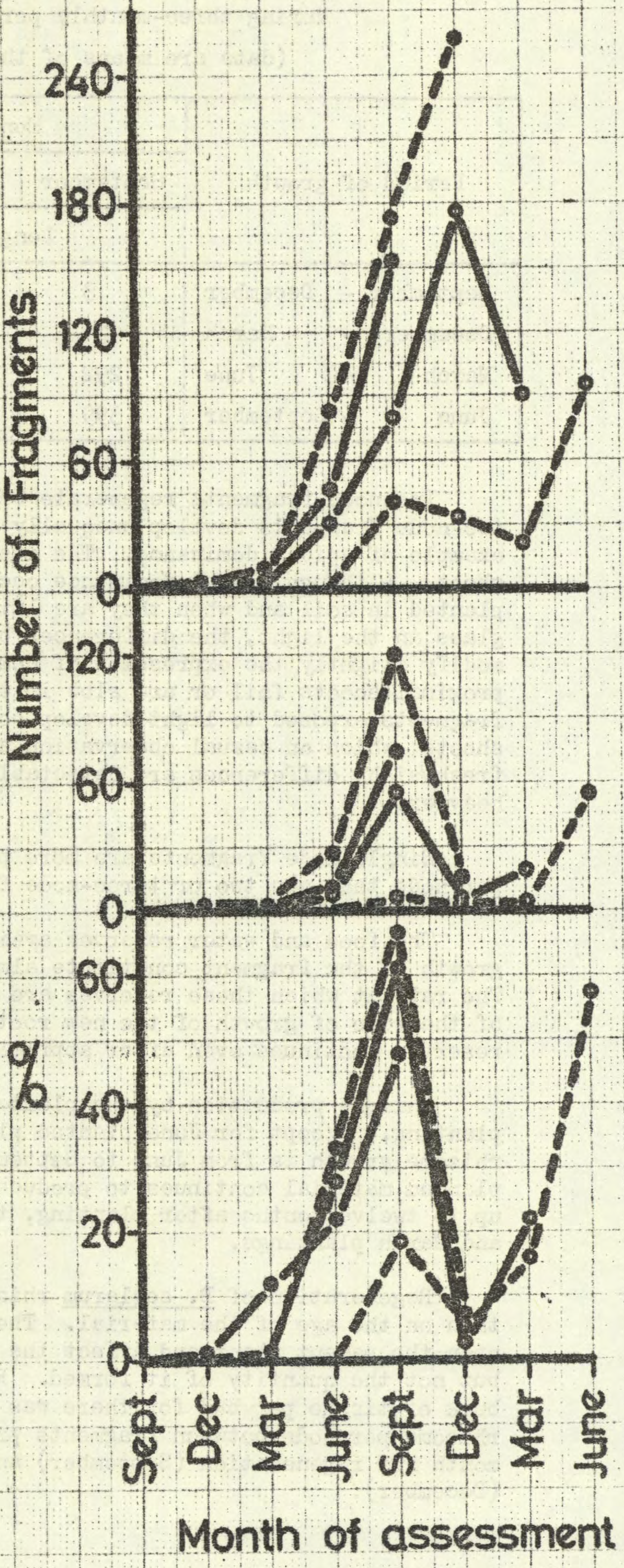

Table VIII

Increments in rhizome length of D. scalarum during three-monthly periods of growth

(data are means of three plants)

Period of growth	Month of planting				Total
	September	December	March	June	
	Length in cm/plant				
September - December	3	-190	109	-178	-256
December - March	21	24	-12	80	113
March - June	292	723	292	673	1980
June - September	399	934	508	377	2218

Two-node fragments regenerate better than one-node but the buds on two-node fragments develop unequally. This unequal development is an example of apical dominance. The distal node produces the dominant shoot. Although apical dominance occurs both when fragments are planted in soil and when they are laid on the surface of moist fibre-glass in the light, the differences between the two environments do modify slightly the expression of dominance. In soil the majority of proximal shoots fail or are slow in developing. On the other hand fragments exposed to light develop both their distal and their proximal shoots, which on casual observation appear equal, but considerable freshweight differences are detectable; the distal shoots being heavier.

Single-node fragments are more productive of shoot and root growth per node than are two or three-node fragments.

The food and water reserves available for the initial regenerative growth of the fragment constitute almost half its initial freshweight. The rate at which these reserves are depleted appears to be independent of the rate of growth of the new roots and shoots. Depletion of these reserves continues even after appreciable root growth has been made.

Rhizome production by the plant is influenced by age and time of planting. Except for June-planted plants the most productive period for rhizome growth is from June to September. While June and September planted material continues to produce appreciable quantities of rhizome up to twelve months after planting, this is not the case for December and March plantings.

Regeneration of D. scalarum rhizome is dependent on season rather than on the age of the material. These seasonal effects are exercised upon the parent plant and affect the physiological status of the rhizome but not the quantity of it formed. Regeneration is not related to the bulk of tissue per bud for there was little difference in the weight of rhizome per node between fragments prepared in the most favourable month for regeneration (September) and the least favourable month (December).

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