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*SOME EFFECTS OF MANUAL AND CHEMICAL DEFOLIATION ON THE GROWTH AND CARBOHYDRATE RESERVES OF *PANICUM REPENS* (L.) BEAUV

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In pot experiments on *Panicum repens* manual and chemical defoliation at intervals of 2-6 weeks decreased the growth of shoots, roots and new rhizomes and reduced the carbohydrate reserves. The most frequent manual defoliation did not completely suppress growth even when continued for 9 months. The plants were killed, however, by application of paraquat at doses of 0.14-0.56 kg/ha every 2 weeks for a period of 3 months. It is suggested that repeated mechanical defoliation may help to reduce plant vigour and limit the rate of spread in the field and that it may be possible to develop a method of more permanent control based on repeated application of paraquat.

INTRODUCTION

Panicum repens (L.) Beauv. is one of the most persistent perennial weeds in Ceylon and has been described in detail by Trimen (1900), Senaratne (1956) and Bor (1960). It is commonly referred to as 'couch grass' in Ceylon and is considered a good pasture grass, but it is also a pernicious weed on cultivated land (Senaratne 1934; Bor 1960). It has the capacity to regenerate from small fragments of rhizome which form a dense subterranean system with abundant food reserves within a short period.

The main method of control is by digging out the rhizomes. This method is laborious and expensive and also leads to scattering of rhizome fragments, thereby encouraging the spread of the weed in the field. Recent investigations have shown that fumigation with methyl bromide gives complete control (Shanmuganathan, personal communication, 1972) but this method is only possible under restricted conditions and subsequent re-invasion of the grass from unfumigated areas cannot be prevented. Some degree of control with hebicides has been reported by various workers (Peng 1970: Ryan 1964; Orsenigo 1962; Burt 1964). In general, paraquat and dalapon have given control for 3-4 months, while high doses of uracil compounds such as bromacil and isocil have given more effective control for longer periods. The use of uracil compounds is, however, limited by their phytotoxicity to most crops even at low doses.

The difficulty of controlling *P. repens* is largely due to its capacity to regenerate rapidly which probably results from the high content of carbohydrate reserves in the rhizomes. In the temperate couch grass, *Agropyron repens* (L.) Beauv. reserve carbohydrates are reported to be 30-50% of total dry matter (Buchholtz, 1962) and frequent defoliation has been reported to check regrowth by depleting these reserves (Dexter, 1936; Turner 1966; 1968, 1969). The authors are not aware of any previous investigation of the effects of manual or chemical defoliation on the growth of *P. repens* and the present paper reports the results of a study designed to provide this information.

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MATERIALS AND METHODS

The experiments were carried out at St Coombs, 1200 m above mean sea level in cement pots of inside dimensions 30 x 30 x 30 cm. The pots were provided with a drainage hole at the bottom and were placed on bricks to facilitate drainage. The pots were kept in the open and watered twice-weekly during dry spells. The soil used was a clay loam. Rhizomes were obtained from the boundary of a nearby tea field.

Experiment 1

The treatments tested were manual defoliation and application of paraquat at 2-, 4- and 6- weekly intervals. Each treatment was replicated three times and two untreated control pots were included in each replicate. The pots were arranged in three blocks and each block contained three rows of eight pots thus allowing for three times of assessment.

Rhizomes of uniform thickness were cut into 15-cm lengths and kept on moist blotting paper until planting to prevent desiccation. The mean number of nodes per section was 7.2, determined from a sample of twenty sections, and the mean dry weight per section determined from a similar sample was 0.86 g. Three sections were planted in each pot at a depth of 10 cm and planting was done within 6 h of collection from the field. The rhizomes were planted on 11 September 1970 and shoots had emerged in most pots by 30 September. The first defoliation was done on 12 November when most shoots had reached a height of 4-6 cm. Manual defoliation consisted of cutting the shoots at ground level with a pair of scissors. Chemical defoliation was by application of paraquat at 0.14 kg in 675.1 of water/ha. After diluting the paraquat to the required concentration, 6.3 ml of solution was discharged from a burette and sprayed onto the plants in each pot by means of a chromatogram sprayer.

Assessments were made 3, 6 and 9 months after the first defoliation. At each assessment the plants were carefully removed from the pots and washed free of soil. After blotting off excess water, they were separated into live shoots, roots and new rhizomes, and the dry weights of each portion determined after drying at 100°C for 24 h. The original rhizome sections planted were not included in the assessments.

The carbohydrate content of rhizomes was determined as follows: fresh rhizomes were cut into 1-2 mm fragments, 10 g accurately weighed and homogenized in 175 ml hot water (95-100°C), simmered for 30 min on a boiling water-bath, centrifuged while hot filtered through cotton wool and concentrated to below 50 ml under reduced pressure in a vaccum evaporator at 35°C. The hot water extraction procedure was repeated for each sample until the residue gave a negative test for starch with I/KI reagent. The final volume was made up to 50 ml with water and 5 ml of the extract hydrolysed with 5 ml 1 n H_2SO_4 for 4 h on a boiling water-bath, cooled and neutralized with 1 N NaOH and the solution made up to 25 ml. This was analysed for reducing sugars by the Shaffer-Somagyi method as described by Browne & Zerban (1941) using glucose as standard. Available carbohydrates were expressed as percentage glucose on a dry weight basis.

Experiment 2

Paraquat was applied every 2, 3 and 4 weeks at doses of 0.14 0.28 and 0.56 kg/ha in a factorial experiment with four replicates. Six 15-cm rhizome sections were planted in each pot on 15 November 1971 at a depth of 10 cm. The mean number of nodes per section was 3.4 and the dry weight 0.66 g. Shoot emergence in most pots had occurred by 30 November. Paraquat was first sprayed on 14 January 1972 when the shoots had reached a height of 4-6 cm. Sprays were applied as in Experiment 1, over a period of 3 months during which the 2-, 3- and 4-weekly frequencies received seven, four and three applications of paraquat respectively. One week after the final spaying,all plants were carefully removed from the pots, washed free of soil and separated into old and new rhizomes, live and dead shoots and roots. Dry weights were determined after drying at 100°C for 24 h.

TABLE 1 — *The effect of defoliation on shoot growth of* P. repens *g dry weight/pot transformed to log*e. $(n+1)$—*Experiment* 1

Defoliation treatment	Time of assessment (months after planting) 5 months	8 months	11 months
2-weekly clipping	1.08 (2.0*)	1.16 (2.2)	0.76 (1.1)
4-weekly clipping	1.72 (4.6)	1.94 (6.0)	1.83 (5.2)
6-weekly clipping	1.87 (5.5)	2.25 (8.5)	2.57 (12.1)
2-weekly paraquat	0.06 (0.1)	0.00 (0.0)	0.00 (0.0)
4-weekly paraquat	2.68 (13.5)	2.76 (15.2)	3.30 (26.2)
6-weekly paraquat	2.87 (16.7)	3.08 (20.7)	3.39 (28.8)
Control	3.40 (29.3)	3.69 (38.8)	4.29 (73.3)
LSD (P=0.05)	0.47	0.45	0.55

* Re-transformed data in parentheses.

TABLE 2 — *The effect of defoliation on root growth of* P. repens *g dry weight pot transformed to log*e. $(n+1)$—*Experiment* 1

Defoliation treatment	Time of assessment (months after planting) 5 months	8 months	11 months
2-weekly clipping	1.33 (2.3*)	1.17 (2.2)	1.21 (2.3)
4-weekly clipping	2.12 (7.3)	2.13 (7.4)	2.30 (9.0)
6-weekly clipping	2.04 (6.7)	2.57 (12.2)	2.75 (14.7)
2-weekly paraquat	0.18 (0.1)	0.00 (0.0)	0.00 (0.0)
4-weekly paraquat	2.45 (10.6)	2.68 (13.6)	2.94 (18.0)
6-weekly paraquat	2.76 (14.8)	2.93 (17.8)	2.99 (19.0)
Control	2.98 (19.3)	3.39 (29.2)	3.45 (33.2)
LSD (P=0.05)	0.79	0.45	0.46

* Re-transformed data in parentheses.

TABLE 3 — *The effect of defoliation on new rhizome growth of* P. repens *g dry weight/pot transformed to log*e. $(n+1)$ *—Experiment* 1

Defoliation treatment	Time of assessment (months after planting) 5 months	8 months	11 months
2-weekly clipping	0.71 (1.0*)	0.65 (0.9)	0.85 (1.3)
4-weekly clipping	1.21 (2.4)	1.43 (3.2)	1.94 (6.0)
6-weekly clipping	1.40 (3.1)	1.82 (5.2)	2.08 (7.0)
2-weekly paraquat	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
4-weekly paraquat	1.68 (4.4)	2.19 (7.6)	2.04 (6.7)
6-weekly paraquat	2.03 (6.7)	2.59 (12.4)	2.70 (14.0)
Control	2.61 (12.6)	3.46 (30.8)	3.52 (32.7)
LSD (P=0.05)	0.63	0.36	0.71

* Re-transformed data in parentheses.

RESULTS

Experiment 1

Growth of shoots, roots and new rhizomes. The effects of defoliation on the dry weights of shoots, roots and new rhizomes are shown in Tables 1, 2 and 3 respectively. In general, the depression in weight increased with frequency of defoliation. Applied at 2-weekly intervals, paraquat reduced growth more than the same frequency of clipping but spraying every 4 or 6 weeks had less effect than clipping at the same interval.

The first shoots growing after paraquat treatment were yellowish-green, later changing to the normal green colour. With paraquat applied every 2 weeks the shoots died completely after about 3 months and no new shoots emerged thereafter. Manual defoliation at 2-weekly intervals, however, did not entirely suppress shoot growth even when continued for 9 months. More detailed information on the effects of clipping on the growth of shoots at the three frequencies of cutting is shown in Fig. 1. The initial clipping was done 2 months after planting with all treatments.

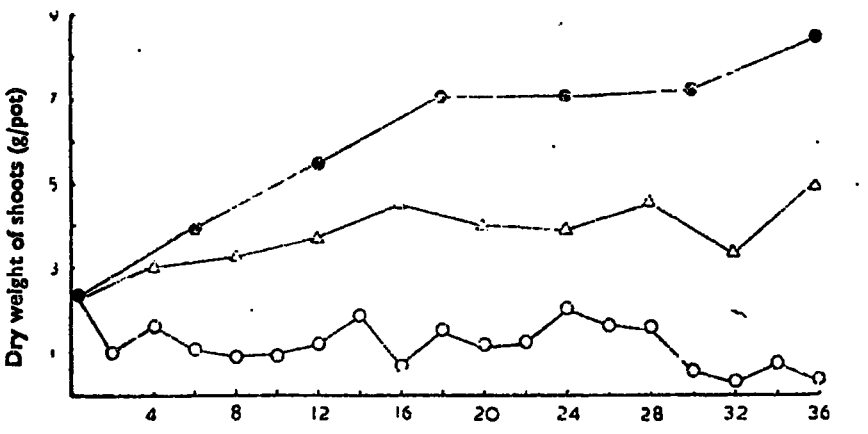

FIG.—*The effect of frequency of defoliation on the dry weight of regrown shoots after 6-weekly* (●), *4-weekly* (△) *and 2-weekly* (○) *clipping.*

With 2-weekly clipping, the dry weight of shoots produced since the previous cut was maintained at a generally low level until the 28th week, after which there appeared to be a further reduction. The weights were greater with 4-weekly than with 2-weekly clipping and increased slightly with time. The greatest weight of shoots was produced with 6-weekly clipping and there was a steady increase with time. The total weights of shoots produced with the clipping treatments during the 5, 8 and 11 months after planting (obtained by adding the weights removed by clipping to those recorded at the final assessment) are shown in Fig. 2. The total harvested dry weights also decreased with increasing clipping frequency and the greatest weights were produced from the untreated control pots. Five months after planting the total weights of shoots harvested at 2-, 4- and 6-weekly clipping intervals were 28, 50 and 58% respectively of the untreated control value and similar trends were observed 8 and 11 months after planting.

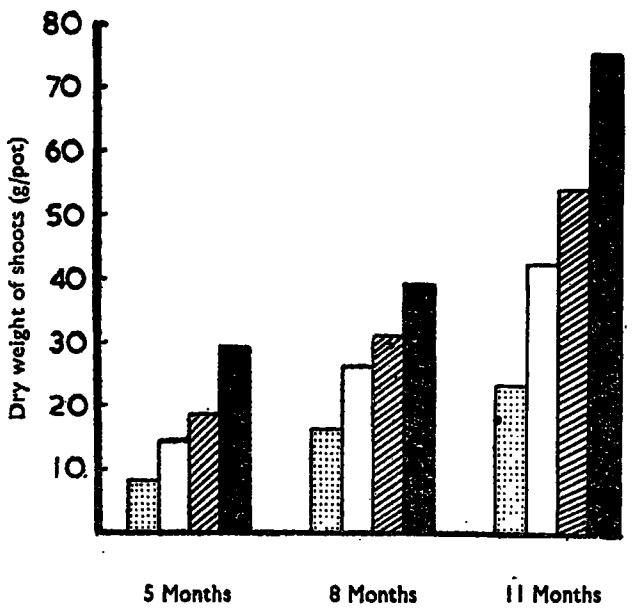

FIG. 2—*The effect of frequency of clipping on the total dry weight of shoots harvested 5, 8 and 11 months after planting. Solid columns, control untreated; hatchee columns, 6-weekly clipping; plain columns, 4-weekly clipping; dotted ns, 2-weekly clipping.*

The dry weights of roots and new rhizomes showed similar trends to those of the shoots weights, decreasing with increasing frequency of clipping and with the controls producing the most growth. The difference between 4- and 6-weekly clipping was relatively small but both produced considerably more growth than the 2-weekly cutting. In the untreated control pots the weight of new rhizomes 11 months after planting was approximately twelve times that of the planted rhizomes. As with shoot growth, 2-weekly application of paraquat caused the greatest reduction in growth of new rhizomes and caused the death of the whole plants within 5 months after planting. The effects of the less frequent paraquat applications on root and rhizome growth were less than those of clipping.

Hydrolysable carbohydrates in new rhizomes. The effects of defoliation on carbohydrate content are shown in Table 4. As there was no appreciable difference in values between the three dates of assessments only those at the final assessment

TABLE 4—*The effect of defoliation on the percentage hydrolysable carborhydrates of new rhizomes* 11 *months after transplanting transformed to log*$_e$ $(n+1)$—*Experiment* 1

Defoliation treatment	
2-weekly clipping	1.57 (3.8*)
4-weekly clipping	1.92 (5.9)
6-weekly clipping	1.95 (6.0)
2-weekly paraquat	0.00 (0.0)
4-weekly paraquat	1.95 (6.0)
6-weekly paraquat	2.21 (8.1)
Control	2.63 (13.0)
LSD (P=0.05)	0.57

* Re-transformed data in parentheses

(11 months after planting) are presented. In the controls, 10—13% of the dry weight of new rhizomes consisted of hydrolysable carbohydrates. With 2-Weekly application of paraquat the new rhizomes were rotting when the assessment was made and their carbohydrate content was taken as zero for the purpose of statistical analysis.

With increasing frequency of clipping, the percentage carbohydrates was decreased and the greatest reduction was caused by 2-weekly clipping. The new rhizomes, for example, contained 3.8% hydrolysable carbohydrates 11 months after planting in the 2-weekly clipping treatment compared with 13% in the controls. With 4- and 6-weekly defoliation, the values ranged from 5 to 8% of the dry weight but there were no consistent differences between clipping and the paraquat treatment.

Experiment 2

The effects of varying frequency of application of paraquat over a period of 3 months on the dry weight of the planted rhizomes, new rhizomes, live and dead shoots and roots one week after the final spraying are shown in Table 5 as means of the three doses applied. There were no significant differences in the weight of planted rhizome between the three frequencies of application. The dry weights of new rhizomes, live shoots, dead shoots and roots, however, were significantly reduced with increasing frequency of application. There were no significant differences between the effects of the different doses of paraquat, except on the dead shoots, where, with the highest dose (0.50 kg/h) the dry weight was significantly lower than with the two lower doses (0.14 and 0.28 kg/h) The interaction between dose and frequency of application was not significant for any of the plant components.

TABLE 5—*The effect of frequency on the of paraquat application growth of* P. repens *(mean for three doses)—Experiment* 2

Frequeucy of application	Dry wt of planted rhizomes g/pot	Dry wt of new rhizomes g/pot	Dry wt of live shoots g/pot	Dry wt of dead shoots g/pot	Dry wt of roots g/pot
14-day intervals	1.95	0.17	0.00	1.60	1.58
21-day intervals	2.07	1.35	1.54	2:66	3.52
28-day intervals	1.84	2.73	2.90	3.45	8.24
LSD (P=0.05)	NS	0.68	0.72	0.73	2.07

DISCUSSION

Repeated defoliation at frequent intervals, reduced the growth of shoots, roots and new rhizomes. With the clipped plants a reduction in shoot growth was evident at each clipping with increasing frequency of defoliation. Reduction in shoot growth with repeated clipping has been reported by Turner (1966, 1968, 1969) in *Agropyron repens* and by Horowitz (1972) in *Cynodon dactylon* and *Sorghum hale*

pense. Horowitz reported complete suppression of shoot growth with 2-weekly clipping in *Cynodon dactylon* over a period of 9 months. With *P. repens,* however, the regrowth of shoots was less drastically reduced indicating a greater resistance to repeated clipping. The effect of 2-weekly application of paraquat on *P. repens* was similar to that observed by Turner (1969) on *A. repens.* The chlorotic regrowth following paraquat application observed in the present study suggests that the chemical may move from the leaves to the rhizomes, later being translocated to the new shoots as regrowth develops, as reported by Akhavein and Linscott (1970) in *A. repens.*

The response of the roots of defoliation was similar to that of the shoots, the greatest, effect resulting from application of paraquat at 2-weekly intervals. In the other perennial grasses studied by Turner (1966, 1968) and Horowitz (1972) repeated defoliation also reduced root growth. As rhizomes are the main storage organs in *P. repens* the effect of treatment on rhizome growth is the most significant in relation to control and Turner's work on *A. repens* showed clearly that repeated defoliation suppressed the growth of new rhizomes and depleted carbohydrate reserves. Similar results were obtained in the present study. In the controls the weight of new rhizomes was twelve times that of the planted rhizomes after 11 months while with 2-weekly clipping it was only 50% of the planted rhizome weight. With 2-weekly paraquat application no new rhizomes were produced. Repeated defoliation decreased the reserve carbohydrates when compared with the untreated control. Two-weekly clipping had the greatest effect while application of paraquat at 2-weekly intervals resulted in the death of the plants when continued for 3 months.

Increasing the doses of paraquat from 0-14 to 0.28 or 0.54 kg/h did not increase the effect on the growth of live shoots, new rhizomes or roots but increasing the frequency of application from 4- to 3- or 2-weekly intervals greatly increased the effect on all these components markedly in experiment 2. The results show that frequent treatment is more important than a high dose in the application of paraquat to control *P. repens.* They also suggest that, although it may be possible to reduce the vigour and limit the spread of *P. repens* in the field by frequent cutting, eradication is unlikely to be achieved by this means alone. Plants that have been repeatedly defoliated may, however, show greater susceptibility to subsequent herbicide treatment due to their reduced vigour and loss of carbohydrate reserves. The complete kill of plants achieved with repeated application of low doses of paraquat at 2-weekly intervals appears to offer the possibility of developing a method of control but this method needs confirmation under field conditions on established stands of *P. repens.*

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