Effects of stage of defoliation on seed production and growth of Stylosanthes humilis

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Seed production is of critical importance in *Stylosanthes humilis* (Townsville stylo or TS): natural regeneration of the sward is dependent on seed population, seed forms a high protein diet for grazing animals during the dry season, and large quantities of commercial seed are sold.

There is increasing producer interest in the use of pure swards of TS for seed production, hay and grazing. Some work has been carried out describing grazing effects on mixed TS swards (Norman 1965); a study of pure TS swards was indicated to consider TS response separately from the effects of defoliation on TS/grass competition. This paper describes TS response to defoliation at differing stages of development in terms of effects on flowering, seed production, and plant growth.

Materials and methods

The experiment was done in the open at the University of Queensland, St. Lucia, Brisbane. The treatments were:

D_0—no defoliation

D_1—defoliated day 56; one half of plants at floral initiation stage.

D_2—defoliated day 76; one-third of plants at first flower appearance stage.

D_3—defoliated day 89; plants at advanced flowering stage.

There were six harvest occasions arranged as split plots: days 56, 76, 89 (D_0 treatments only), and days 104, 132, and 187 (all treatments), and nine absolute replications as randomized blocks. Sub-plot size was 40 cm × 80 cm for harvest 6 and 40 cm × 40 cm for the other harvests.

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An erect, early-flowering line of TS originally collected from 'Greenvale Station', Charters Towers, Queensland, was used. Inoculated seed was sown on January 31, 1969 (day 0), in 80 cm × 80 cm boxes containing 30 cm depth of loamy sand, using hexagonal planting patterns designed to give a plant density of 250 plants per m^2 after thinning. Complete nutrients (—N) were maintained at an adequate level, and plots were irrigated according to plant requirements until day 158, when all plants had almost fully dried off.

On each defoliation occasion, a D_0 series of plants was completely harvested and removed to the laboratory. The main axis of each plant was severed above the third node, and the four remaining laterals were shortened until a total of 60 per cent of the fresh weight of tops had been removed. The plants in the appropriate defoliation treatment were then clipped to the same degree. Characteristics of the plant swards at the time of each defoliation are shown in table 1 and figures 1 and 2. These indicate that removal of leaf material and D_1, D_2, and D_3, and of inflorescence material in D_2 and D_3 exceeded 60 per cent.

Conventional measurements to characterize growth and development were made on the central six plants of each sub-plot at harvests 1-5; 12 plants were used at harvest 6. On five occasions short wave radiation

TABLE 1

Characteristics of swards before and after defoliation.

Parameter	Day 56		Day 76		Day 89	
	D_0	D_1	D_0	D_2	D_0	D_3
Leaf weight (g/m^2)	146.4	43.8	171.2	65.4	165.9	57.4
Stem weight (g/m^2)	102.3	60.1	178.3	97.7	265.4	147.3
Inflorescence weight (g/m^2)	—	—	8.5	0.1	40.3	2.3
Leaf no./plant	70.2	34.3	98.1	33.1	122.9	75.1
Branch no./plant	18.1	13.1	31.9	15.9	42.4	21.4

was measured within 30 minutes of noon with an EEL selenium cell at 2 cm in the sward, and light values were expressed as percentages of the above sward radiation measured with the same instrument.

Results

Climatic records

Some climatic elements for the six harvest periods are recorded in table 2; radiation intensity was estimated after de Vries (1958). Temperature and radiation declined over the duration of the experiment, with notably less radiation received during the wet period 4.

TABLE 2
Climatic data.

Attribute	Period†					
	1	2	3	4	5	6
Mean daily max. temp. (°C)	27.7	28.0	26.2	23.7	21.6	21.3
Mean daily min. temp. (°C)	20.4	18.4	15.9	16.7	13.2	11.8
Radiation‡ (*cal/cm²/day*)	494	461	411	264	319	318
Mean realtive humidity (9 a.m.) (*per cent*)	66.7	63.1	57.5	75.7	66.2	73.3
Total precipitation (*mm*)	66	30	1	188	106	34

† Period 1 Jan. 31-Mar. 27, period 2 Mar. 28-Apr. 16, period 3 Apr. 17-29, period 4 Apr. 30-May 14, period 5 May 15-June 11, period 6 June 12-Aug. 5.

‡ Calculated mean radiation intensity on a horizontal surface.

Flowering

Floral initiation was detected in 50 per cent of plants dissected on day 54, when plants were at the 17-18 node stage (10 nodes externally visible). Defoliation delayed the onset of flower appearance, which was noted in 50 per cent of plants on days 78, 84, 94, and 94 for the Do, D1, D2, and D3 treatments respectively, and also extended the period of flowering. The first green seed was usually detected 7-10 days after external flower appearance.

Seed production

TS is a determinate plant; the inflorescence consists of a short, ovoid crowded spike containing 5-15 flowers. The pod is a hairy lomentum with two articulations; the upper is fertile but the lower is usually sterile. The unhulled pods are popularly known as seed. Seed yield may be regarded as the product of inflorescence density, florets per inflorescence, 'seeds' per floret, and 'seed' size (table 3).

Inflorescence number was greatest at harvest 5 on day 132, and was depressed by the two later defoliation treatments, due to decreased number before harvest 4 on day 104. Defoliation also depressed the number of florets formed in each inflorescence. Dissection of stored inflorescences collected on days 104 and 132 showed that D2 and D3 had proportionately more immature florets on these dates (table 4). However, the predominant control of seed yield was the proportion of florets setting seed. At harvest 5, seeds per floret varied by a factor of eight between treatments; other components of seed yield were less sensitive to treatment. An interesting feature of the

TABLE 3
Townsville stylo seed yield and its components under different defoliation treatments.

Parameter	Harvest day	Defoliation treatment				L.S.D. $P = 0.05$
		D_0	D_1	D_2	D_3	
Inflorescence (*no./plant*)	132	111.0	92.3	73.7	66.0	30.3
Florets per inflorescence	132	7.83	6.81	5.48	5.06	1.06
Seeds per floret	132	0.130	0.065	0.0165	0.0411	
		(62.3)†	(51.2)	(20.1)	(37.2)	(18.3)
Seed size (*mg*)	187	2.54	2.55	2.93	3.04	0.16
Seed yield (g/m^2)	187	42.6	19.1	7.0	6.1	11.4

† Arcsin transformation.

TABLE 4

Floret characterisation (day 132) according to defoliation treatment.

Classification of florets	Percentage of florets at D_0	D_1	D_2	D_3	L.S.D. $P=0.05$
In pre-seed stage	53.3 (82.0)†	59.9 (88.7)	76.7 (107.7)	73.0 (104.1)	(12.6)
Aborted	33.7 (61.8)†	33.6 (61.7)	21.7 (47.5)	22.9 (48.4)	(10.5)
Green seed	8.3 (76.3)‡	4.4 (73.7)	1.1 (71.5)	3.5 (73.1)	(2.6)
Seed dropped	4.8 (73.9)‡	2.1 (72.2)	0.6 (71.1)	0.6 (71.2)	(1.8)
Producing seed	13.0 (62.3)†	6.5 (51.2)	1.7 (20.1)	4.1 (37.2)	(18.3)

† Arcsin transformation. ‡ $\sqrt{x+\frac{1}{2}}$ transformation.

results was the increased size of seeds produced in D2 and D3 ; this effect only occurred in early-formed seeds. Presumably, competition for substrate was lessened in those treatments having a small number of seeds forming.

The net result of these variations was that seed yield in the D1, D2, and D3 treatments was 45, 16 and 14 per cent respectively of seed yield in the Do treatment.

Growth analysis

Dry weight of plant tops present during the course of the experiment (figure 1) was greater in the Do treatment, whose growth rate exceeded that of the D1 treatment in the period days 56-104. Although growth rate differences were suggestive, these did not reach significance. The total dry weight of plant tops produced by day 132, inclusive of clipped material, was 559, 529, 517, and 568 g per m² for the Do, D1, D2 and D3 treatments respectively ($P>0.05$).

Growth rate of tops may be considered broadly as the product of leaf area index (figure 2) and net assimilation rate. Leaf area index was significantly greater in the Do plots, reaching a maximum of 2.9 at day 89 ; net assimilation rates had higher numerical values in the defoliated treatments, but these differences did not reach significance. The findings are in line with the light values at 2 cm (figure 3), which indicate significantly less light interception as time of defoliation advanced.

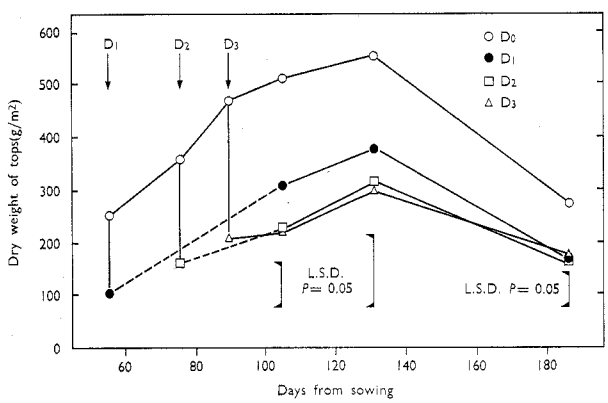

Figure 1—Defoliation treatment and dry matter production.

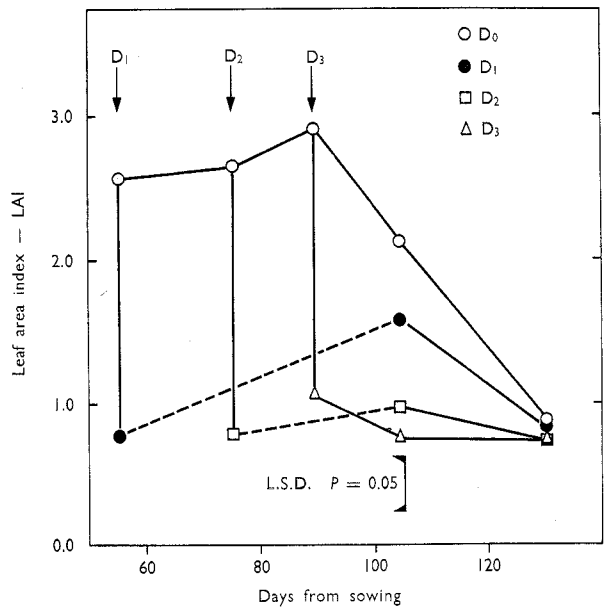

Figure 2—Defoliation treatment and leaf area index.

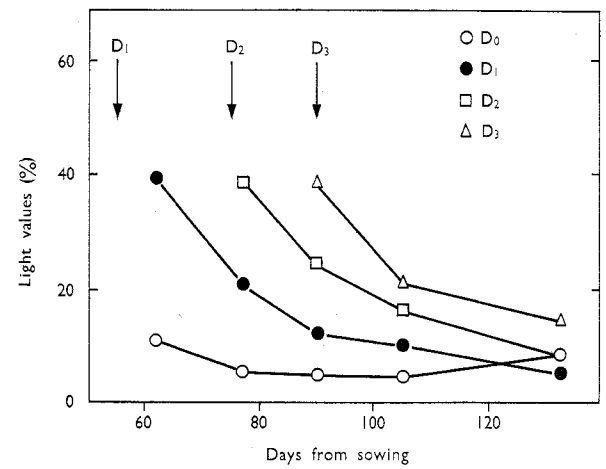

Figure 3—Defoliation treatment and light values.

Root weight was independent of treatment, but whereas leaf growth rate (table 5) was enhanced by defoliation treatments, stem and inflorescence growth showed the reverse effect. Defoliation stimulated the rates of leaf differentiation, particularly when applied at floral initiation. This was associated with increased branching. In a determinate annual that has commenced to flower, branching generates more leaf sites. Despite this, the overall rate of differentiation of inflorescences (which appear in leaf axils) was not increased by defoliation; reference has already been made (table 3) to the decreased inflorescence number evident in the D_2 and D_3 treatments at day 132.

TABLE 5

Effect of defoliation on leaf growth rate, rate of leaf appearance and rate of branch appearance.

Attribute and Period	Defoliation treatment D_0	D_1	D_2	D_3	L.S.D. $P=0.05$
Leaf growth rate	*g/m²/day*				
Days 56-104	0.03	1.44	—	—	0.58
76-104	−0.84	—	0.32	—	n.s.
89-104	−1.22	—	—	0.05	n.s.
104-132	−2.50	−1.41	−0.39	−0.07	1.24
Rate of leaf appearance	*no./plant/day*				
Days 56-104	1.47	2.53	—	—	0.64
76-104	1.53	—	2.18	—	n.s.
89-104	1.20	—	—	−0.12	n.s.
104-132	−0.49	−0.72	0.95	1.17	1.52
Rate of branch appearance	*no./plant/day*				
Days 56-104	0.85	1.18	—	—	0.33
76-104	0.96	—	1.00	—	n.s.
89-104	1.10	—	—	1.14	n.s.
104-132	0.39	0.64	1.18	0.87	n.s.

Discussion

Defoliation at floral initiation, flower appearance, or advanced flowering sharply reduced seed production, despite relatively minor effects on total plant growth. This result might be contrasted with the behaviour of another annual pasture legume, subterranean clover, in which Rossiter (1961) has shown that seed production of pure stands is increased by cutting or grazing at or before the early flowering stage, due mainly to increased branching and inflorescence density. In the more erect TS plants, more bud sites and inflorescences were removed by defoliation than occurred in Rossiter's study, and any increases in branching and leaf differentiation did not compensate. In addition, there is evidence that defoliation reduced the fertility of bud sites. A fertility index (inflorescence no./(leaf no.—branch no.)) at day 104 had values of 0.88, 0.59, 0.55, and 0.61, for the D_0, D_1, D_2, and D_3 treatments respectively.

The main defoliation effect was to reduce the proportion of florets setting seed. This was not due to a simple displacement of flowering time by defoliation, such that inflorescences dissected on any date were more immature from defoliated plants than those from undefoliated plants, since at final maturity on day 187 seeds formed per inflorescence were 0.72, 0.38, 0.13, and 0.12 for the D_0, D_1, D_2, and D_3 treatments respectively. On the other hand, this displacement of flowering meant that inflorescences from defoliated plants matured under conditions of decreased temperature and radiation (table 2), which may have affected seed set; this point will receive more study. It represents another difference from Rossiter's experiment, in that flowering of subterranean clover proceeded under conditions of increasing temperature and radiation.

The effect of flower removal in lengthening flowering period, stimulating branching, and delaying plant senescence is well known in annual legumes (Pate 1958; Leopold, Neidergang-Karmen and Janick 1959; Lockhart and Gottschall 1961).

It is difficult to extrapolate to the field situation with confidence, since swards were grown under irrigated conditions in shallow boxes. Moreover, Brisbane is regarded as a marginal environment for TS. The peak leaf area index of 2.9 was slightly below that recorded for the same density swards in 1967 (Rickert and Humphreys 1970) under similar experimental conditions. However, the plant yields obtained were very similar to those reported from field results in the central Queensland (Shaw, Gates and Wilson 1966) and Katherine (Fisher 1969) environments. TS exhibited plastic responses to a single defoliation: similar total growth was produced irrespective of defoliation or stage of defoliation. This suggests that a single grazing or hay cut may not reduce total seasonal production of a pure stand; however, seed yield or natural regeneration in future years may be affected.

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