THE EFFECT OF WATERLOGGING ON THE GROWTH OF *STYLOSANTHES GUYANENSIS*

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ABSTRACT

The waterlogging tolerance of Stylosanthes guyanensis *accessions was measured in two glasshouse experiments. The yields of all accessions were depressed by waterlogging but there were large differences between accessions in the size of the yield depression. Waterlogged plants of the most tolerant accession (CPI* 40297) *produced* 82% *of the control yield while those of the least tolerant (CPI* 34915) *produced* 5%. *Of the commercial cultivars tested, cv. Cook was the most tolerant* (67% *of control). Soil type influenced the size of the yield depression due to waterlogging but the accession × soil type interaction was not significant.*

INTRODUCTION

Stylosanthes guyanensis (stylo) is a valuable pasture legume in areas of northern Australia with an annual rainfall exceeding 1500 mm (Grof, Harding and Woolcock 1970). Much of the land available for pasture production in this region is often waterlogged for part of the year due to high seasonal rainfall which may be combined with soils of poor internal drainage. The most widely sown cultivar of stylo (Schofield) shows some tolerance to poor drainage (Gilchrist 1967; Teitzel and Mortiss 1971), but it is not known if there is variation in waterlogging tolerance within the species, although it is known to vary considerably for many other characters (Edye *et al.* 1974*a*).

The two experiments reported in this note examined the effect of waterlogging on the growth of stylo. In the first, a wide selection of accessions were compared to determine their waterlogging tolerance with a view to selecting more productive varieties for waterlogged areas. Since soil type may affect the severity of waterlogging, five accessions which were known to vary in their tolerance from the first experiment, were subsequently grown on five different soils to examine this aspect.

MATERIALS AND METHODS

Experiment 1

Thirty-three stylo accessions were selected (Table 1). Most belonged to the agronomically promising morphological-agronomic (M-A) groups (Edye *et al.* 1974*a*) but a wide range of groups was included. Seed was sown on September 9, 1974 into 15 cm diameter plastic pots containing 1540 g of oven dry sandy loam from the top 10 cm of the A horizon of a solodic soil collected near Townsville (Table 2). The seedlings were thinned to five per pot ten days after sowing. A complete nutrient solution with microelements was applied before sowing. A further application of 253 mg/pot of NH_4NO_3 was made five weeks after sowing. The nitrogen was applied to prevent differences in rhizobial effectiveness influencing the results.

All pots were watered to pF2 daily for the first five weeks. During the following three weeks half the pots (three replicates) were watered to pF2 while the other half were immersed in troughs of water. The water level was maintained one centimetre above the soil surface by twice daily additions. The troughs were drained and refilled with fresh water at weekly intervals. During the experiment the glasshouse maximum temperature was maintained below 30°C. The average minimum was 22°C. Eight weeks after sowing the pots were harvested by counting the number of surviving plants, cutting the plants at ground level and oven drying the herbage.

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TABLE 1

The effect of waterlogging on the growth and plant survival of S. guyanensis *accessions (experiment* 1).

Cultivar, C.P.I. No. or Q.No.*	M-A† Group	Herbage Yield		Surviving Waterlogged plants‡
		Control	Waterlogged/Control	
		g/pot	%	no./pot
40297	10B·3	7·02	82	5·0
34661	8C	7·37	79	5·0
34659	8C	5·90	75	5·0
34000	8A	5·37	73	5·0
18750B	10B·2	7·04	71	5·0
38222	8A	5·09	70	5·0
46590	8B	5·84	69	4·7
Cook	8A	8·12	67	5·0
47396	10A·1	7·89	66	5·0
34911	8A	4·99	65	5·0
41209C	8A	6·40	61	5·0
Schofield	7A	8·24	60	5·0
38349	10A·2	7·88	60	5·0
Q8231A	8A	6·52	59	5·0
37205A	10A·3	7·49	58	5·0
38391	10B·1	7·85	58	5·0
41218	8A	6·59	57	5·0
33706B	10A·2	7·85	52	5·0
40567B	10A·2	6·80	51	4·7
46589A	8B	5·97	51	4·7
40255	10B·3	6·96	50	5·0
37204A	10A·3	8·08	49	4·3
38385	10B·1	7·63	49	5·0
T.No.11	10A·1	6·41	49	4·7
34920	14A	5·13	47	5·0
18750A	10B·2	6·59	44	5·0
Oxley	6A	2·71	39	3·0
33501A	11A	3·66	28	5·0
37688	4	1·34	23	3·0
33434B	11A	6·89	22	4·7
34912	13	1·85	16	2·7
38640	6B	2·28	9	3·3
34915	13	2·00	5	1·3
L.S.D. P = 0·05	—	1·27	26	1·3

*Commonwealth Plant Introduction number or Queensland Department of Primary Industries number.
†Morphological-Agronomic grouping of Edye *et al.* (1974*a*).
‡Total survival = 5·0.

Experiment 2

Five accessions (Table 3) selected for the range of waterlogging tolerance they showed in Experiment 1 were grown on five soils (Table 2). The experiment commenced on April 24, 1975 and the procedure was the same as in Experiment 1. However, the temperatures were lower than during the first experiment with an average minimum of 18°C.

RESULTS

General symptoms

The first visual effect of waterlogging was yellowing of the youngest leaves which occurred after six days of waterlogging for some accessions. The yellowing was most intense near the base of the leaflets with the leaf tip and margins less affected. There was also an increase in anthocyanin pigmentation on the stems and stipules. As waterlogging continued the older leaves turned pale green and in the more severe cases the plants wilted and in some cases died. When the pots were harvested the plant roots were concentrated in the top two centimetres of soil in the waterlogged pots but were

TABLE 2

Collection site, soil type and some properties of the soils (0-10 cm) used.

Collection site	Soil type	P.P.F.†	Particle size analysis			Clay	pH
			Coarse sand	Fine sand	Silt		
				%			
Townsville	Solodic	Dy3·43	21	50	14	15	6·6
Koumala	Solodic	Dy3·42	22	40	27	11	6·1
Innisfail	Krasnozem	Gn3·11	2	2	9	87	5·7
Pentland	Red earth	Gn2·11	56	20	8	16	6·2
Hughenden	Grey clay	Ug5·26	1	23	18	58	7·7

†P.P.F. Principal Profile Form (Northcote 1971).

much more evenly distributed through the soil in the control pots. There was a marked increase in the number of adventitious roots in the waterlogged pots, particularly of those accessions least affected by waterlogging.

Experiment 1

The effect of waterlogging on plant survival and herbage yield is shown in Table 1. All control plants survived but among the waterlogged pots survival ranged from 1.3 to 5.0 plants per pot. All accessions yielded less when waterlogged but there was a large variation between accessions with the yield of the waterlogged pots ranging from 5 to 82 per cent of the controls. Despite this large range of values the variation between replicates for individual accessions was not related to their mean values. Accessions with low control yields (less than 3 g) were all severely affected by waterlogging but those with high yields showed a wide range of effects with waterlogged yields ranging from 22 to 82 per cent of the control yields.

Experiment 2

Both species and soil type influenced the effect of waterlogging on herbage yield and plant survival, but there was no significant interaction between them (Table 3). Plant survival was least on the Koumala solodic and greatest on the Innisfail krasnozem. CPI 37688 had fewer surviving plants than the other accessions. Yield depression due to waterlogging was significantly less on the Pentland red earth than the Koumala solodic and Innisfail krasnozem. CPI 37688 suffered the greatest yield depression.

DISCUSSION

Although the yields of all accessions were reduced by waterlogging, there was a large variation between accessions in the size of the yield depression. The field performance of the Oxley and Schofield cultivars agrees with their ratings in Experiment 1—Oxley is intolerant of waterlogging (Stonard and Bisset 1970) while Schofield shows some tolerance (Gilchrist 1967; Teitzel and Mortiss 1971). Other workers (Francis and Devitt 1969; Francis and Poole 1973) have also shown agreement between glasshouse and field performance of waterlogged legumes. Although no accessions had relative yields (waterlogged/control) significantly greater than the best commercial cultivars a number of accessions may be useful in waterlogged situations. They should be tested on seasonally waterlogged areas to measure their performance under field conditions since they may replace cultivars which have some deficiency under these conditions (e.g. lack of persistence, disease susceptibility).

Plant performance has been related to M-A grouping in some situations (Edye *et al.* 1974*b*, 1975) but there was no close relationship in this study. Although accessions in groups 4, 6, 11, 13 and 14 performed poorly the best accessions belonged to various groups, and there were considerable ranges of values within different groups.

TABLE 3

The effect of soil type and waterlogging on the growth and survival of five S. guyanensis *accessions (experiment 2).*

Measurement	Accession	Soil type					
		Townsville solodic	Koumala solodic	Innisfail krasnozem	Pentland red earth	Hughenden grey clay	Mean
				g/pot			
Herbage yield (Control pots)	40297	1·60	1·51	2·54	3·69	2·47	2·36
	Cook	2·75	1·57	2·54	2·81	3·02	2·54
	41209C	1·82	1·33	2·02	2·60	2·56	2·07
	34920	1·02	0·98	1·75	3·36	3·27	2·07
	37688	0·28	0·26	0·52	0·33	0·59	0·40
	Mean	1·50	1·13	1·87	2·56	2·38	1·89
		L.S.D. (P = 0·05) between individual means = 0·63. between soil or species means= 0·28.					
				%			
Herbage yield (Waterlogged/Control)	40297	85	68	52	84	81	74
	Cook	64	73	60	64	52	62
	41209C	62	62	50	78	66	64
	34920	52	40	56	74	75	59
	37688	30	20	35	52	49	37
	Mean	58	53	51	70	64	59
		L.S.D. (P = 0·05) between individual means = 34. between soil or species means = 15.					
				no./pot			
Surviving Waterlogged plants	40297	5·0	5·0	5·0	5·0	4·3	4·9
	Cook	4·7	5·0	5·0	5·0	4·3	4·8
	41209C	4·7	4·0	5·0	5·0	4·3	4·6
	34920	5·0	3·3	5·0	5·0	5·0	4·7
	37688	1·3	0·0	5·0	0·3	2·3	1·8
	Mean	4·1	3·5	5·0	4·1	4·1	4·1
		L.S.D. (P = 0·05) between individual means = 1·1. between soil or species means = 0·5.					

The poor performance of accessions in groups 4, 6, 11, 13 and 14 may be a reflection of low tolerance to stress in these generally less vigorous lines.

It is impossible to determine which of the many factors known to be involved were responsible for the depressed yields of the waterlogged plants. The nitrogen concentration in the tops of waterlogged plants was lower than in the control plants (mean values of 2.0 and 2.6 per cent) while manganese (303 and 175 ppm), iron (291 and 122 ppm), sodium (0.27 and 0.07 per cent) and sulphur (0.33 and 0.15 per cent) concentrations were higher in waterlogged plants. Concentrations of phosphorus, calcium, magnesium, potassium, copper and zinc were not altered by waterlogging. The early symptoms resembled manganese toxicity described by Andrew and Pieters (1970) for *S. humilis*. There are no published values for toxicity levels of manganese for *S. guyanensis* but the highest value recorded in my study (470 ppm) was much lower than the toxicity level of 1140 ppm for *S. humilis* (Andrew and Hegarty 1969). The wilted appearance of some accessions may have been caused by the inability of roots to take up water under anaerobic conditions (Willey 1970).

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REFERENCES

ANDREW, C. S., and HEGARTY, M. P. (1969)—Comparative responses to manganese excess of eight tropical and four temperate pasture legume species. *Australian Journal of Agricultural Research* **20**: 687.

ANDREW, C. S., and PIETERS, W. H. J. (1970)—Manganese toxicity symptoms of one temperate and seven tropical pasture legumes. C.S.I.R.O., Australia, Division of Tropical Pastures, Technical Paper No. 4.

EDYE, L. A., BURT, R. L., NICHOLSON, C. H. L., WILLIAMS, R. J., and WILLIAMS, W. T. (1974*a*)—Classification of the *Stylosanthes* collection; 1928-69. C.S.I.R.O., Australia, Division of Tropical Agronomy, Technical Paper No. 15.

EDYE, L. A., BURT, R. L., NORRIS, D. O., and WILLIAMS, W. T. (1974*b*)—The symbiotic effectiveness and geographic origin of morphological-agronomic groups of *Stylosanthes* accessions. *Australian Journal of Experimental Agriculture and Animal Husbandry* **14**: 349.

EDYE, L. A., WILLIAMS, W. T., ANNING, P., HOLM, A. MCR., MILLER, C. P., PAGE, M. C., and WINTER, W. H. (1975)—Sward tests of some morphological-agronomic groups of *Stylosanthes* accessions in dry tropical environments. *Australian Journal of Agricultural Research* **26**: 481.

FRANCIS, C. M., and DEVITT, A. C. (1969)—The effect of waterlogging on the growth and isoflavone concentration of *Trifolium subterraneum* L. *Australian Journal of Agricultural Research* **20**: 819.

FRANCIS, C. M., and POOLE, M. L. (1973)—Effect of waterlogging on the growth of annual *Medicago* species. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13**: 711.

GILCHRIST, E. C. (1967)—A place for stylo in N.Q. pastures. *Queensland Agricultural Journal* **93**: 344.

GROF, B., HARDING, W. A. T., and WOOLCOCK, R. F. (1970)—Effects of cutting on three ecotypes of *Stylosanthes guyanensis*. Proceedings of the Eleventh International Grasslands Congress, Surfers Paradise: p. 226.

NORTHCOTE, K. H. (1971)—"A Factual Key for the Recognition of Australian soils". Third Edition. (Rellim Technical Pulbications: Glenside, South Australia).

STONARD, P., and BISSET, W. J. (1970)—Fine-stem stylo: a perennial legume for the improvement of subtropical pasture in Queensland. Proceedings of the Eleventh International Grasslands Congress, Surfers Paradise: p. 153.

TEITZEL, J. K., and MORTISS, P. D. (1971)—Pastures for the Ingham coast. *Queensland Agricultural Journal* **97**: 155.

WILLEY, C. R. (1970)—Effects of short periods of anaerobic and near anaerobic conditions on water uptake by tobacco roots. *Agronomy Journal* **62**: 224.

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