INFLUENCE OF CUTTING FREQUENCY AND PHOSPHORUS SUPPLY ON THE PRODUCTION OF *STYLOSANTHES HUMILIS* AND *ARUNDINARIA PUSILLA* AT KHON KAEN, NORTH-EAST THAILAND

A. D. ROBERTSON*, L. R. HUMPHREYS† AND D. G. EDWARDS†

ABSTRACT

The response of (i) Stylosanthes humilis *on a Khorat grey podzolic and (ii)* Arundinaria pusilla *oversown with* S. humilis *on a Yasathon red yellow latosol to phosphate addition and cutting interval was measured.* S. humilis *maximum yield responses to phosphorus were only 26 and 34 per cent respectively at 20 kg P ha*$^{-1}$, *but were increased by increasing cutting interval. Frequent cutting reduced* S. humilis *yield but increased the amount of soil seed reserves.* S. humilis *mortality during the growing season and survival after the dry season were positively related to phosphorus level and to cutting interval. Phosphorus content and, to a lesser extent, nitrogen content were positively associated with phosphorus level and negatively related to cutting interval.* Arundinaria pusilla *did not respond to added phosphate and was intolerant of frequent cutting.*

INTRODUCTION

Large areas of sandy uplands in north-east Thailand bear open dipterocarp woodland with understory grassland dominated by the bamboo grasses *Arundinaria pusilla* or *A. ciliata*. Oversowing the annual self-regenerating legume *Stylosanthes humilis* (Townsville stylo or TS) is a practice which offers scope for improving the fodder supply and maintaining soil fertility in this region (McLeod 1972; Boonklinkajorn and Duriyaprapan 1973; Robertson 1975). Two important management questions to be resolved are (i) the feasibility of applying fertilizer phosphorus in this context, since these upland soils are known to be low in phosphorus (Eyles *et al.* 1973), and (ii) the best cutting frequency to be adopted, since many pastures in the region are cut rather than grazed. A related question is the influence of cutting frequency on the phosphorus response characteristics of the pasture.

This paper reports the response to various levels of phosphorus supply and to differing cutting intervals of (i) TS swards (ii) bamboo grass swards oversown with TS.

METHODS

Experiment 1 was conducted on a level site at Nong Phai on Khon Kaen University campus (lat. 16°20'N), on a grey podzolic Khorat series soil (Department of Land Development 1973). A complete factorial design was used, with six levels of phosphorus (0, 10, 20, 40, 80 and 160 kg P ha^{-1} yr^{-1} as double superphosphate containing 17.6% P), three cutting intervals (2, 4 and 8 wk at 4 cm height), and eight replications. Plots were 2 m × 2.5 m and contiguous.

The area had previously carried an open dipterocarp association with *A. ciliata*, and had been cropped without addition of fertilizer. It was disc-harrowed twice in August 1972, and was surface sown to *S. humilis* cv. Lawson at 15 kg pods ha^{-1} on September 7, 1972 and resown at 10 kg ha^{-1} on July 29, 1974. An adjacent site had shown responses to phosphorus and potassium but not to micronutrients (Eyles *et al.* 1973), and basal fertilizer of gypsum at 40 kg S ha^{-1} and potassium chloride at 100 kg K ha^{-1} was applied on September 20, 1972, June 10, 1973, and June 3, 1974.

---

*Australian Development Assistance Agency, Khon Kaen. *Present address*: N.Z./I.B.R.D. Livestock Development Project, Khon Kaen, Thailand.
†Department of Agriculture, University of Queensland, St. Lucia 4067.

Phosphate applications were made on the same dates. The area was periodically weeded to maintain a pure stand of TS, and damage from termites, beetles and grasshoppers was minimised by periodic applications of dieldrin.

Cleaning cuts at 4 cm height were made on December 16, 1972, August 3, 1973, and July 30, 1974. In 1973 only one eight-week defoliation cycle was imposed, because of a late start to the wet season, and in 1974 accidental grazing both delayed the first cycle and precluded the final harvest of the second cycle. Sampling area was 1.75 m × 2.25 m in each plot. Plant samples were dried at 60°C for 48 h, and after Kjeldahl digestion were analysed for nitrogen colorimetrically on a Technicon autoanalyser using a modified method similar to that of Williams and Twine (1967), and for phosphorus, using a modified version of the molybdo-phosphoric yellow method (Jackson 1958). Available soil phosphorus was measured on samples taken from the 0-15 cm layer on May 5, 1975, using the sodium bicarbonate method (Colwell 1963), with a soil : extractant ratio of 1:20. Plant density was recorded on July 22, 1974, October 10, 1974, and April 17, 1975.

Experiment 2 was conducted in an open dipterocarp forest reserve near Ban Tasala, Amphur Manchakiri, about 50 km south-west of Khon Kaen. This upland site was on a red yellow Yasathon series latosol (Department of Land Development 1973) with a 2 per cent slope, and was evenly covered by *A. pusilla*. The design was similar to experiment 1, with six levels of phosphorus, four cutting intervals (2, 4, 8 and 16 wk), and six replications. Plots were 3 m × 3 m with 1 m laneways.

All vegetation other than bamboo grass was removed, and the area was mown on July 15, 1974 at 5 cm height. The same basal and phosphorus fertilizer as in experiment 1 was applied on July 15, 1974 and TS cv. Lawson was surface sown at 16 kg pods ha^{-1} on June 28, 1974 and at 20 kg ha^{-1} on July 19, 1974. One 16-week defoliation cycle concluding on November 7, 1974 was applied. Cutting height was 6 cm for bamboo grass; for TS it was 8 cm on the September 11 harvest and 3 cm on other occasions. Sampling area was 2.5 m × 2.5 m in each plot. Seed yield was recorded for the final harvest on November 7, 1974, and the residual seed present below harvest height on the plant and on the soil surface was measured about January 20, 1975. Bamboo grass density was recorded on March 12, 1975. Available phosphorus was recorded from soil samples collected on March 12, 1975.

RESULTS AND DISCUSSION

Khon Kaen has a monsoon climate with average annual rainfall of 1198 mm; 88 percent of this falls in the months May-October inclusive. Rainfall was sub-normal in 1973 when 772 mm was recorded from May-October; in 1974 1001 mm fell in the same period.

Growth and survival

Yield of TS (Table 1) was greater at 4 wk cutting interval than at 2 wk in 1973 at Nong Phai, but the difference over the 2 to 8 wk range was less in 1974. However at Manchakiri the 16 wk cutting interval gave a much higher yield; this contrasts with the finding of Fisher (1973) at Katherine that three cuts at 5 cm height reduced TS yield by only 9 per cent relative to a single cut. TS was dominant over bamboo grass in all treatments, and especially under 2 wk cutting.

The maximum response to phosphorus in TS averaged only 21 and 31 per cent at Nong Phai in 1973 and 1974 respectively, and 34 per cent at Manchakiri. At both sites near-maximal response occurred at the 20 kg P ha^{-1} level, and at Manchakiri yield reduction occurred at the highest phosphorus level. The interaction between phosphorus level and cutting interval (not presented) was significant at Nong Phai in 1973, when yield increment due to phosphorus was 290 and 560 kg ha^{-1} in the 2 and 4 wk treatments respectively. At Manchakiri yield increment due to phosphorus was 400 and 1230 kg ha^{-1} at the 2 and 16 wk treatments respectively. The effect of cutting interval on the phosphorus level giving maximum yield was not consistent. Bamboo

TABLE 1

Effect of cutting interval and phosphorus level on yield (kg ha^{-1}).

Site Cutting Interval (wk)	Nong Phai 3.viii.-28.ix.1973	TS 30.vii.-24.ix.1974	Bamboo grass	Manchakiri 19.vii.-7.xi.74 TS	Total	TS seed 7.xi.74	20.i.75*
2	1470	2410	270	840	1110	50	1000
4	2380	2710	580	740	1330	80	830
8	n.a.†	3130	950	990	1950	190	690
16	—	—	1310	2820	4320	1630	220
L.S.D. P = 0.05	118	175	137	230	245	169	124
Phosphorus Level (kg ha^{-1})							
0	1690	2280	770	1260	2030	500	490
10	1920	2730	810	1260	2070	470	720
20	2020	2980	730	1680	2410	590	710
40	1990	2970	810	1400	2210	590	730
80	2040	2720	750	1440	2180	430	760
160	1890	2810	810	1080	1880	350	680
L.S.D. P = 0.05	204	205	N.S.‡	281	300	N.S.‡	152

* residual seed below harvest height
† not available
‡ not significant

TABLE 2

Effect of cutting interval and phosphorus level on Townsville stylo mortality and density at Nong Phai

Phosphorus Level (kg ha^{-1})	0	10	20	40	80	160	Mean
Cutting Interval (wk)			% TS mortality 10.x.74				
2	0.3	0.3	5	6	1	1	2
4	4	9	14	19	22	40	18
8	29	58	62	57	47	64	53
Mean	11	22	27	28	23	35	
L.S.D. P = 0.05	Cutting interval 6.4		Phosphorus level 12.0			Interaction 15.7	
			TS density 17.iv.75 (no.m^{-2})				
2	0.43	0.48	0.75	0.55	0.63	1.48	0.72
4	0.60	0.63	0.80	1.20	1.45	1.50	1.03
8	0.80	1.43	2.33	2.08	1.33	1.33	1.55
Mean	0.61	0.84	1.29	1.28	1.33	1.43	
L.S.D. P = 0.05	Cutting interval 0.36		Phosphorus level 0.51			Interaction 0.88	

grass did not respond to applied phosphorus, and hence TS dominance was increased by phosphorus application. It is inappropriate to draw firm conclusions from such a short-term study, but it is interesting to add this observation to the conflicting Australian experience on the effect of phosphorus supply on percentage TS composition (e.g. Norman 1965; Shaw and 't Mannetje 1970; Ritson, Edye and Robinson 1971).

The amount of TS seed harvested above 3 cm (Table 1) was positively related to cutting interval, and not significantly affected by phosphorus level. However the residual seed below 3 cm on the plant and on the ground was negatively related to cutting interval. The high value of 1000 kg ha^{-1} seed pods at 2 wk cutting interval indicates the capacity of TS to adapt its plant habit by branching and flowering close to ground level, and accounts for its successful regeneration under heavy stocking rates.

TS mortality during the 1974 growing season at Nong Phai (Table 2) was positively related to cutting interval; the detrimental effect of an eight-week cut conforms with the finding of Fisher (1973) that a single cut applied late in the season when growing points were elevated above cutting height caused from 53 to 82 per cent death. Mortality was also positively related to phosphorus level; this is not wholly explicable in terms of the effect of phosphorus on plant yield above cutting height. On the other hand, the density of plants surviving the dry season (Table 2) was positively related to both cutting interval and phosphorus level. This may have been related to unmeasured effects on the extent of the root system or the tolerance of tissues to desiccation; it is unlikely to be an effect of differential flowering on senescence of this annual plant.

Bamboo grass density at Manchakiri on March 12, 1975 was 5.6, 11.1, 14.3 and 16.8 clumps m^{-2} in the 2, 4, 8 and 16 wk cutting treatments respectively. Despite its extensive rhizome development, this erect grass does not tolerate frequent cutting, or frequent grazing (Robertson and Humphreys, unpublished data).

Phosphorus and nitrogen economy

Phosphorus content in TS (Table 3) was little affected by cutting interval, and was positively related to phosphorus application level over the whole range. Phosphorus content at the pre-flowering stage in 1973 and 1974 exceeded the proposed critical value of 0.17 per cent (Andrew and Robbins 1969), and the relatively small yield responses recorded are broadly consistent with this finding. Apparent phos-

TABLE 3

Effect of cutting interval and phosphorus level on phosphorus content

Site	Nong Phai				Nong Phai	Manchakiri	
	% P in TS herbage				ppm P in soil 0—15 cm	0—15 cm	15—30 cm
Cutting Interval (wk)	31.viii.73	28.ix.73	27.viii.74	24.ix.75	5.v.75	12.iii.75	
2	0.34	0.24	0.31	0.36	16.6	13.2	5.3
4	0.34	0.25	0.33	0.35	16.7	14.5	3.4
8	n.a.	n.a.	n.a.	0.32	16.8	12.8	4.7
L.S.D. P = 0.05	N.S.	N.S.	N.S.	0.013	N.S.	N.S.	N.S.
Phosphorus Level (kg ha^{-1})							
0	0.20	0.14	0.25	0.23	3.1	3.1	2.2
10	0.26	0.18	0.29	0.30	3.9	3.9	2.3
20	0.30	0.23	0.32	0.34	6.5	5.8	2.7
40	0.36	0.26	0.34	0.36	13.9	9.6	3.6
80	0.41	0.29	0.36	0.41	26.4	18.0	6.4
160	0.52	0.36	0.38	0.43	46.5	38.7	12.8
L.S.D. P = 0.05	0.024	0.034	0.024	0.018	2.7	2.5	1.6

TABLE 4

Effect of cutting interval and phosphorus level on Townsville stylo nitrogen content and yield at Nong Phai

Cutting Interval (wk)	28.ix.73	24.ix.74	N yield (kg ha^{-1}) 3.viii.-28.ix.73	30.vii.-24.ix.74
2	3.1	4.0	51.5	94.9
4	2.7	3.7	70.7	99.1
8	n.a.*	3.2	n.a.	99.7
L.S.D. P = 0.05	0.18	0.11	4.3	N.S.
Phosphorus Level (kg ha^{-1})				
0	2.8	3.3	50.8	75.6
10	2.9	3.6	61.0	95.3
20	3.1	3.7	67.2	107.2
40	3.0	3.7	64.3	109.3
80	3.0	3.7	66.3	99.0
160	2.8	3.6	57.2	101.1
L.S.D. P = 0.05	0.32	0.15	7.5	9.6

*not available

phorus recovery (not presented; based on current applications) was about 13 and 22 per cent in 1973 and 1974 respectively up to the 20 kg P ha^{-1} level, and decreased thereafter. Available soil phosphorus at Nong Phai (Table 3) was positively correlated with plant phosphorus content ($r^2 = 0.732$) but poorly correlated with yield ($r^2 = 0.005$). At both Nong Phai and Manchakiri near-maximum yield occurred when the available phosphorus level (Colwell 1963) was about 6 ppm in the 0-15 cm level; this contrasts with values of about 20 ppm reported for mixed pastures in North Queensland (Bruce and Bruce 1972). Movement of phosphorus into the 15-30 cm layer was evident at the higher application levels.

Application of superphosphate increased nitrogen content in 1974 (Table 4) from 3.3 to 3.7 per cent, a smaller increase than that reported by Shaw, Gates and Wilson (1966) on a more acutely phosphorus deficient soil. This effect enhances the dry matter response when nitrogen yield is considered; nitrogen yield was increased 31 and 44 per cent by phosphorus application in 1973 and 1974 respectively at Nong Phai. Nitrogen content was negatively related to cutting interval (Table 4); this compensated for dry matter yield increases at greater cutting interval in 1974, but in 1973 nitrogen yield was higher at 4 wk than at 2 wk cutting interval.

In this study TS showed a good capacity to grow and set seed without added phosphate on two major low fertility soil types of the region; it also survived frequent defoliation, albeit with reduced yield. Further research at Khon Kaen University is measuring in terms of animal performance the response of TS to phosphate inputs and to stocking rate variation.

ACKNOWLEDGEMENTS

We are indebted for assistance to Dr. Narong Chomchalow and Mr. Prapandh Boonklinkajorn of the Applied Scientific Research Corporation of Thailand, Dr. Kavi Chutikul and Mr. Prasit Wilaipon of the Faculty of Agriculture, Khon Kaen University, Dr. H. M. Shelton of the Australian Development Assistance Agency, and Dr. C. J. Asher, Dr. L. C. Bell, Mr. W. L. Goodman, and Mrs. J. Mercer of the Department of Agriculture, University of Queensland. The project was supported by the Australian Department of Foreign Affairs under the Colombo Plan, the Applied Scientific Research Corporation of Thailand, Khon Kaen University, and the University of Queensland.

REFERENCES

ANDREW, C. S., and ROBBINS, M. F. (1969)—The effect of phosphorus on the growth and chemical composition of some tropical pasture legumes. 1. Growth and critical percentages of phosphorus. *Australian Journal of Agricultural Research* **20**: 665.

BOONKLINKAJORN, P. and DURIYAPRAPAN, S. (1973)—Studies on Townsville stylo. *Thai Journal of Agricultural Science* **6**: 159.

BRUCE, R. C., and BRUCE, I. J. (1972)—The correlation of soil phosphorus analyses with response of tropical pastures to superphosphate on some north Queensland soils. *Australian Journal of Experimental Agriculture and Animal Husbandry* **12**: 188.

COLWELL, J. D. (1963)—The estimation of the phosphorus fertilizer requirements of wheat in southern New South Wales by soil analysis. *Australian Journal of Experimental Agriculture and Animal Husbandry* **3**: 190.

DEPARTMENT OF LAND DEVELOPMENT (1973)—Detailed Reconnaissance Soil Map of Khon Kaen Province. Province Series No. 14, Bangkok.

EYLES, G. O., SHELTON, H. M., BURANVIRIYAKUL, S., and SUKSRI, A. (1973)—Fertilizer studies on forage legumes in north-eastern Thailand. *Thai Journal of Agricultural Science* **6**: 35.

FISHER, M. J. (1973)—Effect of times, height and frequency of defoliation on growth and development of Townsville stylo in pure ungrazed swards at Katherine, N.T. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13**: 389.

JACKSON, M. L. (1968)—"Soil Chemical Analysis". Constable, London.

MCLEOD, C. C. (1972)—Field Investigation Report, May 1970-October 1972. Borabu Pasture and Range Development Centre, Department of Land Development, Thailand.

NORMAN, M. J. T. (1965)—The response of a birdwood grass—Townsville lucerne pasture to phosphate fertilizers at Katherine, N.T. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**: 120.

RITSON, J. B., EDYE, L. A., and ROBINSON, P. J. (1971)—Botanical and chemical composition of a Townsville stylo-spear grass pasture in relation to conception rates of cows. *Australian Journal of Agricultural Research* **22**: 993.

ROBERTSON, A. D. (1975)—A realistic approach to pasture improvement in north-east Thailand. *Thai Journal of Agricultural Science* **8**: 69.

SHAW, N. H., GATES, C. T., and WILSON, J. R. (1966)—The growth and chemical composition of Townsville lucerne (*Stylosanthes humilis*). 1. Dry matter yield and nitrogen content in response to superphosphate. *Australian Journal of Experimental Agriculture and Animal Husbandry* **6**: 150.

SHAW, N. H., and 't MANNETJE, L. (1970)—Studies on a spear grass pasture in central coastal Queensland—the effect of fertilizer, stocking rate, and oversowing with *Stylosanthes humilis* on beef production and botanical composition. *Tropical Grasslands* **4**: 43.

WILLIAMS, C. H., and TWINE, J. R. (1967)—Determination of nitrogen, sulphur, phosphorus, potassium, sodium, calcium and magnesium in plant material by automatic analysis. C.S.I.R.O. Australia Division of Plant Industry Technical Paper No. 24.

(Accepted for publication January 19, 1976)