COOL SEASON ANNUAL LEGUMES FOR A DOUBLE CROPPING SYSTEM IN THE WAIKATO

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ABSTRACT

The possible use of annual legumes as a cool season forage in double cropping systems has received recent emphasis after a number of small-plot evaluations at Palmerston North and Kaitaia by A.O. Taylor and co-workers.

Further to these trials, testing of the highest yielding species was carried out in small plots at Hamilton in the Waikato, in 1977 and 1978. Planting and harvest date for the legumes were constrained by the optimum growth period for the summer maize crop. The species grown in 1977 were: *Medicago scutellata, Medicago tornata* cv. Tornafield, *Trifolium subterraneum* cv. Woogenellup, *Trifolium resupinatum cv. Maral, Ornithopus sativus* W48, *Vicia dasycarpa* cv. Namoi. In 1978 *T. subterraneum, V. dasycarpa, Medicago polymorpha* SA4364, *T. vesiculosum* cv. Yuchi, *T. balansae* and *Ornithopus sativus* x O. *compressus* (hybrid) were grown. The legumes were planted in early to mid-April and cuts for yield and nitrogen content measurements were made in early October.

Yields ranged from 500 to 3000 kg DM/ha in 1977 and from 2900 to 3900 kg DM/ha in 1978. Yields were lower than at Palmerston North or Kaitaia. The results are discussed in relation to using annual legumes in a double cropping system and their suitability for the Waikato environment.

INTRODUCTION

In recent years annual legumes have been advocated as possible cool season alternatives in double cropping systems following summer crops such as maize (Taylor and Hughes, 1976; Taylor *et al.*, 1979b).

In a series of papers A. O. Taylor and co-workers (Taylor *et al.*, 1977; de Ruiter and Taylor, 1979; Hughes and Taylor, 1979; Taylor *et al.*, 1979a,b) have reported on the growth potential and nutritive value of a number of species from the genera *Medicago, Trifolium, Vicia* and *Ornithopus,* which were grown at Kaitaia and at Palmerston North.

This paper reports on two years of screening trials at the Ruakura Agricultural Research Station, in the Waikato. It describes the forage yields and nitrogen content of annual legumes grown from early April and harvested once in early October and therefore within the time constraints of a double cropping system if maize is used as the summer crop. The legumes used in these studies were some of the higher yielding cultivars grown by A. O. Taylor at Kaitaia.

MATERIALS AND METHODS

The history of the trial sites used in 1977 and 1978, cultivation operations and fertiliser applications are presented in Table 1. Seed of annual legume species, inoculated with effective rhizobia and pelleted with lime were provided by the Plant Physiology Division, DSIR, Palmerston North. Six annual legume species of the genera *Medicago, Trifolium, Vicia* and *Ornithopus* were hand-spread onto small plots (2 m x 1.5 m) at rates of 20, 15, 30 and 15 kg seed/ha respectively, on 18.4.77 and 12.4.78. The seed was raked into the surface of the cultivated seedbed. Yield cuts on approximately 1.8m² of each plot were made using a sickle-bar mower (2.5 cm cutting height), on 6.10.77 and 12.10.78. The herbage was dried in a forced draught oven at 100°C for 48 h before subsampling, grinding and analysis for nitrogen content on a micro-Kjeldahl digest, by reduction with alkaline sodium-phenate.

TABLE 1: History of trial sites, cultivation operations and fertiliser applications:

	Year 1977	1978
Situation	Beef Unit, Ruakura	No.5 Dairy, Ruakura
Soil type	Mixture of Te Rapa peaty loam and Te Kowhai silt loam	Bruntwood silt loam
Previous history	Pasture-maize-oats-maize	Pasture
Cultivation	Plough, disc, rolla-tilled, rolled	Plough, disc, rolla-tilled, rolled
Fertiliser (per hectare)	*Preplant:* 28 kg N, 158 kg P, 56 kg K, 77 kg Mg, 5400 kg lime	*Pre ploughing:* 2500 kg lime, 40 kg P, 35 kg K; *Pre plant:* 49 kg P, 98 kg K, 4700 kg lime
Soil pH	6.0	6.1

All plots (except those containing *Vicia* sp.) were sprayed with 2,4,-DB (0.56 kg a.i./ha) and propyzamide (0.75 kg a.i./ha) on 23.6.77 and 26.5.78, for control of flatweeds and *Poa* sp., respectively.

The plots were arranged in a randomised block design with eight replicates of each block. Least significant differences were calculated to compare mean yields and nitrogen content of legume species using the standard error of the differences between treatment means when the "F" test was significant.

RESULTS AND DISCUSSION

Forage yields for annual legume species of genera *Medicago, Trifolium, Ornithopus* and *Vicia* are presented in Table 2. The range of forage yields in 1977 was greater than in 1978 although the yields achieved in 1977 were lower than in 1978. However, the very low yield of *Medicago scutellata* could be attributed to the development of a fungal root rot *(Fusarium* sp.) disease in approximately 80% of the plants by the harvest in October. All other legumes studied appeared to be disease free for the whole growth period. It should also be noted that the 1977 trial site had a previous history of maize cropping with the use of the persistent herbicide, atrazine, which possibly could have affected subsequent legume growth. However, the poor drainage of the 1977 site was a major determinant of the change in trial site in 1978, as these conditions are considered unsuitable for effective legume growth (Taylor and Hughes, 1978). The drainage problem was accentuated in 1977 by a higher than normal rainfall over the growing period of the legumes (Table 3).

TABLE 2: Dry matter yields (kg/ha) of legumes grown at Ruakura from mid-April until early October.

1977*		Year	1978**	
Legume species	DM yield[a]		Legume species	DM yeild[a]
M. scutellata	581		*M. polymorpha*	3 932
M. tornata	2 213		*T. vesiculosum*	2 361
T. subterraneum	3 065		*T. subterraneum*	3 117
T. resupinatum	2 596		*T. balansae*	3 102
O. sativus	516		*O. sativus x O. compressus*	2 924
V. dasycarpa	2 372		*V. dasycarpa*	3 859
LSD (5%)	491		LSD (5%)	795

* harvest date 6.10.77
** harvest date 12.10.78
[a] Data are means of 8 replicates

TABLE 3: Monthly rainfall (mm) at Ruakura over the 1977 and 1978 legume growth periods (data recorded at the Ruakura Meteorological Station, approx. 2 km from the trial sites).

	Month							
Year	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1977	73	155	188	77	100	100	113	806
1978	168	21	149	168	90	102	59	757
29 year average	99	112	132	117	117	97	107	781

Although there were significant differences between species in yield in both years, yields attained were generally below those obtained for the same species over the same seasons at sites near Kaitaia and at Palmerston North (Taylor *et al.,* 1979a; Hughes and Taylor, 1979). Generally legume growth at Kaitaia in 1977 was 30 to 70% above that at Palmerston North (Taylor *et al.,* 1979a); growth at the latter site was more comparable to that measured at Ruakura which is situated intermediate to the widely spaced Kaitaia and Palmerston North sites. Nevertheless, Hughes and Taylor (1979) reported yields from *T. subterraneum* and *V. dasycarpa* grown over a similar time span at Palmerston North in 1978, that were 36 and 21%, respectively, above those recorded for the same species at Hamilton, while yields of *M. polymorpha* and *T. vesiculosum* were 8 and 67%, respectively, below the yields obtained at Hamilton.

It has been suggested that an accumulation of at least 500 degree days (above 10°C) (Gilmore and Rogers, 1958) during the growing period is necessary to produce legume yields of greater than 6 t DM/ha (Hughes and Taylor, 1979). In the present study, 409 and 565 degree-days, respectively, were accumulated over the 1977 and 1978 growing periods. Even so, the best dry matter yields obtained (Table 2) were about 30% below the predicted yield level of Hughes and Taylor (1979). It should be noted, however, that a high incidence of ground frosts (grass minimum temperature -1°C or lower) occurred in Hamilton in 1977 and 1978 (Table 4). Furthermore, there were 12 and 15 frosts of -5°C and lower over the 1977 and 1978 growing seasons respectively. Freezing of plant tissues can occur at these temperatures, a condition which often results in irrevocable cell damage (Wardlaw, 1979) with death occurring at temperatures of -8 to -10°C. After periods of continuous ground frosts, some leaf distortion and leaf "scorching" was noticed on most of the legumes. These environmental conditions, when ground frosts occurred on 38% of the total days of growth in both seasons, probably severly restricted legume growth. However, according to K.A. Hughes (pers. comm.) it is possible that herbicidal (post emergence) phytotoxicity may also have contributed to restricted growth

TABLE 4: Days with ground frosts at Ruakura over the 1977 and 1978 legume growth periods (data recorded at the Ruakura Meteorological Station, approx. 2 km from the trial sites)

	Month							
Year	Apr.	May	June	July	Aug.	Sept.	Oct.	Total
1977	5	15	7	9	13	14	3	66
1978	-	12	14	14	14	9	9	72
31 year average	3	6	9	11	9	6	3	47

As legume growth increases rapidly from September onwards, dry matter yields are maximised under a single cut system (Taylor *et al.,* 1979b). However, for cuts made in October, the nitrogen content of the legume herbage is reduced compared to that of less mature herbage (Taylor *et al.,* 1977). The nitrogen contents (% of DM) of the legumes harvested in October 1977 and 1978 are presented in Table 5. Taylor *et al.* (1977) reported slightly lower herbage nitrogen contents for the same species grown near Kaitaia but harvests were made 2-3 weeks later than in the present study.

The use of annual legumes rather than small grain cereals or annual ryegrass in a double cropping system incorporating maize as the summer silage crop is an attractive proposition. This is because of the likely savings in fertiliser inputs, removal of host species for insects such as Argentine stem weevil which attack the summer crop, and the generally higher nitrogen content of the conserved forage. In a double cropping system it is likely that the requirements for the highest yielding crop (in this case maize) will dictate that the planting and harvest dates of the cool season crop are not necessarily optimum. In addition, with low winter temperatures, yields of annual legumes would be too low to warrant their inclusion in a double cropping programme, regardless of possible advantages in terms of forage nitrogen content and fertiliser usage.

TABLE 5: Nitrogen concentration (% of DM) in legume herbage harvested on 6.10.77 and 12.10.78

1977		Year 1978	
Legumes species	N %*	Legume species	N%*
M. scutellata	2.60	*M. polymorpha*	3.53
M. tornata	3.63	*T. vesiculosum*	3.11
T. subterraneum	3.54	*T. subterraneum*	2.98
T. resupinatum	4.18	*T. balansae*	2.78
O. sativus	3.00	*O. sativus x O. compressus*	3.18
V. dasycarpa	4.22	*V. dasycarpa*	3.54
LSD (5%)	0.158	LSD (5%)	0.146

* Data are means of 8 replicates

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REFERENCES

de Ruiter, J.M., Taylor, A.O. 1979. Annual cool-season legumes for forage. III. Effects of temperature, photoperiod and vernalisation on flowering. *N.Z. Journal of Experimental Agriculture 7:* 153-156.

Gilmore, E.C. Jr., Rogers, J.S. 1958. Heat units as a method of measuring maturity in corn. *Agronomy Journal 50:* 611-615.

Hughes, K.A., Taylor, A.O. 1979. Forage production from cool-season annual legumes as affected by planting date and temperature. *Proceedings Agronomy Society of N.Z. 9:* 1-4.

Taylor, A.O., Hughes, K.A. 1976. The potential role of legumes in maize grain and forage cropping systems. *Ibid. 6:* 49-52.

Taylor, A.O., Hughes, K.A. 1978. Conversation based on forage crop systems for major or complete replacement of pasture. *Ibid. 8:* 161-166.

Taylor, A.O., Hughes, K.A., Haslemore, R.M. 1977. Influence of maturity and frequency of harvest on the nutritive quality of cool season forage legumes. *Ibid. 7:* 45-49.

Taylor, A.O., Hughes, K.A., Hunt, B.J., Latch, G.C.M. 1979a. Annual cool-season legumes for forage. I. A survey of lines for yield and disease resistance at Kaitaia and Palmerston North. *N.Z. Journal of Experimental Agriculture 7* : 141-147.

Taylor, A.O., Hughes, K.A., Hunt, B.J. 1979b. Annual cool-season legumes for forage. II. Seasonal growth patterns and effects of cutting frequency and cutting height on yield. *N.Z. Journal of Experimental Agriculture 7* : 149-152.

Wardlaw, I.F. 1979. The physiological effects of temperature on plant growth. *Proceedings Agronomy Society of N.Z. 9* : 39-48.