WINTER FORAGE LUPINS AND RESIDUAL SOIL NITROGEN

G.J. Piggot
Agricultural Research Division
Ministry of Agriculture and Fisheries
Whangarei
and
D.M. Cooper
Ruakura Soil and Plant Research Station
Ministry of Agriculture and Fisheries
Hamilton

ABSTRACT

Forage lupins were compared with oats or ryegrass as a winter crop between successive greenfeed maize crops harvested in March. Lupins grew well when direct drilled by early April, and yielded more dry matter and herbage nitrogen than oats or ryegrass to which fertiliser nitrogen had been applied at rates up to 150kg N/ha. All crop vegetation was removed from the site. Soil mineral nitrogen analyses following the harvest of winter forage crops indicated that the third year lupins had significantly improved soil nitrogen levels. No difference was apparent between crops at either of the two preceding measurements.

INTRODUCTION

Recently, considerable interest has been shown in forage cropping for animal feeding in New Zealand (e.g. Stephen and McDonald, 1978). For nothern New Zealand, maize has potential in high dry matter production systems (Taylor and Hughes, 1978), but continual maize culture requires a substantial fertiliser nitrogen input (McCormick, 1975).

Where maize is grown for silage or greenfeed, the land in winter could be used to provide additional stock feed. The use of a winter legume may be a valuable source of soil nitrogen. Lupins grew well in previous winter forage trials in the Auckland district (Piggot, 1976). This paper reports a trial examining the potential of lupins for carrying soil nitrogen over into the succeeding summer crop of greenfeed maize. The trial objective was to investigate the long-term fertiliser requirements of a maize-based forage system where a leguminous or non-leguminous forage crop was grown during the winter and early spring.

MATERIALS AND METHODS

The site was at the D.S.I.R. Research Station, Pukekohe on Patumahoe clay loam. The site was cultivated in spring 1975 and the trial laid out in sixteen 18m x 9m main plots — 4 replicates of 2 winter crops (oats or lupins) x 2 rates of potassium (0 or 100 kg K/ha). All combinations of 3 rates of phosphorus (0,15,45 kg P/ha) and 3 rates of nitrogen (0,50,150 kg N/ha) were broadcast with the potassium onto sub-plots at each sowing (i.e. 2 applications per year), although nitrogen was not applied prior to sowing plots into lupins. The fertilisers used were potassium chloride (K), superphosphate (P), and urea (N). Lime at 1250 kg/ha was broadcast once (May 1978) onto all plots. Lupins were inoculated prior to sowing and, from annual field inspection, the lupin roots were well nodulated.

For lupins, cv. Weiko III was used in 1976 although this was changed to cv. Uniwhite in subsequent years because seed of Weiko III was unavailable. Oats cv. Mapua, were placed by ryegrass (Grasslands Manawa) after two winters because of crown and stem rust (*Puccinia coronata* and *P. graminis*) infection and lodging which could not be overcome by a mid-winter cutting regime tried in the second winter (1977). The sowing rate for oats was 150 kg/ha, for lupins 120 kg/ha and for ryegrass 25 kg/ha. Maize seed, sown in early November following the winter crop harvest, was 2nd generation PX 610 sown at approximately 200,000 seeds/ha.

All crops, except the first maize sowing, were direct drilled by a Duncan 701 Seedliner through triple disc coulters in 15cm rows (30cm for maize), lightly harrowed and rolled (Cambridge roller). No additional fertiliser was applied to the maize, and no herbicidal desiccation or residual herbicidal weed control preceded the sowing of winter crops. Prior to sowing the second and subsequent maize crops the site was sprayed with paraquat or glyphosate. The summer weed spectrum in 1975-76 was primarily annual broadleafs which were well controlled by pre-emergence atrazine (2 kg a.i./ha). However, despite the use of pre-emergence alachlor (2.5 kg a.i./ha), annual grasses (primarily *Digitaria sanguinalis*) began to predominate and became uncontrollable by the 5th summer. For this reason the trial was terminated.

The winter crops were harvested in early October while the maize was harvested in late March. Measurement was by quadrat sampling (2 m^2) and then all crop vegetation was completely removed. Soil samples (0-15 and 15-30 cm) were taken from zero and high NPK plots in late October following the winter crop harvest.

RESULTS AND DISCUSSION

Agronomic Aspects

Lupins grew well and, in two out of three years, significantly outyielded oats or ryegrass to which 150 kg N/ha had been applied (Table 1).

TABLE 1: Yields (t DM/ha) of oats, ryegrass or lupins.

		1976	1977	1978	1979
Oats or	0 N	1.7	1.2	2.9	1.5
Ryegrass	50 N	2.5	2.4	3.9	4.1
	150 N	3.7	3.7	5.9	5.3
Lupins		7.2	8.0	6.3	—
$MSD_{1\%}$		0.5	0.5	0.8	0.5

In 1979 the lupin crop failed. The difficulty with lupin establishment in this trial has also occurred in previous winter forage trials in South Auckland (Piggot, 1976) and a winter forage trial at Dargaville in 1979 (Piggot and Morgan, unpubl.). Two aspects appeared important, sowing date and sowing method. Lupin crops sown after mid-April invariably failed; this included the 1979 sowing in this trial, and lupins sown following a maize grain harvest in May of 1976 and 1977 at this site. These crops germinated but were stunted, apparently by cold, and either remained stunted or were gradually killed by frost or fungal root rots as the winter progressed. In relation to sowing method, crops drilled into cultivated ground in the South Auckland winter forage series (Piggot, 1976) established very sparse stands, seedling death being caused by fungal disease (*Pythium* and *Phytopthora* spp.). Plots direct drilled deeper than 2cm and rolled after sowing failed in the Dargaville trial. The use of fungicidal seed dressing might have prevented these effects, although lupin crops direct drilled to a depth of 2 cm or less always established successfully. Beneficial features of lupins included the lack of lodging and the ease of total vegetation removal at harvest. The bared ground had an excellent tilth for establishment of the succeeding direct drilled summer crop when compared with the oats or ryegrass.

The maize crops were affected by sporadic bird damage at establishment and a progressive weed buildup. Dry matter yield decreased with each successive crop. Mean yield in 1976 was 16 t DM/ha; in 1979 it was 5 t DM/ha. In addition the small size of sub-plots, allied with these cultural problems, masked the fertiliser and crop carry-over effects by increasing the variability of maize yield measurement.

Phosphate and Potassium Response

Lupins showed no significant phosphate or potassium responses; this could be partially caused by the low fertility tolerance of lupins (Gladstones, 1970). However there was no response to phosphate or potassium, nor interactions between them and nitrogen in the oats, ryegrass, or summer maize. From soil test data for the first and final samplings (Table 2) the phosphate levels remained static at an adequate level in the nil fertiliser plots explaining the lack of any phosphate responses despite the level rising in the high fertiliser plots. The potassium level fell in the nil fertiliser plots and a wide differential developed between the nil and high fertiliser plots; however this drop in the potassium level was not yield-limiting.

TABLE 2: Soil tests prior to sowing of summer crop (mean of 0-15 and 15-30cm).

	pH	Ca	K	P	Mg
1975	5.6	7.5	7.6	28.0	12.7
1979 0 NPK	5.7	8.2	3.5	28.0	12.0
High NPK	5.4***	6.7***	9.7***	35.4*	9.3***

Effect of Lupins on Soil Mineral Nitrogen

Mineral nitrogen (NH_4 + and NO_3-) was extracted from samples of soil that had been dried and ground. This could be expected to consist of mineral nitrogen present in the field plus that mineralised in the drying and grinding procedures. Since all samples received the same treatment, a comparison can be made between the mineral nitrogen content of soil which contained lupins or oats/ryegrass. In the three years following good lupin crops, only in the final year was a significant difference in mineral nitrogen content measured in the soil (Table 3).

TABLE 3: Soil nitrogen (µg/g soil from 0-30cm) from sampling following the winter crop harvest in October. The oats/ryegrass plots had received 150 kg N/ha at autumn sowing.

		Oats/-Ryegrass	Lupins	
$NO_3^- - N$	1976	11.0	6.4	NS
	1977	9.8	11.9	NS
	1978	5.7	11.8	***
$NH_4^+ - N$	1976	6.6	6.1	NS
	1977	5.8	6.8	NS
	1978	12.7	27.2	*

The soils were also incubated under aerobic and anaerobic conditions and the results showed a similar pattern. In 1976 and 1977, when no significant differences in soil nitrogen values were obtained, there were no significant differences in dry matter production in the following maize crops. In 1978-79 the maize yields following the lupins or nitrogen-fertilised ryegrass, while poor (5.4 and 4.6 t DM/ha respectively), were significantly different ($P < 0.05$). This dry matter production difference may reflect the measured difference in soil mineral nitrogen content of Table 3.

Effect of Lupins on Nitrogen Carryover

While the carryover of nitrogen in the soil following lupins was inconsistent when compared with oats/ryegrass, the above-ground herbage nitrogen economy of the winter crops differed markedly. Nitrogen was not applied to lupins but was to oats or ryegrass which exhibited strong nitrogen responses (Table 1). Lupins also contained more nitrogen/ha in the herbage than oats or ryegrass to which 150 kg N/ha had been applied (Table 4). Therefore, if the herbage nitrogen had been returned by *in situ* grazing or ploughing in the crops, lupins would have returned more nitrogen to the soil. In addition, lupins avoided the fertiliser nitrogen which oats or ryegrass required.

TABLE 4: Herbage nitrogen (kg N/ha) for oats, ryegrass or lupins.

		1976	1977	1978	1979
Oats or	0 N	43	23	37	21
Ryegrass	50 N	65	54	51	78
	150N	96	98	76	130
Lupins		187	208	126	—
M.S.D.1%		13	11	14	10

ACKNOWLEDGEMENTS

We thank C.A. Farrell, E.N. Honore and R.J. Fris for assistance with field work; M.P. Upsdell for biometrical advice; and the Officer-in-Charge, D.S.I.R. Research Station, Pukekohe for providing the site and assisting with trial management.

REFERENCES

Gladstones, J.S. 1970. Lupins as crop plants. *Field Crop Abstracts 23:* 123-148.

McCormick, S.J. 1975. Advances in maize production through agronomic research, 1967-75. *Proceedings Agronomy Society of N.Z. 5:* 71-74.

Piggot, G.J. 1976. Unpublished Research Report, No. 78, Ministry Agriculture and Fisheries, Auckland.

Stephen, R.C., McDonald, R.C. 1978. The use of crop grazing systems for animal production. *Proceedings Agronomy Society of N.Z. 8:* 167-172.

Taylor, A.O., Hughes, K.A. 1978. Conservation based forage crop systems for major or complete replacement of pasture. *Proceedings Agronomy Society of N.Z. 8:* 161-166.