Long term trends of legume/wheat rotations in southern NSW

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Summary. This paper presents results obtained after 1985 of an experiment, commenced in 1979, to compare rotations of lupin/wheat, mulched sub clover/wheat, grazed sub clover/wheat, and continuous wheat cropping with and without N fertiliser. Treatment effects were not consistent over time and low spring rainfall often limited yields of rotations with high N inputs. While yield and grain protein from continuous wheat showed positive responses to added N fertiliser, the responses were restricted by eyespot lodging and aluminium toxicity in some years. Overall wheat yields were further improved when wheat followed a legume. Lupins promoted higher average wheat grain yield but lower grain protein than sub clover. There was little difference in average wheat yields and grain protein between grazing and mulching the sub clover. Significant differences did occur in some years but these were not consistent.

Introduction

The development of farming systems in which soil carbon and nitrogen (N), depleted by periods of cropping. are restored by leguminous pasture (I), set the basis for profitable mixed farming in much of southern Australia. The stability of such systems however, is only assured if both the biological and economic variables are favourable. If cropping proves more profitable than pasture enterprises over an extended period, farmers will need to use nitrogen fertiliser to maintain cereal yields. Continuous cereal cropping can lead to a build up of disease and yield decline. Alternatively a grain legume may be grown, not only as a cash crop, but also for potential benefits to soil N supply and as a weed and disease break.

A long term experiment was commenced in 1979 at Wagga Wagga, to assess and compare the sustainability of a number of short rotations. This experiment followed other work at Wagga Wagga which showed that wheat grain yields and grain protein can be maintained and soil N used most efficiently by a cropping intensity of 50% and short rotations in a sub clover/wheat system (2).

Methods

The experiment commenced in 1979 at the Agricultural Research Institute Wagga Wagga on a fertile red earth. The rotations studied were lupin/wheat (L/W). lupin/wheat/wheat (L/W /W2), sub clover(grazed)/wheat (Cg/W), sub clover(mulched)/wheat (Cm/W) and wheat/wheat with (W/W+N) and without (W/W) N fertiliser. The N fertiliser (100 kg N/ha as urea) was added as a 3 way split at sowing, mid tillering and anthesis. Lupin/wheat and sub clover/wheat received 3 cultivations and stubble was incorporated. Lupin/wheat/wheat was direct drilled into stubble, while wheat/wheat received 3 cultivations and stubble burnt. Stubble was burnt during early autumn after fire bans were Idled.

Treatments were arranged in a randomised block design with each phase of the rotation being represented each year. Thus there were three replicates of the 50/50 rotations and 2 replicates of lupin/wheat/wheat, making up 6 blocks.

Productivity before 1986 has been reported elsewhere (3), so results from 1986 only are presented here.

Results and discussion

Yields

Annual rainfall varied from a low of 447 mm in 1987 to a maximum of 707 mm in 1989. Low spring rainfall restricted grain tillin[9] and yields in 1987, 1988, and 1991, particularly those treatments grown with high N supply (Table I). As well, yields were also reduced by late sowings in 1988 and 1991. Sowing was

delayed in 1988 to assist in the control of great brome grass *(Bromus diandrus)* which became a major problem in the wheat phase, particularly where stubble was retained and direct drilling used (3).

Table 1. Wheat grain yields (t/ha) over 6 years from different rotations.

Rotations	1986	1987	1988	1989	1990	1991
L/W	2.88	2.07	1.71	3.99	3.78	2.71
$L/W^1/W$	3.10	1.61	2.13	3.62	4.18	2.96
$L/W/W^2$	0.89	0.86	1.51	2.72	3.24	2.85
W/W	1.10	1.67	1.87	2.80	3.20	2.22
W/W+N	1.75	2.48	1.60	2.92	3.20	2.67
C_g/W	2.91	2.44	1.50	3.91	3.20	2.34
C_m/W	2.19	1.90	1.51	3.70	3.29	2.57
l.s.d.($p<0.05$)	0.23	0.44	0.14	0.44	0.42	0.22

[1] First wheat crop; [2] Second wheat crop

Except for 1988, use of a legume in rotation or N fertiliser usually improved wheat grain yield, though the magnitude of the response varied between seasons. A heavy infection of eyespot lodging in 1986 markedly reduced yields of continuous wheat cropping. Thereafter benomyl applied at the appropriate stage effectively controlled this disease. The N fertiliser response in W/W was positive for 1986 and 1987. negative for 1988 with the late sowing and dry spring, negligible for the following 2 years when aluminium toxicity symptoms were observed but positive again in 1991 when symptoms were not apparent.

Overall L/W yielded higher than C_m/W, though not significantly ($p<0.05$) in every year. These differences were not due to lower N uptake following the sub clover, but were related to lower seed weight. Total N uptake from C_m/W was slightly higher than L/W for the 1986-88 years but was similar in the other two years.

Grazing sub clover produced higher wheat yields than mulching in 1986 and 1987 but the reverse was recorded in 1991. These differences were related to differences in seed weight which was higher from C_m/W in most years except 1986 and 1987. Since 1988, seed filling was apparently more restricted in C,/W as evidenced by the earlier appearance of 'haying off' symptoms in the latter years. These differences were accompanied by higher total N uptake over recent years from C,/W. The differences over *time* could be related to changing composition of the pasture, combined with limited spring rainfall events. For example the sub clover component was 65% in 1983 and 92% in 1990, and overall was slightly higher when grazed.

The second crop in L/W/W consistently yielded less than the first crop, particularly in 1986 and 1987. In these years brome grass populations and eyespot lodging were considerably greater in the second crop. Total N uptake was also less for the second crop indicating reduced carryover of N benefits from lupin.

Grain protein

Annual mean grain protein varied according to season and rotation (Table 2).

Table 2. Wheat grain protein (%) from different rotations over 6 seasons.

Rotation	1986	1987	1988	1989	1990	1991
L/W	12.4	13.4	14.0	11.7	12.6	13.6
L/W[1]/W	12.7	10.9	13.1	10.7	11.1	13.4
L/W/W[2]	11.7	10.2	12.8	10.0	10.0	9.5
W/W	12.1	7.9	10.3	9.4	8.8	7.1
W/W+N	13.4	13.6	12.5	12.5	12.9	12.3
C_g/W	11.5	13.5	14.3	12.1	14.1	15.6
C_m/W	13.3	14.3	14.4	11.1	14.2	13.6
l.s.d.($p<0.05$)	1.6	0.8	1.5	1.0	1.1	0.7

[1] First wheat crop; [2] Second wheat crop

Grain protein in W/W declined over time, while the response to N fertiliser or legume rotation increased. In 1987 and 1990, C_m/W was significantly higher than L/W but in other years there were no significant differences. The higher protein levels promoted by the sub clover were usually associated with lower seed weights.

Grazing, compared to mulching the sub clover had no consistent effect on grain protein concentration, increasing them in 1991 and 1989, reducing them in 1986 and 1987, and having no significant effect in other years. It would seem that these results were largely related to grain yield and grain N dilution effects.

The second wheat crop in the L/W/W rotation invariably produced lower protein than the first crop. This result is a further indication of the diminished N benefit from the lupin to a second wheat crop.

Soil pH

From 1979 to 1987-88 soil pHca (0-10 cm) declined at a near linear rate, ranging from 0.05 for W/W to 0.07 units/year for W/W+N. Thereafter it stabilised for a number of years at different levels for the different treatments. In 1988 pHca (0-10 cm) varied from 4.08 for W/W+N to 4.45 for W/W. Aluminium toxicity symptoms were evident in W/W+N in 1989 and 1990 but not in 1991. Over recent years, levels of some of the rotations have slightly increased, but we are unsure of the relevance or the duration of the increase.

Conclusions

This experiment has shown that addition of N fertiliser alone to continuous wheat does not substitute for a legume break crop. due largely to differences in disease build up and soil acidification. Wheat yields following lupins compared very favourably to those following sub clover, but wheat grain protein was often higher from the latter. There was little carryover of benefits to a second wheat crop after lupins. Differences between grazing and mulching of the sub clover pasture, on subsequent wheat yield, varied between years, and appeared to be dependant on differences in the sub clover component of the pasture and seasonal conditions. The variation of treatment effects over time emphasises the importance of long term rotation experiments.

References

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