Nitrogen benefits to wheat from pasture legumes in a low rainfall cropping system

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Abstract

The effect of legume proportion and pasture phase length on wheat nitrogen uptake was investigated in the low-rainfall cropping zone (430 mm average rainfall) of central western NSW on hard-setting red soils. Wheat yields, protein levels and soil mineral nitrogen to 90 cm depth were measured following rotations with lucerne (Medicago sativa L.), and a mix of annual legumes, subterranean clover (Trifolium subterraneum L.), barrel medic (M. truncatula Gaertn.) and rose clover (T. hirtum All.). Treatments included those where the legumes were managed to maintain a high proportion of the pasture stand (>75%) and those mixed with ryegrass (Lolium rigidum Gaudin.) containing lower proportions (<50%) of legumes and pure ryegrass treatments with no legumes present. Four different pasture length treatments ranging from 2 to 5 years of pasture were investigated. Significant increases in wheat yields and / or protein and soil mineral nitrogen were measured from both the (>75%) lucerne and annual legume treatments in the first crop after pasture in each pasture length treatment compared with the ryegrass treatment. The treatments with ryegrass consistently had lower soil mineral nitrogen and wheat responses compared to those with the higher proportion of legumes. The annual legumes were as effective in providing nitrogen to the wheat as lucerne. Seasonal conditions caused large differences in soil nitrogen available and its translation to wheat yield and / or protein. Wheat responses were reduced in the subsequent years of cropping.

Key Words

Pasture legumes, wheat responses, soil mineral nitrogen, lucerne, annual legumes

Introduction

It is well understood that legume pastures provide nitrogen through a symbiotic relationship with soil bacteria (1, 2). This relationship enables nitrogen from the atmosphere to be fixed by the plant into a form that is available for plant growth. This experiment investigates a range of legume pasture species and management practices to determine how much nitrogen is available for the following wheat crops and how these crops respond to the nitrogen that is made available in a low-rainfall environment.

Several management factors are considered important for pasture and crop production, these include the choice of legume species, length of pasture, sowing rates, phosphorus fertiliser, weed management and the effects of pH and lime applications. The effects of pasture species and pasture length on nitrogen contribution from legumes were investigated at Condobolin, NSW (Lat 33?03'S, Long 147?11'E). Some preliminary findings are described here.

Methods

Field trials were located at the Condobolin Agricultural Research and Advisory Station on typical hardsetting red soil or Kandosol (3). The pasture legume species investigated included lucerne, subterranean clover, barrel medic and rose clover. The field trials incorporated a range of treatments including those where legumes were sown alone and managed to maintain a high proportion of the stand (>75%). Other treatments were sown with ryegrass containing lower proportions (<50%) of legumes and pure ryegrass treatments with no legumes present.

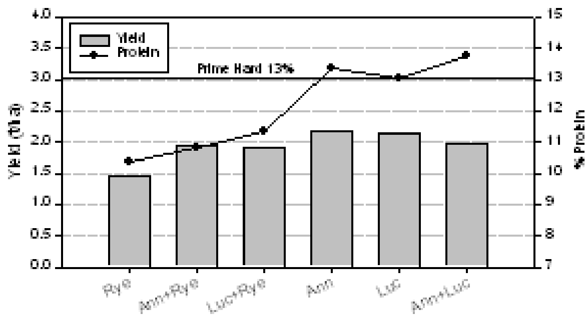
In this experiment, the length of the pasture phase was investigated. Six different pasture treatments were sown in winter 1995. The pasture treatments were pure lucerne (Luc), mixed annual legume species comprising sub-clover, barrel medic and rose clover (Ann), a combination of lucerne and annual legumes (Luc+Ann), ryegrass and annual legumes (Rye+Ann), ryegrass and lucerne (Rye+Luc) and ryegrass (Rye) on its own. The first pasture length (Phase 1), was fallowed in spring 1996 after just 16 months of pasture and cropped in 1997. The second pasture length (Phase 2) was fallowed the following year in spring 1997 and cropped in 1998. The third pasture phase length (Phase 3) was fallowed in spring 1998 and cropped in 1999. The fourth and final length (Phase 4) was fallowed in spring 1999 and cropped in 2000. The phase lengths were main plots and the pasture treatments subplots and there were four replications. The trials were monitored regularly and the pastures were crash grazed with sheep after each peak of growth and then left to regenerate. Chemical weed control was conducted as necessary to keep the species treatments representative.

Results

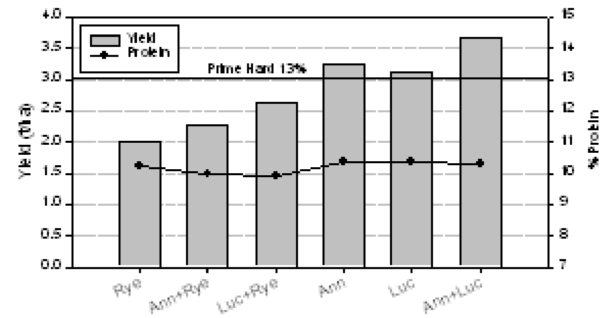
Crop response to the pasture phase

Preliminary wheat harvest results from the four pasture phase lengths are presented in Figures 1.

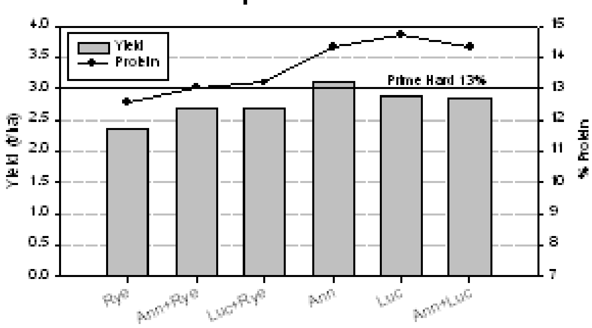
a) First wheat crop 1997 after two seasons of pasture



b) First wheat crop 1998 after three seasons of pasture



c) First wheat crop 1999 after four seasons of pasture



d) First wheat crop 2000 after five seasons of pasture

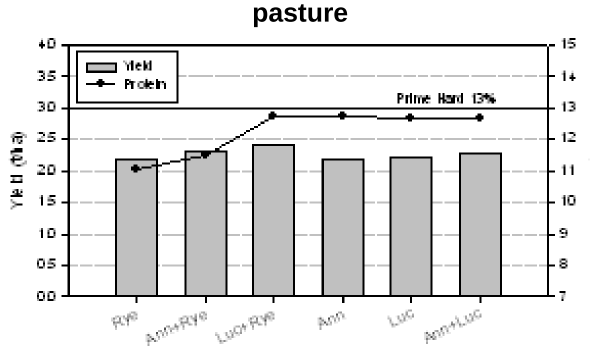


Figure 1. Wheat yield and protein results from the Phase experiment in a) 1997, b) 1998, c) 1999, d) 2000 reflecting the first year of crop following increasing seasons of each pasture treatment. Pasture treatments consist of ryegrass (Rye), lucerne (Luc); a mixture of annual legume species (Ann), including sub-clover, barrel medic and rose clover; and combinations of each of these.

Significant differences were measured between treatments in the first wheat crop after pasture, with higher yields and/or protein levels from the legume treatments. Figure 1(a) shows wheat results from Phase 1 in 1997. This was a dry year with a dry finish that resulted in low wheat yields but a protein response in the pure legume pasture treatments. Figure 1(b) shows the results from Phase 2 in 1998. This year provided a very good season of rainfall and a soft finish that resulted in high yields in the legume treatments but no protein effects at all. Figure 1(c) shows the 1999 crop results, which was a good season with above average rainfall but a dry finish. This gave double benefits for those treatments with legumes, with both higher yields and a large protein response. Figure 1(d) shows the results from the 2000 harvest and the positive effects of the legumes on protein but not yield. It is interesting to note that the Luc + Rye mix also gave a protein response after four years pasture.

Both lucerne and a mix of annual species (barrel medic, subterranean clover and rose clover) contributed to a yield and /or protein response in the following wheat crop compared with pastures containing significant proportions of ryegrass. There was no consistent difference between yields measured following annual species or lucerne. This is in contrast to work conducted in higher rainfall areas showing that lucerne gives better responses than annual legumes (4). All the treatments with ryegrass consistently gave lower yields and proteins in both wet and dry years compared to those with pure legumes. This also relates to other annual grasses and broadleaved weeds that use nitrogen. Keeping pastures free of weeds is the key to ensuring that enough nitrogen is available for the following crop.

Seasonal conditions caused large differences in nitrogen responses in wheat. In dry years, the responses were mainly in protein and in wet years, yield was the main response. The length of the pasture phase was not as important as the seasonal conditions and the presence of a high proportion of legumes in the pasture sward.

Soil response to the pasture phase

Preliminary results from the field trials have shown significant soil nitrogen benefits from pasture legume species. The available soil nitrogen (nitrate plus ammonium) measured to 90 cm depth at wheat sowing time is presented in Table 1. Mineral nitrogen levels were significantly higher in soils where good stands of pasture legumes were present. The effects were present in most years and were most pronounced in 1999 when good summer rainfall was received to aid the soil mineralisation process. The 2000 results show the same trend but the values were not significantly different. It is possible that nitrate was leached below the 90 cm sampling depth in that year. The soil nitrogen results are in good agreement with the crop responses following the pasture treatments.

Table 1. Available soil nitrogen (NO_3 + NH_4) to 90 cm at sowing following each pasture treatment in each year representing different lengths of pasture in the Phase trial. Similar letters in a row do not differ significantly (P>0.05).

Available soil N to 90cm (kgN/ha)	Pasture treatments					
Year sampled/sown (No. seasons in pasture phase)	Rye	Ann + Rye	Luc + Rye	Ann	Luc	Ann + Luc
1997 (2)	89 a	88 a	88 a	134 c	135 c	109 b
1998 (3)	72 a	83 ab	84 ab	110 bc	94 ab	132 c
1999 (4)	132 a	139 ab	117 a	194 c	225 c	184 bc

2000 (5)	103 a	94 a	128 ab	159 b	124 ab	137 ab

Length of the pasture phase

There was no evidence for the response to legumes increasing with the length of the pasture phase. Soil mineral nitrogen levels , for example, were always 50 % higher after annual legumes than after ryegrass. Even a short pasture phase of only two years was able to provide significant nitrogen benefits where legume species were abundant. There was no interaction between phase length and legume species in soil nitrogen or wheat response, the values being similar after the perennial (lucerne) or annual legumes in all comparisons. These results are only for the first crop after pasture and it is possible that the response to phase length will be evident in subsequent crops. The trial is being continued to measure the full effect of pasture phase length.

Conclusion

The choice of legume species or the length of the pasture phase were not critical to the size of the nitrogen benefit. The essential factor was that a high proportion of legume was present in the pasture stand and that enough legume dry-matter was produced. Where pastures contained high proportions of ryegrass, the nitrogen response was significantly reduced.

The presence of annual grasses such as ryegrass in these experiments also relates to other non-fixing species such as broad-leaf weeds that use nitrogen. Managing pastures to keep these species at a minimum is the key to ensuring that enough nitrogen is available for the following wheat crop.

Season conditions play a large role in how the nitrogen from pasture legumes is translated into wheat response. In years with a dry finish, protein benefits are often achieved, whereas in years with a wet finish, yield is mainly affected; in some seasons, both yield and protein can be increased.

References

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