



NSW Agriculture

Lucerne boosts cereals in crop rotations

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INTRODUCTION

The clear outcome of a long-term wheat-pasture rotation trial is that lucerne in a cereal crop rotation will increase wheat production and protein levels, maintain soil health and fertility and reduce fertiliser (nitrogen) costs.

The trial was conducted at NSW Agriculture's Tamworth Centre for Crop Improvement between 1966 and 2001. It consists of 6 treatments on two adjacent but different soil types: a black earth (black vertosol) and a red clay (red vertosol). The trial covered 3 ha in total.

The experiment was conducted in three separate phases. The first phase studied the ability of grazed lucerne to maintain soil fertility and long-term cropping sustainability. Specifically, it identified the optimum period of lucerne pasture and how long the benefits lasted. The second phase measured the effect of lucerne on grain sorghum yields, and the third phase compared lucerne with sub clover, snail medic, chickpea, long fallow and continuous wheat for their effects on the yield and quality of following wheat crops.

Results

- Growing lucerne for 2.5 – 3.5 years optimised the beneficial effects on wheat yields and protein.
- Lucerne grown for 3.5 years eliminated the need for fertiliser nitrogen (N) in the next 5 crops.
- Nitrogen fixed by lucerne was more effective in raising grain protein levels than N derived from fertiliser.
- Lucerne increased total soil N by about 15 kg per tonne of lucerne dry matter

produced. (The N was only measured to a soil depth of 15 cm.)

- Yearly lucerne production of 7–9 t/ha of dry matter added 140 kg of total soil N/ha/year on the black soil and 110 kg/ha/year on the red soil.
- Lucerne improved other factors such as soil organic carbon and aggregate stability, compared with continuous wheat and long fallow.
- Lucerne produced large beneficial effects on grain sorghum yields and N uptake in the first year with smaller effects for the next 3 years.
- Of the legumes investigated, lucerne contributed more available N to the soil than sub clover, snail medic or chickpea.
- Lucerne must be removed in sufficient time to allow soil moisture to be replenished when returning to wheat production.
- Lucerne showed similar trends on the two soil types for all parameters.

Methods

In phase 1, on the black soil, lucerne was sown at 5 kg/ha in June 1966, 1967, 1968 and grown for 3.5, 2.5 or 1.5 years. All lucerne was removed in 1970. Wheat was then sown at 45 kg/ha each year till 1978, except for 1972, a drought year.

On the red soil, lucerne was established in June 1966, 1968, 1970 and grown for 5.5, 3.5 and 1.5 years and all removed in 1972. Wheat was then grown continuously from 1973 to 1978.

On both soils wheat was also grown each year from 1966 to 1969 or 1971. Plots received superphosphate each year and were split for N fertiliser at nil or 45 kg N/ha from 1970 (black soil) or 1973 (red soil) until 1977.

In phase 2, lucerne and wheat were grown on both soils from 1979 to 1983. Both the lucerne and wheat treatments were followed by 4 years of sorghum from 1983 to 1987. Sorghum was sown at 4 kg/ha in November each year with an average N rate of nil or 100 kg N/ha.

In the last phase, lucerne, sub clover and snail medic were grown from 1988 to 1990 followed by 3 years of wheat from 1991 to 1993. These were compared to chickpea/wheat, long fallow/wheat and continuous wheat treatments over the same 6 years. N fertiliser was applied to wheat crops at 0, 60, or 120 kg N/ha. Continuous wheat cropping was the 'control' treatment in each phase.

DETAILS OF RESULTS

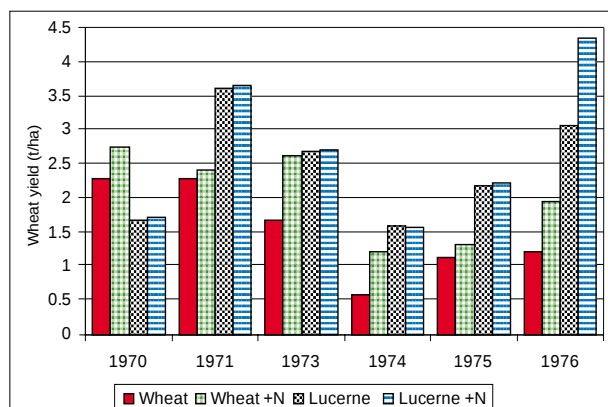
Phase 1. Optimum duration of lucerne pasture

Because the effects of lucerne tended to be similar for yield, quality and soil parameters on both soils (Figure 4), results will be shown for only one soil. However, responses were generally greater on the black soil.

There was little difference between 2.5 and 3.5 years lucerne duration in the benefits on the following wheat crops. Figure 1 shows the comparison of wheat yields, with and without N fertiliser, following either 4 years wheat or 3.5 years lucerne. It can be seen that while fertiliser N increased continuous wheat yields in all years, it had no effect in increasing wheat yields following lucerne until the 6th crop in 1976, indicating that lucerne had fixed sufficient N to maintain 5 wheat crops.

The higher wheat yield from continuous wheat in 1970 was due to lucerne not being removed until February 1970. Wheat was then sown at the end of June and this did not allow sufficient time to replenish the soil moisture reserves. This is one of the major drawbacks of growing lucerne

Figure 1. Wheat yields with and without fertiliser N (45 kg N/ha/year as urea) from 1970 to 1976, following 3.5 years of lucerne or 4 years of wheat on the black soil.



in crop rotations. Lucerne must be removed early enough to allow sufficient time to replenish soil moisture reserves before sowing wheat. In most wheat-growing areas, this will be 9–12 months.

Protein levels of wheat following 3.5 years of lucerne were maintained above those following continuous wheat, whether nitrogen was applied or not, for 4 years on both the red and black soil types. However, while the average protein content for the 4 years (1973–76) was 10.9% for the continuous wheat compared to 13.1% for the lucerne treatments on the red soil, wheat protein after lucerne was only maintained above the Prime Hard level of 12.5% for the first 2 years (Figure 2).

Another benefit of lucerne was in reducing wild oat numbers which fell from 18 plants/m² with continuous wheat to 0.5 plants/m² following 2.5 years of lucerne.

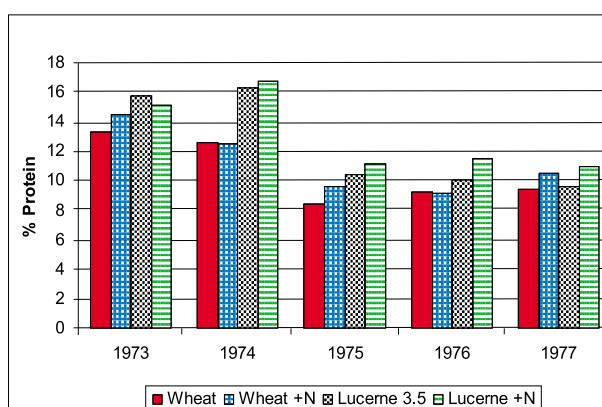
Phase 2. The effects of lucerne on grain sorghum yields

Lucerne on both soil types had a large beneficial effect on the yield and nitrogen uptake of the first sorghum crop. While the first year, 1983/84, was an excellent season for sorghum production, the second year was much drier and this was reflected in the low yields. So the effects were much smaller in the second year, but did continue into the third and fourth years, as seen in Figure 3.

Lucerne production during 1979–83 was low due to drought years in 1980 and 1982 and so this limited the amount of nitrogen that lucerne fixed. However, the first sorghum crop following the lucerne still took up an extra 51 kg of N/ha as measured in the grain, compared to the sorghum after wheat, on both soils.

On the black soil, lucerne produced enough nitrogen to almost double sorghum yields in the first year, compared with sorghum following wheat without N fertiliser. The effect of fertiliser nitrogen gave a slight yield response for sorghum following lucerne in the first year, and bigger

Figure 2. Protein content of wheat, with and without N fertiliser (45 kg N/ha/year as urea), following 3.5 years of lucerne or continuous wheat on the red soil.



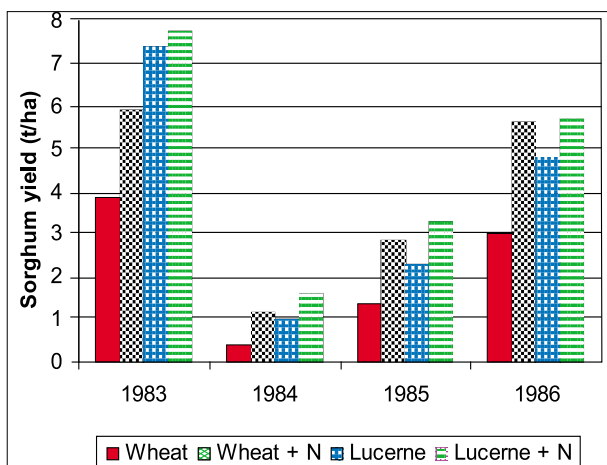


Figure 3. The yields of sorghum with and without fertiliser N (100 kg N/ha/year as urea) following either 4 years of lucerne or 4 years of wheat on the black soil.

responses in the following 3 years. Using fertiliser N gave the largest responses for sorghum following wheat, but these yields were still lower than yields following lucerne with N plots, although there was little difference by the fourth year.

Phase 3. The benefits of lucerne compared with other pasture legumes

The total N uptake (grain yield multiplied by grain N concentration) of the three wheat crops from 1991–93 clearly showed the advantage of having pasture legumes in the rotations (Figure 4). Lucerne and sub clover produced the highest uptake by wheat on both soil types. While snail medic was inferior to the long fallow treatment, it should be remembered that 18 months fallow preceded each of the three wheat crops in that treatment, so more water was stored, giving higher yields for wheat following the fallow treatment.

The long fallow treatment had the greatest effect on running down the organic carbon levels on both soils. Measurements in 1997 of labile carbon (the fraction supplying nutrients and

Aerial view of red soil trial site showing fallow, lucerne and wheat plots.



Darker plots in foreground show the benefits of nitrogen added by pasture growth contrasting with paler, nitrogen deficient plots in the background.

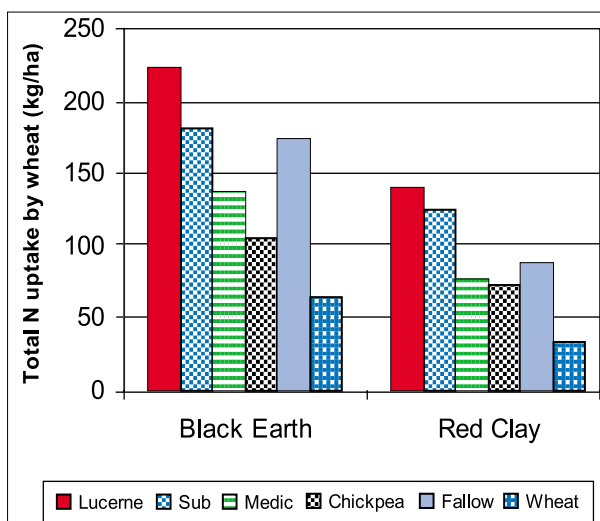
binding soil particles together) following lucerne, clover and medic were, on average, 35% better on the black soil than after the long fallow treatment, and 31% better on the red soil.

CONCLUSION

In all three phases, lucerne provided a large benefit to the following wheat crops by increasing vegetative and grain yield, protein concentration and N uptake. Lucerne also reduced fertiliser requirements. Sub clover also markedly increased wheat yield and N uptake, but less than lucerne, while the effect of snail medic and chickpea were similar, but less than lucerne and sub clover.

Legume pastures clearly provide a major benefit to wheat production and soil health when used in a rotation, and should be an essential part of farming systems in northern wheat-growing areas.

Figure 4. The effect of 2.5 years of lucerne, sub clover, snail medic, chickpea, long fallow and continuous wheat on the total N uptake of the following three wheat crops on both soil types.



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