BREAK CROP FERTILITY AND ORGANIC MANURES AT BUNDALONG SOUTH

KEY MESSAGES

- **This trial is part of a project looking at the legacy effects of organic amendments and manure compared to inorganic fertilisers on cereal and oilseed production following a pulse crop. This is the first year at this trial site, with effects to be assessed over the next two growing seasons.**
- **Wheat yield following faba beans was high at this site, averaging over 9t/ha, demonstrating how legacy nitrogen from a previous pulse crop can contribute to yield and help buffer against high synthetic fertiliser inputs**
- **The lowest average yield at this site was recorded in the fallow treatment with farm-standard nitrogen (7.93 t/ha), while the highest yield was observed in the 10t/ha manure treatment with extra nitrogen (9.68 t/ha). This shows the potential for increased yield when nitrogen (and other nutrient) supply is matched to demand under high yielding seasonal conditions**
- **When wheat yields were averaged across manure treatments, the application of an extra 75kg/ha of nitrogen in-season significantly improved yield when compared to the farm standard, indicating the farm standard rate was not either enough to realise potential yield or supply did not match plant demand from stem elongation onwards this season**
- **When yields were averaged across nitrogen treatments, the 10t/ha manure treatment was the only manure treatment to significantly improve yield when compared to the untreated control**
- **When averaged across all treatments, grain protein increased from 10% to 11.2% when an extra 75kg of nitrogen was applied at stem-elongation, lifting quality from ASW to APW**
- **Slashing at flowering and removal of faba bean biomass reduced the yield benefit to the following crop.**

BACKGROUND

There is an abundance of organic amendment options in north east Victoria due to the proximity of feedlots and other intensive livestock operations. Consequently, there is local interest in using these by-products to supply nutrients for grain production systems and to improve soil constraints.

Nitrogen fixation provides most of the nitrogen demand of grain legume crops at high yields, assuming adequate rhizobial function. A large part of this fixed nitrogen is exported in grain, which can affect the pulse crop's potential to restore fertility to the soil. Consequently, the nitrogen fixed by the legume crop may not be enough to sustain higher-yielding wheat crops the following season.

AIM

This project is evaluating whether the benefits of nitrogen fixation by legume crops can be amplified in a subsequent wheat crop by using added organic amendments (eg. compost) or manure. It also looks at whether the application of manures can buffer the farm business from costs associated with high synthetic fertiliser inputs.

METHOD

A commercial faba bean crop was sown in Autumn 2022 at Bundalong South in Victoria. During September 2022, when the crop was at early to mid-flower, parts of the faba bean crop were slashed and removed to create a 'fallow' effect, while in other areas the beans were slashed and spread evenly on the surface to create a 'green manure' effect. The remaining crop was harvested.

To leverage the fertility of this crop's legacy, a manure trial was established at the same site during 2023, with 16 treatments on paired plots. Treatments received either farm standard nitrogen (N) (92 kg/ha) or farm standard N plus an extra 75 kg N /ha (167 kg N/ha).

Prior to sowing in April 2023, three rates of manure — 2.5, 5.0 and 10 t/ha at 23 percent moisture — were spread on the soil surface. Additional treatments, including a treatment equivalent to the nitrogen (N) value of 5t manure and a blend of ammonium sulphate, monopotassium sulphate, muriate of potash and urea (N-P-K-S) equivalent to 5t manure, were also spread prior to sowing (Tables 1 and 2). A small amount of manure was withheld to allow final testing of its constituents and then applied on 1 June, 2023.

Table 1 Nutrients applied to treatments prior to sowing using ammonium sulphate, monopotassium sulphate, muriate of potash and urea.

NUTRIENTS APPLIED (KG/HA)				
Treatment	Nitrogen	Phosphorus	Potassium	Sulphur
Nil	-	-	-	-
2.5 t/ha manure	23.2	13.7	27.0	7.5
5 t/ha manure	46.3	27.4	54.0	15.0
10 t/ha manure	92.6	54.8	108.0	30.0
N value 5t/ha manure	46.3	-	-	-
NPKS value 5t/ha manure	46.3	27.4	54.0	15.0
Fallow	-	-	-	-
Green manure	-	-	-	-

Note: Nutritional values do not include nitrogen applied in-season as urea.

Table 2 Application dates and rates of artificial nutrients applied to the N value 5t/ha manure equivalent and NPKS value 5 t/ha manure equivalent treatments at Bundalong South, 2023.

NUTRIENTS APPLIED (KG/HA)				
	Nitrogen	Phosphorus	Potassium	Sulphur
App 1 – 26 April	32.7	16.9	50.2	10.6
App 2 – 1 June	13.6	10.5	3.8	4.4
Total	**46.3**	**27.4**	**54.0**	**15.0**

The whole trial site was fertilised with the same rate of urea that the farmer used on the surrounding paddock, which was 46 kg N/ha (100 kg urea) spread on 26 June and 46 kg N/ha (100 kg urea) spread on 24 July, 2023. Following this application, each pair of plots was split, with half of each treatment receiving an extra 75 kg N/ha as top-dressed urea on 4 August at early stem elongation (GS32).

RESULTS AND DISCUSSION

After a wet finish to 2022, stored moisture was high heading into the 2023 season. This, and adequate winter rainfall, helped carry the crop through the warm, dry September. Timely rainfall and mild temperatures during October provided good finishing conditions, and allowed high yields to be achieved.

Table 3 Influence of treatment on grain yield (t/ha) at Bundalong South, 2023

	GRAIN YIELD (T/HA)		
Treatment	**Standard N**	**Standard N + 75 kg N/ha**	**Average**
Nil	8.70 -	9.40 -	9.05 bc
2.5t/ha manure	8.87 -	9.36 -	9.11 abc
5t/ha manure	8.73 -	9.46 -	9.09 abc
10t/ha manure	9.01 -	9.68 -	9.34 a
N value 5t/ha manure	8.56 -	8.98 -	8.77 d
NPKS value 5t/ha manure	9.16 -	9.47 -	9.31 ab
Fallow	7.93 -	8.94 -	8.44 e
Green manure	8.53 -	9.24 -	8.89 cd
Mean	**8.69 b**	**9.32 a**	**9.00 -**

Manure	**LSD**	0.27	**P Val**	<0.001
Nitrogen	**LSD**	0.14	**P Val**	<0.001
Manure x Nitrogen	**LSD**	ns	**P Val**	0.300

Grain yields averaged 9.0 t/ha across the trial (Table 3). While the lowest yielding treatment was the fallow treatment with no additional nitrogen (7.93 t/ha), it's yield was still impressive. The application of an additional 75 kg N/ha to the fallow treatment boosted yield by over 1 t/ha, demonstrating the benefits of high soil nitrogen fertility under high yielding conditions. Applying 10 t/ha of manure with an extra 75 kg/ha of nitrogen produced the highest yield (9.68 t/ha).

There was no interaction between manure treatment, nitrogen treatment and grain yield. However, supplying an additional 75 kg/ha of nitrogen during the growing season increased average yield by 0.63 t/ha, from 8.69 t/ha to 9.32 t/ha. This suggests that nitrogen carried over from the previous faba bean crop and a farm-standard fertiliser application rate could not meet the needs of the wheat crop under high-yielding conditions.

When yields were averaged across nitrogen treatments, the fallow treatment resulted in a lower grain yield the following year (8.44 t/ha), compared to the nil treatment (9.05 t/ha) — a difference of 0.61 t/ha. This was likely due to the removal of nitrogen-rich plant residues, which would have contributed to soil nitrogen stores if left to break-down naturally. The application of 10 t/ha of manure increased grain yield by 0.29 t/ha over the nil treatment, to 9.34 t/ha, however yield for this treatment was not significantly different to the 2.5 and 5 t/ha manure treatments or the NPKS 5t/ha manure equivalent, suggesting that nutrients were not limiting in these treatments. Where only nitrogen was applied in the N value 5 t/ha manure treatment, the yield was lower than the control, suggesting nutrients other than nitrogen limited yield.

Harvest index is the ratio of grain to total shoot dry matter and is used as a measure of reproductive efficiency. Although there were no statistically significant differences in harvest index due to any of the manure treatments, the plots that had an extra 75kg of nitrogen had a significantly higher harvest index (42%) than the plots with the farm-standard nitrogen (40%).

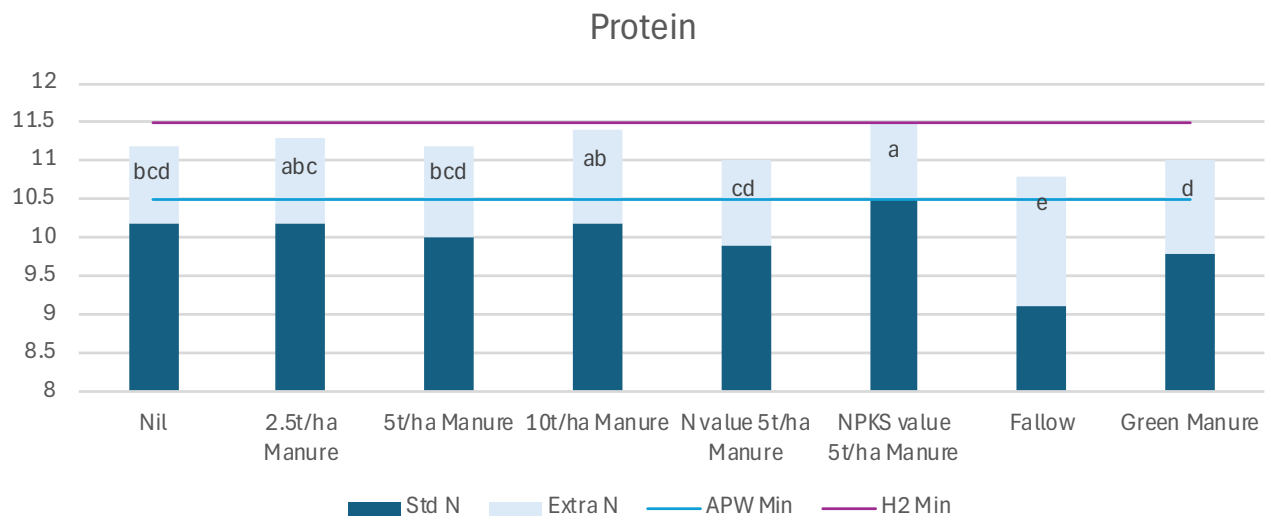

Figure 1 Influence of manure treatment on protein content at Bundalong South.

There was no interaction between manure treatment, nitrogen treatment and grain protein. Adding 75kg of nitrogen per hectare over and above the farm standard increased grain protein from 10 percent to 11.2 percent when averaged across all treatments (Figure 1). When only the farm standard nitrogen rate was applied, grain protein for all treatments was below the 10.5 percent required to meet APW specifications, except for the NPKS 5 t/ha manure equivalent, which was exactly 10.5 percent. The application of an additional 75kg/ha of nitrogen increased grain protein for all treatments, however this was still below the 11.5percent required to meet AH2 specifications, except for the NPKS 5t/ha manure equivalent, which was exactly 11.5 percent.

Both test weight and grain screenings were well within receival standards for all treatments.

SOIL NITROGEN STATUS

Soil samples were collected from selected treatments at GS32. Soil mineral nitrogen in these treatments ranged from 83 to 136 kg/ha over the profile to a depth of 90 cm. Although there were no statistical differences, the lowest levels were recorded in the fallow plots. The highest soil mineral nitrogen was observed in the green manure plots, which was expected given a green manure crop can fix a high amount of nitrogen and can begin returning that nitrogen to the soil shortly after termination, compared to a grain crop that will remove approximately 40kg N per tonne of grain production (Table 5).

Table 5 Influence of manure treatment on soil mineral nitrogen (kg N/ha), sampled 4 August, 2023

	SOIL MINERAL NITROGEN (KG N/HA)			
Treatment	**0-30cm**	**30-60cm**	**60-90cm**	**0-90cm**
Nil	66 -	16 -	15 -	92 -
10 t/ha manure	70 -	17 -	14 -	103 -
NPKS Value 5 t/ha manure	71 -	25 -	13 -	111 -
Fallow	57 -	13 -	11 -	83 -
Green manure	95 -	17 -	11 -	136-
Mean	**72**	**18**	**13**	**107**
LSD	ns	ns	ns	ns
P Val	0.333	0.009	0.430	0.250

Post-harvest soil sampling showed a significant increase in soil mineral nitrogen levels due to the addition of an extra 75kg N/ha. This was replicated at each depth sampled, with an increase of around 24 kg N/ha over the entire profile.

Table 6 Influence of applied nitrogen on soil mineral nitrogen (kg N/ha), sampled 30 January 2024.

SOIL MINERAL NITROGEN (KG N/HA)				
Treatment	**0-30cm**	**30-60cm**	**60-90cm**	**0-90cm**
Farm standard N	43 b	10 b	7 b	60 b
Extra 75kg N/ha	58 a	17 a	10 a	84 a
Mean	**50**	**14**	**9**	**72**
LSD	8.03	2.64	2.24	9.76
P Val	0.001	<0.001	0.002	<0.001

When averaged across nitrogen treatments, the use of manure (or equivalent nutrients) did not significantly increase the soil mineral nitrogen recorded at any depth (Table 7). The NPKS value treatment had the highest soil mineral nitrogen over the entire profile at around 86 kg/ha, which was 32kg/ha greater than the N value treatment, which recorded the lowest nitrogen levels. Soil mineral nitrogen in the manure treatments ranged from 74 to 82 kg/ha, with levels increasing in line with increases in the amount of manure applied.

Table 7 Influence of manure treatment on total soil mineral nitrogen (kg N/ha), sampled 30 January 2024, Bundalong South

TOTAL SOIL MINERAL NITROGEN (KG N/HA) 0-90CM					
Treatment	**Standard N**		**Standard N + Extra 75 kg N/ha**		**Mean**
Nil	48 -		81 -		65 -
2.5t/ha manure	60 -		87 -		74 -
5t/ha manure	77 -		79 -		78 -
10t/ha manure	59 -		105 -		82 -
N Value 5t/ha manure	47 -		60 -		53 -
NPKS Value 5t/ha manure	61 -		110 -		86 -
Fallow	59 -		70 -		65 -
Green Manure	72 -		83 -		77 -
Mean	**60**	**b**	**84**	**a**	
Manure	LSD	ns	P Val		0.078
Nitrogen	LSD	9.762	P Val		<0.001
Manure x nitrogen	LSD	ns	P Val		0.153

ECONOMICS

For the economic evaluation three prices were used for the manure. This allowed for variance in the cost of freight and spreading depending on the distance from the manure supply. The evaluations are called 'cheap', 'dear' and 'expensive' with manure prices of $30, $40 and $50 per tonne respectively. The gross income was calculated on a per plot basis and averaged over the 4 replicates. This was to avoid unfair advantages where one treatment will 'just' meet a higher-grade than another treatment, leading to a substantial difference in gross income.

Nutrients were valued as follows: nitrogen - $1.52/kg, phosphorus - $4.76/kg, potassium - $2.00/kg, sulphur - $0.50/kg, based on fertiliser prices of urea - $700/t, MAP - $1200/t, muriate of potash (MOP) - $1000, gypsum - $80/t.

The NPKS value 5 t/ha manure treatment, which yielded 9.31 t/ha, was 260 kg/ha higher yielding than the Standard treatment (9.05 t/ha), however when taking the extra cost of the fertiliser into account, it was $203/ha less profitable. To have a legacy effect, the extra fertiliser would need to maintain this higher level of production for two to three seasons before it starts to become profitable.

When manure was either cheap ($30/t) or dear ($40/tonne), then any rate of manure (2.5 – 10t/ha) was statistically as profitable as the NPKS equivalent. When manure was expensive ($50/t), then the higher rate of manure (10 t/ha) becomes less profitable, while the other rates (2.5 – 5 t/ha) were equally profitable to the NPKS equivalent.

In any situation, the legacy effect of the nutrients or manure, as well as the nutrients that are lacking in the soil, needs to be considered.

SUMMARY

Organic manures have the potential to be a profitable addition to the farmers toolkit if the manure can be sourced and applied economically. An extension to this project will enable the legacy effects of the manure and synthetic fertilisers to be monitored at this site over the next two growing seasons.

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