Yield and protein benefits from application of nitrogen fertiliser to wheat on upper Eyre Peninsula

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Abstract

Replicated field trials were established in 2001 to examine the responses to nitrogen (N) fertiliser in wheat on two important soil types of the upper Eyre Peninsula. Three experiments were conducted at sites with grey calcareous soil and one at a site with a sand over clay. The effects of different rates and forms of N applied in conjunction with different forms of phosphorus (P) fertiliser on the grey calcareous soils and the effects of N rate, depth of placement and late N applications on a sand over clay were investigated. On the grey calcareous soils, responses to N were greatest when P limitations were reduced by using fluid fertiliser. Applying N deep in the profile followed by broadcast applications of N later in the season resulted in substantial yield and protein improvements on the duplex soil. The results indicate that there is potential to improve N responses in the region by fertiliser management.

Key Words

Nitrogen Phosphorus Calcareous Eyre Peninsula Wheat

Introduction

The grain yields of wheat in the low rainfall areas of the upper Eyre Peninsula are generally low and the nitrogen (N) requirements of these crops have traditionally been satisfied through biological fixation from a medic pasture phase. Farmers have applied little or no N fertiliser to their wheat crops, but recent work on improving the form and placement of N and phosphorus (P) fertiliser may mean that the use of N fertiliser should be re-examined. On the grey calcareous sandy loams substantial increases in yield can be achieved by using fluid phosphorus fertiliser (Holloway et. al., 2001). Correcting the chronic P deficiency in the region may improve the responsiveness to N fertiliser. On a duplex soil, Doudle et al. (2001) found that deep (40 cm) placement of N and other nutrients throughout the sandy A horizon increased yields significantly. However the practicalities of placing N deep in the soil could limit the uptake of this research on farm, unless the benefits are considerable. This study evaluated the responses to N fertiliser when applied with or without adequate sources of P to grey calcareous soils on upper Eyre Peninsula and investigated different options for improving the N status, grain yield and protein of wheat grown on sand over clay.

Methods

N and P Interaction Trials

Wheat (cv. Frame at Miltaburra and cv. Yitpi at Yandra and Warramboo) was sown at 62 kg/ha in a fully randomised block design with 4 reps. Three rates of N, as urea (0, 15 and 30 kg N/ha) were applied below the seed in either granular or fluid form. Two rates of P (0 or 15 kg P/ha) were also applied below the seed in either granular (triple superphosphate, 20%P) or fluid (phosphoric acid based, 27%P w/w) form. A post-emergent foliar spray containing zinc sulphate, copper sulphate and manganese sulphate at 1.5, 0.2 and 2 kg/ha of the element respectively was applied.

N Application Technique Trial

A trial was established at Wharminda where approximately 40 cm of sand overlays clay. A nutrient blend was injected throughout the sand layer with a paraplow on May 4. The blend contained P, K, S, Cu, Mn and Zn applied at rates of 20, 25, 12.8, 4, 10 and 10 kg/ha of the element respectively. N was applied at three rates (0, 15 or 60 kg N/ha) either as dissolved urea at the beginning of the season or in a 2:1 split application of dissolved urea at the beginning of the season and broadcast urea 79 days after sowing. The initial N application was either distributed throughout the top 40 cm of the sand layer (deep) with the paraplow or applied 5 to 10 cm below the soil surface (shallow) during the seeding operation. Wheat, cv. Yitpi was sown at 70 kg/ha with triple superphosphate + 5% Zn at 50 kg/ha beneath the seed.

Soil and plant sampling and analysis

Soil samples were taken from each trial prior to sowing to determine the initial N status. Plant samples were collected at tillering and anthesis, dried at 60?C for 48 h and weighed. At maturity fertile tiller numbers were counted, the samples weighed and threshed. Rooting depth and root length density were measured in the N application technique trial during September. Plots were harvested at maturity and grain samples were retained to measure screenings and grain protein concentration. The total amount of N removed in the grain was derived and the agronomic efficiency of fertiliser N uptake was calculated using the N difference method of Craswell and Godwin, 1984.

Results

N and P Interaction Trials

At Miltaburra growing season rainfall was average and there was relatively high initial mineral N in the profile (Table 1). Crop emergence and growth through the season were unaffected by the application of N or P except for a small increase in total crop biomass, yield, grain protein and screenings following the addition of 15 kg N/ha (Table 2).

Table 1: Initial soil N, Colwell P, and April-October rainfall for each site

	Miltaburra	Yandra	Warramboo	Wharminda
Initial Nitrate N (mg/kg) 0-30 cm	74	44	47	11
30-60 cm				16
Colwell P (mg/kg) 0-10 cm	32	25	26	15
April-October rainfall (mm) 2001	236	354	314	187
Average	236	298		215

Table 2: Influence of applied N on yield, grain quality and economic return at Miltaburra in 2001.

N Rate	DM at maturity (kg/ha)	Grain Yield (kg/ha)	Protein (%)	Screenings (%)	N Removed in Grain (kg/ha)	Agronomic Efficiency (kg grain / kg N)

Nil	3099	1503	12.8	2.3	34.4	-
15 kg/ha	3375	1580	12.9	2.4	36.4	5.12
30 kg/ha	3293	1520	13.0	2.4	35.3	1.57
LSD (P<0.05)	202	72	0.1	0.1	1.7	3.33

At Yandra, the application of both N and P increased crop growth and produced large grain yield increases (Table 3). Tiller number was increased by adding P (nil = 125, granular = 134 and fluid = 147 tillers/m^2) and N (nil = 120, 15 or 30 kg/ha = 143 tillers/m^2). Grain yield increased with increasing rates of N and there was a significant yield advantage through the use of fluid P rather than granular P. Mean grain protein concentration and screenings concentrations were 10.8% and 0.6% respectively and were not affected by any treatment.

Table 3: Influence of N rate and source of P on the grain yield (kg/ha) of wheat (lsd=124) and N content (lsd=2.4) at Yandra

N Rate	P Source					
	None		Granular		Fluid	
	Grain Yield	Grain N	Grain Yield	Grain N	Grain Yield	Grain N
Nil	1578	30.7	1681	33.0	1721	33.2
15 kg/ha	1708	33.1	2077	40.2	2213	42.7
30 kg/ha	1760	34.0	2264	43.5	2421	46.8

At Warramboo, crop growth was improved by applying P, particularly when applied in fluid form. The benefits of P nutrition were most pronounced early in the season. At tillering, applying fluid P increased growth by 37% compared to the granular P treatments and by 113% compared to nil P. The difference between fluid and granular P was reduced to 12% by anthesis and 6% by harvest. Tiller number was greatly increased by P nutrition. The addition of N did not affect tiller production or crop growth before anthesis but increased grain yield when applied with P (Table 4). Grain protein levels were increased by using fluid or granular P (Table 4) and with increasing rates of N. Up to 50 kg N/ha was removed when P and N were both applied (Table 5) although a large proportion of this is likely to have come from the soil since 38 kg N/ha was removed in the nil treatment. Agronomic efficiency was relatively poor overall and declined at the higher N rate (Table 5). In the absence of P fertiliser, applying N caused a reduction in grain yield (Table 4), and a negative agronomic efficiency.

Table 4: Influence of N rate and P source on the yield (kg/ha) and grain protein (%) of wheat at Warramboo

N Rate	No P	Granular P	Fluid P	Average (lsd = 128)
		Grain yield		
Nil	2081	2446	2550	2359
15 kg/ha	2003	2633	2783	2473
30 kg/ha	1796	2483	2680	2320
Average (LSD = 221)	1960	2521	2671	2384
		Grain protein concentration		
Nil	10.3	10.3	9.8	10.2
15 kg/ha	10.9	10.7	10.3	10.6
30 kg/ha	11.2	11.0	10.6	10.9
Average (LSD = 0.5)	10.8	10.7	10.3	10.6

Table 5: Influence of N rate and P source on N removal in wheat grain (kg/ha) and the agronomic efficiency (kg gain/kg N fertiliser) at Warramboo

N Rate	No P	Granular P	Fluid P
		N removal	
Nil	37.76	44.30	44.14
15 kg/ha	38.19	49.17	50.23
30 kg/ha	35.25	47.73	50.22
LSD=4.25			

		Agronomic efficiency	
15 kg/ha	-5.2	12.5	15.5
30 kg/ha	-9.5	1.2	4.3
Average (LSD = 8.6)	-7.3	6.9	9.9

Wharminda N Technique Trial 2001

The growing season at Wharminda was slightly drier than average (Table 1). Increased rates of fertiliser increased dry matter at tillering, regardless of the application method (Table 6). Root measurements (data not shown) taken prior to anthesis showed that root growth beyond 10 cm was encouraged by deep N placement and high N rates. Plant biomass at anthesis was mainly influenced by the amount of N added rather than the depth of application. The main benefits of subsoil nutrition and of late N applications became apparent towards harvest where a combination of 40 kg of N applied to the subsoil in addition to 20 kg of N broadcast at late tillering produced the highest yields (Table 6). Grain protein was relatively unaffected by the depth of N placement but was increased by the higher N rate and responded well to the late N applications. The amount of N removed in the grain and agronomic efficiency also increased with late N applications.

Table 6: Influence of treatments on crop growth, grain yield, quality, N removal and agronomic efficiency of wheat at Wharminda.

Depth and N rate (kg/ha)	Dry matter (kg/ha)			Grain Yield	Protein	Screenings	Grain N removal	Ag. eff.
	Tiller	Anth.	Mat.	(t/ha)	(%)	(%)	(kg/ha)	(kg/kg)
Nil	311	3111	5028	1.69	8.9	1.0	26.6	
15 Shallow	428	3730	6259	1.71	9.0	1.2	27.3	1
10 Shallow + 5 Late	371	3483	5015	1.91	9.6	1.2	32.4	14
15 Deep	436	3594	5777	2.00	8.7	1.2	31.2	20
10 Deep + 5 Late	383	3524	6653	2.20	9.0	1.1	34.9	33
60 Shallow	483	3867	5783	1.98	9.0	1.2	31.8	6
40 Shallow + 20 Late	470	3614	6643	2.09	11.4	1.6	42.9	8

60 Deep	532	4325	7581	2.24	9.7	1.6	38.8	11
40 Deep + 20 Late	397	4775	6830	2.53	10.9	1.5	49.3	15
LSD	121	827	1272	0.25	0.3	0.3	3.9	15

Conclusions

On the grey calcareous soils, correcting P deficiency was a critical factor determining the response to N. On the duplex soil at Wharminda, high rates of N, distribution into the subsoil and an application of N at late tillering all contributed to improving crop yield and grain protein.

Acknowledgements

Leon & Marilyn Mudge, Ian & Gladys Morgan, Tim & Tracy VanLoon and John Masters for the provision of trial sites. Penny Day and staff of Minnipa Agricultural Centre who gave input and technical assistance. This research was supported by the South Australian Grains Industry Trust Fund and the Grains Research and Development Corporation.

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