Nitrogen management for increased wheat production in the High Rainfall Cropping Zone of Western Australia

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Abstract

This study examined the production of wheat under various nitrogen management regimes in the high rainfall cropping zone of Western Australia (HRCZ). The aim of the study was to explore wheat yield potential by increasing N rates to 160 kg/ha and applying it according to crop demand, phenology, weeks after seeding ('timed') and after waterlogging/major rainfall ('tactical'). These split N treatments were compared to applying all N at seeding and to farmer practice rates (100N) either as split N or all N applied at seeding. Wheat yields in 2005 reached 6.4 t/ha with 'tactical N', an increase in returns of $484/ha over the Nil, $239/ha over applying 160 kg/ha N at seeding, and $169/ha over 100 kg/ha N applied as Farmer N. Noodle protein (9.5%) was met only when 160 kg N/ha was split applied. Wheat yields were in excess of 6 t/ha with split N treatments, however the grain production efficiency of 10.7 kg/ha/mm rainfall was well below the target production efficiency; 16.3 kg/ha/mm. Nitrogen rates, plant number and tiller retention may have limited wheat production. Alternatively, wheat grain production efficiency may need to be adjusted for the zone, which varies with other factors including frost and rainfall distribution

Key words

Wheat production, seasonal conditions, target yields, Kojonup

Introduction

Increasing fertiliser nitrogen (N) rates improves wheat yield and quality in the high rainfall cropping zone of Western Australia (HRCZWA) (Simpson *et al.* 2006). However, there is a strong interaction between seasonal conditions and the demand and efficient use of fertiliser nitrogen. Applying fertiliser N tactically after major rainfall and waterlogging in 2003 trials increased grain yields by up to 60% over current practices (Simpson *et al In press*). The aim of this study was to explore the response of wheat yield and quality to N applications timed according to phenology, weeks after seeding, incident of waterlogging and critical tissue N.

Methods

The experiment was conducted in 2005, on a farm 25 km south west of Kojonup. Annual rainfall during 2005 was 704mm, with 597 mm falling in the growing season (April-October). Calingiri wheat was sown on 23 May 2005 to a plant density of 200 plants/m^2. 270 kg/ha Pasture fertiliser (50P, 27S, 38Ca) was applied at seeding and 100 kg/ha muriate of potash (50K) top dressed the following day. On 19th August, an additional 600 mL/ha Coptrel (1Copper) was applied across the whole site. 350 kg/ha (160N) and 210 kg/ha (100N) urea (total) were applied to selected plots at times and rate specified in table 1. The experiment was a randomised complete block design with four replicates of eight N treatments. The plots were 4 m wide x 20 m long. Data was statistically analysed with GENSTAT.

Table 1. Nitrogen application timing and rates (kg/ha) for treatments in 2005 experiment

Timing of Nitrogen application	Total rate N (kg/ha)

Control	Nil
All N at seeding for 4 t/ha wheat	100 N
Farmer N (1/3 seeding, 2/3 tillering)	100 N
All N at seeding for 6 t/ha wheat	160 N
Phenology N (1/3 seeding, 1st node and 2nd node)	160 N
Timed N (1/4 at seeding, 6 WAS, 12 WAS and 16 WAS	160 N
Tactical N (1/4 at seeding, 1st WL, 2nd WL and 3rd WL (or flag emergence)	160 N
Demand N (%N) (1/4 at seeding plus 3 times based on plant tissue analysis	160 N

Tillers and plants were counted fortnightly from 28 June from a permanent 1 metre row in each plot. Plant N (nitrate and ammonium in mg/kg and total N %) and soil water, Nitrate (mg/kg), ammonium (mg/kg) and total N (%) were determined before all N applications. To determine dry matter partitioning throughout the season for the different N timing and rate treatments, plant samples were collected at 4-week intervals commencing 5 July using a 0.25 m^2 quadrat (2 x 0.25m^2 at final harvest) from each plot and the number of plants and tillers counted. Ten plants were randomly subsampled from these samples and separated into leaf lamina, stems with leaf sheath, spikes. Leaf area index (LAI) was determined and all leaves, stems with leaf sheath, spikes and the rest of the bulk samples were dried to constant weight in a forced-draught oven at 70?C and weighed separately. To determine if waterlogging may affect N availability, free water in the root zone (waterlogging), was measured weekly throughout the growing season from 10 randomly placed ‘dip-wells’. Dip-wells showed waterlogging occurred at least 3 times during the season, only ever in four of the ten tubes, one tube showing water at the surface for three separate weeks during the season (10 June, 23 June and 19 August). Tactical N treatments were applied after the first waterlogging (10 June), third water logging (19 August) and at flag emergence (1 September). Grains per ear and grain weight (mg) were determined at hand harvest (7 December), and grain yield and quality (Hectolitre wt (kg/HL), moisture (%), protein (%) and screenings (%)), at final harvest (21 December).

Results and Discussion

The highest grain yields were achieved when 160 kg/ha N was split applied compared to applying 160 kg/ha N all at seeding. Within the 160 kg/ha N split applied treatments, Tactical N (6.4 t/ha) was not significantly greater than Timed or Phenology N treatments. Applying 160 kg/ha N ‘tactically’ ensured a significant 128% increase in grain yield over the Nil treatment, and a 14% increase over both the Farmer N (total of 100 N) and 160 kg/ha N applied at seeding treatments. Increasing N, regardless of method, increased grain yield through increased ears/m^2 at a similar grain weight (Table 2), with 440 to 480 ears/m^2 at harvest sustaining grain yields in excess of 6 t/ha. Although 160 kg/ha N at seeding had lower grain yield, it had more tillers, less ears/m^2, and similar grain weight to split N treatments. At 100 kg/ha N, the response to splitting N was similar to 160 kg/ha N, with the exception that at seeding N had more ears/m^2, but less grains/ear than the farmer N treatment. There is evidence to suggest that applying 160 kg/ha N at seeding will reduce biomass and grain weight more than applying the lower rate of 100 kg/ha N at seeding.

At both rates of N, split N applications resulted in higher yield and protein than up front N, regardless of method. Wheat grain protein for Timed N, Tactical N, Phenology N and Demand N produced significantly increased protein levels over the other treatments. As a result, Calingiri wheat grain quality was increased to that required for ASWN (noodle) segregation (9.5% - 11.5%). Returns were the highest when 160N was split applied, with tactical N increasing farm income by $239/ha over 160N at seeding, $169/ha over Farmer N and $484/ha over the Nil.

Table 2. Tiller numbers (Tillers/m^2) at z30 (end of tillering), biomass (t/ha) at Z65 (anthesis) and ear numbers (ears/m^2), grain yield (GY) and protein (%) at Z93 (maturity). Returns ($/ha) for Nitrogen treatments are also presented. a denotes values not significantly different.

Treatment	Tillers/m^2	Biomass (t/ha)	Ears/m^2	Grain wt. (mg)	Grains/ear	Protein (%)	GY (t/ha)	Return* ($/ha)
Nil	413	5.6	277	47a	33	9.0	2.8	0
100 N at seeding	603	11.4a	393	48a	33	8.4	5.0	+225
Farmer N	413	9.7a	353	46a	36a	9.0	5.6	+315
160 N at seeding	668a	10.4a	440a	45	33	8.8	5.6	+245
Phenology N	506	11a	438a	45	37a	10.2	6.1a	+436
Timed N	589	11.1a	453a	47a	37a	11.3a	6.2a	+452
Tactical N	765a	11a	479a	46a	41a	10.6	6.4a	+484
Demand N	612	10.5a	434a	45	41a	11.3a	5.9	+403
lsd ($p<0.05$)	*115*	*2.4*	*61*	*2*	*8*	*0.6*	*0.4*	

* Return ($/ha) = gross income relative to Nil minus cost of N ($500/tonne) and according to price received for grade ($135.9/tonne – feed; 162,40/tonne ASWN) and extra yield reached.

Critical values of wheat nutrient requirements for maximum wheat production were derived from Reuter and Robinson (1997) and compared to experimental treatments. Low plant N% for all treatments at some time during the growing season suggests that splitting N at high rates of 160 kg/ha was still insufficient to support maximum grain production efficiencies. Although not shown, leaf area index (LAI) values reached by all treatments, except the Nil, suggest that wheat growth rates were not limited by light.

Conclusion

Wheat yields in 2005 reached 6.4 t/ha with 'tactical N', and increased returns to $484/ha over the Nil and $169/ha over the Farmer N. Noodle protein (9.5%) was met only when 160 kg N/ha was split applied.

Wheat yields were in excess of 6 t/ha with split N treatments, however, the maximum grain production efficiency of 10.7 kg/ha/mm rainfall was well below the target production efficiency; 16.3 kg/ha/mm rainfall. Nitrogen rates, plant number and tiller retention may have limited wheat production. Alternatively, wheat production efficiencies may need to be adjusted for the zone, which varies with other factors including frost and rainfall distribution.

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