Waterlogging and Nitrogen Management for Wheat in High Rainfall Cropping Areas of Southern Western Australia.

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Abstract

Timing nitrogen (N) according to soil and weather conditions can give a 60% lift to wheat yields. In 2003, waterlogging reduced N uptake in Calingiri wheat during crop growth at Cranbrook. Our trial results suggest that timing of N application was critical and should be more dependent upon rainfall and waterlogging. These results need confirmation at other sites and seasons but the probability of waterlogging and the expectation of specific grain quality and final grain yield will all influence future strategies. It is likely that some N will be required to ensure adequate plant numbers and tillers. To avoid substantial losses of N and profits, our results suggest that subsequent applications should be determined at least in part, according to major rainfall and waterlogging to replace N lost and to maximise final wheat grain yield. For maximum crop returns, farmers are urged to determine the waterlogging probability of their cropping land by using dipwells. Further confirmation of this strategy will be sought in 2004 with large scale trials throughout the high rainfall, cropping zone.

Media summary

Increased soil nutrition (particularly N) and timing N application according to rainfall and waterlogging is a major key to increased grain yield and quality in the high rainfall, cropping zone of south Western Australia

Key Words

Waterlogging, nutrition, nitrogen timing, grain yield and quality, cereal

Introduction

The high rainfall, cropping zone of south Western Australia has an annual rainfall between 400–800mm and a 6-8 month growing season between April and October. The farmers in the zone have an advantage over others in more traditional cropping areas as they have the potential for higher crop yields because of the higher rainfall. Unfortunately, average grain yields of 2.7 t/ha and 2.4 t/ha for wheat and barley, respectively, is well below potential yields of 6 – 10 t/ha (1,2). Research conducted during 2001 and 2002 as part of this project showed that nutrition is a major limitation to crop yields in the area. Grain yield increases of up to 55% were reached, particularly with additional nitrogen (N) and phosphorus (P) (3,4). At the same time, research by CSIRO revealed that transient waterlogging might also be a major constraint to cereal production in the zone, occurring in 50% of all years (5).

Major effects of waterlogging include the loss or leaching of nutrients (particularly N) out of the crop root zone, thus plant uptake of N, potential grain yield, quality and farmer profit are reduced. If N was supplied after large amounts of rain to replace the N lost during the resultant waterlogging, it is possible that crops will compensate by being driven through the waterlogging effect and increase grain yield and quality. The aim of this trial is to investigate how often waterlogging occurs on normal cropping land in the high rainfall cropping zone, and to determine the most economical N application under high rainfall and waterlogging situations to maximise cereal grain yield, quality, nutrient use and final economic return.

Materials and Methods

One small plot trial (1.45 m x 30 m) was sown at Cranbrook with a growing season rainfall in 2003 (Apr – Oct) of 464 mm. The site was selected, as it was known to be prone to waterlogging. Soil tests in the top 10 cm were pH ($CaCl_2$) 4.5, 2.1% organic carbon (OC), 42 ppm total nitrogen, 33 ppm phosphorus, 38 ppm potassium(K), 12 ppm sulphur , 0.2 ppm copper , 0.4 ppm zinc.

Calingiri wheat, following a canola crop in 2002, was sown on the 7 June 2003 at 90 kg/ha using a cone seeder fitted with knifepoints and presswheels at 18 cm spacing. 100 kg/ha muriate of potash (50 kg K/ha) was top dressed before seeding and 145 kg/ha triple superphosphate (30 kg P/ha) mid row banded at seeding. A total of 320 kg/ha urea (147 kg N/ha) was applied to selected plots at specified times and rates indicated in table 1. An additional 107 kg/ha urea (49 kg N/ha) was applied to the back half of treatments four and five on 25 September. Optimum management was practised during the growing season to ensure only water and nitrogen could limit crop yield and quality. Two dipwells were inserted in each plot immediately post sowing. Rainfall, yield and quality components, plant tissue analysis immediately before N application, and free water in the root zone were measured.

Results and Discussion

Rainfall and free water in root zone

Daily rainfall (mm) and weekly depth to water below the soil surface (cm) show that water in the root zone at Cranbrook in 2003 increased most after significant rainfall, and was considered waterlogged (depth to water less than 30 cm below the soil surface) four times (Figure 1.). It was after the first waterlogging that the first split N treatment was applied (27 August 2003), and after the third waterlogging that the additional N was added to the back half of treatments four and five (25th September 2003). 112 mm of rainfall fell before seeding, and a total of 586mm fell throughout the year.

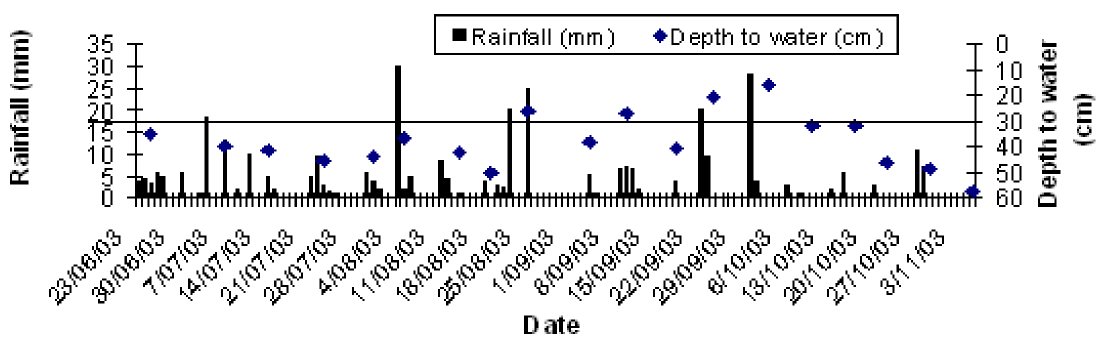

Figure 1. Average rainfall (mm) and depth to water (cm) at Cranbrook in 2003.

Plant analysis

N (%) in the whole plant was adequate for each treatment prior to 1st node N application (23 July). However, prior to successive applications of N, N (%) was low for all treatments except where N was applied after waterlogging (sampled 14 August, 24 September and 22 October). Magnesium and sulphur were at very low levels in the plant at all sampling times.

Grain components, quality and yield

Grain yield (t/ha) was increased by 60% when N was split applied at seeding (33%) and again after the first waterlogging event (66%) compared to when it was all applied at seeding, which was no different to yields when no nitrogen was added (Table 1.). The major response was due to the application of N after waterlogging as yields weren't significantly different to when N was split evenly between seeding, 1st node and after the waterlogging event (treatment 5).

The increase in grain yield (t/ha) was a result of an increase in the number of tillers/m^2 and dry matter production, but not seed weight (mg), which was reduced when nitrogen was split at seeding and again after waterlogging (Table 1). There were no significant differences between treatments with regards to seed number/head, plants established and plants remaining, with an average of 35 seeds/head, 173 plants/m^2 established on 4th July and 107 plants/m^2 remaining on 22nd October. The Calingiri wheat did not achieve noodle grade (9.5 – 11.5% protein) for any of the treatments except when N was applied as the split application at seeding, 1st node and after waterlogging, and when extra N was applied later (Table 1). Screenings were below 10% for all treatments.

Table 1. N timing on tillers/m^2, seed wt (mg), dry matter (t/ha), screenings (%), protein (%) and grain yield (t/ha) on Calingiri wheat at Cranbrook, 2003. 33% N = 49kg N/ha, 66% N = 97kg N/ha

No	Treatment	Tillers/m^2	Seed wt (mg)	Dry matter (t/ha)	Scrns (%)	Protein (%)	Grain yield (t/ha)
1	Nil	239	37	4.5	2.7	9.1	2.2
2	All N at seeding (160 kg N/ha)	228	36	4	2.3	9.1	2.2
3	33% N at seeding, rest at 1st node	272	38	5.3	2.7	9.1	2.7
4	33% N at seeding, rest after waterlogging	344	34	7.5	4.7 (*5.5)	9.3 *10.4)	3.5 (*3.8)
5	33% N at seeding, 1st node and after waterlogging	426	35	8.9	4.3 (*5.8)	9.5 (*10.7)	3.5 (*4.0)
	Lsd (p<0.05)	34	3	1.0	2.1	0.8	0.6

(*) additional 49 kg N/ha applied to back half of treatment on 25 September 2003.

Conclusion

Waterlogging occurs in 50% of years in the high rainfall, cropping zone. Results of this trial show that it could be a potential major contributor to substantial losses of N and profits. In the 2003 season at Cranbrook, waterlogging occurred four times during the growing season, reducing N uptake during crop growth by loss or leaching out of the root zone, and accounting for a reduced final grain yield of up to 60%. Timing of N applications was critical and appears related to rainfall events and subsequent waterlogging. A possible strategy for farmers could be to apply some N at seeding to get the crop started and to ensure adequate tiller numbers. Subsequent applications could be made with regards to rainfall and waterlogging probability, with major rainfall and waterlogging requiring more N. Further confirmation of this strategy will be sought in future at other sites and in other seasons.

This research will be important for farmers in the future as they will be able to make better crop nutrition management decisions when they know what is happening to their fertilisers. Farmers who know where the water table is under the crop can adjust N timing, and possibly rate, to drive the crop through the waterlogging effect and increase cereal yield and quality. To work out waterlogging probability, farmers can insert dip wells into the soil onto the lower lying cropping land, enabling them to measure depth to water after major rainfall. This tactic will allow farmers to make informed N decisions and as a result, increase crop yields by at least 1 t/ha, increasing returns and reducing nutrient losses.

References

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