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Effect of Post-Emergent Applied Nitrogen on Grain Yield and its Components and Malting Quality of Malting Barley.

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Introduction

While the effects of post-sowing N application have been well established in wheat (Doyle and Shapland 1992, McDonald 1989), there are limited data available for barley, especially for northern New South Wales and Queensland. In addition, there seems to be a perception among some farmers influenced by budgetary constraints, that malting barley can be grown successfully with low nitrogen (N) supply. If post-emergent application of N to barley gives adequate responses in malting quality as well as grain yield, then such a practice would have similar advantages to those for wheat, including spreading production costs thus facilitating cash flow (Doyle and Shapland 1992). Post- sowing N application also offers growers greater flexibility in risk management with respect to loss of malting quality due to a dry period (McDonald 1989).

Materials and Methods.

Two commercial barley crops of cv. Grimmett (a malting variety) growing under low N conditions were chosen for this study at two sites near Gunnedah, NSW. The soil at both sites is a red-brown clay-loam overlying red clay. The crops were sown at 50 kg/ha at 22 cm rowspacing with 85 kg/ha of MAP (12:10:0) fertiliser on April 23, 2000 (site 1) and June 3, 2000 (site 2). Crop density at site 2 was 91 plants/m^2, and a similar value would be expected at site 1. A soil sampling closely adjoining site 1 found 38 kg N/ha of nitrate N in the 0-90 cm soil zone at sowing. Site 2 was estimated to have only 9 kg N/ha of nitrate in the same zone on July 18. The soil samples were air dried and analysed by the KCl-nitrate extraction method. The field experiments were marked out of the crops with a plot size of 16.0 x 1.5 m and four replications. The plots were treated at early jointing (Zadoks 32) at site 1 or early tillering stage (Z14,21) at site 2 on July 4. The N treatments comprised ammonium nitrate (Nitram ®-designated A25, A50, A75, A100 at 0, 25, 50, 75, and 100 kg N/ha respectively and urea at 50 and 100 kg N/ha designated U50 and U100 respectively) spread by hand.

Conditions were favourable for crop growth until mid September, and about 21 mm rain fell 7-8 days after topdressing, with another similar fall on July 26, and about 43 mm of rain in August until September 2. A hot, dry finish began on September 15 and continued until October10 (maximum temperatures 25^0 C to 34^0 C, pan evaporation usually 5 to 8 mm/day, total rainfall Sept. 3 -Oct.10: 3 mm; data courtesy Department of Land and Water Research Station, Curlewis, about 10 km distant).

Three crop samples each comprising 0.345 m^2 were taken from each plot treated with Nitram only at site 2 for yield analyses on November 2. Both sites were harvested with a plot header on November 8. Grain sub-samples were analysed for protein by the Kjeldahl method, and data on 1000 kernel weight, retention with a 2.5 mm screen, and screening through a 2.2 mm sieve, were also recorded.

Results and Discussion

Marked growth responses were observed some three weeks after topdressing at site1, while the responses at site 2 were dramatic. Heading (Z50-59) occurred about August 26 at site1 and September 11 at site 2. The plots did not show any signs of stress or haying-off on October 3 towards the end of the hot, dry period in late September and early October. Site 1 reached physiological maturity about October 8 and site 2 on October 19.

Table 1. Grain yield, malting quality and N uptake data.

Note: soil mineralisations of 9 units for site 1 and 4 units for site 2 were not allowed for in soil total N.

Treatment	**Total N in soil***	**Grain Yield**	**Grain Protein**	**1000 KW (air dry)**	**Retention by 2.5 mm**	**Screenings by 2.2 mm**	**N Uptake in Grain**	**Relative N Uptake**
	kgN/ha	t/ha	% d.b.	g	%	%	kgN/ha	%
Site 1.								
0	48	1.92	8.93	37.70	92.08	1.30	27.4	57
A25	73	2.42	9.23	37.16	86.08	2.53	35.7	49
A50	98	2.51	9.78	35.72	80.15	3.75	39.3	40
A75	123	2.66	11.22	33.76	70.43	7.25	47.8	39
A100	148	2.82	12.20	32.01	58.60	12.65	55.0	37

U50	98	2.51	10.08	35.40	79.28	4.52	40.5	41
U100	148	2.78	11.98	33.01	61.33	11.20	53.3	36
s.e. of diff.		0.18	0.28	0.51	2.12	0.58		
Site 2.								
0	9	1.03	8.40	33.89	86.78	1.70	13.8	73
A25	34	1.76	8.20	34.69	86.80	1.88	23.1	53
A50	59	2.22	9.35	35.88	84.40	2.50	33.2	48
A75	84	2.51	10.23	34.67	78.00	4.20	41.1	44
A100	109	2.72	11.33	34.53	79.53	4.10	49.3	41
U50	59	2.24	9.20	36.53	84.93	2.63	33.0	48
U100	109	2.76	10.65	35.06	75.80	7.03	47.0	39
s.e.of diff.		0.14	0.36	0.81	3.40	1.09		

Table 2. Yield Data , Analysis for Site 2.

Treatment	**Weight of Tops** g/m2	**Weight of Grain** g/m2	**Number of Grains** /m2	**Harvest Index**
0	346	145	194	0.42
A25	654	249	237	0.38
A50	847	315	267	0.37
A75	719	310	276	0.43
A100	925	369	277	0.40
s.e.of diff.	66	25	14	not sig.

Grain yield responses of 26 to 45 percent to the nitrogen topdressing were obtained at site 1, and 71 to 266 percent at site 2, with no significant differences between the different fertilisers. The response patterns are typical curves, with yield increases of 31 percent and 119 percent of the control yield obtained by the 50 unit Nitram treatment at site 1 and site 2 respectively. The greater yield response at site 2 is attributable mainly to the initial very low soil N level as well as the crop being at an earlier growth stage at treatment than site 1. Doyle and Kingston (unpublished) obtained similar response patterns in field experiments at some 8 sites with N applied at sowing in several varieties including Grimmett over 4 years in northern New South Wales. They also found larger responses when the initial soil N was low. Doyle and Shapland (1992) reported that N applications made to wheat at a later growth stage result in lower yield responses.

Grain protein responses were also very significant. Higher levels were obtained at site1 since the nitrogen was applied at a later growth stage, as found in wheat by Strong (1986) and Doyle and Shapland (1992), and the initial soil N level was higher. Similar protein response patterns were found by Doyle and Kingston (unpublished) in the work mentioned above, with a greater response obtained when the initial soil N level was low, and by Fettell (unpublished) from work done in barley and wheat at Condobolin, New South Wales. Protein levels at site1 were below malting minimum of 10.0 percent for the nil and 25 unit treatments, the 50 unit treatments were marginal at around 10 percent, and the 100 unit treatments resulted in borderline excessive protein contents of about 12 percent.

At site 2, protein contents adequate for malting were not reached until the 75 unit treatment at 10.2 percent, while the 100 unit treatment with Nitram gave only 11.3 percent protein. This effect would be due to the very low initial soil N contents, as well as the treatments being applied at an earlier growth stage as reported by Doyle and Shapland (1992) Strong (1986) and McDonald (1989) in wheat, and in barley, Fettell (unpublished) and Mason and Rowland (1995). The 100 unit treatment with urea gave a significantly lower protein level of 10.7 percent, compared with 11.3 percent for the Nitram treatment at 100 units, possibly due to differing uptake patterns; the yields were the same for both, however. At site 2, proteins suitable for malting occurred with treatments 75 and 100 units.

An interaction between the two sites was found in 1000 kernel weight (1000KW), which fell 12 percent at site1 in response to N, while at site 2 it rose significantly by 3.5 percent. This effect may be attributed to the soil N level being low at site1, but very low at site 2, and also that the N was applied at a later growth stage at site 1 compared with site 2. Linked to this relationship is grain protein; in wheat, Doyle and Shapland (1992) found N applied after tillering stage had less effect on grain yield, and more on grain protein. and the initial soil N level was higher,

Retention (R) and screenings (S) relate directly to grain size. At site 2 however, R fell and S rose with increasing soil N levels, in spite of the rise in 1000KW. A reason for this is unclear. Similarly, R decreased and S rose at site 1, as would be expected, in relation to the fall in 1000KW. This probably occurred through the plants growing more grains on later tillers in response to N, then not filling them so well, especially with the effects of the hot, dry September (N.. Fettell, pers. com.).

Grain uptake of N was estimated from grain yield and protein data and showed that at site 1, from 57 to 36 percent of total soil N was taken up by the grain, with the relative uptake dropping with higher N status. At site 2, however, the uptakes were higher relative to N status at 73 to 39 percent, but lower per ha, reflecting the lower N status and the earlier application. There was no difference in uptake at either site between Nitram and urea.

The results from the yield analyses show substantial responses to N for biomass yield at harvest as well as grain yield. Grain number per m^2 also increased greatly while 1000KW increased by barely significant margins, suggesting that grain number was the chief component involved in grain yield response, as reported by Mason and Rowland (1995), and Strong (1986) in wheat. Harvest index data for site 2 varied from 0.37 to 0.43 with no significant differences. These indicate that the ratio of grain growth to growth of the total biomass was constant in relation to N treatment, and there was no haying-off. McDonald (1989) states that the greatest risk of haying-off in wheat is when moisture stress occurs at the pre-anthesis stage.

The implication from this and similar work for barley growers is that N may be effectively applied post-sowing, but it should be done during tillering stage to maximise the yield response without raising protein content beyond the malt upper limit as indicated in wheat by Doyle and Shapland (1992) and McDonald (1989), and in barley by Fettell (unpublished), and Mason and Rowland (1995).

While it is apparent that with an increase in N application barley protein rises and grain size tends to fall, this work suggests that at a yield potential level of 2.7 to 3.0 t/ha, total soil N levels of 100 to 120 units should be aimed at by growers to optimise grain yield and protein within malting specifications. This confirms the report by Edwards and Herridge (1998).

This range of soil N is suggested as an appropriate target for achieving the best balance between yield and quality attributes.

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References.

1. Doyle, A. D., and R. A. Shapland, (1991). Effect of split nitrogen applications on the yield and protein content of dryland wheat in northern New South Wales. *Aust. J. Exp. Agric*, **31**, 85-92.
2. Edwards, J. and D. Herridge, editors, (1998). Nitrogen budgeting for winter cereals. Growers Workbook. (NSW Agriculture).
3. McDonald, G. K. (1989). The contribution of nitrogen fertiliser to the nitrogen nutrition of rainfed wheat crops in Australia: a review. *Aust. J. Exp. Agric.*, 29,455-481.
4. Mason, M. and I. Rowland (1995). Nitrogen and Rotation. In *The Barley Book*, W. A. Dept. of Agric.Bull. No. 4300, 42-48.
5. Strong, W.M. (1986). Effects of nitrogen application before sowing, compared with effects of split applications before and after sowing, for irrigated wheat on the Darling Downs. *Aust. J. Exp.Agric.* **26**, 210-7.

6. Zadoks, J. C., *et al* (1974). A decimal code for the growth stage of cereals. *Weed Research* **14**, 415-21.