The effect of nitrogen on the yield and selected aspects of quality of two varieties of malting barley grown under contrasting conditions of water availability

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Summary. The effect of N on the yield, individual grain weight, proportion of plump grain (greater than 2.5 mm) and grain protein concentration of two varieties of barley was studied over four years at several sites in South-east Queensland with varying water and soil N supply conditions. Application of N raised yield on low to moderate N status sites. On some sites it was necessary to raise grain protein concentration to the lower end of the range acceptable for malting purposes. Grain protein concentration remained acceptable even at N rates producing 90% of maximum yield. The effect of N on individual grain weight depended on soil N status and cultural conditions but individual grain weight was reduced consistently by high N rates. The proportion of plump grain was usually <75% even in the control treatments.

Introduction

Barley is grown for both malting and stockfeed purposes in South-eastern Queensland. To meet malting quality standards, barley grain must have protein concentration in the range 8.5 - 12.0% on a dry weight basis and the grain should be large. Barley production in Queensland relies on the use of nitrogenous fertiliser. Long-term production of non-legume crops has depleted the initially moderate to high soil N levels. Little use is made of either ley pastures or grain legumes to improve N levels. There is a widely held belief that barley should be grown on less fertile sites than are used for wheat since premium payments are made for high protein wheat. Birch and Long (I) found that moderate rates of nitrogen application lowered or maintained grain protein concentration in some varieties of barley and Strong (2) found the same in wheat. This paper reports the effect of N application on grain yield, individual grain weight. proportion of plump grain and grain protein concentration of two varieties of barley - Grimmett and Tallon - used for malting purposes.

Materials and Methods

Trials were located at Gatton and at various locations on the eastern Darling Downs between 1989 and 1992. A wide range of water supply conditions and soil N status was included in the experimental sites. At each site, the concentrations of nitrate and ammonium N in the soil in 0-10, 10-30, 30-60, 60-100 cm depth segments were determined prior to fertiliser application. From these data and soil bulk density the amount of nitrate and ammonium N to I m was calculated.

The varieties and sites used were Grimmett at Gatton 1989-1992. Warwick 1989 - 1990 and Acland 1990, and Tallon at Allora, Brookstead, Jondaryan, Tannymorel - hillside site, Tannymorel - alluvial site and Gatton in 1992. Nitrogen rates (kg/ha) used were 0, 40, 80, 160 and 320 (Gatton 1989, Warwick 1989), 0, 45, 90, 130 and 195 (Gatton 1990) and 0, 40, 80, 120 and 160 (all other sites). Experimental designs used were randomised complete block (where one variety was grown) and split plot (where more than one variety was grown) with varieties as the main plots and nitrogen rate the sub-plots. Weed, disease and insect incidence were monitored and chemically controlled as necessary.

Four water regimes were used at Gatton in 1989 - irrigated (I); irrigated pre-anthesis, dryland thereafter (IPA); dryland pre-anthesis, irrigated thereafter (DPA); and dry land (D). Other trials were conducted under either irrigated (I) or dryland (D) conditions. Irrigation treatments were scheduled from pan evaporation and crop cover factors to limit accumulated water deficit to 40 mm (80 mm in 1991). Total irrigation applications at Gatton were: I - 305 mm , IPA - 150 mm, and DPA - 210 mm (1989); I - 190 mm (1990), 345 mm (1991) and 240 mm (1992). Grain yield was determined from quadrat samples taken at maturity and sub-samples from the grain were used to determine individual grain weight and grain protein

concentration. The percentage of plump grain in Grimmett was determined from mean individual grain weight using the regression:

% of plump grain = -199.9 + 6.82*mean grain weight (r^2 = 0.95) (H. Cox. pers. comm., 1993)

Grain protein concentration was calculated from grain nitrogen concentration determined by the standard Kjeldahl technique (assuming 1%N = 6.25% protein). Water supply to the crop was estimated from efficiency of storage (25%) of fallow rainfall, soil water holding capacity to I m (or if soil depth < 1 m, the limit of effective rooting depth) and in-crop rainfall to 2 weeks before maturity.

Results and discussion

Table I shows the amount (kg/ha) of pre-treatment nitrate and ammonium N to lm at the experimental sites, estimates of water use (mm) by the crops, control and maximum grain yields (GY) for Grimmett (G) and Tallon (T) for dryland production under two categories of estimated water use and under irrigated conditions. The N rate for 90% of maximum yield (0.9*Ymax) is also shown.

Table I. Variety, pretreatment nitrate (NO3-N) and ammonium (NH4-N), estimated water use (EW), control and maximum (Ymax) grain yields at 12% water content and N rate for 0.9*Ymax at various locations in four years.

Year	Site	Variety	NO_3-N (kg/ha)	NH_4-N (kg/ha)	EW (mm)	GY (t/ha)		Signif of N applic	N rate 0.9*Ymax
						Control	Ymax		
Dry land trials: Low water availability sites (<150 mm)									
1990	Acland	G	10	64	125	1.77	3.59	*	100
1991	Gatton	G	20	12	140	2.69	3.23	n.s.	0
1992	Allora	T	11	23	92	1.31	2.03	*	40
Dry land trials: Medium water availability sites (>151 mm)									
1989	Gatton	G	66	86	172	4.80	5.26	n.s.	0
1989	Warwick	G	37	47	180	1.68	3.03	*	120
1990	Gatton	G	19	44	240	4.71	6.90	*	65
1990	Warwick	G	48	36	281	2.56	3.07	*	45
1992	Gatton	G	66	17	155	5.48	5.72	n.s.	0
		T				5.40	6.28	n.s.	0
1992	Brookstd	T	125	8	239	4.04	4.04	n.s.	0
1992	Jond'n	T	70	27	252	4.46	4.66	n.s.	0
1992	T'ml(hill)	T	30	17	239	3.19	5.18	*	110
1992	T'ml(alv)	T	71	23	239	3.31	3.92	n.s.	0
Irrigated sites									
1989	Gatton(I)	G	66	86	477	5.34	6.65	n.s.	0
	(IPA)	G			422	5.82	6.64	n.s.	0
	(DPA)	G			382	5.22	6.36	*	35
1990	Gatton	G	19	44	430	3.79	7.69	*	80
1991	Gatton	G	20	12	485	6.63	6.63	*	0
1992	Gatton	G	66	17	395	8.73	8.73	*	140
		T				8.79	8.79	*	100

* $P < 0.05$; n.s.- no significant effect

Sites that showed little or no effect of N on grain yield were Gatton (1989 - I and IPA and 1991 - I and D and 1992 - D), Brookstead, Jondaryan and Tannymorel (alluvial site). The lack of grain yield response to

N fertiliser at Gatton under full irrigation and pre-anthesis irrigation in 1989 can be attributed to the relatively high mineral N content of the soil and in 1991 (I & D) it appears that the crop may have obtained N from below the depth (I m) of soil sampling for N analysis. Other sites where the application of N failed to increase yield were all dryland sites and also had relatively high mineral N content (Table 1) ranging from 66 - 128 kg/ha nitrate N, 8 to 84 kg/ha ammonium N and total mineral N content to 1 m of 83 kg/ha or more. Dryland sites where response to N application occurred viz. Warwick (1989 and 1990), Acland, Allora and Tannymorel (hillside site) had 10 to 48 kg/ha of nitrate N, 13 to 64 kg/ha of ammonium N and total mineral N content to I m of 34 to 84 kg/ha. Responses under irrigation occurred up to 66 kg nitrate N, 86 kg ammonium N and total mineral N of 152 kg/ha e.g. Gatton, 1989 DPA.

Nitrogen application at low to moderate rates (up to 90 kg/ha) did not reduce individual grain weight (Table 2) at sites where grain yield responded to N (Table I). At sites where yield was unaffected by N application and at rates above those shown for maximum grain weight in Table 2 grain weight declined except at Brookstead and Tannymorel (hillside site). Under irrigated conditions, higher rates of N (up to 160 kg/ha under low N conditions) could be applied without reducing grain weight. Nevertheless, for Grimmett the proportion of plump grain was generally low and unacceptable regardless of N rate except in some irrigated trials at Gatton.

Table 2. Control individual grain weight (mg/grain), control grain protein concentration (%, dry weight basis) and N rates (kg/ha) for maximum individual grain weight, >75% plump grain and for >8.5% and <12% grain protein (dry weight basis) for two barley varieties.

Year	Site	Variety	Control grain weight	Signif of N applic	N rate for max grain weight	N rate for >75% plump grain	Control grain protein %	Signif of N applic	N rate for >8.5% protein	N rate for <12% protein
			Dry land trials: Low water availability sites (<150 mm)							
1990	Acland	G	31.9	*	0-8	-	8.0	*	>45	<100
1991	Gatton	G	39.3	*	0	-	13.8	*	all	< 50
1992	Allora	T	34.2	n.s.	0	n.a.	7.3	*	>30	< 80
			Dry land trials: Medium water availability sites (>151 mm)							
1989	Gatton	G	38.9	*	0-40	-	10.8	*	all	< 25
1989	Warwick	G	38.3	n.s.	0	-	10.2	*	all	< 55
1990	Gatton	G	38.7	*	0-90	-	8.3	*	>10	<145
1990	Warwick	G	33.9	n.s.	0	-	9.2	*	all	< 90
1992	Gatton	G	39.7	*	0	n.a	10.3	*	all	< 20
		T	34.7	*	0	n.a	10.5	*	all	< 30
1992	Brookstd	T	29.6	n.s.	0	n.a	15.4	*	all	nil
1992	Jond'n	T	34.9	*	0	n.a	10.1	*	all	< 30
1992	T'ml (hill)	T	35.9	n.s.	0	n.a	7.6	*	>40	<135
1992	T'ml (alv)	T	35.1	*	0	n.a	8.6	*	all	< 50
			Irrigated sites							
1989	Gatton(I)	G	38.4	*	0-80	-	10.7	*	all	< 15
	(IPA)	G	41.1	*	0-40	<40	9.9	*	all	< 30
	(DPA)	G	40.0	*	40-80	40-160	10.4	*	all	< 40
1990	Gatton	G	38.7	*	0-90	-	7.4	*	>60	<170
1991	Gatton	G	41.3	*	0-40	-	9.5	*	all	< 45
1992	Gatton	G	39.2	n.s.	0	-	8.8	*	all	< 70
		T	38.1	n.s.	0	n.a.	9.0	*	all	<125

n.a. - not available
* P < 0.0, n.s - no significant effect

At several sites (Gatton, 1990, irrigated and dry land, Acland, 1990, and Allora, 1992) protein concentrations were below 8.5%, and thus below the acceptable range for malting purposes were obtained at low rates of N. Grain protein concentration increased in response to N application at all sites. though at two (Gatton, 1990 - I and D and Acland), 45 or 40 kg/ha respectively failed to raise protein concentration, findings that are consistent with those of Birch and Long in barley (I) and Strong in wheat (2). At these sites and at Warwick in 1989 and 1990, protein concentration did not exceed that acceptable for malting even at rates that produced 90% of maximum yield (Tables I and 2). With the exception of one site - Brookstead 1992 - low to moderate rates of N (up to 50 kg/ha) produced grain with acceptable protein concentration though grain yield did not increase. Individual grain size was generally marginal as in most cases less than 75% of grain were plump (a minimum individual grain weight of 40.3 mg is needed) in Grimmett (Table 2).

This project has produced data that will be of assistance to farmers and advisers in decision making on nitrogen fertiliser use. Nitrogen fertiliser application is necessary on low to very low N status soils to raise yield and also protein content to the lower end of the range acceptable for malting purposes. On soil of moderate N status, application of moderate N rates is unlikely to produce grain of unacceptably high protein concentration (except under severe water stress) though individual grain size is likely to be reduced.

References

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