THE EFFECTS OF NITROGEN APPLICATION ON THE YIELD AND QUALITY OF BOUNTY WINTER WHEAT

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ABSTRACT

An investigation of the effects of nitrogen on yield, protein levels and MDD bake scores on Bounty winter wheat was carried out on three sites in Canterbury over 2 years.

The N treatments were no – N (control), 100 and 200 kg N/ha applied at early tillering (GS 2) or at late stem elongation (GS 9) in the form of urea.

Grain yield responses were recorded from the early N application at low N status sites while no yield increase was recorded at the high site.

All sites recorded highly significant increases in protein levels and MDD bake scores with the GS 9 applications showing the greatest increase. This increase in bake score lifted the quality of the wheat from undergrade to Category B at site 1, undergrade to Category A at site 2 and Category B to Category A at site 3 from the later application of N.

Correlations taken between protein levels and MDD bake scores were highly significant in all trials.

In the National List Trials from 1980/81 to 1983/84 Bounty showed significant correlations between protein and MDD bake scores while over the same period a non-significant correlation was recorded for Rongotea. These results suggest that protein is more important in determining the MDD bake score in Bounty than in Rongotea.

Additional Key Words: Grain protein, MDD bake score, time of N application, National List trials, kernel weight

INTRODUCTION

The introduction of overseas cultivars into New Zealand has accelerated over the past 10-15 years since the passing of the Plant Varieties Act in 1973. Bounty, one such introduced cultivar, was bred by the Plant Breeding Institute in the U.K. as a high yielding bread wheat where it quickly developed to become one of the major bread wheats in the late 1970's.

In New Zealand this variety immediately became one of the highest yielding wheats in the National List Trials significantly out-yielding the then standard wheats Rongotea and Kopara.

Bounty, a semi-dwarf, true winter wheat, was later maturing and showed better resistance to Stripe Rust and Mildew than both Rongotea and Kopara. However numerous trials showed that its MDD bake score was more variable than that of standard cultivars.

Since Bounty is a variety that responds to high N inputs in the U.K. it was felt that an investigation should be set up to see what effect N applications would have on its yield and quality especially to try to reduce its MDD bake score variability and to maintain it within category A. (MDD 15 and above). If N affected these significantly it would then be essential for farmers to consider the use of strategic N as a management tool when growing Bounty.

To evaluate this, three rates of N were chosen (0, 100 and 200 kg N/ha) and applied at GS 2 or at GS 9.

MATERIALS AND METHODS

Sites

Three sites in South Canterbury (Table 1) were chosen to provide a range of potentially different soil N status resulting from paddock history. Sites 1 and 3 had been continuously cultivated for 5 years with the previous crop being ryegrass seed. Both sites were considered to have a low soil N status. Site 2 was previously 5 years in pasture and was therefore considered to be high in soil N. All sites were flat. Adequate rainfall occurred with particularly good falls over the spring-summer period which precluded the use of irrigation.

TABLE 1: Trial site details.

Trial site	1	2	3
Location	Timaru	Rangitata	Timaru
Soil type	Waimak.s.l	Waimak.sd.l	Waimak.s.l
Date sown	7.5.82	19.5.82	7.7.83
Date harvested	15.2.83	22.2.83	27.2.84
Rainfall over growing period	321 mm	320 mm	454 mm
Basal fertilizer Dressing	125 kg/ha Superphosphate	Nil	125 kg/ha Superphosphate

Experimental

The seed of the winter wheat cultivar Bounty was treated with Vitaflo 200 and sown at a rate equivalent to 100 kg/ha. A 3 x 3 factorial four replicate design was used. All trials were drilled with a ten coulter Oyjord plot drill with each plot being 1.2 m wide x 12.5 m long.

Treatments consisted of 0, 100, 200 kg N/ha applied at early tillering (Growth Stage 2) or at late stem elongation (Growth Stage 9). The N was broadcast on each plot by hand in the form of urea and between each treatment a buffer plot of Bounty was placed to eliminate the possibility of lateral movement of N effecting neighbouring treatments.

Weeds were controlled by various herbicides. At sites 1 and 3, no disease control measures were employed, (moderate levels of *Septora nodorum* were recorded) while site 2 had a full disease control programme using Bayleton.

All trials established well and made satisfactory growth to harvest when the total plot was harvested with a small plot header.

Grain samples were taken and adjusted to 14% moisture, then sent to the Wheat Research Institute for N.I.R. protein determination and 125 g MDD bake test.

An analysis of variance was carried out on the data and an F test applied. Where this test was significant an LSD test was carried out at the 5% and 1% level.

RESULTS

Yield responses to Nitrogen

Analysis of grain yield data showed significant responses at site 1 and 3 to increasing rates of nitrogen applied at GS 2 while no responses were recorded to the GS 9 applications (Table 2).

TABLE 2: Grain yield responses to N application at GS 2 and GS 9 at each trial site (t/ha).

Site	1	2	3
GS 2			
0 kg N/ha	8.26	8.38	6.76
100 kg N/ha	9.00	8.70	7.48
200 kg N/ha	9.38	8.54	7.39
Significance	*	NS	*
GS 9			
0 kg N/ha	8.64	8.14	6.87
100 kg N/ha	8.92	8.89	7.26
200 kg N/ha	9.09	8.59	7.48
Significance	NS	NS	NS
LSD (5%)	0.78	1.23	0.59
Interaction	NS	NS	NS
CV%	10	17	10

Maximum yield increase occurred at Site 1 with the 200 kg N/ha yielding 13% or 1.12 t/ha above the control (no N). At Site 3 the maximum response occurred with the 100 kg N/ha and equated to an 11% or .72 t/ha increase. There were no significant interactions.

Kernel weight

Kernel weight showed significant reductions from the N applied at GS 2 and this was consistent over all three sites. With the late application, kernel weight increased at the low N sites only, with the largest increase coming from site 3 (Table 3).

No increase in kernel weight was recorded at the high N potential site from the late application of N.

Protein responses to N

The increases in protein levels to applied N was highly significant at both application stages and all sites. The greatest response occurred with the GS 9 application (Table 4).

TABLE 3: Thousand grain weight responses to Nitrogen (g/1000 seeds).

Site	1	2	3
GS 2			
0 kg N/ha	55.25	49.73	49.83
100 kg N/ha	53.58	46.31	49.37
200 kg N/ha	51.33	44.92	46.31
Significance	**	**	**
GS 9			
0 kg N/ha	52.00	46.50	45.31
100 kg N/ha	53.22	47.30	49.23
200 kg N/ha	54.85	47.16	50.97
Significance	**	NS	**
LSD (5%)	1.70	2.60	2.03
Interaction	NS	NS	NS
CV%	4	7	5

TABLE 4: Protein responses to nitrogen application at individual trial sites, (% protein).

Site	1	2	3
GS 2			
0 kg N/ha	8.10	8.42	8.94
100 kg N/ha	8.54	9.00	9.10
200 kg N/ha	9.54	9.66	9.64
Significance	**	**	**
GS 9			
0 kg N/ha	7.80	8.01	7.65
100 kg N/ha	8.80	9.25	9.71
200 kg N/ha	9.57	9.82	10.31
Significance	**	**	**
LSD (5%)	0.41	0.42	0.34
Interaction	NS	NS	NS
CV%	6	6	4

MDD responses to Nitrogen

The greatest increase in MDD bake scores came from N application at GS 9 which lifted bake scores at all three sites with the largest response occurring at site 2 raising bake scores by 68%.

With the early N application, bake scores also showed significant increases, however not as great as the GS 9 application (Table 5).

Correlation between protein and MDD bake score

There was significant correlation between protein and MDD bake scores at all sites.

Site 1 — MDD = − 5.101 + 2.051 Protein SED = 0.273
$r^2 = .64$**

Site 2 — MDD = − 14.214 + 3.079 Protein SED = 0.303
$r^2 = .7$**

Site 3 — MDD = − 0.274 + 1.901 Protein SED = 0.271
$r^2 = .59$**

TABLE 5: MDD scores at each site.

Site	1	2	3
GS 2			
0 kg N/ha	11.6	11.8	16.0
100 kg N/ha	13.1	13.7	18.3
200 kg N/ha	13.8	15.3	17.6
Significance	*	**	*
GS 9			
0 kg N/ha	10.3	10.0	14.4
100 kg N/ha	13.4	13.9	17.7
200 kg N/ha	14.7	16.8	19.8
Significance	**	**	**
LSD (5%)	1.5	1.4	1.8
Interaction	NS	NS	NS
CV%	14	13	13

The low N potential sites produced similar gradients while that at the high N site, (site 2) was significantly steeper. These results indicate that a large percentage of the variation in bake score can be explained by changes in protein. To find if a similar pattern occurred in the National List Trials, correlations were carried out on data from 1980/81 to 1983/84 for Rongotea and Bounty.

Bounty MDD = − .046 + 1.721 Protein SED = 0.44
$r^2 = 0.298^{**}$

Rongotea MDD = 10.323 + 0.691 Protein SED = 0.351
$r^2 = 0.10$ NS

Bounty had a significant r^2 value while the Rongotea value was non-significant suggesting that the bake score of Bounty is more responsive to N. This is also suggested by comparing the gradients, with Bounty having a significantly steeper slope.

DISCUSSION

Quality

Significant MDD responses to N application were recorded at all sites, the largest increase in bake score coming from N applied at GS 9. The resulting changes in quality were as follows:

Site 1 — undergrade to Category B
Site 2 — undergrade to Category A
Site 3 — Category B to Category A

Similar results were also recorded from the N applied at GS 2, however at site 3 all treatments scored within category A. It is clear from these trials that it is possible to raise the quality of the wheat by N management, possibly maintaining the variety within category A (standard milling wheat).

It is important to note that the GS 9 application gave the greatest increase in protein and bake scores indicating that this time is more important than applications at GS 2.

The increase in baking score from the N application was due in part to increases in protein levels as highly significant correlations were recorded at all sites (Wilson, 1983; Douglas and Dyson, 1985). Since similar results were obtained at the high and low N status sites it is considered that the high rainfall recorded over the spring-summer period (above 300 mm) would have caused considerable leaching losses of N therefore decreasing the N status at the high N site. The explanation for protein increases at GS 2 is that N caused reductions in kernel weight thus increasing the ratio of protein to carbohydrate in the grain.

When using data from the National List Trials, results also showed statistically significant relationships between protein and MDD bake scores. However when compared with Rongotea from the same trials, a non-significant result was obtained indicating that protein levels are more important to the bake score of Bounty than Rongotea.

Yield

Grain yield responses to N applied at early tillering were recorded at the low N sites while no responses were recorded at the later application. This is similar to work on winter-sown Karamu by Scott (1978) who demonstrated yield responses up to 100 kg N/ha and on Rongotea by Stephen (1983) who showed yield responses up to 140 kg N/ha at low N status sites when rainfall was above 300 mm during the spring-summer period.

The one yield component examined was grain weight. This showed a reduction from early tillering applications of N at all sites. This is likely to be due to higher tiller number. Feyter (1977) attributed grain weight reductions with Karamu and Kopara to the stimulation of tillering by N and the resulting reduction of carbohydrates to the ear reducing seed size.

With the N application at GS 9, grain weight increased at the low N sites. Since adequate moisture was available during grain filling the increase is considered to be because the presence of fewer tillers allowed the grain to fully develop with high rates of N. No increase in kernel size was recorded on the high N site.

CONCLUSION

1. N at GS 9 caused greater protein and MDD bake score increases in the grain than N at GS 2. The resultant increase in bake score increased the milling grade of the wheat to Category A at sites 1 and 2. Therefore it is possible for farmers to influence the milling grade of the wheat by N applications.
2. MDD bake scores showed a highly significant positive correlation to protein levels.
3. Data from National List Trials between 1980/81 and 1983/84 showed Bounty to have a greater correlation between protein and MDD bake scores and to be more sensitive to protein changes than Rongotea.
4. N application applied at GS 2 increased the yield of Bounty on low N potential sites with adequate spring-summer rainfall.
5. N caused a decrease in kernel weight from N at GS 2 and increased kernel weight from N at GS 9 at the low N potential sites.

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