Some notes on yield and protein responses to nitrogen in bread and durum wheats

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Abstract

This paper summarises the results of 6 years trials in Canterbury with various milling wheat and pasta varieties. Yield and protein responses to timing of nitrogen application are reported. There are significant seasonal, site and cultivar effects which determine the relative yield and protein responses to the timing of applied nitrogen. The use of foliar applied liquified urea was a treatment in a number of these trials, and was effective in increasing grain protein content.

Additional key words: *yield, fertiliser, timing.*

Introduction

Since 1985, there have been a number of field trials evaluating the response of various wheat and Durum cultivars to the timing and rate of nitrogen. This has been in response to changes in the structure of the New Zealand wheat industry after deregulation, with high quality standards now required by the users of New Zealand wheat. Farmers however still require maximum yields for the best returns (J. Lay, pers. comm.). There has been some concern that increasing yields could mean decreasing protein content (Smith, 1981), resulting in lower prices per tonne and not meeting market requirements. The results and subsequent management recommendations for a number of these trials have been presented in management guideline booklets for farmers.

Much of the work was conducted on a contractual basis, and the authors are indebted to Goodman Fielder Wattie (NZ) Ltd and the Timaru Milling Company for allowing the publication of results.

This paper presents a summary of trial results from four different seasons and 8 sites. Four milling wheat and 2 durum wheat cultivars were evaluated. In the interests of brevity and clarity, only summary results are presented.

Materials and Methods

Trial A (a series of 4 trials) was conducted over the 1985/86 season and involved four autumn sown milling wheat cultivars: Otane, Rongotea, Weka and Oroua. Early N (112 kg N/ha at the tillering stage) and late N (25, 50 and 100 kg N/ha at ear emergence) were the treatments (Stevenson, 1986).

Trial B, conducted by MAFTechnology on contract to Goodman Fielder Wattie (GFW) grains, investigated early N (50 kg N/ha at tillering) and late N (25 kg/ha and foliar N at ear emergence) in spring sown Otane.

Trials C1 and C2 were conducted during the 1989/90 season on Tara durum. The treatments were early N (40 kg N/ha at mid-tillering, and late N (nil, 40 kg N/ha ground applied and 20 kg N/ha as foliar applied urea at the rate of 44 kg urea per 200 litre water applied at 200 l/ha) at sites on Wakanui and Waimakariri silt loams.

Trial D during the 1990/91 season was used to investigate the same treatments as for trial C on Tara durum. The site was on a Chertsey silt loam and was severely affected by late season moisture stress, resulting in small grains with very high protein contents.

Trial E1 and E2 during the 1990/91 season was used to investigate the same treatments as in trial C on Waitohi durum, one site being heavy Temuka silt loam and the other a lighter Templeton silt loam.

Trial F during the 1990/91 season investigated the same treatments as for trial C in spring sown Otane wheat on a heavy Temuka silt loam.

In every trial situation a farmer's paddock was selected that would be considered moderate to low fertility, i.e., it had at least one, and usually two or three depletive crops prior to the trial crop being established. Invariably other treatments were tested as well, such as higher rates of N or multiple applications.

Yields were determined using quadrat samples (5 or 10 quadrats per plot, 3 replications per treatment); protein analysis was by Kjeldahl analysis in trials A and C; NIR analysis in all other trials.

Quadrat sampling invariably over-estimated header yield by 1 to 1.5 t/ha. Samples were taken usually about one week prior to normal header harvest. Samples were analysed for head number through total sample count, spikelet number from a sub-sample of 20 heads, and yield determined after threshing in a stationary harvester. Kernel weight determined by counting 1000 unscreened seeds.

All yields and protein contents are expressed on a 14% moisture content basis.

Results

Results for trial A are given in Table 1 and results from the other trials are given in Table 2. As the trials span a number of seasons, sites of varying fertility and soil water-holding capacity, and a range of wheat varieties, it can be seen there is some variability in the relative response of yield and protein to various timings and rates of N application. However, the purpose of this paper is not to provide precise N recommendations for a range of cultivars but rather to present a series of trial results and identify key features from these results.

The application of early N (at the crop tillering stage) on average gave lifts to both yield and grain protein content. In some trials there was a relatively greater response of yield, e.g., trial E2, while in others there was a relatively greater protein response to this early N application, e.g., trial C1 and C2.

While there was usually a significant protein response to the late N application (notable exception trial D which was very dry during later crop growth stages, probably affecting N uptake and utilisation); there was also often a surprising yield response to this late N. Yield component analysis identified this as coming from both increased number of productive spikelets and an increase in grain set per spikelet (i.e., improved grain set per head, no doubt being a result of improved plant N status). N application had no consistent effect on grain weight.

The fact that early N reduced the protein response to late N is illustrated in Figure 1. Interestingly the protein response to increasing rates of late N in this figure was linear within the range observed. This site could not be

Table 1. Yield and protein content responses to early and late nitrogen application to wheat cultivars on irrigated, Templeton Silt Loam(Trial A).

Cultivar x early N rate

Yield (t/ha)

	Otane		Rongotea		Oroua		Weka		Mean of Cultivars	
Late N	nil	112kg	nil	112kg	nil	112kg	nil	112kg	nil	112kg
nil	6.5	7.4	7.2	9.0	7.8	8.2	8.0	8.1	7.4	8.2
25kg	6.9	7.5	7.7	8.9	8.2	8.7	8.5	8.4	7.8	8.4
50kg	6.9	8.0	7.6	9.0	8.4	8.4	8.4	8.2	7.8	8.4
100kg	6.9	7.5	8.4	9.0	8.6	8.6	8.8	8.3	8.2	8.4
$LSD_{0.05}$	within early N 0.3t/ha between early N 0.55t/ha		within 0.35t/ha between 0.62t/ha		within 0.29t/ha between 0.41t/ha		within 0.39t/ha between 0.48t/ha		within 0.22t/ha between 0.34t/ha	

Protein content (%)

	Otane		Rongotea		Oroua		Weka		Mean of Cultivars	
Late N	nil	112kg	nil	112kg	nil	112kg	nil	112kg	nil	112kg
nil	12.5	13.4	13.0	14.0	12.2	13.1	11.6	13.3	12.3	13.7
25kg	13.8	14.6	13.6	14.4	12.5	14.0	12.4	13.8	13.1	14.2
50kg	14.9	15.1	15.1	14.9	13.4	14.0	12.5	13.7	14.0	14.4
100kg	15.0	15.5	16.2	15.9	14.8	15.1	14.1	14.9	15.0	15.4
$LSD_{0.05}$	within early N .51% between early N .61%		within .45% between .52%		within .47% between .51%		within .61% between .74%		within .33% between .37%	

considered excessively depleted (and hence give responses to quite high rates of N), as yields and protein contents overall were quite high even with nil or low rates of N.

The yield and protein response to 20 kg N/ha foliar spray was often comparable to the protein and yield response to 40 kg N/ha ground applied. This is attributed to improved efficiency of N utilisation.

Discussion

A total of 8 trial site result summaries are given in this paper. As would be expected, there is some variation in relative protein and yield responses to the timing and rate of N application.

Seasonal water supply, inherent soil fertility and subsequent N mineralisation, cultivar and crop yield

Table 2. Effect of early and late N application on grain yield (t/ha) and protein content (%) for seven Trials involving a range of cultivars and soil types.

		Late N					
		nil		25 kg N/ha granular		20 kg N/ha foliar	
Trial B - Spring sown Otane, irrigated Wakanui silt loam							
Early N	nil	5.7 t/ha	10.7%	6.3 t/ha	11.2%	6.3 t/ha	11.0%
	50 kg N/ha	6.4 t/ha	11.3%	6.7 t/ha	11.8%	6.5 t/ha	11.9%
		$LSD_{.05}$ for grain yield = 0.48 t/ha.		$LSD_{.05}$ for protein content = 0.42%.			
		nil		40 kg N/ha granular		20 kg N/ha foliar	
Trial C1 - Tara durum, irrigated Wakanui silt loam							
Early N	nil	8.2 t/ha	11.8%	7.7 t/ha	14.6%	8.1 t/ha	13.9%
	40 kg N/ha	8.1 t/ha	14.7%	7.7 t/ha	15.5%	8.0 t/ha	14.7%
		$LSD_{.05}$ for grain yield = 0.41 t/ha.		$LSD_{.05}$ for protein content = 0.62%.			
Trial C2 - Tara durum, irrigated Waimakariri silt loam							
Early N	nil	4.3 t/ha	9.8%	4.3 t/ha	13.3%	4.0 t/ha	11.8%
	40 kg N/ha	4.0 t/ha	11.3%	4.5 t/ha	13.5%	4.3 t/ha	13.6%
		$LSD_{.05}$ for grain yield = 0.52 t/ha.		$LSD_{.05}$ for protein content = 0.81%			
Trial D - Tara durum, dryland Chertsey silt loam							
Early N	nil	3.4 t/ha	17.1%	3.7 t/ha	17.2%	3.3 t/ha	17.2%
	40 kg N/ha	3.6 t/ha	18.1%	3.8 t/ha	18.0%	2.9 t/ha	18.1%
		$LSD_{.05}$ for grain yield = 0.28 t/ha.		$LSD_{.05}$ for protein content = 0.35%			
Trial E - Waitohi durum, dryland Temuka clay loam							
Early N	nil	8.8 t/ha	12.9%	8.8 t/ha	13.2%	8.8 t/ha	13.1%
	40 kg N/ha	8.2 t/ha	13.9%	8.7 t/ha	14.0%	8.5 t/ha	14.2%
		$LSD_{.05}$ for grain yield = 0.42 t/ha.		$LSD_{.05}$ for protein content = 0.55%			
Trial E2 - Waitohi durum, dryland Chertsey stony silt loam							
Early N	nil	5.5 t/ha	14.0%	6.7 t/ha	14.6%	6.6 t/ha	14.6%
	40 kg N/ha	6.4 t/ha	14.5%	6.9 t/ha	14.8%	7.2 t/ha	15.2%
		$LSD_{.05}$ for grain yield = 0.58 t/ha.		$LSD_{.05}$ for protein content = 0.45%			
Trial F - Spring sown Otane, dryland Templeton sandy silt loam							
Early N	nil	6.5 t/ha	11.9%	6.6 t/ha	12.6%	6.5 t/ha	12.5%
	40 kg N/ha	6.7 t/ha	12.7%	7.1 t/ha	12.9%	6.4 t/ha	12.7%
		$LSD_{.05}$ for grain yield = 0.35 t/ha.		$LSD_{.05}$ for protein content = 0.52%			

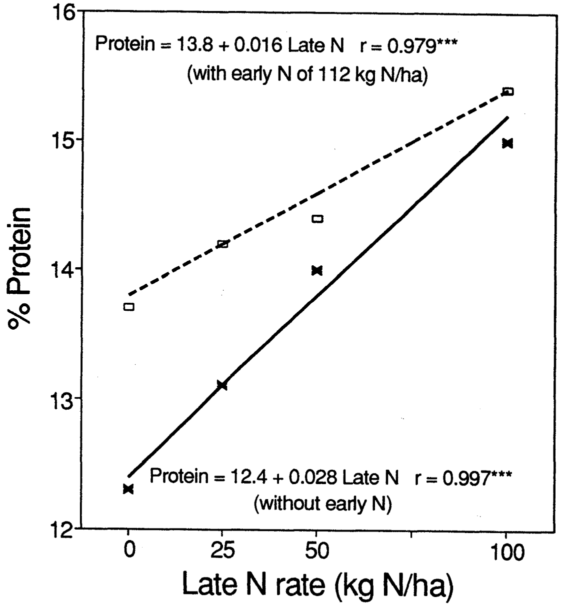

Figure 1. Protein response to increasing rates of late N application : mean of 4 bread-wheat cultivars in Trial A.

potential all play significant roles in determining the response of protein and yield to N application.

In spite of all these variable factors, farmers wishing to optimise yield and protein have plenty of opportunity to do this without being too concerned that increases in yield automatically mean declines in quality (Smith, 1981). Until the mid 1980s, which corresponded to the time of wheat industry deregulation, the bulk of wheat research centred on maximising yield as this usually equated with profit (McCloy 1980, Wilson 1985), and many trial results were given without protein results, e.g., Withers and Pringle 1981, although this was not always the case (Drewitt 1982).

Work with many cultivars in the 1980s identified that maximum yield was obtained from nitrogen application at early crop growth stages and grain protein was increased from applications of N at later growth stages (Drewitt 1982). Subsequently, management recommendations were published which advocated the use of splits of nitrogen to ensure optimum yield or quality (Montgomery *et al.*, 1986). The results of the trials given in this paper and the subsequent conclusions do not differ materially from these earlier recommendations.

However, the results given above indicate there is a lot of flexibility in the timing of N application to high protein wheat crops, i.e., early or late application, both of which will give responses in yield and protein. One of the main constraints to wheat production in New Zealand is water supply: whether this be too little or erratic supply in Canterbury, or too much in the Manawatu and Southland. Thus farmers can time N application to suit weather conditions as opposed to feeling obliged to apply N at a certain growth stage. A combination of early and late N would appear to give maximum increases in yield and protein content as shown in the trial results. Total N input and the way this may be "split" would depend on individual situations, taking into account paddock fertility, potential yield, crop water supply at later growth stages and target protein content.

Growers will need to calculate economic returns to multiple applications according to the returns of the day and the practicality of application.

For high protein wheat and durum varieties, it would appear that timing of N application is less critical than the fact that N application has been made.

The use of foliar urea application, perhaps in conjunction with a late fungicide, has been found to be an inexpensive way to boost grain protein content.

The author does not have the confidence to recommend solely late N applications to achieve yield and protein; and suggests a balanced approach of 2 or 3 applications starting at mid-tillering depending on situation and in response to a season as it develops.

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