THE EFFECTS OF LATE NITROGEN ON THE YIELD AND QUALITY OF MILLING WHEAT

A thesis
presented in partial fulfilment of the requirements
for the degree of
Master of Agricultural Science
in
Agronomy
at
Massey University

James Millner

1992

ABSTRACT

The quality of wheat milled to produce flour for leavened bread is related to its protein content. The presence of specific proteins in milling wheat gives dough its elastic properties and dertermines baking quality. Good quality wheat will produce loaves with high volumes and a fine crumb texture. It is known that wheat cultivars differ in their ability to produce good quality bread through differences in the composition of their protein. In cultivars of good quality, the greater the protein content, the better the quality of bread produced.

The Manawatu Mills Limited, Palmerston North varies the price it pays for milling wheat according to cultivar and protein content. Premiums can be obtained by increasing grain protein content. This presents local wheat growers with the financial incentive to improve the yield and quality of their crops.

To investigate the feasibility of using late applications of nitrogen fertiliser to increase the protein content and yield of milling wheat three trials were carried out at different sites during the spring and summer of 1989/90. These sites were at Kairanga, Almadale and Waituna West in the Manawatu region using the cultivar Rongotea. They were chosen to provide a range of environmental conditions, particularly temperature, over which to test the effect of nitrogen fertiliser on protein content. To achieve different temperature regimes, these sites are situated at low, medium and high altitude. It has been suggested that temperature over the grain-fill period can influence both protein content and composition of wheat, which in turn influences its ability to produce good quality bread. Four different rates of nitrogen fertiliser were applied just prior to the boot stage. These were 0, 20, 40 and 80 kg N/ha.

There were significant differences in grain yield amongst sites with Kairanga achieving 6.4 tonnes/ha, Almadale 5.9 tonnes/ha and Waituna West 6.8 tonnes/ha. These yields were above the long term district average. Grain yield responded to late nitrogen at Kairanga and Waituna West. Yields increased from 6.1 to 6.9 tonnes/ha at Kairanga and from 6.4 to 7.2 tonnes/ha at Waituna West as application rates increased from zero to 80 kg N/ha. Any potential yield response at Almadale was suppressed due to an

infection of the root rot fungus, 'take-all'. The yield response at Kairanga resulted from an increase in grain weights whereas at Waituna West it resulted from an increase in ear numbers at harvest. At both responsive sites late nitrogen delayed conopy senescence.

Protein contents also varied significantly amongst sites and in response to the application of nitrogen fertiliser. Protein content (14% moisture basis) ranged from 8.87 to 10.87% at Kairanga, from 10.35 to 11.28% at Waituna West and from 12.97 to 13.69% at Almadale as application rates increased from zero to 80 kg N/ha. The differences in protein levels obtained from different sites resulted in a considerable variation in baking quality. Samples from eight plots from each site were sent to the Wheat Research Institute, Christchurch, for test baking. Average bake scores were 19 at Kairanga, 21 at Waituna West, and 26 at Almadale. There was a strong, positive relationship between bake score and grain protein content amongst these samples. A convenient measure of baking quality, the sodium dodecyl sulphate test, was used to estimate baking quality of each plot. This allowed the relationship between baking quality and grain protein content to be identified for each site. The relationship between protein and baking quality differed between sites, being much stronger at Kairanga than at Almadale and Waituna West. The relatively poor relationship between protein and baking quality at Waituna West and Almadale can be partly explained by the limited range of protein contents resulting from treatment effects, particularly at Almadale. There was evidence that site had influenced the relationship between protein content and baking quality.

At Kairanga and Waituna West late applications of nitrogen fertiliser significantly increased both grain yield and protein content. The yield increases, combined with the price premiums for increased protein, meant that it would have been profitable to apply late nitrogen. At Almadale there was no yield response and the protein response was limited, making late applications of nitrogen uneconomic. Pest and disease pressure at Almadale reduced yield, contributing to grain protein content being above the point where premiums are available. It was concluded that it can be economically feasible to use late applications of nitrogen on crops which have a high potential yield. Factors limiting yield, such as pests, diseases and moisture stress, will limit any potential benefit.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS USED

°C	degrees Celsius
cv	coefficient of variation
DM	dry matter
gr	grain
G.S.	growth stage
ha	hectare
HI	harvest index
HMW	high molecular weight
kg	kilograms
LAD	leaf area duration
LAI	leaf area index
LMW	low molecular weight
LSD	least significant difference
m	metre
mm	millimeter
MDD	mechanical dough development
mg	milligrams
MJ	megajoules
N	nitrogen
NAR	net assimilation rate
NHI	nitrogen harvest index
SDS	sodium dodecyl sulphate
W	Watts
WRI	Wheat Research Institute
wt	weight

CHAPTER I

INTRODUCTION

New Zealand has an annual requirement for milling wheat of approximately 300,000 tonnes (Loney, 1989). However there has nearly always been a shortfall in supply, with importation of mainly Australian wheat required in most years (Logan, 1985). The level of imports has risen from approximately 26,000 tonnes in 1979 (Stonyer and Durbin, 1981) to 170,000 tonnes in 1989 (Anon., 1990a). During this period the New Zealand wheat industry was deregulated.

In February 1987 the New Zealand Wheat Board no longer controlled the internal market or importation of milling wheat. Individual mills were responsible for securing their own supplies and determining the quality requirements for the wheat they purchased. Deregulation was implemented to expose the industry to market forces. Under Wheat Board control there was no emphasis placed on quality requirements nor were there any objectives in place to meet future needs (Lindley, 1989).

Deregulation occurred at a time when increasing emphasis was being placed on milling wheat quality as competing exporters have attempted to hold or improve market share (Wilson, 1990). This and the fact that the New Zealand industry had been insulated from market forces meant that deregulation was traumatic for the industry (Ryan, 1989).

Today the New Zealand wheat crop is competing against imported wheat of high quality with both price and quality set by wheat on the world market, particularly Australian wheat (Gray, 1989).

The Manawatu Mills in Palmerston North supplies flour to bakeries in the southern North Island. Their annual requirement for bread wheat is 22,500 tonnes and for biscuit wheat 5,500 tonnes (Mitchell, 1990). Wheat growers supplying the Manawatu Mills are contracted to sell wheat at a price which can vary according to the quality of the wheat they supply. Quality is determined by an index system with lines of wheat achieving

100 index points receiving the base price (Anon., 1989). Lines can achieve more or less than the base price depending on the final index points they achieve. The index is made up of two parts: one is the contribution from the cultivar growers choose and the other from the protein content of the wheat produced. Only cultivars with acceptable baking characteristics are eligible. Protein content is included in the index because protein is the most important constituent of wheat affecting its baking quality (Moss, 1981). The cultivar index has a narrow range with only two points separating the three cultivars specified. However the protein index provides wheat producers with the opportunity to achieve price premiums of up to 16% with index points rising as protein contents go from 10.0% to 12.9% and over (Anon., 1989). There is a positive relationship between protein content and baking quality in milling wheat (Moss, 1981). Even though this relationship is imprecise (Wilson, 1990), protein content is used as a convenient measure of quality in milling wheat. The relationship also varies with cultivar (Cawley, 1981), hence the inclusion of cultivar in the quality index.

The last nationwide surveys of wheat protein contents occurred in 1982 and 1983. The mean levels in those years were 10.7% and 10.5% respectively (Lindley and Humphrey-Taylor, 1987). Two milling wheat cultivars, Oroua and Rongotea eligible for supply to the Manawatu Mills were included in those surveys. In 1982 Oroua grown in the southern North Island had a protein content of 10.9% and Rongotea 10.2%. In 1983 protein contents rose to 11.2% and 10.8% for Oroua and Rongotea respectively. More recently protein contents have apparently increased (G Georgiou, Manawatu Mills, pers. comm.). In the 1989/90 season for example Rongotea achieved an average protein content of 11.5% for lines received at the Manawatu Mills.

For wheat with a protein content of less than 10.0%, the Manawatu Mills reserves the right to decline purchase. For many lines of southern North Island wheat there is an opportunity to increase returns from price premiums for achieving higher protein levels.

Nitrogen fertiliser can be used to increase grain protein content (Martin *et al.*, 1989). While applications applied early in the crop's development have more effect on yield than protein content, applications made after the main yield determining growth stages raise grain protein content (Drewitt and Dyson, 1987). Yield increases may be possible with latter use of nitrogen fertiliser through increased grain size (Drewitt, 1985).

Environmental factors can influence the relationship between grain protein and baking quality. In particular, temperatures over the grain-fill period have been shown to influence this relationship (Randall and Moss, 1990; Stevenson, 1987a).

This study was undertaken to examine the use of late applications of nitrogen fertiliser on milling wheat at different sites in the Manawatu. The following objectives were set:

- Assess the feasibility of using late applications of nitrogenous fertiliser to increase the yield and premiums received for milling wheat.

- Investigate the use of the SDS sedimentation test as a measure of baking quality.

- Determine the response of bake score and SDS volume to increased grain protein content.

- Investigate the influence of environment on the relationship between grain protein content and baking quality.

A review of the literature on yield and baking quality in milling wheat and the effect of nitrogen on these attributes is presented in chapter II. Chapter III describes the proceedures used in the field and laboratory during this study. The results have been presented in four different chapters covering environmental aspects, yield, protein content and baking quality. A preliminary discussion is also presented in each of the results chapters. A final discussion brings all results together. The major conclusions from this study are listed in the final chapter.