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# **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 determines 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 canopy 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

|   |             |
|---|-------------|
| <b>List of Tables</b>   | <b>v</b>    |
| <b>List of Figures</b>  | <b>vi</b>   |
| <b>List of Plates</b>   | <b>vii</b>  |
| <b>List of Appendices</b>   | <b>viii</b> |
| <b>Abbreviations</b>  | <b>ix</b>   |
| <br>  |             |
| <b>CHAPTER I      Introduction</b>  | <b>1</b>    |
| <b>CHAPTER II     Review of Literature</b>  | <b>4</b>    |
| <br>  |             |
| 2.1    Yield development  | 4           |
| 2.2    Effect of Nitrogen Fertilisation on Yield  | 7           |
| 2.2.1 Effect of Early Nitrogen on Wheat Yields  | 8           |
| 2.2.2 Effect of Late Nitrogen on Wheat Yields   | 10          |
| 2.3    Determination of Grain Protein   | 11          |
| 2.4    Harvest Index  | 13          |
| 2.5    Nitrogen Harvest Index   | 14          |
| 2.6    Recovery of Nitrogen Fertiliser  | 14          |
| 2.7    The relationship between Protein Content<br>and Baking Quality                           | 17          |
| 2.7.1 Introduction  | 17          |
| 2.7.2 Baking Quality  | 17          |
| 2.7.3 Relationship between Protein Content<br>and Quality                                       | 19          |
| 2.8    Factors influencing the Relationship between<br>Grain Protein Content and Baking Quality | 22          |
| 2.8.1 Fertiliser  | 22          |
| 2.8.2 Environment   | 23          |
| 2.9    The influence of Temperature on Wheat Yields   | 24          |

|                    |   |           |
|--------------------|---|-----------|
| <b>CHAPTER III</b> | <b>Materials and Methods</b>  | <b>28</b> |
| 3.0                | Introduction  | 28        |
| 3.1                | Trials Sites  | 28        |
| 3.2                | Treatments  | 32        |
| 3.3                | Crop Sampling   | 33        |
| 3.4                | Crop Management   | 35        |
| 3.5                | Field Measurements  | 36        |
| 3.6                | Laboratory Procedures   | 38        |
| 3.7                | Baking Quality  | 39        |
| 3.8                | Analysis of Data  | 39        |
| <b>CHAPTER IV</b>  | <b>Results and Discussion,<br/>Climatic Data, Crop Growth and<br/>Development</b> | <b>42</b> |
| 4.0                | Introduction  | 42        |
| 4.1                | Climate   | 42        |
| 4.1.1              | Temperature   | 42        |
| 4.1.2              | Rainfall  | 45        |
| 4.1.3              | Radiation   | 45        |
| 4.2                | Crop Development and Grain Growth   | 46        |
| 4.3                | Dry Matter and Nitrogen Yield at Feekes 5.5.9                                     | 49        |
| 4.4                | Nitrogen Uptake and Canopy Senescence   | 51        |
| 4.5                | Grain Growth Rates  | 54        |
| <b>CHAPTER V</b>   | <b>Results and Discussion<br/>Grain Yield and Yield Components</b>                | <b>57</b> |
| 5.1                | Introduction  | 57        |
| 5.2                | Results   | 57        |
| 5.2.1              | Site 1  | 57        |
| 5.2.2              | Site 2  | 59        |
| 5.2.3              | Site 3  | 59        |
| 5.3                | Discussion  | 59        |
| 5.3.1              | Yield   | 59        |
| 5.3.2              | Ear Numbers/m <sup>2</sup>  | 60        |
| 5.3.3              | Spikelet/Ear and Grains/Spikelet  | 62        |
| 5.3.4              | Grains/m <sup>2</sup>   | 63        |
| 5.3.5              | Grain Weight  | 64        |
| 5.3.6              | Total Crop Dry Matter and Harvest Index   | 67        |

|                    |  |           |
|--------------------|--|-----------|
| 5.4                | Yield Data Correlation   | 68        |
| 5.5                | Combined Grain Yield (across three sites)  | 71        |
|                    | 5.5.1 Treatment Effects  | 71        |
|                    | 5.5.2 Site Effects   | 71        |
|                    | 5.5.3 Treatment and Site Interaction   | 72        |
| <b>CHAPTER VI</b>  | <b>Results and Discussion</b>  |           |
|                    | <b>Nitrogen Distribution</b>   | <b>74</b> |
| 6.1                | Introduction   | 74        |
| 6.2                | Results  | 74        |
|                    | 6.2.1 Site 1   | 74        |
|                    | 6.2.2 Site 2   | 74        |
|                    | 6.2.3 Site 3   | 75        |
| 6.3                | Discussion   | 75        |
|                    | 6.3.1 Grain Protein  | 75        |
|                    | 6.3.2 Total Nitrogen Yield and Nitrogen Harvest Index  | 78        |
| 6.4                | Nitrogen Recovery  | 81        |
| 6.5                | Combined Grain Protein Content (Across three sites)  | 83        |
|                    | 6.5.1 Treatment Effects  | 83        |
|                    | 6.5.2 Site Effects   | 84        |
|                    | 6.5.3 Treatment and Site Interaction   | 85        |
| <b>CHAPTER VII</b> | <b>Results and Discussion</b>  |           |
|                    | <b>Baking Quality</b>  | <b>86</b> |
| 7.0                | Introduction   | 86        |
| 7.1                | Relationship Between Grain Protein Content and Baking Quality                                  | 86        |
|                    | 7.1.1 Bake Score   | 89        |
|                    | 7.1.2 Optimum Work Input   | 90        |
|                    | 7.1.3 Water Absorption   | 93        |
| 7.2                | Relationship Between Bake Score and SDS Sedimentation Volume                                   | 95        |
| 7.3                | Relationship Between Grain Protein Content and SDS sedimentation Volume - Three sites combined | 95        |
| 7.4                | Relationship Between Grain Protein Content and SDS sedimentation Volume - Individual sites     | 98        |

|                           |  |            |
|---------------------------|--|------------|
| <b>CHAPTER VIII</b>       | <b>Final Discussion</b>  | <b>104</b> |
| 8.0                       | Introduction   | 104        |
| 8.1                       | Yield and Yield Components   | 104        |
| 8.2                       | Grain Protein Content  | 106        |
| 8.3                       | Relationship Between Grain Yield and<br>Grain Protein Content                    | 107        |
| 8.4                       | Relationship Between Harvest Index and<br>Nitrogen Harvest Index                 | 109        |
| 8.5                       | Baking Quality   | 110        |
| 8.6                       | The Feasibility of Using Late Nitrogen on<br>Milling Wheat Crops in the Manawatu | 111        |
| <b>CHAPTER IX</b>         | <b>Conclusions</b>   | <b>116</b> |
| <b>LIST OF REFERENCES</b> |  | <b>118</b> |
| <b>ACKNOWLEDGEMENTS</b>   |  | <b>143</b> |
| <b>APPENDIX</b>           |  | <b>144</b> |

## LIST OF TABLES

|                  |   |     |
|------------------|---|-----|
| <b>Table 4.1</b> | Maximum minimum and average daily temperature   | 43  |
| 4.2              | Average daily temperature over the grain-fill period  | 43  |
| 4.3              | Average monthly rainfall  | 43  |
| 4.4              | Mean daily global solar radiation   | 43  |
| 4.5              | Crop dry matter and nitrogen content at Feekes G.S.9  | 49  |
| 4.6              | N content of ears at anthesis   | 51  |
| 4.7              | Dry weight of flag leaves at 34 and 41 days after anthesis  | 52  |
| 5.1              | Grain yield, yield components, total dry matter and harvest index by site   | 58  |
| 5.2              | Simple correlation coefficients for yield components, HI and % discoloured ears (site 2 only)   | 69  |
| 5.3              | Effect of N on grain yield  | 71  |
| 5.4              | Influence of site on grain yield  | 71  |
| 6.1              | Treatment effects on the distribution of crop N at harvest  | 76  |
| 6.2              | Simple correlation coefficients for NHI with straw N content and total N yield  | 80  |
| 6.3              | Simple correlation coefficients for total N yield and straw N content   | 80  |
| 6.4              | Simple correlation coefficients for N uptake after Feekes GS9 with total N yield and NHI  | 81  |
| 6.5              | Nitrogen recovery   | 82  |
| 6.6              | Effect of Nitrogen on Grain Protein Content   | 83  |
| 6.7              | Simple correlation coefficients for grain protein content and total N yield   | 84  |
| 6.8              | Influence of site on grain protein content  | 84  |
| 7.1              | Simple correlation coefficients for grain protein content, loaf bake score, SDS sedimentation volume, optimum work input and water absorption | 88  |
| 8.1              | Correlation coefficients between HI and NHI   | 109 |
| 8.2              | Net return from the application of late N   | 112 |

## LIST OF FIGURES

| <b>Figure</b> |     |  |     |
|---------------|-----|--|-----|
|               | 3.1 | Map of Manawatu with site location   | 29  |
|               | 4.1 | Temperatures over the grain fill period  | 44  |
|               | 4.2 | The course of grain growth   | 48  |
|               | 4.3 | Grain Growth Rates   | 55  |
|               | 5.1 | The effect of N on grain weight at site 3  | 66  |
|               | 5.2 | The interaction of N and site on grain yield   | 73  |
|               | 6.1 | Effect of N on grain protein content   | 77  |
|               | 7.1 | The regression of bake score on grain protein  | 91  |
|               | 7.2 | The regression of optimum dough work input<br>on grain protein                       | 92  |
|               | 7.3 | The regression of dough water absorption on<br>grain protein                         | 94  |
|               | 7.4 | The regression of bake score on SDS<br>sedimentation volume                          | 96  |
|               | 7.5 | The regression of SDS sedimentation volume<br>on grain protein (all sites)           | 97  |
|               | 7.6 | The regression of SDS sedimentation volume<br>on grain protein, site 1               | 99  |
|               | 7.7 | The regression of SDS sedimentation volume<br>on grain protein, site 2               | 100 |
|               | 7.8 | The regression of SDS sedimentation volume<br>on grain protein, site 3               | 101 |
|               | 8.1 | The effect of N on the relationship between<br>grain yield and grain protein content | 108 |

**LIST OF PLATES**

|                |   |    |
|----------------|---|----|
| <b>Plate 1</b> | View of the three trial sites   | 30 |
| <b>Plate 2</b> | Stripe rust infection at site 3   | 37 |
| <b>Plate 3</b> | View of canopy at site 2 showing slug damage<br>(striped feeding pattern) and early senescence<br>of flag leaves soon after anthesis.   | 37 |
| <b>Plate 4</b> | The visual response (green pigmentation and<br>delayed leaf senescence) resulting from the<br>application of late N at site 3. On the<br>right, a plot which received 80 kg N/ha<br>compared to a plot receiving 20 kg N/ha on<br>the left. | 53 |
| <b>Plate 5</b> | The effects of "Take-all" at site 2. The<br>discoloured ears on the left are from<br>diseased plants while the normal ears on the<br>right are from healthy plants.   | 61 |
| <b>Plate 6</b> | The SDS sedimentation test. These samples are<br>ready to have the sediment volume recorded.  | 87 |

**LIST OF APPENDICES**

|                 |          |  |            |
|-----------------|----------|--|------------|
| <b>Appendix</b> | <b>1</b> | Recorded rainfall from time of N application until final harvest   | <b>144</b> |
|                 | <b>2</b> | Gravimetric soil water content   | <b>145</b> |
|                 | <b>3</b> | Daily maximum, minimum and average temperature   | <b>146</b> |
|                 | <b>4</b> | Daily solar radiation  | <b>147</b> |
|                 | <b>5</b> | The proportion of discoloured and healthy ears at site 2   | <b>148</b> |
|                 | <b>6</b> | Paired comparison of healthy and diseased (discoloured) ears for yield components differences, at site 2 | <b>148</b> |
|                 | <b>7</b> | The effect of site on the total N yield at harvest   | <b>149</b> |
|                 | <b>8</b> | The regression of grain protein content on total N yield at harvest                                      | <b>149</b> |
|                 | <b>9</b> | Manawatu Mills Ltd North Island Milling Contract   | <b>150</b> |

## 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 procedures 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.