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EFFECTS OF VARIOUS NITROGEN-FERTILIZER REGIMES ON THE MILLING AND BAKING QUALITIES OF HOME-GROWN BREADMAKING WHEATS

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Effects of various nitrogen-fertilizer regimes on the milling and baking qualities of home-grown breadmaking wheats

by

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Final report of a project lasting three and a half years commencing August 1985 which was carried out at the Flour Milling and Baking Research Association, Chorleywood. The project was funded with a grant of £47,287 from the Home-Grown Cereals Authority (Project No. 0001/1/86).

EFFECTS OF VARIOUS NITROGEN-FERTILIZER REGIMES ON THE MILLING AND BAKING QUALITIES OF HOME-GROWN BREADMAKING WHEATS

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Final report on a project of duration 3.5 years, starting date August 1985

Abstract

Wheat trials involving several regimes of fertilizer treatment using top dressings of ammonium nitrate and application of urea solution applied at various growth stages were carried out by the Agricultural Advisory and Development Service. Wheat from these trials, harvested in 1985, 86 and 87 was examined by the FMBRA for milling and baking qualities. Grain N values were usually increased by additional N whenever and however applied. When applied at GS75, foliar urea usually gave greater increases than ammonium nitrate applied earlier. Apparent flour protein contents closely followed grain N values; in particular late applications of urea increased apparent flour protein correspondingly more than the same total N applied earlier as ammonium nitrate. SDS sedimentation values did not always follow grain N values. On some occasions late urea treatments resulted in lower SDS values than would be expected. For some sites in some years there was a suggestion that increased apparent flour protein from late urea applications was not giving the expected increase in baking quality. However, the results taken as a whole were not conclusive on this point. The Long Fermentation Process baking tests, done in 1986 only, showed a much stronger response to changes in apparent flour protein than did the Chorleywood Bread Process baking tests. There were no effects of treatment on specific weight or Hagberg Falling Number.

1. OBJECTIVES

To investigate the effect of different nitrogenous fertilizers applied at various growth stages on the milling and baking quality of several breadmaking varieties of home-grown wheat grown on different sites. To establish whether nitrogen fertilizer applied late is in fact absorbed and converted to useful protein as measured by an improvement in breadmaking performance.

2. INTRODUCTION

Flour for breadmaking is milled from a grist of wheats, and the miller has to blend these from available supplies in attempting to produce flour with consistent quality characteristics.

A certain amount of Canadian wheat has traditionally featured in UK breadmaking wheat grists, but in recent years has increasingly been replaced by home-grown varieties. A strong impetus to such a move was given by Britain's entry into the EC, whereupon the levy became payable on 'third country' imports. In the last decade, such wheat imports have fallen from some 2 million tonnes to 500,000 tonnes per annum. Canadian wheat is characterised by consistently high protein quantity and protein quality, both of which are important in wheat for breadmaking. Clearly, when it is replaced by home-grown wheat, this should ideally have comparable characteristics.

Protein quality is controlled genetically, and is therefore in the hands of the plant breeders, who have successfully produced varieties which combine high yield and disease resistance with good breadmaking quality. The amount of protein in the grain shows some variability between varieties when these are grown under identical conditions, but it is mainly affected by growing conditions, particularly by the use of nitrogenous fertilizers. In general, when these are applied to the crop at a relatively early stage, an increase in the yield of grain is obtained, whereas later applications are useful in producing an increase in protein content within the grain. For the latter effect to give a beneficial response in the breadmaking quality of flour milled from the grain, it is important that the fertilizer which is usually applied as a foliar spray of urea solution, is fully converted to gluten-forming proteins. (Gluten is the hydrated protein formed when wheat flour is mixed with water, and its unique visco-elastic properties enable well-risen bread with a soft, well- aerated crumb structure to be produced. These proteins are not present in other cereals).

When a typical breadmaking wheat is given increasing amounts of late nitrogenous fertilizer in the field, there is usually a corresponding increase in the breadmaking quality of flour produced from it. However, at high apparent protein contents there is often a disappointing response for which two explanations are offered.

One is lack of sulphur which may reduce the sulphur/nitrogen ratio below that needed to produce the sulphur-containing amino-acids which give gluten its characteristic properties, the other concerns the incomplete conversion of the applied nitrogen into gluten-forming proteins.

A clear need for a greater understanding of the effects of various nitrogen fertilizer treatments on the properties of breadmaking wheat varieties prompted the investigations.

3. MATERIALS AND METHODS

3.1 Source of samples

Numerous field trials of wheat crops grown under various conditions are conducted by the Agricultural Advisory and Development Service (ADAS). Included in these over the last three years were several measuring the effects of nitrogenous fertilizers on the quality of breadmaking varieties. The FMBRA was asked to examine grain harvested from these trials in 1985, 86 and 87 for milling and baking qualities, and this part of the investigation was financed by the HGCA.

The selected trials, SB38 and C103, involved regimes of fertilizer treatment using top dressings of ammonium nitrate and application of urea solution. The SB38 trials included the following treatments (GS = growth stage, N as ammonium nitrate unless stated):

Treatment

N1 Treatment N2 minus 50 kg/ha at GS31.

N2 Recommended level of N for site, 50 kg/ha at GS23, balance at GS31.

N3 Treatment N2 plus 50 kg/ha at GS31.

N4 Level as N2 but in single application at GS31.

N5 Treatment N1 plus 50 kg/ha at GS39.

N6 Treatment N2 plus 50 kg/ha aat GS39.

N7 Treatment N1 plus 50 kg/ha N as urea at GS59.

N8 Treatment N2 plus 50kg/ha N as urea at GS59.

N9 Treatment N1 plus 50 kg/ha N as urea at GS75.

N10 Treatment N2 plus 50 kg/ha N as urea at GS75.

N11 Treatment N1 plus 50 kg/ha sulphur as gypsum.

N12 Treatment N2 plus 50 kg/ha sulphur as gypsum.

N13 Treatment N3 plus 50 kg/ha sulphur as gypsum.

Other treatments, varying in detail from year to year, involved applications of urea split between GS59 and GS75.

The C103 trials applied fewer treatments (including N1, N2, N4 and N8 above), to a number of different varieties. In each of the three years samples from a number of sites from each trial were tested at Chorleywood.

3.2 Methods of quality testing

The following measurements were made on samples of grain or on flour milled from the grain.

1. Wheat SDS sedimentation volume (ml). This is a rapid predictive test of protein quality for breadmaking potential.
2. Wheat protein content (N x 5.7, %). This is based on measuring total nitrogen content, and converting to 'protein' using the factor 5.7. Where fertilizer N has not been completely converted to protein the results will thus be misleadingly high. Values were measured by the Kjeldahl and near infrared reflectance methods.
3. Wheat moisture content. This measurement was made by oven drying (2 hours at 130^{o}C) or near infrared reflectance methods in order to correct the protein contents to a standard moisture basis (14%).
4. Wheat specific weight (kg/hl) after cleaning the sample and conditioning. This measurement provides a somewhat crude evaluation of grain plumpness.
5. Buhler milling of wheat sample. The flour extraction rate (%) is the yield of flour using a fixed test milling system for purposes of comparison.
6. Flour Grade Colour Figure. This indicates the bran particle content of flour, using a photoelectric reflectance method. Low figures denote low bran contamination.
7. Flour Falling Number. This uses the Hagberg apparatus and gives an indication of *alpha*-amylase activity which is associated with sprouting of the grain.
8. Flour protein content (%). The same procedures as for wheat protein content. Flour protein content is always lower than the value for the corresponding wheat.
9. Flour moisture content (%). The same procedures as for wheat moisture content, except that the time of drying at 130^{o}C is 1.5 hours.

10. Water absorption. The optimum flour water absorption for the test-baking procedure was measured using the Research extrusion meter.

11. Loaf volume (ml). This was measured on a loaf produced from a standard Chorleywood Bread Process test-baking procedure using the flour from the test milling.

12. Loaf score (maximum 50). This was obtained on a loaf produced from a standard Long Fermentation Process (LFP) test-baking procedure using the flour from the test milling. The loaf volume is included as part of the loaf score.

3.3 Testing performed.

1985 harvest. 441 samples of grain were examined and measurements 1-11 were made on all samples. The samples of flour were not baked by the LFP due to low Falling Numbers resulting from the wet conditions at harvest.

1986 harvest. A number of samples were sent by ADAS for preliminary testing, prior to deciding which sites would be chosen for full quality testing. This procedure was instituted after problems arose with poor quality samples from the 1985 harvest. In this preliminary testing 130 samples were examined for Falling Number, SDS, and protein and moisture contents (NIR) and 28 samples were examined for protein content (Kjeldahl) and moisture content (oven drying). Gluten was washed out and its quality assessed from 53 samples. Subsequently 407 samples were submitted to tests 1 - 12. Harvest conditions were better in 1986 and it was possible to bake the samples of flour by the LFP and score the resulting loaves.

1987 harvest. Due to the poor harvesting conditions associated with the 1987 harvest it was decided to carry out some preliminary tests on the grain samples. The following tests were carried out: Falling Number, SDS, protein and moisture contents (NIR), 142; assessment of gluten, 8. As a result of the preliminary tests it was decided to carry out the full testing on 319 samples of grain. Tests 1 - 11 were carried out. As in 1985, Falling Numbers on the grain were in the majority of cases too low to enable a loaf baked by the LFP to be given a meaningful score.

4. RESULTS

The results of all the quality testing performed at FMBRA were reported to ADAS for statistical analysis and interpretation along with ADAS's own data. Some of the baking quality data were also examined at Chorleywood. The following is a brief summary of the findings from the trials as a whole.

Yield was sometimes increased by ammonium nitrate at GS31 or 39 but not by foliar urea application.

Grain N values were usually increased by additional N whenever and however applied. When applied at GS75, foliar urea usually gave greater increases than ammonium nitrate. Earlier applications of urea had less effect on grain N. There was little difference in grain N from extra ammonium nitrate applied at GS31 or 39.

On average, 50 kg/ha extra N as ammonium nitrate at GS31 or 39 increased grain protein by about 0.5-0.6% compared with 0.7-0.8% from 50 kg/ha urea N at GS75. In 1987, application of 100 kg/ha urea N at GS59 + 75 gave significantly higher grain protein values than from 50 kg/ha urea N.

A single application of N (i.e. no early spring N) tended to give an average lower yield but higher grain protein.

Flour protein content closely followed grain N values; in particular late applications of urea increased flour protein correspondingly more than the same total N applied earlier as ammonium nitrate.

SDS sedimentation volume did not always follow grain N values. On some occasions late urea treatments resulted in lower SDS values than would be expected. However the pattern of results was not consistent from site to site or year to year.

The same was true of the results of the baking tests. For some sites in some years there was a suggestion that increased flour protein from late urea applications was not leading to the expected increase in baking quality. However, the results taken as a whole were not conclusive on this key point. The LFP baking tests, done in 1986 only, showed a much stronger response to changes in flour protein than did the CBP tests.

There were no effects of treatment on specific weight or Hagberg Falling Number.

There were no clear responses to sulphur application.

5. DISCUSSION

The failure to reach definite conclusions on the usefulness for breadmaking of wheat protein derived from late application of urea was disappointing. Two poor harvests, in 1985 and 1987, were the main reason for this. The better harvest of 1986, when both CBP and LFP baking tests produced meaningful results, showed that the latter test was far more sensitive to variations in protein quantity, producing much larger treatment effects than the CBP test. Even in 1986 however it was not possible to draw firm conclusions because of the amount of variability in the test baking results between samples from replicate plots.

There are two clear messages for the continuing work on this topic. First that the level of replication on each site should be increased, to improve the chances of detecting small effects, and second that the LFP baking test should be used if at all possible. In the current work, on samples for the 1988 harvest, the number of replicates has been increased from 3 to 4, and LFP baking tests are being performed.

6. CONCLUSIONS

The effect of late urea applications in increasing grain N and hence flour protein has been confirmed. Further work is needed however before firm conclusions can be reached about the usefulness of the resulting flour protein for breadmaking. Such work is underway, its design and execution influenced by the nature of the trials reported here.