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RHEOLOGICAL PROPERTIES OF WHEAT IN RELATION TO NITROGEN FERTILIZATION

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The effect of nitrogen fertilizer (ammonium nitrate) on yield, protein concentration and rheological properties of Mexi-Pak-65 wheat was studied in a field experiment, Ammonium nitrate was applied at varying rates (20 to 120 kg N ha^{-1}) either in single dose or 2-3 split applications at different growth stages. Application of 120 kg N ha^{-1} in three splits (20 kg N ha^{-1} at seeding, 50 kg N ha^{-1} at tillering and 50 kg N ha^{-1} at boot stage) resulted in the highest increase in grain yield (113.9% higher than control). The concentration of protein in grains increased from 7.4 to 9.8% with increased level of ammonium nitrate. Added levels of fertilizer exhibited no influence on the test weight, generally decreased the mixing time, and increased the water absorption capacity of the flour as well as the loof volume. The total area of alveograph curve (S) and the curve length (L) showed an increasing trend with increased rate of fertilizer nitrogen.

INTRODUCTIGN

Cereals are generally regarded low in protein. As most of the world population is almost totally dependent on cereals as the source of dietary protein, it will be highly desirable if improvement programmes with respect to crop yield could also consider improvements in the concentration and quality of protein. It has been reported that in addition to genetic, the environmental factors also have profound influence on wheat quality; often a greater effect than even the inherent factors (Bequette *et al.*, 1963). One of the environmental factors is the nitrogen available to the plant, and its application to the medium is known to increase the concentration of protein, gluten and non protein nitrogen in wheat (El-Gindy *et al.*, 1957; Wu and McDonald, 1976). The other important proper-

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ties of wheat are its rheological properties because such properties may determine the quality and production cost of wheat products. The nitrogen fertilization studies carried out in this country on widely grown wheat varieties have not given due attention to these properties. This paper discusses the effect of rate and time of nitrogen fertilization on grain yield, the concentration of protein and some rheological properties of wheat.

MATERIALS AND METHODS

A field experiment was conducted on a sandy clay loam soil with pH 8.2. Mexi-Pak-65 wheat sown at a seed rate of 120 kg ha^{-1} and was fertilized with 20, 60 and 120 kg N ha^{-1}, using ammonium nitrate as the source of nitrogen. A basal dose of 30 kg P ha^{-1} was given in the form of triple superphosphate to all treatments. N was applied as follows :

—20 kg N ha^{-1} at seeding (basal dressing).
—60 kg N ha^{-1} at seeding (basal dressing).
—120 kg N ha^{-1} at seedidg (basal dressing).
—20 kg N ha^{-1} at seeding (basal dressing). +40 kg ha^{-1} top dressed at growth stage II (Steu extension),
—20 kg ha^{-1} at seeding + 100 kg N ha^{-1} top dressed at growth stage II, or
—20 kg N ha^{-1} at seeding + 50 kg N ha^{-1} top dressed at growth stage III (tillering stage)+50 kg N ha^{-1} top dressed at growth stage IV (boot stage).

The treatments were given in a randomized complete block design with five replicates, with plots 5x1m containing 5 rows of wheat plants 20 cm apart. The nitrogen and phosphorus fertilizers applied at seeding were banded together and approximately 2 cm below the seed, and post emergence applications of N top dressed at the appropriate growth stages, as described by (Hera, 1969). The crop received normal cultivation and irrigation practices. At maturity, grain samples were taken for analysis and rheological measurements.

Moisture was determined in an air oven at 105°C and flour protein by Kjeldahl method (AOAC, 1975). Test weight of the wheat grains was expressed in terms of kg hecto $liter^{-1}$. The rheological properties of wheat flour doughs

were also measured. Water absorption of flour samples in order to produce dough of a required consistency was determined (AACC, 1962). The samples from each treatment were tested on a mixograph and the mixing time was recorded (Shuey, 1975). A standard alveograph method (System and Chopin, 1960) was employed for dough testing. Measurements made on the mean alveograph curve were : the height of the curve (T), which indicates tenacity of the douhg; the length of the curve (L), which measures extensibility of the dough; the area under the curve (S), which indicates strength of the dough, and the alveograph T/E value (elasticity) which is the ratio between measured dough tenacity (T) and the exapnsion (E). The baking quality of the wheat flour dhugh was conducted through a baking test-loaf volume, which was measured within 10 min. after removal from even (AACC, 1962).

RESULTS AND DISCUSSION

The effect of nitrogen fertilizers on the yield and protein concentration of Mexi-Pak wheat is shown in Table 1. The data revealed a consistent increase in the yield (43 to 80%) as compared to the control with the increased addition of ammonium nitrate (20-120 kg N ha^{-1}) when applied at the sowing time. Applicatlon of 60 kg N ha^{-1} in two splits (20 kg at sowing time and 40 kg at stem extension stage) showed no addeu aavantage in the yield; however, addition of 120 kg N ha^{-1} in two splits (20 kg at sowing and 100 kg at stem extension stage), significantly increased the yield (88%) over the control. Interestingly, application of 120 kg N ha^{-1} in three splits (20 kg at sowing, 50 kg at tillering and 50 kg at boot stages) resulted in the highest increase (113.9%). Like the yield data, application of increasing quantities of the N fertilizer increased the protein concentration of grains from 7.4 to 9.3%. The use of 120 kg N ha^{-1} in two splits (20 kg at sowing and 100 kg at stem extension) further raised the protein concentration to 9.8%. Although increases in the yield and protein concentration with increased levels of nitrogen application have been reported (Finney *et al.*, 1957; Terman *et al.*, 1969; Hucklessly *et al.*, 1971), significance of the increase in yield as well as protein with nitrogen application in relation to different growth stages is less known. Application of nitrogen in second split during the active vegetative stage is beneficial for the production of more number of fertile tillers which resulted in higher grain yield as compared to two split applications of nitrogen. The increase in grain yield could be the cause of lower percent protein in grain. However, the total protein production per hactare was about 32 kg higher in three split applications.

Table 1 : *Effect of nitrogen fertilizer (ammonium nitrate) on yield and protein contents of Mexi-Pak wheat.*

	Nitrogen added kg ha^{-1}						
	0	20*	60*	120*	20* + 40**	20 + 100**	20* + 50 + 50
Grain yield (kg ha^{-1})	2242a	3103b	4368e	3858cd	3387c	4004d	4520e
Increase in yield (%)	—	43.0	61.3	80.8	57.3	88.1	113.9
Protein (%)	7.4a	7.4a	8.0b	9.3cd	9.0cd	9.8d	9.4d
Increase in	—	—	0.6	1.9	1.6	2.4	2.0

*Nitrogen fertilizer applied at seeding.

**Nitrogen applied at stem extension stage.

+ Nitrogen applied at tillering stage.

+ Nitrogen applied at boot stage.

a, b, c, d : In each row, values sharing common letter are not significantly different ($P<0.05$).

Quality characteristics and the rheological behaviour of Mexi-Pak wheat flour in relation to different treatments are presented in Table 2. The results showed that there was no effect of the increased levels of fertilizer added on the moisture, and test weight. This implied that various quantities of nitrogen had no influence on the size of the kernels. Water absorption capacity of the flour slightly increased with higher doses of fertilizer. However, the mixing time generally decreased at higher doses of nitrogen. The data on loaf volume revealed that higher doses of fertilizer improved the backing quality of the flour. Application of 120 kg ha^{-1} of nitrogen in single or split doses increased the loaf volume as compared to 20 and 60 kg ha^{-1} of nitrogen; the highest loaf volume (595 cc) being when 120 kg N ha^{-1} was applied in two splits.

From the baking point of view, good quality gluten absorbs more water than the weak or poor quality gluten, and the increased fertilizer levels slightly improved the gluten quality. Triticales although contain more protein than wheats, the short development time and low absorption in the triticales suggest that they have a low concentration of gluten, which is essential for dough structure (Tsen *et al.* 1973). Mixing tolerance increases as the mixing time increases

upto about 4 min. and remains constant thereafter with longer mixing time. It is important in the selection of new varieties since wheats with mixing requirements greater than 4 min. do not have improved mixing tolerance and it consequently results in an increased production cost. The shortest mixing time and tolerance are obtained with the highest protein values. Huebner (1970) reported positive correlation between mixing and bread making quality of wheat and the quantity of glutenin in the flour.

Table 2 : *Effect of nitrogen fertilizer (ammonium nitrate) on the quality and rheological properties of Mexi-Pak wheat.*

	Nitrogen added kg ha^{-1}						
	0	20*	60*	120*	20*+40**	20*+100**	20*+50+50
Moisture (%)	16.7b	16.6b	16.4b	16.0a	16.7b	16.4b	16.5b
Test weight (kg/hectoliter)	80.8a	80.1a	79.8a	80.0a	80.7a	79.4a	80.2a
Water absorption (%)	55a	55a	56a	57a	56a	57a	57a
Mixing time (min.)	4.10cd	4.40d	4.11cd	3.20b	3.50bc	2.40a	3.10b
Loaf volume (cc)	500a	495a	535b	555c	545bc	595d	585d
Alveograph length L (mm)	33a	30a	47b	55b	69c	66c	51b
Alveograph height H (mm)	117.7cd	129.8d	112.2c	125.4d	75.9a	104.5b	112.2c
Alveograph T/E ratio	8.4b	10.4d	7.1c	7.3c	3.9a	5.5b	6.8c
Alveograph curve area-S (cm^2)	222a	239b	221a	342d	222a	222a	280c

*Nitrogen applied at seeding.

**Nitrogen applied at stem extension stage.

+Nitrogen applied at tillering stage.

++Nitrogen applied at boot stage.

a, b, c, d : In each row, values sharing common letter are not significantly different (P 0.05).

As for the values of the alveogram, it was found that the curve length (L) generally increased with higher fertilizer applications. The maximum L

being with 60 kg N ha^{-1} applied in two splits followed by that of 120 kg N/ha^{-1} (two splits). The pattern of curve height (H) and the ratio of T/E were not regular. The total area of the alveograph curve (S) generally showed an increasing trend with increased levels of fertilizer application; the maximum being 342 cm^2 when 120 kg ha^{-1} N (single dose), followed by when the seme amount was applied in two splits. It hsa been reported (Shuey, 1975) that the alveograph curve (S) generally showed an increasing trend with increased levels of fertilizer application the maximum being 342 cm^2 when 120 kgha^{-1}N (single dose), followed by when the same amount was applied in two splits. It has been reported (Shuey, 1975) that the alveograph generally shows a high correlation with protein content; the more the protein content, the higher the curve height. Besides nitrogenous compounds, the role of sugars and sugar/fat ratios on the rheology of wheat and wheat products has been reported (Olewnik and Kulp, 1984; Curley and Hoseney, 1984; Steel, 1979). Although the dough extensibility is related to loaf volume, the flour with a balanced relation between resistance to deformation (P) and extensibility (L) produces a maximum loaf volume with well proportioned interior grain structure. Since the S value is reported to have a better correlation with loaf volume than either the P or the W value of the extensogram (Kattak *et al*, 1974), present study suggests that the application of 120 kg ha^{-1} N in a single dose or in splits gives a wheat with higher protein, better loaf volume and improved rheological parameters as compared to lower doses of the fertilizer.

REFERENCES

A. A. C. C. 1962. Approved Methods. The Association; St. Paul, Minn. U. S. A.

A. O. A. C. 1970. Official Methods of Analysis 11th. Ed. The Association of Analytical chemists, Washington, D. C.

Bequette, R. K; C. A. Watson, B. S. Miller, J. A. Johnson and W. G. Schrenk. 1963. Mineral composition of gluten. starch and water soluble fractions of wheat flour and its relationship to protein quality. Agron. J. 55 : 537 542.

Curley, L. P. and R. C Hoseney. 1984. The effect of corn sweetners on cookie quali'y. Cereal Chem. 61, : 274.

E-Glindy, M. M; C. A. Lamb, and R. C. Burrell. 1957. Influence of variety, fertilizer treatment and soil on the protein content and mineral composition of wheat flour and flour fractions. Cereal Chem. 34 : 185-347.

Finney, K. F; T. W. Meyer, F. W. Smith and H. C. Fryer. 1957. Effect of foliar spraying of Pawnee wheat with urea solutions on yield, protein content and protein quality. Agron. J. 49 : 341-347.

Hera, C. 1969. Development and standardization of experimental techniques involving isotopes for conducting field experiments. Tech. Rep. IAEA-113 : 141-170.

Hucklessly, D. P; C. M. Prown, S. E. Howel and R. H. Hageman. 1971. Late spring applications of nitrogen for efficient utilization and enhanced production of grain and protein of wheat. Agron. J. 63 : 274-276.

Huebner, F. R. 1970. Comparative studies of glutenins from different classes of wheat. J. Agric. Food Chem. 18 ; 256-260.

Khattak, S; B. L. Dappolonia and O. J. Banasik. 1974. Use of the alveograph for quality evaluation of hard red spring wheat. Cereal Chem. 51 : 355-363.

Olewnik, M. C. and K. Kulp. 1984. The effect of mixing time and ingredient variation on Farinograms of cookie doughs. Cereal Chem. 61 : 532.

Shuey, W. C. 1975. Practical instruments for rheological measurements on wheat products. Cereal Chem. 52 : 42-81.

Steel, I. 1977. The search for consistency in biscuit doughs. Baking Ind. J. 9 : 21.

Syetem, Chopin, M. 1960. Instructions for using the alveograph apparatus for mechanically testing flour doughs.

Terman, G. L; R. E. Raming, A. F. Drier, and H. D. Fryer. 1969. Yield protein relationships as affected by nitrogen and water. Agron. J. 61 : 755-759.

Tsen, C. C., W. J. Hoover; and E. P. Farrell. 1973. Baking quality of triticale flours. Cereal Chem. 50 : 16-26.

Wu, K. Y. and C. E. Mc Donald. 1976. Effect of nitrogen fertilizer on nitroge fractions of wheat and flour. Cereal Chem. 53 ; 242-249.