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Effect of Nitrogen Fertilization on Yield, Technological and Rheological Characters of Wheat (*Triticum aestivum* L.)

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THIS INVESTIGATION was carried out at the Experimental Farm, Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt during 2004/2005 and 2005/2006 seasons to study the effect of nitrogen (N) fertilization (0. 25 , 50 , 75 and 100 kg N/fed) on yield and its components, milling, technological and rheological characters of wheat crop (*Triticum aestivum* L.). The data revealed that plant height, number of tillers , spikes/ m^2, spike length, number of spikelets, number of grains and yield/spike, 1000-grain weight and grain, straw and biological yields/fed as well as harvest index were significantly affected by N fertilization . Increasing nitrogen fertilization from zero up to 100 kg N/fed significantly increased also flour and fine bran, but decreased coarse bran. Protein , wet and dry gluten fractions were significantly increased with increasing nitrogen applications up to 75 kg N/fed. The highest values of total carbohydrate content and the lowest value of ash content were recorded when using 100 kg N/fed . On the other hand, the highest values for farinograph characters (water absorption percentage, dough stability time) were obtained by using 100 kg N / fed , but the highest value of dough weakness was recorded by unfertilized plants.

Keywords: Bread wheat . Nitrogen levels . Grain yield. Quality rheological properties .

Wheat *(Triticum aestivum* L.*)* is one of the important winter cereal crops in Egypt. The local production of wheat is not sufficient to meet the excessive demand resulted from the continuous increase of population. The present investigation was carried out to determine the proper nitrogen level to obtain the best characters for productivity, milling, technological and rheological characters of wheat crop. It has been reported regularly that yield and yield components of wheat were increased by increasing nitrogen fertilization (El-Nagar, 2003; Ali *et al.*, 2004; Allam, 2005 and Gafaar, 2007) . Ibrahim *et al.* (1996) and Toaima *et al.* (2000) showed that the content of flour and grain protein, water absorption fraction and dough stability time were increased by raising nitrogen fertilization up to 80 kg N/ fed. Moreover, Ibrahim *et al.* (1996) reported that

fine bran percentage was significantly increased but coarse bran percentage was significantly decreased by increasing nitrogen fertilization up to 80 kg N/fed.

Materials and Methods

The present investigation was conducted at the Experimental Farm, Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt, during 2004/05 and 2005/06 seasons. The experiment included five nitrogen fertilization levels, *i.e.* 0, 25, 50, 75 and 100 kg N/ fed (fed = 4200 m^2). The treatments were arranged in a randomized complete blocks design with four replications. Wheat grains (Gemmeiza 9 cv.) were hand drilled in fifteen rows 20 cm apart at a rate of 60 kg/fed. Calcium super phosphate (15.5% P_2O_5) was applied during soil preparation at the rate of 15.5 kg P_2O_5/fed. Sowing was done on 15th November in both seasons. Nitrogen fertilization was applied in the form of Urea (46.5%) in two equal doses before the first and second irrigations, *i.e.* 21 and 50 days after sowing . The plants were irrigated six times and the irrigation was held three weeks before harvesting. The preceding crop was maize in both seasons. The soil texture of the experiment field was clay loam. Some physical and chemical properties of the soil were performed according to Jackson (1973) and recorded in Table 1.

TABLE 1 . Mechanical and chemical properties of the experimental field soil during 2004 / 2005 and 2005 / 2006 seasons .

A- Mechanical properties.

properties / Seasons	Fine sand %	Coarse sand %	Silt %	Clay %	Texture class
2004 / 05	22.2	13.7	28.7	35.4	Clay loam
2005 / 06	25.7	6.2	36.0	32.1	Clay loam

B- Chemical properties.

properties / Seasons	pH	O.M %	Available N ppm	Available P ppm	Available K ppm
2004 / 05	7.8	2.0	25.0	7.6	414.4
2005 / 06	7.9	1.8	30.0	6.5	351.2

Characters studied

Yield and its components

Plant height, number of tillers and spikes/m^2, spike length, number of spikelets and grains/spike, 1000-grain weight, grain yield/spike, grain, straw and biological yields/fed and harvest index .

Milling characters

Flour, fine bran and coarse bran percentages were determined according to A. A. C. C. (1983).

Grain quality

1. Grain protein %: grain nitrogen percentage was determined using micro - Kjeldahl method as described by Peter &Young (1980). The crude protein percentage was obtained by multiplying the nitrogen content by 5.7 according to the method described by A.A.C.C. (1983).
2. Total carbohydrate %: Total carbohydrate percentage in the grains was measured using the method described by Dubois *et al.* (1956).
3. Ash %: it was determined according to A.A.C.C. (1983).
4. Wet gluten %: it was described by A.A.C.C. (1983).
5. Dry gluten %

Rheological properties of doughs

The rheological properties of the different doughs were carried out using Brabender Farinograph apparatus according to the method described by A.A.C.C. (1983). Farinograph properties are percentage of water absorption, dough development time (min) , dough stability time (min) and dough weakness (p.u) .

Statistical analysis

The data were statistically analyzed according to the method outlined by Snedecor & Cochran (1967). Mean of values were compared at 5 % level of probability using Duncan's multiple range test (Duncan, 1955). Means followed by the same alphabetical letter (s) are not significantly different at the level of probability (5%).

Results and Discussion

Yield and its components

Data presented in Table 2 show that plant height was significantly increased with increasing N level up to 75 kg N/fed. The differences in plant height among plants receiving either 25 or 50 kg N/fed were not significant. This was true in both growing seasons. These results mean that N application enhanced early vegetative growth by increasing number of internodes and/ or internodes length, probably resulted from the increase in the activity of meristematic tissue due to the increase in the rate of cell division and elongation. In this respect, many workers found that wheat plant height was increased by increasing N levels up to 75 or 100 kg N/fed (El- Habbasha, 2001 and Abdel-Hameed, 2005) .

TABLE 2. Effect of nitrogen fertilization on yield and yield components during 2004/ 2005 and 2005/ 2006 seasons .

Characters / N-levels (kg N/ fed)	Plant height (cm)	No. of tillers/ m^2	No. of spikes/ m^2	Spike length (cm)	No. of spikelets/ spike	No. of grains/ spike	1000 – grain weight (g)	Grain yield/ spike (g)	Grain yield/ fed (ton)	Straw yield/ fed (ton)	Biological yield/ fed (ton)	Harvest index
2004/ 2005 season												
Zero	101.70 c	266.00 e	200.00 e	8.55 d	16.20 d	43.50 c	34.9 d	1.70 e	1.630 d	4.446 d	6.076 d	0.268 d
25	111.71 b	278.72 d	252.70 d	11.65 c	20.90 c	69.55 b	45.8 c	2.60 d	2.27 0 c	4.800 c	7.070 c	0.321 c
50	112.94 b	357.50 c	337.50 c	12.00 b	22.00 b	74.30 a	48.65 b	2.81 c	2.542 b	4.909 b	7.451 b	0.341 b
75	121.10 a	376.25 b	357.50 b	12.59 a	23.00 a	74.70 a	50.50 a	3.10 b	2.730 a	4.984 a	7.714 a	0.353 a
100	121.54 a	397.00 a	371.50 a	12.62 a	24.00 a	75.45 a	50.2 a	3.25 a	2.782 a	5.076 a	7.858 a	0.354 a
2005/ 2006 season												
Zero	103.70c	266.00 e	210.00 e	9.59 d	17.50 d	45.70 c	35.10 d	1.85 e	1.650 d	4.280 d	5.930 d	0.278 d
25	114.55 b	286.00 d	263.50 d	12.35 c	22.00 c	71.90 b	47.90 c	2.70 b	2.480 c	5.200 c	7.680 c	0.322 c
50	115.60 b	361.50 c	343.75 c	12.60 b	23.30 b	76.35 a	49.22 b	2.86 b	2.765 b	5.350 b	8.115 b	0.340 b
75	123.22 a	380.00 b	362.00 b	13.36 a	24.20 b	76.80 a	51.12 a	3.20 a	2.935 a	5.350 a	8.285 a	0.354 a
100	123.75 a	411.00 a	393.50a	13.16 a	25.30 a	77.75 a	50.96 a	3.30 a	2.990 a	5.480 a	8.470 a	0.353 a

Number of tillers and spikes/m^2 showed a positive response to higher N levels. The highest number of tillers and spikes/m^2 was recorded at 100 kg N/fed which significantly differed from either control treatment (zero kg N/fed) or the other levels (25, 50 and 75 kg N/fed) in the two growing seasons. This means that N application promoted tiller formation and spikes initiation and also seemed to be important in promoting grain set through enhancing the production of spikes per unit area and the number of grains / spike . Similar results were reported by other investigators (El-Nagar, 2003; Ali *et al.,* 2004; Allam, 2005 and Gafaar, 2007).

Spike length was significantly increased with raising N levels up to 75 kg N/fed. The references indicate that spike length was increased by raising N levels up to 75 or 100 kg N/fed (Moursy, 1999; El- Habbasha, 2001 and Abdel-Hameed, 2005).

The number of spikelets/spike, 1000- grain weight and grain yield/spike were significantly increased with increasing N level up to 75 kg N/fed, while the lowest values were obtained by control treatment (unfertilized plants) in both growing seasons (Table 2) . However, number of grains/spike was significantly increased by raising N fertilization up to 50 kg N/fed. From the above results, it seems that 75 kg N/fed was sufficient for a high number of spikelets/spike which increased the number of grains through the reduction of grain abortion.

Data reveal significant differences in grain yield/fed among the various levels of nitrogen in both seasons (Table 2) . However, differences between 75 and 100 kg N/fed were not significant. It is apparent that the addition of the first 25 kg N/fed increased grain yield/fed by 25.6 and 33.2 kg grain for every kg N over the control treatment in the first and second seasons, respectively. The application of the second 25 kg N/fed increased grain yield/fed by 10. 9 and 11.4 kg grains for each kg N applied over the first 25 kg N/fed in the first and second seasons, respectively. On the other hand, the addition of the third 25 kg N/fed increased grain yield/ fed only by 7.5 and 6.8 kg grains for each kg N addition over the second 25 kg N/fed in the first and second seasons, respectively. These results clearly show that the effect of nitrogen on grain yield mainly can be attributed to the positive effect on the number of spikes/m^2, spike characters and 1000-grain weight. Many researchers concluded that wheat grain yield/ fed was increased by raising N levels up to 75 and 90 kg N/ ha (Abd El-Ghany, 1997 and Moursy, 1999, respectively).

Straw and biological yields/fed as well as harvest index were significantly increased with increasing N application up to 75 kg N/fed and remained relatively constant by increasing N level up to 100 kg N/fed in both seasons as shown in Table 2 . Similar results were reported by Abdel-Hameed (2005), Hussain *et al.* (2006) and Gafaar (2007) for straw and biological yields and by Moursy (1999) and El-Habbasha (2001) for harvest index .

Milling characters

The highest values of flour and fine bran percentages were obtained when the plants were fertilized with 100 kg N/fed (Table 3) . However, the differences between 100 and 75 kg N/fed were not significant for the two characters in both seasons. On the other hand, coarse bran percentage was significantly decreased by raising N fertilization up to 75 kg N/fed. The highest value of coarse bran was obtained by unfertilized plants in both seasons. In this respect, Toaima *et al.* (2000) reported that flour percentage was increased by raising N fertilization up to 80 kg N/fed. Moreover, Ibrahim *et al.* (1996) reported that fine bran percentage was significantly increased but coarse bran percentage was significantly decreased by increasing nitrogen fertilization up to 80 kg N/fed.

TABLE 3. Effect of nitrogen fertilization on milling characters of wheat grains during 2004/ 2005 and 2005/ 2006 seasons .

Characters / N-levels (kg N/ fed)	Flour %	Fine bran %	Coarse bran %
2004/ 2005 season			
Zero	55.5 d	7.0 d	37.5 a
25	64.0 c	8.0 c	27.3 b
50	68.5 b	8.8 b	22.8 c
75	72.0 a	9.0 a	19.0 d
100	72.4 a	9.1 a	18.5 d
2005/ 2006 season			
Zero	56.5 d	7.1 d	36.4 a
25	65.7 c	8.4 c	25.9 b
50	69.0 b	8.9 b	22.1 c
75	72.3 a	9.4 a	18.3 d
100	72.8 a	9.5 a	17.80 d

Technological characters

Protein content and its related traits (wet and dry gluten percentages) were significantly increased with increasing N application up to 75 kg N/fed (Table 4) . Further increase in N level up to 100 kg N/fed had no significant effect on these traits. However, 25 and/ or 50 kg N/fed did not significantly differ for protein content in the two growing seasons. The favorable effect of nitrogen on protein, wet and dry gluten contents might be due to macronutrient occuring in nucleic acids which are necessary for protein synthesis. Many workers reported that grain protein percentage was increased by raising N fertilization up to 80 or 100 kg N/fed (Ibrahim *et al* . 1996; El-Habbasha, 2001 and Toaima *et al.*, 2000).

TABLE 4. Effect of N fertilization on technological characters of wheat grains during 2004 / 2005 and 2005/ 2006 seasons .

Characters / N-levels (kg N/ fed)	Protein %		Wet gluten %		Dry gluten %		Ash %		Total carbohydrate (%)	
	2004/ 05	2005/ 06	2004/ 05	2005/ 06	2004/ 05	2005/ 06	2004/ 05	2005/ 06	2004 / 05	2005/ 06
Zero	9.45 c	9.81 c	20.21 d	22.42 d	8.9 d	11.38 d	1.79 a	1.80 a	50.67 e	52.17 e
25	11.78 b	11.95 b	26.52 c	29.07 c	11.7 c	11.90 c	1.76 a	1.77 a	58.12 d	58.35 d
50	12.11 b	12.53 b	27.35 b	30.90 b	12.07 b	12.55 b	1.55 b	1.60 b	61.22 c	62.22 c
75	13.28 a	13.36 a	28.77 a	32.05 a	12.87 a	13.24 a	1.50 c	1.53 c	64.76 b	64.95 b
100	13.28 a	13.57 a	28.82 a	32.31 a	12.93 a	13.46 a	1.39 d	1.43 d	69.37 a	69.95 a

In dissimilarity with protein percentage, results obtained in this study indicated that, unfertilized plants significantly exhibited a higher ash percentage followed by 25, 50, 75 and 100 kg N/fed in a descending order in the two growing seasons. However, the differences between unfertilized plants and 25 kg N/fed did not reach the level of significant in both growing seasons. In this respect, Abd El-Gawad *et al.* (1994) found that increasing N fertilization decreased ash percentage up to 75 kg N/fed. The total carbohydrate percentage of wheat grains recorded the highest value with 100 kg N/fed, while the lowest one was achieved by unfertilized plants. The increasing in total carbohydrate percentage by N application might be due to nitrogen (I) linked with carbohydrate metabolism and enhanced the transport of nitrate and (II) increased the endogenous cytokinin which accelerate carbohydrate storage (Micheal & Beringer, 1980). In this respect , Ahmed (1995) found that total carbohydrate content was increased by raising N fertilization up to 90 kg N/fed.

Rheological properties

The results presented in Table 5 and Fig. 1 reveal that the rheological characters (water absorption percentage and dough stability time) were increased, but dough weakness was decreased by increasing nitrogen fertilization levels from zero up to 100 kg N/fed. The superiority of the dough quality characters (water absorption percentage and dough stability time) and the inferiority of dough weakness obtained herein by increasing nitrogen fertilization levels may be attributed to the increase in the protein and wet and dry gluten percentages in wheat grains as shown in Table 4. However, the highest value of dough development time was obtained by nitrogen applications of 50 and 75 kg N/fed in the first season and 100 kg N/fed in the second season. Toaima *et al.* (2000) found that the highest values of water absorption percentage and dough stability time were increased by raising N fertilization up to 80 kg N/fed. On the other hand, Boehem *et al.* (2004) found that raising N fertilization from zero up to 67.2 kg N/fed increased water absorption percentage and dough development time.

TABLE 5. Effect of nitrogen fertilization on rheological properties (farinograph properties) of wheat dough during 2004/ 2005 and 2005/ 2006 seasons .

Properties / N-levels (kg N/ fed)	Water absorption (%)		Dough development time (min)		Dough stability time (min)		Dough weakness (B.U.)	
	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06
Zero	57.5	59.5	1.50	1.50	3.00	4.00	155	100
25	61.5	62.0	1.00	1.50	3.75	4.00	95	95
50	62.0	63.0	2.00	1.50	4.00	4.50	90	90
75	65.5	66.5	2.00	1.50	5.00	6.50	60	60
100	68.0	69.5	1.00	2.00	6.50	9.50	50	35

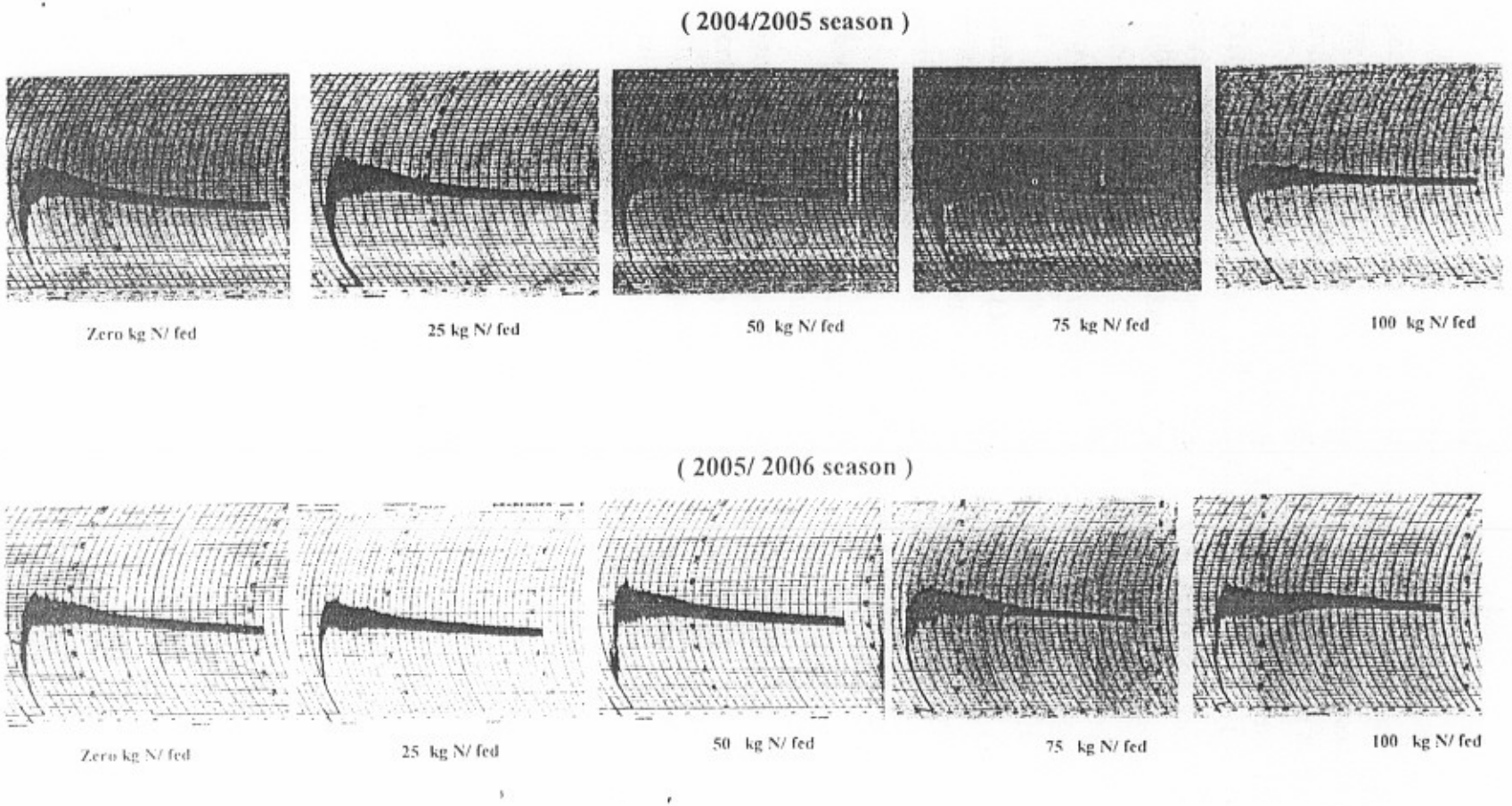

Fig.1. Effect of nitrogen fertilization on rheological properties (farinograph properties) of wheat dough during 2004/2005 and 2005/2006 seasons.

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تأثير التسميد الآزوتى علي الصفات المحصولية والتكنولوجية والريولوجية لقمح الخبز

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أجريت هذه الدراسة بمزرعة كلية الزراعة جامعة المنوفية بشبين الكوم خلال موسمي ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦ بهدف دراسة تأثير مستويات التسميد الأزوتى (صفر ، ٢٥، ٥٠ ، ٧٥ ، ١٠٠ كجم ن / فدان) على المحصول ومكوناته وصفات الطحن والصفات التكنولوجية والريولوجية لمحصول القمح (صنف جميزة ٩)

ويمكن إيجاز أهم النتائج المتحصل عليها فيما يلى :-

١- أدى زيادة التسميد الأزوتى من صفر إلى ٧٥ أو ١٠٠ كجم ن / فدان إلى زيادة معنوية فى الصفات المحصولية التى تم دراستها وهى طول النبات، عدد الفروع والسنابل / م^2 ، طول السنبلة ، عدد السنيبلات والحبوب ووزن الحبوب / سنبلة، وزن ١٠٠٠ حبة ، محصول الحبوب والقش والبيولوجي / فدان ، دليل الحصاد . هذا ولم يكن هناك فروقا معنوية بين مستويى التسميد الآزوتى ٧٥ و ١٠٠ كجم ن / فدان لمعظم هذه الصفات .

٢- تشير نتائج صفات الطحن إلى زيادة معنوية فى كل من النسبة المئوية للدقيق المستخلص والردة الناعمة بينما تشيرإلى نقص معنوى فى النسبة المئوية للردة الخشنة وذلك بزيادة التسميد الأزوتى حتى٧٥ أو ١٠٠ كجم ن / فدان خلال موسمي الزراعة .

٣- تشير نتائج الصفات التكنولوجية إلى زيادة محتوى الحبوب من البروتين والجلوتين الطرى والجاف بزيادة التسميد الأزوتى حتى٧٥ كجم ن/ فدان وإلى زيادة محتوى الحبوب من الكربوهيدرات بزيادة التسميد الأزوتى حتى ١٠٠ كجم ن / فدان .

٤- أدى تسميد النباتات بأعلى مستوى من التسميد الأزوتى (١٠٠ كجم ن / فدان) إلى زيادة فى الصفات الريولوجية المدروسة وهى نسبة امتصاص الدقيق للماء ، زمن تطور العجينة ، زمن ثبات العجينة ، مقاومة العجينة للمطاطية وذلك مقارنة بمعدلات التسميد الأزوتى الأخرى فى حين أعطت حبوب النباتات غير المسمدة أزوتيا عجينة ضعيفة عالية المطاطية .