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Quality of wheat (*Triticum aestivum*) as influenced by sowing dates and nitrogen scheduling

ANUREET KAUR[1], R K PANNU[2] and G S BUTTAR[3]

CCS Haryana Agricultural University, Hisar 125 004

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ABSTRACT

An experiment was conducted during winter (*rabi*) season of 2003–05 to find out the effect of sowing time and nitrogen scheduling on the quality of wheat at Hisar, on sandy loam soil conditions. The results revealed that delayed sowing from 15 November to 5 December and 25 December decreased the grain yield significantly during both the years, whereas protein content increased significantly with delayed sowing. The different fractions of protein in wheat grain, viz albumin, globulin and glutenin and sedimentation value were not affected significantly, however, prolamin content, wet gluten and zeleny content in grain increased significantly with delayed sowings. The hectoliter weight decreased significantly with delayed sowing. The quality of grain and fractions improved in term of increased protein content by 0.6% by the application of nitrogen over the control. Wet gluten content and zeleny increased significantly over control. There was a reduction of 15.7 kg/ha/day in grain yield when sown on 5 December than 15 November and 23.0 kg/ha/day when sown on 25 December than 15 November and 30.4 kg/ha/day from 5 December to 25 December sown wheat. There was 57.7% increase in grain yield in foliar application at anthesis over the control. The foliar application of nitrogen increased the grain yield up to 3% than soil application, but the difference in grain yield was non-significant.

Key words: Nitrogen Scheduling, Protein content, Protein fractions, Sowing time, Wheat

India is the major wheat (*Triticum aestivum* L.) producing country in the world. Sometimes the export of the grains is affected owing to its quality parameters. In the changing scenario both consumers and processors are becoming quality conscious and at global level, the quality of wheat plays an important role.

Amongst various agronomic manipulations, the time of sowing plays an important role in influencing the quality and yield of wheat. The delay in sowing of wheat crop is exposed to sub-optimal temperatures at establishment and supra-optimal temperature at reproductive phases, which leads to forced maturity coupled with reduction in grain yield. However, the higher protein yield, grain protein content, dry gluten content, beta carotene content and sedimentation index in late sown wheat have been reported by Zende *et al.* (2005). The favourable condition for rapid translocation of protein vegetative parts to grains late in the growing season seems essential for maximum grain protein content (Sardana 2003).

Various essential nutrients play pivotal role in maintaining the quality of grains. Nitrogen being the constituent of all amino acids and protein fractions has great influence on the growth and yield-attributing characters of wheat. Proteins are the most important constituent of wheat in relation to its major uses in bread making. Different protein fractions are considered responsible for the quality of grains. Glutenins and gliadins are the major components of the storage protein and make a significant contribution in dough rheology and baking quality (Panazzo and Eagles 2000). The top-dressing method of nitrogenous fertilizer application is considered as most effective in attaining higher grain protein concentration, yield and higher fertilizer-use efficiency. Therefore, the availability of nitrogen to wheat during various phases of its growth and development is an important factor influencing the yield and quality of grain. Hence, the present study was carried out to investigate the effect of sowing dates and nitrogen scheduling on the yield and quality of wheat.

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) 2003–05 at the Agronomy Research Area, CCS Haryana Agricultural University, Hisar (29°17□N 75°77□E and 215.2

Based on the complete information of Ph D thesis of the first author submitted to CCS HAU, Hisar

[1]Assistant Agronomist (e mail: anureet_1@yahoo.com), PAU, Regional Station, Bathinda. [2]Professor of Agronomy, (e mail: pannurk@hau.ernet.in) CCS, HAU, Hisar, [3]Senior Agronomist cum Director (e mail: buttargs@rediffmail.com), PAU, Regional Station, Bathinda

meters above mean sea level). The soils of the area are derived from Indo-Gangetic alluvium, which are very deep and sandy loam in texture, with *p*H 8.1, organic carbon 0.09%, EC 0.31 dS/m and available N (133 kg/ha), P (12.4 kg/ha) and K (238 kg/ha), respectively at 0–15 cm soil depth. The mean weekly maximum and minimum temperatures fluctuated between 13.2 to 39.8°C and 2.9 to 20.9°C and the total rainfall was 18.2 mm during 2003–04. The mean weekly maximum and minimum temperatures varied between 15.9 to 37.9°C and 3.4 to 16.0°C and the total rainfall was 117.9 mm during 2004–05.

The experiment was laid out in split-plot design with 3 sowing dates as main plot treatments and 7 nitrogen schedule treatments in sub-plot by growing 'PBW 343' variety. The experiment was laid out in split-plot design with 4 replications. The 3 sowing dates were, D_1 (15 November), D_2 (5 December), D_3 (25 December) and 7 methods of nitrogen scheduling were F_0 (no nitrogen), F_1 (75 kg N at sowing + 75 kg N at first irrigation), F_2 (50 kg N at sowing + 50 kg N at first irrigation + 50 kg N at anthesis), F_3 (37.5 kg N at sowing + 75 kg N at first irrigation + 37.5 kg N at anthesis), F_4 (68 kg N at sowing + 75 kg N at first irrigation + 7 kg N (3% urea spray) at anthesis), F_5 (50 kg N at sowing + 50 kg N at first irrigation + 43 kg N at anthesis + 7 kg N through 3% urea spray at milk stage), F_6 (37.5 kg N at sowing + 68 kg N at first irrigation + 37.5 kg N at anthesis + 7 kg N through 3% urea spray at milk stage) of the crop.

Protein content, moisture, starch, wet gluten and zeleny content were analyzed by Infrared 1241 Grain Analyzer. It is equipped with multigrain cell having automatically variable path length and analyzes without any demand on the operator. Proteins were fractionated into 4 classes (albumin, globulin, prolamin and glutenin) by using a modified Osborne method of step-wise extraction based on protein solubility in different solvents (Lookhard and Bean 1995). Albumins were extracted with water, globulins with 0.5 M NaCl, prolamins with 70% ethanol and glutenins with 0.5% SDS (sodium dodecyl sulphate) + 0.6% 2-mercaptaethanol in 0.1 M borate buffer (*p*H 10). Flour to solvent ratio was kept as 1 : 5. Nitrogen in each fraction was determined by the micro-kjeldhal method. For hectoliter weight, the weight of 100 ml volume of grains was determined by using an instrument developed at Directorate of Wheat Research, Karnal for determining the test weight. The sedimentation value was estimated by sodium dodecyl sulphate (SDS) test as suggested by Axford *et al*. (1979).

RESULTS AND DISCUSSION

Protein content and fractionation of proteins

The delayed sowing significantly increased the protein content (Table 1) of wheat grains. The protein content in 15 November and 5 December sowing were found at par with each other. However, one per cent higher protein content in wheat grain was recorded under delayed sowing from 15 November to 25 December. The variation in protein content can be explained by the dilution effect as the grain yield in 15 November sown crop was 24.5% higher than 25 December sown crop. This fact can further be verified from the significantly lower nitrogen content in grains of timely-sown crop. Whereas, the total nitrogen uptake was significantly higher in timely-sown crop (Table 3). Similarly, Zende *et al.* (2005) also reported 1–2% higher protein content in delayed sowing.

The different fractions of protein in wheat grains, viz albumin, globulin and glutenin were not affected significantly, whereas prolamin content increased with delayed sowing. The higher temperature prevailed in the late and very late-sown crop during grain-filling stage increased the prolamin content of wheat crop significantly and resulted in reduction of glutenin. However, the differences were statistically non-significant. The temperature above 30°C during the first 14 days after anthesis explained a significant

Table 1 Effect of sowing dates and nitrogen schedules on protein content and different fractions of protein in wheat grain (pool over 2 years)

Treatment	Protein content (%)	Albumin (%)	Globulin (%)	Prolamin (%)	Glutanin (%)
Date of sowing					
15 November	11.30	2.35	0.78	2.50	3.10
5 December	11.65	2.40	0.79	2.65	3.05
25 December	12.20	2.55	0.80	2.70	3.00
CD (*P* =0.05)	0.40	NS	NS	0.10	NS
Nitrogen schedule					
F_0	10.60	2.05	0.52	2.05	2.75
F_1	11.05	2.40	0.69	2.50	2.95
F_2	11.20	2.40	0.81	2.55	3.00
F_3	11.30	2.40	0.81	2.60	3.10
F_4	12.60	2.55	0.92	3.05	3.45
F_5	12.50	2.45	0.88	2.90	3.15
F_6	12.55	2.50	0.89	2.90	3.20
CD (*P*=0.05)	0.30	0.10	0.05	0.10	0.10

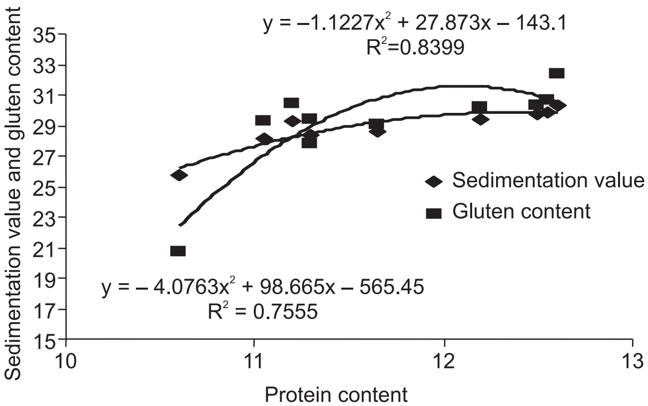

Fig 1 Relationship of protein content with sedimentation value and gluten content

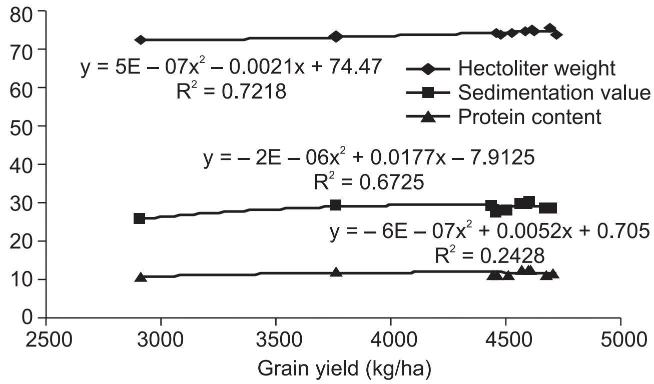

Fig 2 Relationship of grain yield with hectoliter weight, sedimentation value and protein content

proportion of increase in prolamine and to lesser extent the decrease in glutenin was also observed by Panazzo and Eagles (2000).

The quality of grain improved in term of increased protein content by 0.6% through N application over control. Triboi *et al.* (2000) also concluded that nitrogen application is the most important factor affecting protein content and its composition and further reported that it can further be increased by splits and through foliar nitrogen spray of about 1–2%. The increase in protein content was due to consistent increase in different fractions of protein. The application of 68 kg N at sowing + 75 kg N at first irrigation + 7 kg N through 3% urea spray at anthesis recorded 14% increase in protein content over recommended (F_1) schedule of nitrogen application. The protein fractions (albumin, globulin, prolamin and glutenin) increased significantly with split application of nitrogen over control (F_0). However, the treatments F_4, F_5 and F_6 were statistically at par and found significantly more effective in increasing the protein content and its fractions in grain as compared to F_1, F_2 and F_3 treatments. Similar results were also reported by Lestache *et al*. (2004). The contribution is also evident from the significant positive correlation of grain protein content with albumin content (r=0.81), globulin (r=0.85), prolamin (r=0.93) and glutenin (r=0.79). The increase in protein content may be explained by higher availability, absorption and nitrogen uptake in these treatments. Proteins are formed by different amino acids whose concentrations are higher due to higher availability of nitrogen in more nitrogen splits. Secondly, the foliar application of 3% urea at reproductive phase directly contributed to the grain protein formation and its different fractions. Nitrogen applied at heading stage markedly increased the content of prolamin while that applied at booting stage significantly increase the content of globulin and glutenin in wheat grains.

The protein content in wheat grain had a significant interaction between sowing time and nitrogen application schedules (Table 4).The protein content increased

Table 2 Effect of sowing time and nitrogen schedule on hectoliter wt, sedimentation value, moisture, starch, gluten and zeleny content in wheat grain (pool over 2 years)

Treatment	Hectoliter wt (g)	Sedimentation value (ml)	Moisture (%)	Starch (%)	Wet Gluten (%)	Zeleny (%)
Date of sowing						
15 November	75.7	28.4	9.30	65.79	27.81	36.54
5 December	73.8	28.6	9.30	64.54	29.05	40.74
25 December	73.1	29.6	9.13	65.72	30.21	41.70
CD (*P*=0.05)	1.0	NS	NS	NS	1.20	3.20
Nitrogen schedule						
F_0	72.3	25.7	9.28	65.50	20.76	22.43
F_1	73.7	28.2	9.06	65.28	29.23	40.48
F_2	74.4	29.3	9.31	65.48	30.43	46.18
F_3	74.3	28.4	9.34	65.40	29.40	41.60
F_4	74.8	30.4	9.29	65.20	32.33	42.43
F_5	74.6	29.8	9.17	65.10	30.35	45.20
F_6	74.9	29.9	9.26	65.47	30.65	42.03
CD (*P*=0.05)	0.5	0.8	NS	NS	1.02	2.93

Table 3 Effect of sowing time and nitrogen schedules on grain yield, N content and uptake of wheat (pool over 2 years)

Treatment	N content (%)		Grain yield	N uptake (kg/ha)		
	Grain	Straw	(kg/ha)	Grain	Straw	Total
Date of sowing						
15 November	1.79	0.56	4 687	84.35	43.00	127.35
5 December	1.83	0.54	4 374	80.35	38.60	118.95
25 December	1.87	0.52	3 766	70.90	33.25	104.15
CD (*P*=0.05)	0.03	NS	14 2.0	1.60	1.30	2.00
Nitrogen schedule						
F_0	1.63	0.42	2 909	47.40	21.30	68.70
F_1	1.79	0.57	4 416	79.00	41.25	120.25
F_2	1.82	0.57	4 396	80.15	41.00	121.15
F_3	1.85	0.57	4 473	82.55	41.30	123.85
F_4	1.91	0.56	4 599	87.65	40.55	128.20
F_5	1.90	0.56	4 546	86.15	40.85	127.00
F_6	1.91	0.55	4 588	87.30	40.45	127.75
CD (*P*=0.05)	0.10	0.05	2 64.0	1.80	2.40	6.00

significantly under all nitrogen schedules under very late sown conditions over timely-sown crop except under control.

Hectoliter weight and sedimentation value

The hectolitre weight (Table 2) decreased significantly with delayed sowing of the crop. The reduction in hectoliter weight may be due to forced maturity and drying of immature seeds due to higher thermal regime prevailed in late-sown crop during the time of grain filling. However, sowing time did not affect the sedimentation value of wheat grain. The hectolitre weight increased significantly in all other nitrogen schedule treatments (F_2 to F_6) over the control and F_1 treatments. This might be due to increased accumulation of photosynthates from source to sink with increased level of nitrogenous fertilizer (Singh and Agarwal 2005). The sedimentation value increased significantly in nitrogen schedule treatments (F_1 to F_6) over control (F_0) treatment. The nitrogen starvation in treatment F_0 also deteriorated the quality of wheat in terms of hectoliter weight and sedimentation value. This is also clearly reflected from significant positive correlation of grain yield with hectoliter weight (r=0.89) and sedimentation value (r=0.75). The regression analysis of protein content and sedimentation value shows that both quality parameters have significant linear positive correlation with grain yield (Fig 1). Similarly, regression analysis of grain yield with hectoliter weight showed 72% contribution towards grain yield and sedimentation value (Fig 2) contributed 67%.

Moisture, starch, zeleny and wet gluten content

Moisture percentage and starch were also not affected by sowing time. The wet gluten in wheat grain increased significantly with each successive delay in sowing from 15 November to 25 December. Whereas, zeleny content in 25 December sown crop increased significantly over 15 November and were found at par with 5 December sowing. The significant increase in wet gluten and zeleny content might be due to dilution effect in timely sown crop, whereas the grain yield was significantly higher than late (5 December) and very late (25 December) sowing.

Wet gluten content and zeleny content increased significantly over control (F_0).The maximum wet gluten and zeleny was recorded in F_4 and F_5 treatments. The wet gluten is also associated with the grain protein content as the application of 150 kg N/ha increased the percentage of wet gluten by 8–9%, which further increased by foliar spray of 3% urea to about 10%. Sip *et al.* (2000) also observed that application of nitrogen in split increased grain protein content by 1.55%, wet gluten content, zeleny and sedimentation value.

The regression analysis of grain yield and protein content (Fig 2) shows that higher grain yield and better quality in terms of protein content, hectoliter weight and sedimentation value can be increased through proper management and timely application of nitrogen. Bushuk (1985) also reported that there is strong dependence of protein content on agronomic and environmental factors during the growing season of the crop. When the nitrogen is applied in splits, crop gets continuous supply of nitrogen throughout the crop season and results in higher grain yield along with better quality.

Grain yield

The grain yield decreased significantly as the sowing was delayed from normal sowing of 15 November. The reduction of 15.7 kg/ha/day in grain yield was recorded when crop was sown on 5 December than 15 November and 23.0 kg/ha/day when the crop was sown on 25 December than 15 November and 30.4 kg/ha/day from 5 December to 25 December sown crop. The higher temperature at later stage of the crop in late-sown conditions leads to its forced maturity

Table 4 Interaction effect of sowing time and nitrogen schedules on grain yield, nitrogen-use efficiency and protein content of wheat (pool over 2 years)

Nitrogen schedule	Date of sowing		
	D_1	D_2	D_3
	Grain yield (kg/ha)		
F_0	3 173	2 840	2 715
F_1	4 854	4 481	3 912
F_2	4 838	4 489	3 865
F_3	4 893	4 649	3 878
F_4	5 017	4 741	4 040
F_5	4 926	4 701	3 962
F_6	5 055	4 718	3 992
CD (*P*=0.05)		488	
	Nitrogen-use efficiency (%)		
F_0			
F_1	27.7	27.9	19.5
F_2	27.6	28.7	19.2
F_3	27.9	29.6	19.4
F_4	29.4	30.5	21.4
F_5	29.3	30.6	20.7
F_6	30.1	30.9	21.0
CD (*P*=0.05)		2.6	
	Protein content (%)		
F_0	10.5	10.7	10.8
F_1	10.7	11.0	11.5
F_2	10.8	11.2	11.7
F_3	10.7	11.2	11.9
F_4	12.2	12.6	13.1
F_5	12.1	12.5	13.0
F_6	12.1	12.5	13.1
CD (*P*=0.05)		0.8	

and reduction in grain yield. The delay in wheat sowing by one week from the recommended time (first fortnight of November) may cause 150 kg/ha reduction in yield (Gill *et al*. 2008). The significant increase in grain yield of wheat was recorded by application of 150 kg N/ha by any nitrogen application schedule as compared to no nitrogen. There was 57.7% increase in grain yield of wheat in nitrogen application schedule (F_4) over control. The foliar application of nitrogen (F_4, F_5 and F_6) increased the grain yield up to 3% than N application in soil. However, the difference in yield was non-significant. The increased grain yield due to foliar application of N during reproductive phase may be due to better distribution and consistent availability of nitrogen to the plant throughout the crop season, which helped the plants to grow better and continuous supply of nitrogen to the grains during its development.

It may be concluded that delayed sowing from 15 November to 5 December and 25 December significantly decreased the grain yield during both the years. However, protein content increased significantly with delayed sowing. The different fractions of protein in wheat grain, viz prolamin content, wet gluten and zeleny content increased significantly. However, with delayed sowing albumin, globulin and glutenin and sedimentation value were not affected significantly. But the hectoliter weight decreased significantly with delayed sowing. The quality of grain and fractions improved in term of increased protein content by 0.6% with the application of nitrogen over the control. There was 57.7% increase in grain yield of wheat in foliar application at anthesis over the control.

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