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Physio-chemical Qualities of Wheat Varieties as Influenced by Nitrogen and Sulfur Fertilization

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Abstract: Nitrogen and sulfur supplies have a strong influence on the physio-chemical characteristics of crop as well as on the quality and quantity of wheat storage proteins, which play an important role in bread-making process. In order to evaluate the contribution of soil and foliar fertilization of nitrogen and sulfur on quality assessment of wheat, a field trail was carried out having RCB design with four replications and eight different treatments of N and S combinations allotted to plots at different growth stages. Results indicated that highest gluten content (28.35%) was recorded when the wheat crop was fertilized with treatment number-6. Likewise minimum ash contents (1.83%) and minimum electrical conductivity was observed with fertilization of treatment number-8, while control practice result low gluten contents, low standard germination %age and minimum accelerated aging germination test value. In all the recorded observations concerning the experiment wheat cultivar Pirsabaq-2005 showed appreciable response as compared with other variety. So it is possible to obtain maximum quality assessment traits of wheat grain and flour through soil and foliar application of N and S.

Key words: Wheat (*Triticum aestivum* L.), foliar N and S, soil applied N and S, quality of flour and grain

INTRODUCTION

Wheat is nature's unique gift to mankind as it produces excellent source of nutrition in terms of carbohydrates, minerals and proteins. Balanced nutrition is an essential component of nutrient management and plays a significant role in increasing crop production and its quality. For the major processes of plant development and yield formation the presence of nutrients like N, P, K, S and Mg etc in balance form are essential (Randdhawa and Arora, 2000).

N the component of protein and nucleic acid and when nitrogen is sub-optimal, growth is reduced (Haque *et al*., 2001). Likewise S is recognized as the fourth major nutrient after N, P and K. Quality of food grain is a complex phenomenon and may be influenced by several factors which may be genetic and/or environmental. N as well as S are utmost important constituents of plant proteins and are required throughout the crop growth period from vegetative stage to subsequent harvesting. Foliar fertilization, that is nutrient supplementation through leaves, is an efficient technique of fertilization which enhances the availability of nutrients. It has been observed that utilization of fertilizers especially urea applied through soil is not as effective as when it is supplied to the plants through foliage along with soil application (Mosluh *et al*., 1978).

S deficiency significantly effects the production and quality of wheat (Gyori, 2005). Without adequate S, crops can't reach their full potential in terms of yield, quality or protein content; nor can they make efficient use of applied nitrogen (Sahota, 2006). At high N fertilization levels significant responses to S fertilization were found which emphasized the need for precision application of S in intensive wheat production systems. Continued use of N fertilizer without supplemental S on low S soils will reduce flour quality (Flaete *et al*., 2005). S does not affect only N utilization and grain quality, but it also plays an important part in the formation of the baking quality (Ryant and Hrivna, 2004). Reproductive growth of wheat appears to be more sensitive to S deficiency than vegetative growth, with decreased grain size under S limiting condition. In addition to the effects of yields, the S status of wheat grain is an important parameter for the quality of wheat products (Gyori, 2005). S deficiency in crop plants has been recognized as a limiting factor not only for crop growth and seed yield but also for poor quality of products, because S is a constituent of several essential compounds such as cysteine, methionine, coenzymes etc. It was also shown that S application altered the amino acid composition with a greater proportion of S containing cysteine and methionine (Singh, 2003). Mature wheat grains contain 8-20% proteins. The gluten proteins, the gliadins and glutenins, constitute up to 80-85% of total flour proteins and confer properties of elasticity and extensibility that are essential for functionality of wheat flours (Kuktaite, 2004). The nutritional value of cereals is also determined by the proportion of containing amino acids (Katyal *et al*., 1987).

The study under report was initiated to investigate physio-chemical quality of wheat varieties as influenced by nitrogen and sulfur fertilization.

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MATERIALS AND METHODS

Site description and experimental design: Experiment was conducted at New Developmental Farm of Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan during 2008 and 2009. Soil of the experimental site is clay loam, low in nitrogen (0.03-0.04%), low in organic matter (0.8-0.9%), extractable phosphorus (6.57 mg/kg), exchangeable potassium (121 mg/kg) and alkaline in reaction with a pH of 8.0-8.2 (Amanullah *et al*., 2009). A basal dose of P (100 kg/ha) and K (60 kg/ha) was applied at sowing. Urea was applied as a source for nitrogen and ammonium sulphate was applied as a source for sulfur. In which half dose of urea and ammonium sulphate was applied at the time of sowing and the remaining half dose of both was applied at different growth stages. The experiment was laid out in RCB Design having four replications. Subplots size was 5 m x 3 m having 10 rows 5 m long and 30 cm apart. Two varieties pirsabaq-2005 and Khyber-87 were used.

Fertilizer treatments: Details of the treatments are as followed

- Control treatment
- Recommended Treatment (60 kg N/ha at sowing + 60 kg N/ha at tillering)
- Soil Applied N (60 kg N/ha at sowing + 40 kg N/ha at tillering + 10 kg N/ha anthesis +10 kg N/ha after anthesis)
- Soil + Foliar applied N [60 kg N/ha at sowing + 40 kg N/ha at tillering + 10 kg N/ha at anthesis (Foliar) +10 kg N/ha after anthesis (Foliar)]
- Soil Applied AS (15 kg S/ha at sowing + 10 kg S/ha at anthesis + 5 kg S/ha after anthesis)
- Soil + Foliar applied AS [15 kg S/ha at sowing + 10 kg S/ha at anthesis (Foliar) + 5 kg S/ha after anthesis (Foliar)]
- Soil applied N + Soil applied AS (combination of treatment number 3 + treatment number 5)
- Soil+ Foliar applied N + Soil+ Foliar applied AS (combination of treatment number 4 + treatment 6).

The determination of gluten was made on dry and wet basis in accordance with the conventions of American Association of Cereal Chemists AACC (1983). According to this method 25 g flour was weighed into porcelain cup then added to it sufficient tap water (15 ml) to form firm dough ball and worked into dough with spatula taking care that no material adhered to utensil. Dough was then put in water at room temperature for 1 h. The dough was gently kneaded in stream of tap water over a blotting cloth until all starch and soluble matter was removed. This operation took approximately 12 min. The gluten obtained by washing was left to stand in water for 1 h pressed as dry as possible between the hands rolled into ball placed in weighed flat bottom dish and weighed as most gluten. It was then transferred to oven dried to constant weight at 105°C (6 h) and cooled and weighed as dry gluten. Gluten was determined by dividing weight of wet gluten over total weight of sample and then multiplied with 100. For the determination of ash about 2 g of each of the treatment sample was taken in a dried and cleaned china dish and charred over a slow burning flame. The samples were then placed in the muffle furnace at 550°C until constant weight was obtained. The ash content was calculated on percentage basis by dividing difference of initial and final weight over total weight of the sample and then multiplied with 100. SG tests were made in accordance with the method prescribed in the rules for testing seeds (AOSA, 1986). Four replications of 100 seeds from each treatment were placed on moistened blotting paper in germination tray. The seed in the tray were covered with another moistened blotting paper and the tray was placed in incubator at 25°C for 10 days. First count was made at 7th day after incubation while final count was made at 10th day of incubation. The seedlings were evaluated as normal and abnormal seedlings and then found the germination percentage. AA test was conducted by using the "Jar" accelerated aging system proposed and described by Baskin (1976). EC test was conducted by taking sample of 50 seeds from each treatment, placed in a 250 ml flask and 200 ml of distilled water was added. The flask was stirred to removed air bubbles and floating seed, covered with aluminum foil and was kept at 20°C for 24 h. After soaking, the seeds were gently swirled and the conductivity of the soaked water was measured with a dip type cell conductivity meter. Conductivity was expressed on a weight bases in micro-siemens $cm^{-1}g^{-1}$ of seed (ISTA, Handbook of vigor test methods, 1987).

Statistical analysis: All data are presented as mean values of four replicates. Data were analyzed statistically for analysis of variance following the method described by (Gomez and Gomaz, 1984). MSTATC computer software was used to carry out statistical analysis (Russel and Eisensmith, 1983). The significance of differences among means was compared by using Least Significance Difference (LSD) test (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Data concerning gluten content is elaborated in Table 1. Data showed that significant differences were found among the mean values of different fertilizer treatment combinations. The reason may be that differences in N and S uptake and redistribution of N and S in wheat may influenced the grain protein contents and flour gluten concentrations as well as composition of dough. These results are in line with those of Moss *et al*. (1981) who proved that the metabolism of N and S are interrelated and an optimal N:S ratio in grain has been shown to

Table 1: Effect of various N and S fertilizer treatment combinations on quality assessment of two varieties of wheat

	Gluten content (%)			Ash content (%)			EC test			SG test			AA test		
	Varieties			Varieties			Varieties			Varieties			Varieties		
Fertilizer treatments	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
Control treatment (T1)	25.91^{e}	25.54^{e}	25.73^{c}	1.85	1.82	1.83	19.62^{ef}	14.83^{h}	17.22^{g}	80.0^{fgh}	98.0^{a}	89.0^{ab}	61.53	61.53	61.53^{d}
Recommended control (T2)	26.51^{d}	26.84^{d}	27.68^{b}	1.87	1.82	1.85	23.90^{b}	24.20^{b}	24.05^{a}	76.0^{h}	83.0^{efg}	79.5^{e}	61.53	61.53	61.53^{d}
Soil applied N (T3)	28.23^{ab}	28.41^{a}	28.32	1.90	1.80	1.85	21.62^{d}	19.47^{f}	20.54^{d}	85.5^{cde}	95.5^{ab}	90.5^{a}	77.00	77.00	77.00^{c}
Soil and foliar applied N (T4)	27.78^{bc}	28.47^{a}	28.12^{a}	1.90	1.82	1.86	16.47^{g}	22.80^{c}	19.63^{e}	82.5^{efg}	86.0^{cde}	84.25^{cd}	77.00	77.00	77.00^{c}
Soil applied S (T5)	28.15^{ab}	27.77^{bc}	27.96^{a}	1.87	1.82	1.85	19.62^{ef}	26.60^{a}	23.11^{b}	83.5^{ef}	81.5^{efg}	82.5^{de}	77.00	77.00	77.00^{c}
Soil and foliar applied S (T6)	28.33^{ab}	28.37^{a}	28.35^{a}	1.87	1.82	1.85	23.90^{b}	20.70^{de}	22.30^{c}	78.0^{gh}	90.5^{bc}	84.25^{cd}	84.61	77.00	78.00^{b}
Combination of T3 and T5 (T7)	28.31^{ab}	28.17^{ab}	28.24^{a}	1.87	1.85	1.86	21.62^{d}	24.20^{b}	22.91^{bc}	85.0^{def}	82.5^{efg}	83.75^{cd}	92.30	92.30	92.30^{a}
Combination of T4 and T6 (T8)	28.52^{a}	27.45^{c}	28.0^{a}	1.85	1.82	1.83	16.47^{g}	20.30^{ef}	18.38^{f}	83.5^{ef}	90.0^{cd}	86.75^{bc}	92.30	92.30	92.30^{a}
Mean	27.72	27.63	-	1.87	1.82	-	20.40	21.63	-	81.75	88.37	-	78.00	77.70	-
2008-09	27.74	27.64	27.69	1.86	1.83	1.85	20.40	21.63	21.02	81.75	88.37	85.06	78.00	77.60	78.00
2009-10	27.69	27.62	27.65	1.88	1.81	1.85	20.40	21.63	21.02	81.75	88.37	85.06	77.80	77.60	77.69
LSD															
Fertilizer Treatments	0.4102			-			0.7777			3.612			0.812		
V x F	0.5801			-			1.100			5.108			-		
Interactions	p-value														
Y x F	0.5671			0.8820			1.0000			1.0000			0.9343		
Y x V x F	0.5991			0.7193			1.0000			1.0000			0.9343		

Mean of the same category followed by different letters are significantly different ($p \geq 0.05$) using LSD test. V1 = Pir sabaq-2005, V2 = Khyber-87, Y = Year, F = Fertilizer treatments, V = Variety, LSD =Least Significant Difference, EC = Electrical Conductivity, SG = Standard Germination, AA = Accelerated Aging

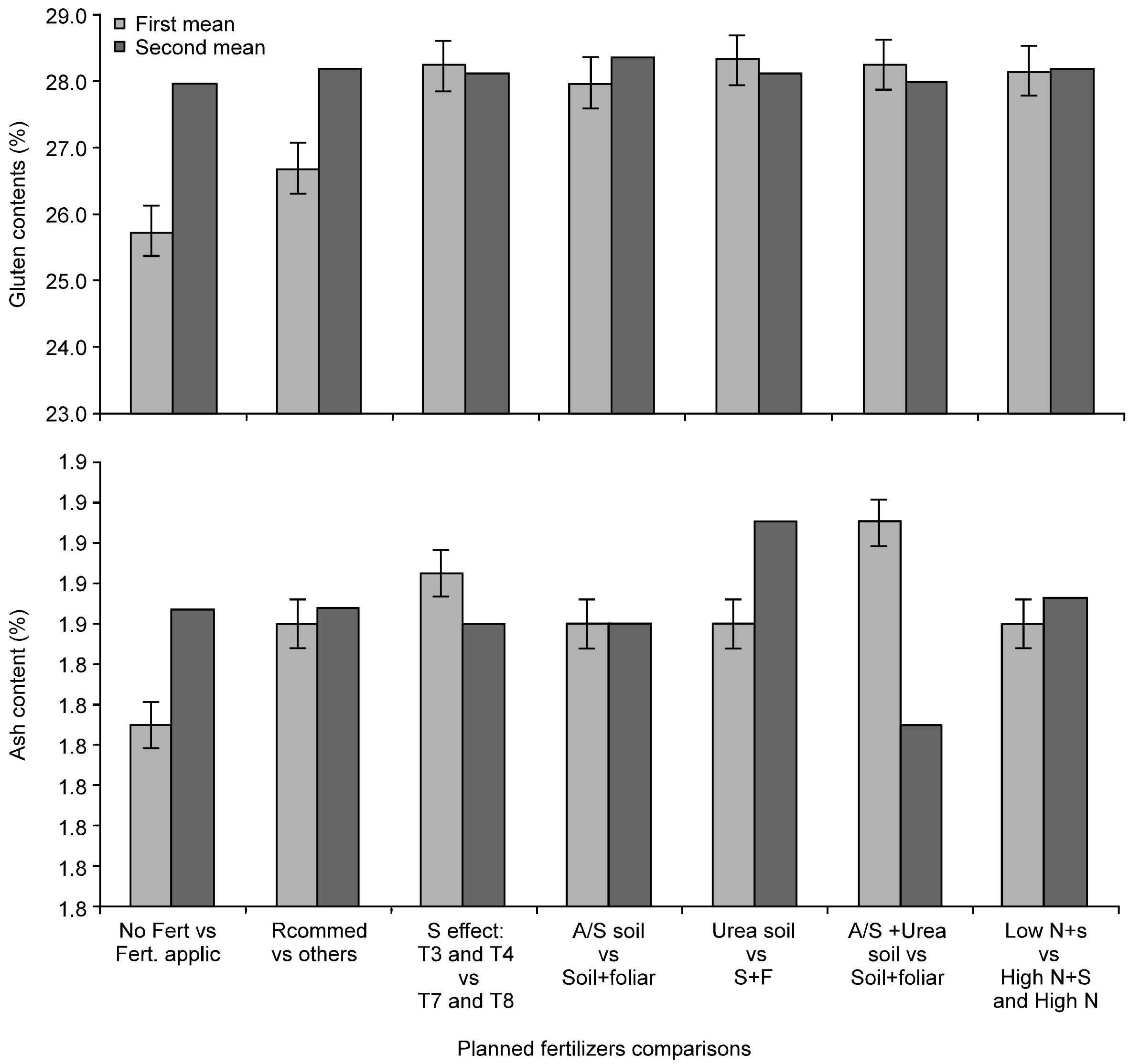

Fig. 1: Planned comparisons of fertilizer treatments of gluten content (%) and ash content (%) of two wheat varieties during 2008-09 and 2009-10

improve bread-making quality. Maximum gluten content (28.35%) was recorded in treatment number-6. While control treatment showed minimum gluten contents (25.73%). It is also observed from the data that the interaction of fertilizer treatments with both the varieties gave significant association. From the results of mean of planned comparison of the two varieties it was investigated that the comparison between no fertilizers vs. fertilizer combination as well as recommended dose vs. other fertilizers comparison found significant results (Fig. 1). The possible reason may be due to that N applied mainly as foliar spray increased the efficiency of leaves for sufficient N uptake at vegetative growth stages which further resulted improvement in the gluten contents of wheat grain. Means of planned comparison also explained that the effect of S alone treatment was also found significant (Fig. 1). It might be due the fact that S application to wheat during different growth stages increased gluten concentration and grain protein contents which in turns enhanced the extensibility of dough and improved the loaf volume of bread. These results agreed with those of Gooding and Devies (1992) who indicated that fertilizer application containing sulfur may lead to increased grain quality due to beneficial N: S ratios within the plant. Similarly the comparison of soil and foliar applied urea also proposed significant association with gluten contents of flour (Fig. 1). Data concerning ash content of wheat flour is given in Table 1. Data showed that different fertilizer treatment combinations showed non significant effect on ash content of flour. It may be due to the fact that N as well as S uptake mainly responds to protein contents in flour due to which ash content reduced. These results are in comparison with those of Podlesna and Cacak (2008) who observed that N as well as S application positively affected the quality of flour by decreasing ash content and increasing gluten and protein concentration. Data showed that the lowest ash contents were found in the treatment number-8 (Table 1). Likewise the interaction of fertilizer treatments and varieties also reported non significant effect. The concern data also explained that non significant differences were found among the means of the two varieties of wheat. Results from the means of planned comparison of two varieties on the concern data showed that all the fertilizer treatments comparisons reported non significant effect on ash content of wheat flour (Fig. 1). The data regarding EC test revealed that significant differences were found among the means of fertilizer treatment combinations on the concern parameter reported in Table 1. The maximum value of EC (24.05 μs/cm^2) was showed by recommended dose and minimum EC (17.22 μs/cm^2) of seed leachate was recorded from the seed samples of treatment number 8. The possible reason may be due to that non viable and deteriorated seeds have been reported to leak more solute when placed in water than viable and vigorous seeds. Matching results were produced by (Warriach and Basra, 2002) who proposed that the leachate of the seeds obtained from the crop fertilized with N have the minimum EC than the all other treatments. It is also evident from the data that the interaction between two varieties of wheat and fertilizer treatments reported significant association. It is depicted from the means of planned comparison of two varieties that the comparison of no fertilizer vs. fertilizer treatment as well as comparison of recommended practice vs. other treatments reported significant relationship (Table 2). It might be due to the reason that nutrients like nitrogen prevent the degradation of membranous seed structure and so the loss of seed solutes prevented. These results are in agreement with those of Warriach and Basra (2002) who suggested that the increase in EC of the seed leachates in low nitrogen caused the degradative changes in cellular membrane due to which they become “leaky” and allow the flow of solutes out of the cells resulting in decreased of reserves. Likewise the effect of sulfur alone treatment was also observed significant on the EC of the wheat seed (Table 2). It may be due to the fact that sulfur sufficient seeds have high %age of germination, lower EC of seed leachates and production of normal seedlings. These results are similar with those of Fujisaka *et al.* (1992) who reported that seeds enriched in various nutrients specifically sulfur have high vigor and low EC of seed leachates resulting in good seedlings stand. Persuals of the data concerning SG test elaborated that different fertilizer treatment combination observed significant results on SG test. Maximum germination percentage (90.5%) was recorded from seed samples fertilized with treatment number-3 reported in Table 2. The convincing reason might be that N is an integral part of chlorophyll and hence it accelerated the source sink relationship from flag leaf to grain, which resulted in proper utilization of carbohydrates to produce vigorous and viable grain and due to which the germination potential of the seed grain improved. These results fits well with those of Otteman *et al.* (2000) who concluded that the increased in germination percentage is due to N application that increased grain protein contents, grain protein yield, grain volume and weight. While minimum germination (79.5%) was showed by recommended dose applied seed samples. It was also reported from the results that the interaction between fertilizer treatments and two varieties of wheat also gave significant records (Table 1). It may be due to the fact that both N and S increased the grain protein contents when both are applied at anthsis stage of the crop growth. These results are similar with those of Wuest and Cassman (2000) who explained that N and S application at anthesis stage are more efficient to increase grain protein yield which may further help in reducing to the time 50% germination. Results also revealed that both the wheat varieties presented significant association with SG test. The data (Table 1) presented that wheat variety, Khyber-87 produced high germination (88%) as compared with other variety. It may be due to the genetic potential of the specific cultivar to produced seed with high germination capacity. The results depicted from the means of planned comparison of two varieties proposed that the comparison between no fertilizers vs. fertilizer as well as the comparison between recommended vs. others was also observed significant results (Table 2). It might be due that both N and S fertilization at various growth stages helps in the formation of large number of mature flowers which resulted in the production of bold and vigorous seed. These results are similar to those of Warriach and Basra (2002) who investigated that N fertilization produced heavier seeds with high germination percentage. Likewise from the results of means of planned comparison of two varieties explained that the effect of S alone treatment also reported significant association with SG test (Table 2). The possible reason may be that S fertilization enhanced the grain protein contents which ultimately increased the viability of seed and hence the germination efficiency also increased. These reports are in matching with those of Ortiz-Monsester *et al.* (1997) who suggested that S fertilization improve the protein contents of wheat grain which in turn reduces the mean germination time. It was also concluded from the results of the planned comparison that urea + AS soil applied vs. soil and foliar applied also showed significant observations on the

Table 2: Planned comparison showing means, difference and significance for average of two varieties of wheat

The comparison	Electrical conductivity test 1st Mean	2nd Mean	Diff./ effect	Standard germination test 1st Mean	2nd Mean	Diff./ effect	AAGT 1st Mean	2nd Mean	Diff./ effect
No fertilizer vs. fertilizer application	17.2	21.6	4.3/***	89.0	84. 5	-4.5/**	61.5	80.2	18.7/***
Recommended vs. others	24.1	21.1	-2.9/**	79.5	85.3	5.8/**	61.5	83.3	21.8/***
S effect: T3 and T4 vs. T7 and T8	20.1	20.7	0.6/ns	87.4	85.3	-2.1/**	77.0	92.3	15.3/***
AS soil vs. soil + foliar applied AS	23.1	22.3	-0.8/*	82.5	84.3	1.8/ns	77.5	83.7	6.2/***
Urea soil vs. soil + foliar applied urea	20.5	19.6	-0.9/*	90.5	84.3	-6.3/ns	77.0	77.0	0.0/***
AS + urea soil vs. soil + foliar applied	22.9	18.4	-4.5/*	83.8	86.8	3.0/***	92.3	92.3	0.0/ns
Low N + S vs. High N + S and high N	22.7	20.1	-2.3/**	83.4	86.3	2.9/ns	80.6	84.7	4.1/ns

AAGT = Accelerated Aging Germination Test

concern data. Data concerning AA test is described in Table 1. Elaboration of the data revealed that different treatments combination of fertilizer reported significant effect on the concern test. Maximum AA test value (92.3%) was observed in those seed samples to which treatment number-7 as well as treatment number-8 were applied. The improvement in germination of the aged seed during both these fertilizer treatments may be due to the maximum protein and starches development in the seed which further enhanced the vigor of the concern seed lot. Similar results were produced by Vieira *et al.* (1999) who suggested that nutrient supplementation to seed improved the age of the seed lot for efficient and long storability. While minimum AA germination value (61.53%) was reported in control practice. It was also found from the data that both the wheat varieties also showed significant effect on the concern data. The possible reason might be due to that aging of seed for long span of life depends on the genetic constitution of the specific cultivar. While the effect of the interaction between fertilizer treatments and varieties were found not significant. The observations from the means of planned comparison of the two varieties of wheat showed that no fertilizers vs. fertilizer combination as well as recommended practice vs. others comparison showed significant results. The results of the planned comparison also elaborated that the effect of S alone treatment also gave significant association with the AA germination test (Table 2). The probable reason may be due to the fact that S fertilization increased the gluten content in wheat seed as well as helped in maintain the proper range of moisture content in seed for best longevity of life. This statement suited well with those of Alsandon *et al.* (1995) who proposed that both primary and secondary nutrients enhanced the vigor of seed for aging. Similarly the comparison of soil and foliar applied urea as well as soil and foliar applied S also presented significant results.

Conclusion: This work proposed that foliar and soil application of nitrogen and sulfur at various growth stages of wheat improved the rheological properties of dough, extensibility of flour and ultimately bread making quality of wheat. The fertilization of nitrogen and sulfur at anthesis stage enhanced the gluten content as well as improved the ability of grain for best vigor, viability and strong source-sink relationship to minimize risk of leachates losses.

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