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Effect of Nitrogen on Grain Quality and Vigour in Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted to evaluate the effect of different levels of N on grain quality and vigor in wheat. Quality of grains was determined by their protein and phosphorous percentage. Nitrogen application improved grain protein and reduced phosphorous percentage. Seed vigor was determined by standard germination and electrical conductivity tests. Seeds obtained from nitrogen fertilized plots showed increased final germination percentage, while time to 50% germination (T_{50}) and mean germination time (MGT) were significantly reduced with the nitrogen application. Seeds obtained from 120 kg N ha^{-1} treatment showed more vigor during electrical conductivity test as compare to 0, 60 and 180 kg N $ha^{-1.}$

Key Words: Nitrogen; Grain quality; Vigor; Wheat

INTRODUCTION

In cereals, dry matter production depends upon source-sink relationship, where the source being the potential capacity for photosynthesis and the sink is the potential capacity to utilize the photosynthetic products. Balanced mineral nutrition is the most important for the best source-sink regulation. An adequate supply of nitrogen to the crop plants during their early growth period is very important for the initiation of leaves and florets primordia (Tisdale & Nelson, 1984). Grain yield of wheat per unit area depends upon number of Kernels per unit area and kernel weight. Grain weight is a genetically controlled trait which is greatly influenced by environmental conditions during grain filling (Kausar *et al*., 1993). Nitrogen application also increases the rate of grain filling (Langer & Liew, 1973; Whingwiri & Stern, 1982; Eichenaur *et al*., 1986). Differences in final grain weight were primarily determined by the differences in grain filling rates (Nass & Reiser, 1975) and grain filling duration (Gebeyehou *et al*., 1982). The grain filling rate and grain filling duration depends both on genetic (Wiigand & Cuellar, 1981; Mashiringwani *et al*., 1994; Mou & Kronstad, 1994) and environmental factors (Sofield *et al*., 1977; Wiegand & Cuellar, 1981; Bauer *et al*., 1985; Wheeler *et al*., 1996). Grain filling rate is dependent upon the average temperature during grain filling (Zhaq, 1986). High temperature accelerates assimilation rate and enhances movement of Photosynthates from flag leaf to spike but shorten the grain filling duration (Sofield *et al*., 1977; Bruckner & Frohberg, 1987). Nitrogen plays a very vital role in the process of grain filling (Green, 1984), increase leaf area of the crop and may result in increased dry matter production by intercepting more sun light (Wilhelm, 1998). A good supply of nitrogen also results in higher net assimilation rate (Sage & Pearcy, 1987), more productive tillers (Wilhelm, 1998), more number of spikes per unit area, number of grains per spike, biological yield and grains yield (Al-Abdulsalam, 1997). Nitrogen fertilization increase wheat protein contents (Robinson *et al*., 1979; Knowles *et al*., 1991) which is a good indicator of grain quality and vigour.

Among various constraints limiting, wheat productivity in Pakistan such as delayed sowing, lower fertilizer rate and water shortage, availability of good quality seed is a major hindrance.

Low soil nitrogen contents result in low protein content in wheat grain (Fowler *et al*., 1989). Nitrogen fertilization increases wheat protein content (Ortiz-Monasterio, 1997; Robinson *et al*., 1979; Knowles *et al*., 1991) which increases grain quality and vigour. Application of nitrogen later in the season is more effective than earlier application in increasing grain protein content (Kelley, 1995). Application of nitrogen fertilizer near anthesis is more efficient in increasing grain protein content than earlier application (Wuest & Cassman, 1992).

The objective of this experiment was to explore the role of nitrogen fertilizer application in wheat grain quality and vigor.

MATERIALS AND METHODS

The study was carried out at the Students Farm, Department of Agronomy, University of Agriculture, Faisalabad during the year 2000-2001. The treatments used in the experiment were: T_1: 0 kg N ha^{-1};T_2: 60 kg N ha^{-1} applied at sowing; T_3: 120 kg N ha^{-1} 1/2 was applied at sowing and ½ with first irrigation; T_4: 180 kg N ha^{-1} 1/3 was applied at sowing, 1/3 with first irrigation and remaining 1/3 with third irrigation.

The experiment was laid out in randomized complete block design with three replications and the net plot size was 1.5 x 6 m. Wheat variety, Auqab-2000, at a seed rate of 100 kg ha^{-1} was sown in 6 rows spaced at 30 cm in each plot. All Phosphorus in the form of Triple Supper Phosphate was also applied at recommended rate at sowing. At maturity tillers were counted a week before harvesting from a unit area (1 m^2). Grain yield was recorded after harvesting the central four rows from each plot. Grain quality and vigor was tested in the laboratory by adopting the following procedure

Grain Quality

Determination of protein (%). Total nitrogen contents of grains were estimated according to Ginning and Hibbards method of sulphuric acid. Digestion and distillation was made into saturated boric acid solution by Microkjeldahl's apparatus. The percentage of protein was calculated by multiplying the grain N content with a constant factor of 6.25 (A.O.C.S., 1989).

Determination of phosphorous (%). One gram of seed was digested in 20 mL of concentrated HNO_3 and then 10 mL of 72% $HClO_4$ was added to heat it to get colorless end point. The digestion material was cooled and transferred to 100 mL volumetric flask, and to it 5 mL each of H_2SO_4, ammonium vendate (0.25%) and ammonium molybadate (5%) were added and allowed to stand for 3 min. Reading was recorded on Backman Photometer 1211 using blue filter paper. From standard curve actual reading was calculated (Method 61, P-134.Agriculture Hand Book, US Department of Agriculture.)

Grain Vigor

Standard germination test. Germination of control and treated seeds was carried out between two layers of moist filter paper in petridishes (Ashraf *et al.,* 1999). Before sowing, seeds were surface sterilized in 10 g L^{-1} sodium hypo chlorite for 10 min, rinsed three times with distilled water, soaked in 0.7 L L^{-1} ethanol for 1 min and again rinsed three times with distilled water (Morris & Demacon, 1994). There were 10 seeds sown per dish and experiment was replicated thrice. The petridishes were covered with lids and placed in an incubator at 25^{o}C. Petridishes were monitored daily and water was applied when needed.

Electrical conductivity of seed leachates. After washing with deionized water, 5 g of wheat seeds was soaked in beakers having 10 mL of deionized water. Electrical conductivity of seed leachate was measured at room temperature after 0.5, 1, 1.5, 2, 6, 12 and 24 h of the start of the soaking (Ashraf *et al.*, 1999).

The data were analysed according to the methods described by Steel and Torrie (1984) at 1% probability level.

RESULTS AND DISCUSSION

Grain Quality

Grain protein (%). Quality of cereal grains is determined by their protein percentage. Nitrogen application to wheat crop improves grain protein percentage. The results showed that the protein percentage significantly increased with increase in N fertilization rate (Table I). There was a significant linear increase in protein percentage of grains with increase in the nitrogen fertilizer rate. The highest protein percentage was obtained from the seeds of the plots fertilized @ 180 Kg N ha^{-1}, while the lowest protein percentage was found is the seeds that were obtained from control plots.

Table I. Effect of nitrogen on grain quality in wheat

Treatments	Grain nitrogen (%)	Grain phosphorous (%)
T_1	1.49c	0.84a
T_2	1.84b	0.79a
T_3	1.92b	0.61b
T_4	2.27a	0..57b
LSD(at p=0.01)	0.09	0.09

Table II. Effect of nitrogen on grain vigor in wheat

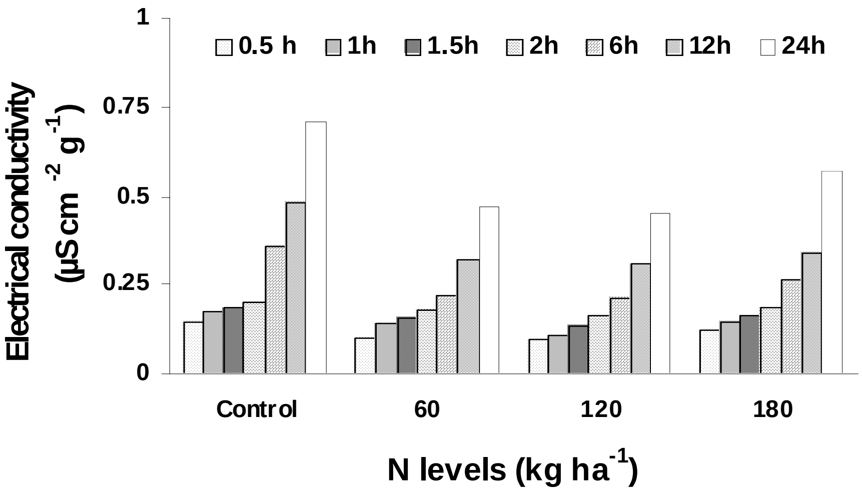
Treatments	Standard germination tests		
	Final germination (%)	T_{50} (days)	Mean germination time(days)
T_1	80c	3.00a	2.5a
T_2	90b	2.00b	2.00b
T3	100a	2.00b	2.00b
T4	100a	2.00b	2.00b
LSD(at p=.01)	2.11	0.06	0.06

Application of N late in the season is more effective compared with earlier application in increasing grain protein content (Kelley, 1995). Application of nitrogen near anthesis is more efficient in increasing grain protein content than earlier applications (Wuest & Cassman, 1992). The increase in grain protein percentage with increasing levels of nitrogen may be due to an increase in soluble proteins (Krishchenko, 1984). Nitrogen application near anthesis increased hard vitreous amber count (HVAC) which is similar to grain protein contents (Robinson *et al*., 1979).

Grain phosphorous (%). The effect of different levels of nitrogen on grain phosphorous percentage is shown in Table I. Comparison of means for grain phosphorous percentage revealed that increasing levels of nitrogen significantly reduced grain phosphorous contents .The minimum value of phosphorous percentage was observed in seeds that were obtained from 180 kg N ha^{-1} fertilized plots while the maximum phosphorous percentage was found in seeds obtained from control plots.

Nitrogen application to wheat crop reduced grain phosphorous percentage (House & Welch, 1984). Cereal grains are major source of protein, and ideal wheat cultivar should be high in grain nitrogen content but low in grain phosphorous. High grain phosphorous levels may have adverse effects on human health, because of anti-nutrient phytate which is the major storage form of phosphorous in wheat (House & Welch, 1984; Raboy *et al.,* 1991). These results are in good agreement with the findings of Dikeman *et al*. (1982), Peterson *et al*. (1983), Raboy *et al*. (1991) and Schulthess *et al*. (1997).

Fig. 1. Effect of different N levels on the electrical conductivity of seed leachates



Grain Vigor

Final germination percentage. The most important vigor evaluation test is germination percentage of seeds as it helps to achieve target plant population. Individual comparison of treatment means (Table II) shows the significant effect of different nitrogen levels on final germination percentage of wheat seeds in standard germination test. The germination percentage of seeds of those plots, which were fertilized with 60, 120, and 180 kg N ha^{-1} were statistically higher to that of control. The maximum final germination percentage (100%) was obtained from seeds of the plots that were fertilized with 120, and 180 kg N ha^{-1}.

The increase in final germination percentage may be due to nitrogen application that increased grain protein contents, grain protein yield, Hard Viterous Amber Count(HVAC), grain volume, weight and kernel size (Ottman *et al.*, 2000).

Time to 50% germination (T_{50} days). The seeds which showed less T_{50} were vigorous and able to germinate in less time. The individual comparison of treatment means (Table II) shows significant effect of different nitrogen treatments on the t_{50} of wheat seeds in standard germination tests. The time to 50% germination of seeds of those plots, which were fertilized with 60, 120, and 180 kg N ha^{-1} was statistically less to that of control. Seeds from the plots that were fertilized with nitrogen showed less t_{50}, because nitrogen application near anthesis are more efficient at increasing grain protein content (Wuest & Cassman, 1992), which may help in reducing the time to 50% germination

Mean germination time (MGT) (days). It is an important indicator of seed vigor. The seeds which show less mean germination time (MGT) are designed as more vigorous seeds and are able to germinate with less period of time. The comparison of treatment means (Table II) show significant effect of different nitrogen treatments on the mean germination time of wheat seeds in standard germination tests. The MGT of seeds of those plots, which were fertilized with 60, 120, and 180 kg N ha^{-1} was statistically less to that of control. The reduction in mean germination time with nitrogen application may be due to that nitrogen fertilization increase wheat grain protein contents. (Robinson *et al.*, 1979; Knowles *et al.*, 1991; Ortiz-Monasterio, 1997), which in turn increased the grain vigor and reduces the mean germination time.

Electrical conductivity of seed leachets (µs/cm^2). The rate of solute leakage measured by conductivity test has been widely used as vigor test. Non-viable and deteriorated seeds have been reported to leak more solute when placed in water than viable or vigorous seeds. The Fig. 1 shows the effect of different nitrogen treatments on the solute leakage of wheat seeds. The leachates of the seeds obtained from the crop fertilized @ with 120 kg N ha^{-1} had the minimum electrical conductivity than the all other treatments. Maximum EC value was recorded in control. Overall results of electrical conductivity test show that EC of the seed leachates was decreased with increase in nitrogen level upto 120 kg N ha^{-1}, after that it increased with increase in nitrogen level but less than control.

CONCLUSION

The conclusion of this experiment is that nitrogen application improves the grain quality and vigor in wheat by improving the grain protein contents. The improved protein contents increase the final germination percentage and reduced the T_{50} and Mean Germination time.

REFERENCES

Al-Abdulsalam, M.A., 1997. Influence of nitrogen fertilization rates and residual effect of organic manure rates on the growth and yield of wheat. *Arab Gulf J. Sci. Res.,* 15: 647–60.

Ashraf, M., N. Akhtar, F. Tahira, and F. Nasim, 1999. Effect of NaCl pre treatment on the germination and emergence of seven cultivars of wheat seeds. *Pakistan J. Biol. Sci.,* 2: 1594–7.

Bauer, A., A.B. Frank and A.L. Black, 1985. Estimation of spring wheat grain dry matter assimilation from air temperature. *Agric. J.,* 77: 743–52.

Bruckner, P.L. and R.C. Frohberg, 1987. Rate and duration of grain filling in spring wheat. *Crop Sci.,* 27: 451–5.

Dikeman, E., Y. Pomeranz and F.S. Lai, 1982. Minerals and proteins contents in hard red winter wheat. *Cereal Chem.,* 59: 139–42.

Eichenauer, J., C. Natt and W. Hoefner, 1986. Variability of the yield structures of spring wheat ears caused by nitrogen supply, thermoperiod and growth regulators. *Z. Pflanzen.,* 149: 147–56.

Fowler, D.B., J. Brydon, and R.J. Baker, 1989. Nitrogen fertilization of non-till winter wheat and rye-II. Influence on grain protein. *Agron. J.,* 81: 72–7.

Gebeyehou, G., D.R. Knott and R.J. Baker, 1982. Rate and duration of grain filling in durum wheat cultivars. *Crop Sci.,* 22: 337–40.

Green, C.F., 1984. Dry matter accumulation: a logical work for wheat husbandry. *Arable Farming,* 11: 26–30.

House, W.A. and R.M. Welch, 1984. Effects of naturally occurring antinutrients on the nutritive value of cereal grains, Potato tubers and legume seeds. p. 9–35. *In*: R.M. Welch and W.H. Gabelman (ed). Crops as Sources of Nutrients for Humans. ASA, CSSA, and SSSA, Madison, WI.

Kausar, K., M. Akbar, E. Rasul and A.N. Ahmad, 1993. Physiological responses of nitrogen, phosphorous and potassium on growth and yield of wheat. *Pakistan J. Agric. Res.,* 14: 2–3.

Kelley, K.W., 1995. Rate and time of N application for wheat following different crops. *J. Prod. Agric.,* 8: 339–45.

Knowles, T.C., T.A. Dooerge and M.J. Ottman, 1991. Improved nitrogen management in irrigated durum wheat using stem nitrate analysis: II.Interception of nitrate-N contents. *Agron. J.,* 83: 353–6.

Krishchenko, V.P., 1984.Changes incontents of nitrogeneous substances and composition of protein complex in spring wheat, grown at different nutritional levels. *Fiziologiya Bio-Khimiya kul, turnykh Rastenii,* 16: 360–8 (*Field Crop Absts.,* 38: 3751–81).

Langer, R.H.M. and F.K.Y. Liew, 1973. Effect of varying nitrogen supply at different stages of the reproductive phase on spikelet and grain production and on grain nitrogen in wheat. *Australian J. Agric. Res.,* 24: 647–56.

Mashiringwani, N.A., K. Mashingaidze, J. Kangai and K. Olsen, 1994. Genetic basis of grain filling rate in wheat. *Euphytica*., 76: 33–44.

Mou, B.Q. and W.E. Kronstad, 1994. Duration and rate of grain filling in selected winter wheat populations: I. Inheritance. *Crop Sci.,* 34: 833–7.

Nass, H.G. and B. Resier, 1975. Grain filling period and grain yield relationships in spring wheat. *Canadian J. Plant Sci.,* 55: 673–8.

Ortiz-Monsasterio, I.J., R.J. Pena, K.D. Sayre and S. Rajaram, 1997. CIMMYT'S genetic progression wheat grain quality under four nitrogen rates. *Crop Sci.,* 37: 892–8.

Ottman, M.J., T.A. Doergeand E.C. Martin, 2000. Durum grain quality as affected by nitrogen fertilization near anthesis and irrigation during grain fill. *Agron. J.,* 92: 1035–41.

Peterson, C.J., V.A. Johnson and P.J. Mattern, 1983.Evaluation of variation in mineral element concentration in wheat flour and bran of different cultivars. *Cereal Chem.,* 60: 450–5.

Raboy, V., M.M. Noaman, G.A. Taylor and S.G. Pickett, 1991.Grain phytic acid and protein are highly correlated in winter wheat. *Crop Sci.,* 31: 631–5.

Robinson, F.E., D.W. Cudeny, and W.F. Lehman, 1979. Nitogenferrtilizer timing, irrigation, protein and yellow berry in durum wheat. *Agron. J.,* 71: 304–8.

Sage, R.F. and R.W. Pearcy, 1987. The nitrogen use efficiency of C3 and C4 plants. *Plant Physiol.,* 84: 954–8.

Schulthess, U., B. Feil and C.J. Samuel, 1997.Yield independent variation in grain nitrogen and phosphorous concentration among Ethiopian wheat. *Agron. J.,* 89: 497–506.

Sofield, I., L.T. Evans, M.G. Cook and I.F. Wardlaw, 1977. Factors influencing the rate and duration of grain filling in wheat. *Australian J. Plant Pysiol.,* 4: 785–97.

Steel, R.G.D. and J.H. Torrie, 1984. *Principals and Procedures of Statistics,* 2^{nd} Ed., pp: 172–7. McGraw Hill Book Co. Inc., Singapore.

Tisdale, S.L. and W.L. Nelson, 1984. *Soil Fertility and Fertilizers,* 3^{rd} Ed., pp: 68–73. MacMillan Publishing Co., INC New York.

Wheeler, T.R., T.D. Hong, R.H. Ellis, G.R. Batts, J.I.L. Morison and P. Hadley, 1996. The duration and rate of grain growth and harvest index, of wheat in response to temperature and CO_2. *J. Exp. Bot.,* 47: 623–30.

Whingwiri, E.E. and W.R. Stern, 1982. Floret survival in wheat: Significance of the time of floret initiation relative to terminal spikelet formation. *J. Agric. Sci.,* 98: 257–68.

Wiegand, C.L. and J.A. Cueller, 1981. Duration of grain filing and kernel weight of wheat as affected by temperature. *Crop Sci.,* 21: 95–101.

Wilhelm, W.W., 1998. Dry matter partitioning and leaf area of winter wheat grown in a long term fallow tillage comparisons in US central great plains. *Soil and Tillage Res.,* 49: 49–56.

Wuest, S.B. and K.G. Cassman, 1992. Fertilizer-N use efficiency of irrigated wheat: I. Uptake and efficiency of pre-plant versus late season application. *Agron. J.,* 84: 682–8.

Zhaq, Q., 1986. A preliminary study on physiological characteristics of spring wheat grown in summer. II. Dry matter accumulation in ears during the grain filing period. *J. Shaanxi. Agric.Univ.,* 6: 99–108.

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