Science, Technology and Development 37 (2): 89-92, 2018
ISSN 0254-6418 / DOI: 10.3923/std.2018.89.92

Effect of Nitrogen Fertilizer Application Methods on Wheat Yield and Quality

Muhammad Sohail, Imtiaz Hussain, Sikander Khan Tanveer, Syed Haider Abbas, Maqsood Qamar, Muhammad Shahzad Ahmed and Sundas Waqar

Wheat Program, Crop Sciences Institute, National Agricultural Research Center, Islamabad 45500, Pakistan

Abstract: Nitrogen fertilizer application at different growth stages is likely to improve N use efficiency, grain quality and yield of wheat crop. Application of right N fertilizer dose at right time can help to reduce production cost and environmental pollution as well. The research work was carried out to examine the effect of nitrogen fertilizer, when applied in different combinations of split doses at sowing, tiller formation, stem elongation and grain filling. The trial was carried out in RCBD with four N fertilizer application treatments and three replications. The recommended dose of nitrogen fertilizer application (120 kg N ha^{-1}) produced significantly higher grain yield (5060 kg ha^{-1}), when it was applied in four split doses (30, 30, 30 and 30 Kg ha^{-1}) at sowing, tiller formation, stem elongation and grain filling stages, respectively (T4). Grain yield was observed minimum (3230 kg ha^{-1}), when nitrogen was applied as single basal dose (120 Kg ha^{-1}) at sowing time. The results indicate that no N fertilizer applied at tiller formation significantly ($P<0.05$) reduced numbers of spikes m^{-2} and grains per spike. Grain weight was significantly reduced when no N application was done during grain filling duration. At the same time, N application in four split doses (T4) also resulted in significantly increased ($P<0.05$) seed protein (14.9%) in comparison to treatments T3, T2 and T1. Results also showed similar trend in case of gluten content of the grain. However, no nitrogen application during grain filling stage reduced gluten content significantly. The results revealed that N fertilizer application in four split doses at sowing, tiller formation, stem elongation and grain filling stages not only enhanced grain yield but also improved grain quality.

Key words: Wheat, *Triticum aestivum* L., Nitrogen dose, Method of application, Grain yield, Protein contents.

INTRODUCTION

Wheat (*Triticum aestivum* L.) serves as the main staple food and a vital source of energy in human diet. Wheat contributes about 30% of the grain and 44% of cereal production worldwide (FAOSTAT, 2009). It also provides around 55% and 20% of carbohydrates and food calories consumed across the globe, respectively. Nitrogen fertilizer rate and time of application significantly influence wheat grain yield (Sohail *et al*., 2013) and quality (Abedi *et al.,* 2010). The estimated nitrogen use efficiency of cereal crops is about 33%, showing that nitrogen fertilizer applied is not fully consumed by the crop. Matson *et al.* (1998) and Riley *et al.* (2001) reported that the nitrogen that was not utilized by the crop may be lost to the atmosphere through a process of gaseous emission, soil denitrification, volatilization, or by leaching below the root zone. Crop usually suffers from nitrogen deficiency when it is most needed and nitrogen application at that particular stage is expected to improve N use efficiency and profitability (Mullen *et al.,* 2003). Excessive nitrogen application can be reduced by applying N fertilizer at the correct rate and at right time with financial advantage to farmer income by yield improvement (Lobell *et al*., 2004), fertilizer savings and reduction in environmental hazards (Lobell *et al.,* 2004; Christensen *et al.,* 2006).

Bread making quality of wheat heavily depends on composition of protein contents in wheat grain. Although, grain protein content is a genotypic character of wheat crop but it is greatly affected by variation in availability of nutrients to the crop (Daniel and Triboi *et al.,* 2000). Nitrogen fertilizer application is one of the main factors that affect wheat grain quality. Therefore, N fertilizer management is a key source to produce high quality wheat (Abedi *et al.,* 2010). Nitrogen application enhances flour protein contents by increasing gliadins and glutenins together (Dupont and Altenbach, 2003; Johansson *et al.,* 2004). It is reported that N fertilization at flower

Corresponding Author: Muhammad Sohail, Wheat Program, Crop Sciences Institute, National Agricultural Research Center, Islamabad 45500, Pakistan
E-mail: sohail.parc@gmail.com

initiation (near anthesis) increased protein contents effectively (Ottman *et al.,* 2000).

The objective of the research work was to observe the impact of the dose and time of nitrogen fertilizer applications on grain yield and quality of promising wheat cultivar, Pakistan 2013. Moreover, the purpose of the study was also to reduce the risk of over N fertilizer application for environmental hazards.

MATERIALS AND METHODS

A field trial was carried out during wheat growing season 2013-14 at the experimental area of National Agricultural Research Centre, Islamabad; located at longitude 73° 10′ and latitude 33° 42′. The trial was arranged in Randomized Complete Block Design, comprising four treatments and three replications. Treatments were in four different combinations of N fertilizer and were applied at different growth stages (Table 1). After land preparation, spring wheat cultivar ‘Pakistan 2013’ was planted at seeding rate of 120 kg ha^{-1} with row to row distance of 25 cm.

Table 1: Detail of treatments.

Treatments	Nitrogen Kg ha^{-1}			
	Sowing	Tiller formation	Stem elongation	Grain filling
T1	120	0	0	0
T2	60	60	0	0
T3	40	40	40	0
T4	30	30	30	30

Phosphate fertilizer was applied in the form of DAP (46% P O and 18% N)@85 kg P_2O_5 ha^{-1}. Full dose of phosphorus was incorporated in the soil at planting, while, nitrogen was applied in split doses in the form of granular urea. N fertilizer (Urea) was broadcasted and incorporated into the soil at sowing time and N applied at tiller formation and stem elongation and grain filling stages were top-dressed. Weeds were controlled, using chemical herbicides. The harvesting of crop was done in first week of May, 2014.

Data on grain yield and yield components were measured after harvest of one meter square area. Grain yield was determined by weighing total grains, after threshing one meter square harvested area. Numbers of spikes m^{-2} were determined by counting spike bearing tiller of the harvested area. 1000 grain weight was measured by counting and weighing 1000 seed samples obtained from the threshed seeds of every plot. The average number of grains $spike^{-1}$ was determined by randomly selecting 20 spikes per treatment.

Protein and gluten contents were determined by using seed samples from all four treatments and three replications. Grain samples were ground to a fine powder. Protein extraction for each treatment was done, using 100 mg of powder. Each micro tube, containing 100 mg powder, received one ml extraction buffer and centrifuged at 13000 g for 10 min at 4 °C. The concentration of protein was measured by Bradford method (Bradford, 1976). According to the standard method (AACC, 1983), flour was hand washed with 30 min of resting time and evaluated isolated drying gluten.

The data were tested for ANOVA (analysis of variance), using Statistix v. 7.0 package, while Tukey’s HSD test (Tukey, 1949) at $P \leq 0.05$ was used to compare treatment means.

RESULTS AND DISCUSSION

The results showed that nitrogen application dose and timing treatments significantly influenced ($p<0.05$) grain yield. Nitrogen application in four split doses at sowing, tiller formation, stem elongation and grain filling stages (T4) produced maximum grain yield (5060 Kg ha^{-1}) as compared to other treatments. Likewise, significant ($p<0.05$) influence of N application timings on number of $spikes^{-2}$, grains $spike^{-1}$ and 1000 seed weight was also noticed (Table 2). The crop produced higher number of $spikes^{-2}$ (337) grains $spike^{-1}$ (56) and 1000 grain weight (44 gm.) when N application was done in four split doses (T4). No application of N fertilizer at tiller formation stage significantly reduced ($p<0.05$) number of spike bearing culm. The lowest number of spike m^{-2} (280) was obtained, when no N fertilizer dose (T1) was applied at tiller formation stage (Table 2). The results claim that the number of productive tillers is set before node formation stage (Li *et al.,* 2001). It indicates that N fertilizer application at tiller formation stage has a significant effect on crop stand. Deficiency of nitrogen at stem elongation stage produced lesser number of grains per spike. No Nitrogen fertilizer application at stem elongation stages (T1 and T2) produced minimum grains $spike^{-1}$ counted as 40 and 42 gm, respectively (Table 2). The data also showed that significantly higher 1000 grain weight (44 gm) was obtained when N fertilizer dose was also applied during early grain filling period (T4), as compared to treatments with no nitrogen fertilizer application at this stage.

Table 2: Effect of nitrogen application dose and timing on wheat yield and yield components.

Treatments	Grain yield ($Kg\ ha^{-1}$)	Spikes m^{-2} (No.)	Grains spikes^{-2} (No.)	1000 grain weight (gm)
T1	3230 d	280 c	37 c	32 c
T2	4050 c	340 a	42 b	36 b
T3	4620 b	335 b	55 a	38 b
T4	5060 a	337 b	56 a	44 a

Means sharing same letter(s) do not differ significantly (p>0.05).

N application timing treatments significantly influenced ($p<0.05$) grain protein contents, while at grain filling stage (T4), they resulted in significantly higher grain protein (14.9%) contents as compared to other N application treatments. Lower protein contents of 10.1% and 12.7% were noticed in treatments with single basal N dose at sowing (T1) and in two split doses at sowing and tiller formation stages (T2) stages, respectively (Fig. 1). At the same time treatments with nitrogen application at grain filling also significantly increased ($p<0.05$) wet and dry gluten contents of the grain up to 27.1 and 8.9%, respectively, as compared to 18.6 and 3.9%, when full nitrogen dose was applied only at sowing time (Figs. 2-3). The data showed that N fertilizer application at stem elongation and grain formation growth stages contributed to an increase in kernel protein and gluten contents.

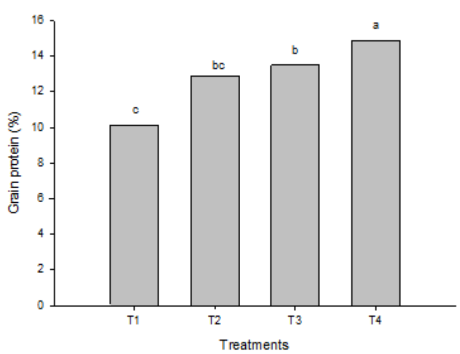

Fig. 1: Effect of nitrogen application dose and timing on wheat grain protein contents. Bar means sharing same letter(s) do not differ significantly (p>0.05).

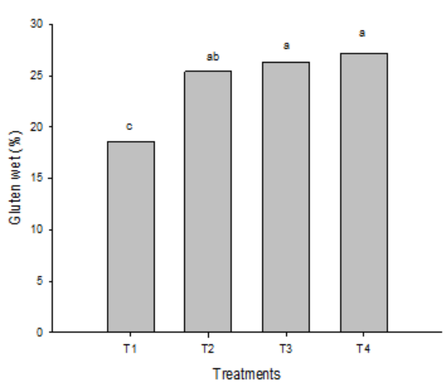

Fig. 2: Effect of nitrogen application dose and timing on wet gluten percentage of wheat grain. Bar means sharing same letter(s) do not differ significantly (p>0.05).

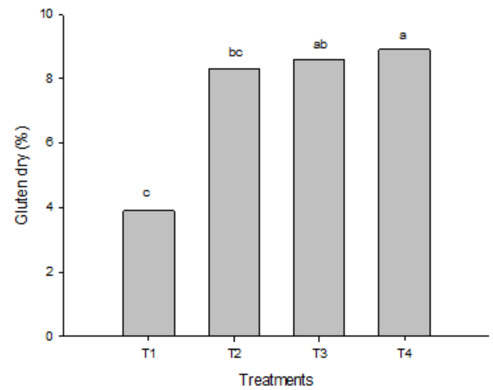

Fig. 3: Effect of nitrogen application dose and timing on dry gluten percentage of wheat grain. Bar means sharing same letter(s) do not differ significantly (p>0.05).

These results revealed that the recommended amount of N fertilizer is important, nevertheless, timing of fertilizer dose is more vital to affect grain yield and quality. Sufficient N fertilizer application during early vegetative growth stages significantly increased tiller formation in wheat crop (Sohail *et al.*, 2013); however, it did not ensure to enhance grain weight and protein contents. However, late-season N fertilizer application will be needed to improve grain protein contents. N application in split doses throughout growth period up to grain filling stage ensures well establishment of sink capacity (Mader *et al.*, 2007) by increasing nitrogen availability for cell elongation, growth, photosynthesis and metabolism (Haberle *et al.*, 2008). Results of current study showed an increased grain weight and protein contents, when N application was done during grain filling period. It may also be attributed to sufficient distribution of nitrogen to flag leaf which enhanced dry matter accumulation, healthier and increased stay-green duration (Gaju *et al.*, 2014). Moreover, appropriate N supply at right time facilitated sufficient nitrogen partitioning towards spike and grain (Pask *et al.*, 2012). A-type starch granule accumulation also increased by sufficient nitrogen availability at reproductive growth stages (Kindred *et al.*, 2008). These starch granules were a source of amylose contents that contributed towards healthy and bold grains (Wei *et al.*, 2010). Excessive N fertilizer application increased yield losses due to crop lodging and increased susceptibility to diseases, while, well distribution of N fertilizer dose up to reproductive growth stages helped to avoid these losses and enhance grain yield and quality.

CONCLUSION

Nitrogen fertilization in three to four split doses helped to improve wheat grain yield and quality. Adequate N fertilizer application during early vegetative growth stages increased tillering, mid-season enhanced grain weight while late-season N fertilizer availability improved grain protein contents.

REFERENCES

AACC, 1983. Approved methods of the AACC, 8th ed. S Paul, MN: American Association of Cereal Chemistry (Method 38-10, approved April 1961).

Abedi, T., A. Alemzadeh and S.A. Kazemeini, 2010. Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Aust. J. Crop Sci., 4: 384-389.

Bradford, M., 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal. Biochem., 72: 248-254.

Christensen, L., W.J. Riley and I. Ortiz-Monasterio, 2006. Nitrogen cycling in an irrigated system in Sonora, Mexico: measurements and modeling. Nutr. Cycl. Agroecosys., 75: 175-186.

Daniel, C. and E. Triboi, 2000. Effects of temperature and nitrogen nutrition on the grain composition of winter wheat: effects on gliadin content and composition. J. Cereal Sci., 32: 45–56.

Dupont, F.M. and S.B. Altenbach, 2003. Molecular and biochemical impacts of environmental factors on wheat grain development and protein synthesis. J. Cereal Sci., 38: 133–146.

FAOSTAT, 2009. http://www.fao.org.

Gaju, O., V. Allard, P. Martre, J.L. Gouis, D. Moreau, M. Bogard, S. Hubbart and M.J. Foulkes, 2014. Nitrogen partitioning and remobilization in relation to leaf senescence, grain yield and grain nitrogen concentration in wheat cultivars. Field Crops Res., 155: 213-223.

Grant, C.A., K.R. Brown, G.J. Racz and L.D. Bailey, 2001. Influence of source, timing and placement of nitrogen on grain yield and nitrogen removal of durum wheat under reduced and conventional tillage management. Can. J. Plant Sci., 81: 17–27.

Haberle, J., P. Svoboda and I. Raimanova, 2008. The effect of post anthesis water supply on grain nitrogen concentration and grain nitrogen yield of winter wheat. Plant Cell Environ., 54: 304-312.

Johansson, E., M.L. Prieto-Linde and G. Svensson, 2004. Influence of nitrogen application rate and timing on grain protein composition and gluten strength in Swedish wheat cultivars. J. Plant Nutr. Soil Sci., 167: 345–350.

Kindred, D.R., T.M.O. Verhoeven, R.M. Weightman, J.S. Swanston, R.C. Agu, J.M. Brosnan and R.S. Bradley, 2008. Effects of variety and fertilizer nitrogen on alcohol yield, grain yield, starch and protein content, and protein composition of winter wheat. J. Cereal Sci., 48: 46-57.

Li, C., W. Cao and T. Dai, 2001. Dynamic characteristics of floret primordium development in wheat. Field Crops Res., 71: 71–76.

Lobell, D.B., J.I. Ortiz-Monasterio and G.P. Asner, 2004. Relative importance of soil and climate variability for nitrogen management in irrigated wheat. Field Crops Res., 87: 155-165.

Mader, P., D. Hahn, D. Dubois, L. Gunst, T. Alfoldi, H. Bergmann, M. Oehme, R. Amado, H. Schneider, U. Graf, A. Velimirov, A. Fliebbach and U. Niggli, 2007. Wheat quality in organic and conventional farming: results of a 21 year field experiment. J. Sci. Food Agric., 87: 1826-1835.

Matson, P.A., R. Naylor and I. Ortiz-Monasterio, 1998. Integration of environmental, agronomic, and economic aspects of fertilizer management. Science, 280: 112-115.

Mullen, R.W., K.W. Freeman, W.R. Raun, G.V. Johnson, M.L. Stone and J.B. Solie, 2003. Identifying an in-season response index and the potential to increase wheat yield with nitrogen. Agron. J., 95: 347–351

Ottman, M.J., T.A. Doerge and E.C. Martin, 2000. Durum grain quality as affected by nitrogen fertilization near anthesis and irrigation during grain fill. Agron. J., 92: 1035–1041.

Pask, A.J.D., R.S. Bradleyb, P.D. Jamiesonc and M. J. Foulkes, 2012. Quantifying how winter wheat crops accumulate and use nitrogen reserves during growth. Field Crops Res., 126: 104-118.

Riley, W.J., I. Ortiz-Monasterio and P.A. Matson, 2001. Nitrogen leaching and soil nitrate, and ammonium levels in an irrigated wheat system in northern Mexico. Nutr. Cycl. Agroecosys., 61: 223-236.

Sohail, M., I. Hussain, Riaz-ud-Din, S.H. Abbas, M. Qamar and M. Noman, 2013. Effect of split N fertilizer application on physioagronomic traits of wheat (*Triticum aestivum* L.) under rainfed conditions. Pakistan J. Agric. Res., 26(2): 71-78.

Tukey, J., 1949. Comparing individual means in the analysis of variance. Biometrics. 5(2): 99–114.

Wei, C.X., J. Zhang, Y.F. Chen, W.D. Zhou, B. Xu, Y.P. Wang and J.M. Chen, 2010. Physicochemical properties and development of wheat large and small starch granules during endosperm development. Acta Physiol. Plantarum, 32: 905-916.