Pak. J. Bot., 41(3): 1197-1204, 2009.

RESPONSE OF WHEAT TO FOLIAR AND SOIL APPLICATION OF UREA AT DIFFERENT GROWTH STAGES

PARVEZ KHAN*, MUHAMMAD YOUSUF MEMON, MUHAMMAD IMTIAZ AND MUHAMMAD ASLAM

*Soil Science Division,
Nuclear Institute of Agriculture, Tando Jam -70060, Pakistan.

Abstract

A field experiment was conducted to evaluate the effect of foliar application of urea applied in different concentrations and at different stages on yield and yield components of wheat (*Triticum aestivum* L) *cv*. "Kiran-95" under agro-climatic condition of Sindh. The experiment was laid out according to randomized complete block design having two factors with four repeats. Six concentrations of urea i.e., 0, 2, 4, 6, 8 and 10% as foliar application along with 60 and 120 kg N ha^{-1} were applied as soil application. The results revealed that foliar application of urea significantly increased plant height, spike length, number of grains $spike^{-1}$, hundred grain weight, biological yield, grain yield and N uptake by the crop. The foliar spray of 4% urea solution was found to be most effective for enhancing the quantitative and qualitative traits when sprayed at tillering, stem elongation and boot stage. The grain yield was increased by 32% when 4% urea solution was applied as foliar spray. Further increase in the concentrations of urea spray was not found to be useful and economical as it declined the grain yield by 25% or even more probably due to its toxicity.

Introduction

The role of macro and micro nutrients is crucial in crop nutrition for achieving higher yields (Raun & Johnson, 1999). The soils of Pakistan are deficient in nitrogen and are supplemented with chemical fertilizer for enhancing the crop productivity. Nitrogenous fertilizers play a vital role in modern farm technology, however only 20-50% of the soil applied nitrogen is recovered by the annual crops (Bajwa, 1992). The left over nitrogen is lost from the soil system through denitrification, volatilization and leaching. The partial and in-efficient use of nitrogen results in lower crop harvests. Moreover, fertilizers are energy intensive to produce and are very expensive. The present price hike of fertilizers is one of the main constraints to increase the economic yield of crops. Thus efforts are needed to minimize its losses and to enhance its economic use. 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 plant through foliage along with soil application (Mosluh *et al.*, 1978). It also ensures the ample availability of nutrients to crops for obtaining higher yield (Arif *et al.*, 2006). Several researchers justified the idea that nutrients (like N) may be taken up through roots and leaves and may spread within the plant (Ahmed & Ahmed, 2005; Hassanein, 2001). The efficiency of N assimilation through foliage, however, depends upon several factors including varieties or genotypes. The study under report was initiated to investigate the efficiency of foliar application of urea for yield and yield components of wheat when applied at different growth stages.

*Corresponding author E-mail: parvez_08@yahoo.com; Telephone No. 022-3880868, 2765750

Materials and Methods

A field study was conducted at NIA, Experimental Farm during 2004-05 to evaluate the effect of foliar application of urea on yield and yield components of wheat genotype "Kiran-95". The experimental site was silty clay in texture, non-saline (ECe, 0.88 dS m^{-1}), low in organic matter (0.81%), Kjeldahl N (0.046 %) and Olsen's P (6.8 mg kg^{-1}). The experiment was laid out in randomized complete block design having two factors with four replications. The basal dose of phosphorus @ 90 kg ha^{-1} and nitrogen @ 60 and 120 kg ha^{-1} was applied at the time of sowing. Foliar spray of urea at concentrations 0, 2, 4, 6, 8, 10% was prepared by the addition of urea fertilizer in water (w/v) and a surfactant tween-80 was mixed @ 0.1% v/v (1 ml/ 1 liter) with the solution to increase adhesion of solution with plant foliage. The required quantity of foliar spray of urea in formulated concentrations was applied to crop at tillering, stem elongation and boot stage according to the respective protocol of the treatment. The control treatment was sprayed with sole water. Leaf samples were collected to determine N at tillering, stem elongation and boot stage after 24, 48 and 72 hour of spray. The data were recorded for yield and yield parameters at maturity. After harvesting the crop, plant samples were collected randomly from each treatment for grain and straw. Both of these plant parts were dried at 70 ^{o}C for 48 hours in forced draft oven. A uniform sub portion of the dried material was ground in Wiley's mill and a known quantity of the ground material was digested by modified Kjeldahl's method in which N is converted in NH_4^+ form by digestion with H_2SO_4. The NH_3 is distilled into boric acid and determined by titration with standard H_2SO_4 (Jackson, 1979). The results obtained were subjected to statistical analysis using standard method of analysis (Steel *et al.*, 1997). The differences among the treatment means were compared by using Duncan Multiple Range test (Duncan, 1970).

Results and Discussion

Nitrogen concentration at different stages: The data regarding N concentrations in plant at tillering stage have been shown in Table 1. It is obvious from the data that N concentration within the plant leaves increased by increasing N concentration either in soil or by foliar applications. The maximum N concentration in leaves after 72 hours was recorded when 10% urea spray was applied which was 5.67%. The N concentration in plant leaves was 5.61% after 48 hours and 5.57% after 24 hours at said level of foliar application. Minimum absorption of N was noted in plants when sprayed only with water having no urea. Soil application however, showed marginal increasing trend for N in plant when N application was raised from 60 to 120 kg N ha^{-1}. The higher N concentrations reflect the higher absorption of NH_4^+ ions when the urea spray concentrations were increased from 2 to 10%. These results are in line with Altman *et al.*, (1983) who also reported increase in N concentration in plant leaves with the increase of urea spray in wheat. Similar trend was noted at stem elongation and boot stages (Tables 2 & 3). At stem elongation stage, the absorption of N was higher after 48 hours which again declined after 72 hours. However, increasing N trend in plant was similar to that in tillering stage. The maximum N concentration of 6.05% was found at stem elongation stage after 48 hours in the leaves of plants when supplied with 10% urea spray. These results are in agreement with the result of those of Vagen, (2003) in broccoli.

Table 1. Effect of foliar spray and soil application of urea on nitrogen concentration at tillering stage.

Treatments (Urea spray)	N concentration (%) after 24 hours			N concentration (%) after 48 hours			N concentration (%) after 72 hours		
	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean
	60	120		60	120		60	120	
Control	4.27 c	4.20 c	4.24 c	4.16 c	4.23 c	4.20 c	4.19 c	4.23 c	4.21 d
2%	5.04 b	5.23 ab	5.14 b	5.23 b	5.26 b	5.24 b	5.19 b	5.36 ab	5.28 c
4%	5.04 b	5.29 ab	5.16 ab	5.34 b	5.36 b	5.35 ab	5.36 ab	5.42 ab	5.39 bc
6%	5.14 b	5.44 ab	5.29 ab	5.47 ab	5.48 ab	5.48 ab	5.45 ab	5.49 ab	5.47 abc
8%	5.34 ab	5.50 ab	5.42 a	5.49 a	5.52 a	5.50 a	5.49 ab	5.61 a	5.55 ab
10%	5.63 a	5.51 ab	5.57 a	5.55 a	5.64 a	5.61 a	5.63 a	5.71a	5.67 a

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 2. Effect of foliar spray and soil application of urea on nitrogen concentration at stem elongation stage.

Treatments (Urea spray)	N concentration (%) after 24 hours			N concentration (%) after 48 hours			N concentration (%) after 72 hours		
	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean
	60	120		60	120		60	120	
Control	4.05 e	4.38 cd	4.21 c	4.15 e	4.35 e	4.25 d	4.11 d	4.42 c	4.26 c
2%	4.23 de	4.66 bc	4.44 bc	5.02 d	5.33 cd	5.17 c	5.13 c	5.42 ab	5.27 b
4%	4.31 cd	4.74 bc	4.52 bc	5.25 cd	5.32 cd	5.28 c	5.37 b	5.56 ab	5.46 ab
6%	4.24 de	4.99 ab	4.61 b	5.16 d	5.72 abc	5.44 bc	5.49 ab	5.75 ab	5.62 ab
8%	5.01 ab	5.34 a	5.18 a	5.44 bcd	5.86 ab	5.65 b	5.58 ab	5.67 ab	5.62 ab
10%	5.32 a	5.44 a	5.38 a	6.05 a	6.01 a	6.03 a	5.71 ab	5.80 a	5.75 a

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 3. Effect of foliar spray and soil application of urea on nitrogen concentration at boot stage.

Treatments (Urea spray)	N concentration (%) after 24 hours			N concentration (%) after 48 hours			N concentration (%) after 72 hours		
	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean
	60	120		60	120		60	120	
Control	4.10 de	4.22 cd	4.16 c	4.14 g	4.21fg	4.18 e	4.13 f	4.22 ef	4.17 d
2%	4.11 de	4.33 b-e	4.22 c	4.18 fg	4.33 efg	4.26 de	4.18 ef	4.35 def	4.26 cd
4%	4.05 e	4.53 a-e	4.29 bc	4.39 d-g	4.53 d-f	4.46 cd	4.41 c-f	4.58 bcd	4.50 bc
6%	4.88 abc	4.67 a-e	4.77 ab	4.50 c-g	4.74 a-d	4.62 bc	4.52 cde	4.77 abc	4.65 ab
8%	4.88 abc	4.75 a-d	4.81 a	4.67 a-c	4.88 ab	4.78 ab	4.54 cde	4.90 ab	4.72 ab
10%	5.22 a	5.00 ab	5.11 a	4.81 abc	5.02 a	4.92 a	4.60 bcd	5.08 a	4.84 a

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 4. Effect of foliar spray of urea on plant height and spike length of wheat.

Treatments (Urea spray)	Plant height (cm)			Spike length (cm)		
	N level (kg ha $^{-1}$)		Mean	N level (kg ha $^{-1}$)		Mean
	60	120		60	120	
Control	65.2 c	74.7 b	70.0 b	9.8 c	10.9 ab	10.3 b
2%	80.4 ab	83.3 a	81.9 a	10.4 abc	10.5 abc	10.5 ab
4%	85.3 a	86.9 a	86.1 a	10.9 ab	11.2 a	11.1 a
6%	85.2 a	85.8 a	85.5 a	10.8 ab	11.1 a	11.0 ab
8%	81.2 ab	84.5 a	82.9 a	10.8 ab	11.1 a	11.0 ab
10%	85.3 a	85.6 a	85.4 a	10.2 bc	10.7 ab	10.5 ab

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 5. Effect of foliar spray of urea on numbers of grain spike and 100 grain weight of wheat.

Treatments (Urea spray)	Numbers of grain spike			100 grain weight (g)		
	N level (kg ha $^{-1}$)		Mean	N level (kg ha $^{-1}$)		Mean
	60	120		60	120	
Control	48.0 b	48.3 b	48.1 b	3.45 d	3.54 d	3.49 c
2%	65.4 a	67.7 a	66.5 a	4.07 c	4.20 bc	4.14 b
4%	66.7 a	68.3 a	67.5 a	4.31 abc	4.55 a	4.42 a
6%	65.9 a	67.8 a	66.8 a	4.14 bc	4.57 a	4.35 a
8%	65.6 a	66.3 a	65.9 a	4.14 bc	4.51 a	4.32 ab
10%	65.7 a	65.9 a	65.8 a	4.11 c	4.43 ab	4.27 ab

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Plant height and spike length: The data revealed that foliar application of urea resulted in a significant increase in plant height (Table 4). Maximum plant height of 86.9 cm was recorded where 4% urea solution was sprayed while the minimum plant height of 65.2 cm was recorded in control (water spray). The data on spike length revealed significant increase with foliar application of urea (Table 4). Maximum spike length of 11.2 cm was produced by 4% urea spray, while minimum spike length was recorded by control (water spray). These results are in agreement with those of Alston (1979) who reported better vegetative growth of wheat with foliar application of N. Similarly, (Soylu *et al*., 2005; Kenbaev & Sade (2002) and Arif *et al.,* (2006) reported significant increase in plant height of wheat crop with foliar application of different nutrients individually or in combination.

Number of grains per spike and 100-grain weight: The data revealed significant effect of foliar application of urea on number of grains per spike (Table 5). Number of grains spike^{-1} increased significantly in all the urea sprayed treatments as compared to sole water supply treatments, whereas differences among fertilizer treatments were at par to each other. Gooding & Devies (1992) reported better performance of wheat crop for foliar application of N. Similarly, Seth & Mosluh (1981) reported marked increase in number of grains per spike of wheat when urea was applied as foliar spray.

In case of 100 grain yield the analysis of the data revealed that foliar application of urea solution resulted a significant increase in hundred grain weight (Table 5). The foliar spray of 4% urea solution yielded heavier grains (4.42g) followed by 6% urea spray (4.35g), while control (water spray) produced grains with lesser weight (3.49g). This may be due to the provision of N through urea spray at later growth stages which might have enhanced accumulation of assimilates in the grains and thus resulting in heavier grains of wheat. These results are in line with Soylu *et al*., (2005) and Guenis *et al*., (2003) who reported significant increase in thousand grains weight with foliar application of nutrients.

Table 6. Effect of foliar spray of urea on yield of wheat.

Treatments (Urea spray)	Biological yield (ton ha^{-1})			Grain yield (ton ha^{-1})		
	N level (kg ha^{-1})		Mean	N level (kg ha^{-1})		Mean
	60	120		60	120	
Control	8.13 d	12.08 abc	10.10 c	3.18 f	3.91 ef	3.54 d
2%	11.78 bc	12.89 ab	12.34 b	4.01 cdef	4.84 abcd	4.43 bc
4%	13.52 a	13.75 a	13.63 a	4. 90 abc	5.73 a	5.31 a
6%	12.16 abc	13.03 ab	12.60 ab	4.22 bcde	5.15 ab	4.68 ab
8%	11.77 bc	12.29 abc	12.03 b	4.04 cdef	4.01 cdef	4.02 bcd
10%	10.94 c	12.08 abc	11.51 b	4.01 cdef	3.96 def	3.99 cd

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Crop harvest: The data on biological yield revealed significant increase with foliar application of urea (Table 6). Maximum biological yield was produced by 4% urea spray (13.75 ton ha^{-1}) followed by 6% urea spray (13.03 ton ha^{-1}), while minimum biological yield was recorded in control treatment (water spray) (8.13 ton ha^{-1}). These results are in line with those of Alston, (1979) who reported better vegetative growth with foliar application of N. Soleimani (2006) also reported increase in biological yield of wheat by foliar application of zinc.

The grain yield also increased significantly with foliar application of urea (Table 6). Maximum grain yield was produced by 4% urea spray (5.73 ton ha^{-1}), while minimum grain yield was produced in control (3.18 ton ha^{-1}). All sprays were found beneficial as compared to control (water spray) at both levels of N application in soil. The results are in conformity with Alston (1979) who reported increased straw yield with foliar application of N. Kolota & Osinska (2001) concluded that a multi-component foliar fertilizer containing N significantly increased the yield of cabbage. The high efficiency of foliar urea application found in this study is in agreement with the findings of Zahran & Abdoh (1998) for onion and Zeidan (2003) for faba bean.

Nitrogen uptake: The enhanced yield of a crop is often associated with optimum nutrient uptake particularly N. It has been observed that integrated application of N through soil and foliage facilitated the higher N uptake in plants. There was a substantial increase in N uptake in plants sprayed with urea as compared with control. Average N uptake of 149.9 kg ha^{-1} was observed in the treatment where 6% urea solution was sprayed at tillering, stem elongation and boot stage, which was significantly higher than all other treatments (Table 7). The higher concentration of urea (10%) significantly reduced N uptake which may be due to phyto-toxicity of urea and leaves could not function properly thus the additional N uptake was hindered (Vagen, 2003).

Conclusion

Foliar application of urea increased the productivity and quality of crops and the N fertilizer efficiency can be increased with foliar application it can be safely concluded that 4% foliar application of urea enhanced yield and yield parameters of wheat.

Table 7. Effect of foliar spray of urea on N uptake (kg ha^{-1}).

Treatments (Urea spray)	N uptake in Grain N level (kg ha^{-1})			N uptake in straw N level (kg ha^{-1})			Total N uptake N level (kg ha^{-1})		
	60	120	Mean	60	120	Mean	60	120	Mean
Control	53.8 e	69.2 de	61.5 c	10.0 g	17.9 fg	14.0d	63.8 f	87.1 ef	75.5 d
2%	78.7 cde	102.9 bc	90.8 b	18.2 fg	21.8 def	20.0 cd	96.8 de	124.7 bc	110.8 c
4%	88.2 cd	118.6 ab	103.4a	18.5 efg	25.3 c-f	21.9 c	106.7 cde	143.9 ab	125.3 bc
6%	106.0 bc	134.0 a	120.0a	28.5 bcd	31.3 bc	29.9 b	134.5 bc	165.3 a	149.9a
8%	94.9 bcd	94.4 bcd	94.4 b	27.1 cde	32.4 bc	29.7 b	121.4bcd	126.7 bc	124.1 bc
10%	94.9 bcd	95.9 bcd	95.4 b	36.5 ab	41.4 a	38.9 a	131.3 bc	137.3 ab	134.3 ab

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

References

Ahmed, M.A. and M. K.A. Ahmed. 2005. Growth and productivity of wheat plants as affected by complete foliar fertilizer compound under water stress conditions in newly cultivated sandy land. *Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo*, 13 : 269-284.

Alston, A. M. 1979. Effects of soil water content and foliar fertilization with nitrogen and phosphorus in late seasons on the yield and composition of wheat. *Aus. J. Exper. Agric*., 30(4): 577-585.

Altman, D. W., W. L. McCuistion and W. E. Kronstad. 1983. Grain protein percentage, kernel hardness, and grain yield of winter wheat with foliar applied urea. *Agron. J*., 75:87-91.

Arif, M., M. A. Chohan, S. Ali, R. Gul and S. Khan. 2006. Response of wheat to foliar application of nutrients. *J. Agric. and Bio. Sci*., 1(4): 30-34.

Bajwa, M. I. 1992. Soil fertility management for sustainable agriculture. *Proc. 3rd National Congress of Soil Science, held at Lahore from 20th to 22nd March 1990*. pp: 7-25.

Duncan, D.B. 1970. Multiple range and Multiple F. tests. *Biometrics*, 11:1-42.

Gooding, M. J. and W.P. Devies. 1992. Foliar urea fertilization of cereals. *Nutrient Cycling in Agroecosystems*. 32: 209-222.

Guenis, A., M. Alpaslan and A. Unal. 2003. Effects of boron fertilization on the yield and some yield components of bread and durum wheat. *Turk. J. Agric*., 27: 329-335.

Hassanein, M.S. 2001. Effect of variety and nitrogen levels on growth, yield and yield components of wheat (*Triticum aestivum* L.) in newly cultivated land. *Egypt. J. Agron.*, 23, 111-131.

Jackson, M. L. 1979. *Soil Chemical Analysis: Advanced course*. 2nd Ed. Department of Soil Science, University of Wisconsin, Madison, USA.

Kenbaev, B. and B. Sade. 2002. Response of field-grown barley cultivars grown on zinc-deficient soil to zinc application. *Comm. Soil Sci. Plant Anal*., 33(3-4): 533-544.

Kolota, E. and M. Osinska. 2002. Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. In: *Proc. IC Environ. Probl. N-Fert. Acta. Hort*., 563: 87-91.

Mosluh, K. I., J. Seth and A.K.K. Rashid. 1978. Efficacy of urea spray for wheat crop under irrigated conditions on Iraq. *Plant and Soil*, 49: 175-178.

Raun, W. R. and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. *Agron. J*., 91: 357-363.

Seth, J. and K. I. Mosluh. 1981. Effect of urea spray on wheat in Iraq. *Expl. Agric*., 17: 333 -336.

Soleimani, R. 2006. The effects of integrated application of micronutrient on wheat in low organic carbon conditions of alkaline soils of western Iran, *18th World Congress of Soil Sci*., pp. 22.

Soylu, S., B. Sade, A. Topal, N. Akgun and S. Gezgin. 2005. Responses of irrigated durum and bread wheat cultivars to boron application in low boron calcareous soil. *Turk. J. Agric*., 29: 275-286.

Steel, R.G.D., J.H. Torrie and D. Dickey. 1997. *Principles and Procedures of Statistics: A biometrical approach*. 3rd Ed. McGraw-Hill Book Co., New York, USA.

Vagen, I .M. 2003. Nitrogen uptake in a broccoli crop. 1. Nitrogen dynamics on a relative time scale. In: *Proc. XXVI IHC-Fertil. Strateg. Field Veg. Prod. Acta Hort*., 627: 195-202.

Zahran, F.A. and A.E. Abdoh. 1998. Nitrogen fertilization of onion in sandy soils. *Egypt. J. Agr. Res*., 76: 903-911.

Zeidan, M.S. 2003. Effect of sowing dates and urea foliar application on growth and seed yield of determinate faba bean *(Vicia faba* L.) under Egyptian conditions. *Egypt. J. Agron*., 24: 93-102.

(Received for publication 29 January 2009)