Plant Pathology Journal

ISSN 1812-5387

science alert

ANSInet
an open access publisher
http://ansinet.com

Pakistan Journal of Plant Pathology 2 (1): 48-55, 2003
ISSN 1680-8193

Response of Wheat to Foliarly Applied Urea at Different Growth Stages and Solution Concentrations

K.H. Shah, M.Y. Memon, S.H. Siddiqui, M. Imtiaz and M. Aslam
Nuclear Institute of Agriculture, Tandojam, Sindh, Pakistan

Abstract: Field investigations were carried out to evaluate the performance of two wheat genotypes when sprayed at different growth stages using 2, 4 and 6% urea solution. Compared to standard soil application, foliarly applied urea was betterly utilized by Soghat-90 and Sind-81. Irrespective of growth stages, foliage efficacy of urea was most prominent at 4% solution. Significantly higher crop harvests, N uptake and agronomic efficiency were recorded when both wheat cultivars were sprayed at tillering and heading stages. Grain protein content was improved by late season spraying with 6% urea solution.

Key words: Foliar spraying, urea, spray concentrations, growth stages, wheat genotypes

Introduction

Pakistan has 20.8 million hectares of cultivated land, which is roughly 25% of the total land area of the country. About 16.0 million hectares of the cultivated land is irrigated, while the remaining 4.8 million hectares is dry farmed. The soil resources of Pakistan, though limited, would be sufficient to meet future requirements for feeding ever increasing population of the country, provided that they are properly managed and protected against active degradation processes. With the introduction of high yielding crop varieties in the recent past coupled with non-judicious and irrational usage of chemical fertilizers, there has been continuous mining of soil reserves, which ultimately resulted into depletion of soil fertility. Nitrogen is one of the major plant nutrients, which plays a vital and key role in plant growth and crop production. The element being extremely deficient in soils is supplemented to crops in the form of different nitrogenous fertilizers. It has however, been established that despite extensive research efforts, the recovery of fertilizer N applied through soil is very low and varies from 25-40% in lowland rice and from 50-60% in upland crops (McMahon, 1988; Bajwa, 1992; Tahir and Salim, 1992; Zia, 1994; Soomro ***et al.***, 1999). The left over N usually remains in the soil as residues, leaches beyond the rooting zone (McNeal and Pratt, 1978) or lost from the soil through denitrification and volatilization (Eibner, 1986; Freney and Black, 1987). The partial and inefficient utilization of nitrogen results into lower crop harvests. Foliar fertilization in which nutrients are sprayed on plant foliage in solution form has long been known as a method for extra radical absorption of

plant nutrients. This technology is gaining renewed interests on global level owing to continuous hike in the cost of chemical fertilizers and acute shortage of irrigation water. There are documentary evidences, where foliar application of nitrogen has been reported to increase the yield (Jagdesh and Mosluh, 1981; Altman ***et al.***, 1983; Shah and Saeed, 1989; Rajput ***et al.***, 1995; Sabir ***et al.***, 2002) and grain protein content (Shah ***et al.***, 1985; Gooding and Davies, 1992) in many crops including wheat. The efficiency of N assimilation through foliage however, depends upon several factors including crop varieties or genotypes (Eibner, 1986). The present studies were therefore, undertaken to evaluate the relative effectiveness of urea when applied through soil and plant herbage and the responses of different wheat genotypes in terms of yield and quality of grain.

Materials and Methods

A field study was conducted during Rabi 1996-97 at Experimental Farm of Nuclear Institute of Agriculture, Tandojam to evaluate the performance of two wheat genotypes i.e., Soghat-90 and Sind-81, when fertilized through foliage at different growth stages using three urea concentrations. The experiment comprising of eleven treatments was laid out according to RCB design with three factor factorial arrangements. Nitrogen as urea was applied at a uniform rate of 120 kg ha^{-1} throughout the experiment excluding control in two splits i.e., half at sowing and remaining half at first irrigation. Phosphorus in the form of single superphosphate was applied at 80 kg P_2O_5 ha^{-1} as a blanket dose to all treatments at sowing. Foliar fertilization of urea using 2 (C_1), 4 (C_2) and 6% (C_3) urea solution was initiated at peak tillering stage, when the leaves were dry and free of morning dew and completed according to crop stage combination of tillering+boot (S_1), tillering+heading (S_2) and boot+heading (S_3). Foliar solution was mixed with a surfactant tween-80 at a concentration of 0.1% V/V for improving leaf wetting and preventing droplets from immediate drying thereby prolonging the time for absorption. The crop was sampled and harvested at maturity for recording yield and other parameters. Standard laboratory procedures were adopted to analyze plant and grain samples for nitrogen (Jackson, 1962). The results were subjected to statistical analysis using methods prescribed by Steel and Torrie (1986). The differences among the treatment means were compared by using DMR test (Duncan, 1970).

Results and Discussion

Fertilization through roots and foliage had a strong positive influence on the yield of both wheat cultivars. Integrated management of soil and foliar application of urea showed an edge and predominance over soil application (Table 1). Foliar spraying of urea at different growth stages also had a pronounced effect on crop harvests. Compared to standard soil application, foliar spraying at different crop stage combinations produced higher yields. Response of both wheat varieties to foliarly applied urea varied significantly with the change over of growth stage

combinations. Tillering surfaced as a critical stage of wheat development for realization of maximum advantages in terms of yield from foliar spraying of urea, since any shift from this stage has been found to alleviate the grain harvests. The data further indicated that among various crop stage combinations, foliar fertilization at tillering+heading produced significantly higher yield followed by tillering+boot and boot+heading, respectively. It transpires from the findings that as a supplement to soil fertilization, foliar spraying is an efficient technique, which helps in promoting health and vigour of crop plants by rapid absorption and accelerated translocation of the assimilated nitrogen from the leaves to different plant organs through the phloem cells (Kannon, 1980). The results are in close agreement to those reported by Klein and Weinbaum (1984), while working on translocation of foliarly applied urea nitrogen as influenced by sink demand and nitrogen deficiency in olive. The data further reflected (Table 1) that spraying at tillering and at heading enhanced the yield. Nitrogen requirements may be higher at these stages, which were met by foliar application. The photosynthetic activity after heading, which chiefly contributes to the final yield of grain (Poter ***et al.***, 1950) was apparently influenced by N fertilization through foliage, coupled with the effect of sprays in prolonging the functional life of leaves (Watson, 1955) may account for the increase in yield. Concentration of spray solution is another factor that played very important role and contributed significantly towards grain harvesting in both genotypes. Irrespective of the growth stages, crop harvests were enhanced linearly with the corresponding increase upto 4% in solution concentration. However, leaf burning was observed at 6% urea solution, which caused significant reduction in wheat yield, when compared with the treatments receiving 2 and 4% urea solution through the leaves. This may be attributed to the phytotoxicity of higher concentration of urea solution (Sadaphal and Das, 1966), which caused yellowing of leaf tips due to temporary toxic ammonia level, thereby inflicting sufferings on the carbohydrate content by restricting the photosynthetic leaf area.

Table 1: Grain yield of wheat as affected by foliar fertilization of urea

Treatments	Soghat-90	Sind-81 (kg ha^{-1})	Mean yield
Control	2732f	2131h	2431f
Soil	3368de	2804g	3086e
C_1 S_1	3585cd	3314de	3450c
C_1 S_2	3879b	3648b	3764b
C_1 S_3	3459cde	3103f	3281d
C_2 S_1	3875b	3510bc	3692b
C_2 S_2	4201a	3975a	4088a
C_2 S_3	3700bc	3267e	3483c
C_3 S_1	3385de	3179ef	3282d
C_3 S_2	3556cd	3439cd	3497c
C_3 S_3	3273e	2935g	3104e

Means followed by similar letters do not differ significantly from each other at 5% level by DMR test

Table 2: Nitrogen uptake (kg ha^{-1}) as affected by foliar fertilization of urea

Treatments	Soghat-90	Sind-81	Mean
Control	94.13f	67.45g	80.79f
Soil	125.57c	91.21f	108.39e
C_1 S_1	137.35bcd	112.88d	125.11cd
C_1 S_2	142.34bcd	121.09b	131.71b
C_1 S_3	133.89cde	108.56e	121.22d
C_2 S_1	145.12b	116.53cd	130.82b
C_2 S_2	156.07a	128.99a	142.53a
C_2 S_3	143.45bc	112.96d	128.21bc
C_3 S_1	132.79de	108.34e	120.57d
C_3 S_2	140.59bcd	118.10bc	129.35bc
C_3 S_3	133.28de	107.34e	120.31d

Means followed by similar letters do not differ significantly from each other at 5% level by DMR test

Table 3: Grain protein (%) content in wheat by foliar spray of urea solution

Treatments	Soghat-90	Sind-81	Mean
Control	13.40f*	12.41g	12.91g
Soil	14.92e	13.68f	14.30f
C_1 S_1	15.31de	14.39e	14.85e
C_1 S_2	15.57bcd	14.74cde	15.16de
C_1 S_3	15.84bc	15.07bc	15.45bc
C_2 S_1	15.47cd	14.53de	15.00e
C_2 S_2	15.72bcd	14.92cd	15.32cd
C_2 S_3	16.03ab	15.11bc	15.57bc
C_3 S_1	15.57bcd	14.69cde	15.13de
C_3 S_2	15.90bc	15.36b	15.63b
C_3 S_3	16.37a	15.77a	16.07a

Means followed by similar letters do not differ significantly from each other at 5% level by DMR test

Nitrogen uptake and protein contents

The enhanced yield of a crop is often associated with optimum nutrient uptake particularly nitrogen. It has been observed that integrated application of N through soil and foliage facilitated the higher N uptake in plants. There was a significant increase in N uptake in plants sprayed with urea as compared with control and standard soil application. Average N uptake of 142.53 kg ha^{-1} recorded in the treatment, where 4% urea solution was sprayed at tillering and heading, was highest and significantly different as compared to other treatments (Table 2). Under optimal root fertilization and with foliar application of 2 and 4% urea solution, significantly higher

Table 4: Agronomic efficiency as affected by foliar fertilization of urea

Treatments	Soghat-90	Sind-81	Mean
Control	-	-	-
Soil	5.30de	5.61f	5.45e
C_1 S_1	7.11cd	9.12de	8.11cd
C_1 S_2	9.55b	12.64b	11.10b
C_1 S_3	6.05cde	8.10e	7.07d
C_2 S_1	9.51b	11.49bc	10.50b
C_2 S_2	12.24a	15.36a	13.80a
C_2 S_3	8.06bc	9.46d	8.76c
C_3 S_1	5.44de	8.73de	7.09d
C_3 S_2	6.86cd	10.90c	8.88c
C_3 S_3	4.50e	6.70f	5.60e

Means followed by similar letters do not differ significantly from each other at 5% level by DMR test

quantities of N scavenged by Soghat-90 and Sind-81, might have been the outcome not only because of the additional N supplied to the leaves, but also by a stimulating effect of foliar spraying of urea on N absorption of the roots. (Alexander and Schroeder, 1987; Altman ***et al.***, 1983). Concentrations higher than 4% urea solution suppressed the N uptake by both genotypes. This may be ascribed to phytotoxic effects of urea, which damaged sufficient portion of the leaves, thereby hindering the photosynthesis and N acquisition, since leaf is the principal seat of several metabolic activities in higher plants (Kannon, 1980).

The quality of grain in terms of protein contents is directly related to the absorption and accumulation of N in edible part of plant. The grain protein was significantly affected by concentration of urea solution and stages of crop development (Table 3). Improvement in grain protein was more pronounced, when urea was sprayed with higher concentrations at advanced phases of crop growth stages. Significantly, highest protein content of 16.37% in Soghat-90 and 15.77% in Sind-81 were recorded by foliage spraying of 6% urea solution at later growth stages i.e., booting and heading. These findings have been upheld by Muller (1981) who studied the effect of foliar fertilization on the yield and quality of different crops and reported that once the predominantly nutrient metabolising phase of plant development has finished when growth is more advanced, supplementary foliar application from the flowering period onward is more intended to foster the development of the quality aspects of the useable plant parts than to build yield. Significantly enhanced grain N content and percent protein in winter wheat with late season foliar N applications before or immediately following flowering has also been demonstrated by Woolfolk ***et al.*** (2002).

Agronomic efficiency

This is an important criterion, which determines the vehemence of certain inputs on per unit basis in quantitative terms (Tandon, 1987) and is calculated by subtracting the yield of control from the yield recorded in fertilized treatment and dividing by rate of fertilizer application (Shah ***et al.***, 2001). Since, it is a yield dependant trait, hence those parameters influencing crop harvests would also be responsible for bringing likely changes in agronomic performance of the applied nutrients. Compared to soil application, the efficiency of fertilizer urea was significantly enhanced when applied through plant foliage. Concentrations of urea solution and crop development stages contributed significantly towards effective utilization of foliarly applied urea in terms of yield per kg of applied nutrient. Highest agronomic efficiency of 12.24 kg in Soghat-90 and 15.36 kg grain per kg N in Sind-81 was recorded in the treatments sprayed with 4% urea solution (Table 4). Irrespective of solution concentration, response of wheat to foliarly applied urea was most prominent at tillering+heading, followed by tillering+boot and boot+heading, respectively. Higher agronomic performance at tillering+heading might be the outcome of higher N uptake due to enhanced utilization efficiency of foliarly sprayed urea (Altman ***et al.***, 1983). Out of the two wheat varieties, grain yield was higher for Soghat-90, but Sind-81 proved to be argonomically efficient cultivar.

Foliar spraying specifically as a supplement to soil application has significant impact on crop harvests and nutrient utilization efficiency. Crop development stages and concentration of spray solution plays vital and key role in this regard. Foliar sprayings of urea at vegetative phases were found to promote crop health and yield whereas productive phases were relatively more conducive for translocation of assimilated nitrogen towards grain.

References

Alexander, A. and M. Schroeder, 1987. Modern trends in foliar fertilization. J. Pl. Nut., 10: 1391-1399.

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.

Bajwa, M.I., 1992. Soil fertility management for sustainable agriculture. Proc. 3rd National Congress of Soil Science, pp: 7-26.

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

Eibner, R., 1986. Foliar fertilization: Importance and prospects in crop production. Development in Plant and Soil Sci., 22: 3-13.

Freney, J.F. and A.S. Black, 1987. Importance of ammonia volatilization as a loss process. In (Ed) J. R. Wilson. In. Proc. Symp. Advances in Nitrogen Cycling in Agricultural Ecosystems, Brisbane, Australia, pp: 156-173.

Gooding, M.J. and W. P. Davies, 1992. Foliar urea fertilization of cereals. A Review, Fertilizer Res., 32: 209-222.

Jackson, M.L., 1962. Soil Chemical Analysis. Prentice Hall Inc., Englewood Cliffs, N. J., pp: 151-153.

Jagdesh, S. and K. I. Mosluh, 1981. Effect of urea spray on wheat in Iraq. Expl. Agri., 17: 333-336.

Kannon, S., 1980. Mechanism of foliar uptake of nutrients: Accomplishment and prospects. J. Pl. Nut., 2: 717-735.

Klein, J. and Weinbaum, 1984. Foliar application of urea to olive: Translocation of urea nitrogen as influenced by sink demand and nitrogen deficiency. J. Amer. Soc. Hort., 109: 356-360.

McMahon, M.A., 1988. Fertilizer use and high yields are compatible with quality environment. Better Crops International, 4: 12-17.

McNeal, B.L. and P.F. Pratt, 1978. Leaching of nitrate from soil. In. (Eds) P. F. Pratt, In. Proc. Natl. Conf. Management of N in irrigated agriculture, Sacramento, Univ. California, Riverside, pp: 195-230.

Muller, K., 1981. The effect of foliar fertilization on the yield and quality of different crops. Qualitat-Blattusgleichsdungung-Kartoffelbau, 32: 434-451.

Poter, A.K., N. Pal and R.V. Martin, 1950. Assimilation of carbon by the ear of barley and its relation to accumulation of dry matter in grain. Ann. Bot. (London) New Ser., 14:307-310.

Rajput, A.L., D.P. Singh and S.P. Singh, 1995. Effect of soil and foliar application of nitrogen and zinc with farmyard manure in late sown wheat. Ind. J. Agron., 40: 598-600.

Sabir, S., J. Bakhat, M. Shafi and W.A. Shah, 2002. Effect of foliar versus broadcast application of different doses of nitrogen in wheat. Asian J. Pl. Sci., 4: 300-303.

Sadaphal, M.N. and N.B. Das, 1966. Effect of spraying urea on winter wheat (***Triticum aestivum*** L.) Agron. J., 38: 137-141.

Shah, K.H. and M. Saeed, 1989. Effect of combination of soil and foliar application of urea on three wheat genotypes. Pak. J. Sci. Indus. Res., 32-813-815.

Shah, K.H., M. Saeed, S.H. Siddiqui and B.A. Panhwar, 1985. Foliar feeding of fertilizer nitrogen in wheat. Proc. Intl. Seminar on fertilizer use efficiency, Lahore, Pakistan, pp: 183-190.

Shah, K.H, M.Y. Memon, S.H. Siddiqui and M. Aslam, 2001. Response of wheat to broadcast and fertigation technique for P application. Pak. J. Biol. Sci., 4: 543-545.

Soomro, A.W., A.R. Soomro and G.H. Mallah, 1999. Recovery of N fertilizer and growth of cotton as affected by various levels of flooding. Pak. J. Biol. Sci., 2: 1507-1509.

Steel, R.G.D. and J.H. Torrie, 1986. Principles and Procedures of Statistics. 2nd Ed. McGraw Hill, Book Co. Inc. New York, pp: 187.

Tahir, M. and M. Salim, 1992. Relative efficacy of different N sources and levels for wheat crop under rainfed conditions. Pak. J. Agri. Res., 13:227-231.

Tandon, H.L.S., 1987. Phosphorus research and agricultural production in India. Fertilizer Development and Consultation Organization, New Delhi, India.

Watson, D.J., 1955. The effect on yield and leaf area of wheat of applying nitrogen as a top dressing in April or in sprays at ear emergence. J. Agri. Sci., 47:449-456.

Woolfolk, C.W., W. R. Raun, G.V. Johnson, W.E. Thomason, R.W. Mullen, K.J. Wynn and K.W. Freeman, 2002. Influence of late-sown foliar nitrogen application on yield and grain nitrogen in winter wheat. Agron. J., 94: 429-434.

Zia, M.S., 1994. Nitrogen use efficiency in flooded rice soils. Proc. 4th National Cong. Soil Sci., Islamabad, Pakistan, pp: 141-149.