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# Effect of foliar application of nutrients on wheat (*Triticum aestivum*) crop performance, economics, resource use efficiency and soil properties under rainfed conditions

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ABSTRACT

Field studies were conducted during *rabi* season of 2015–16 to 2017–18 at research farm of Advanced Centre for Rainfed Agriculture, SKUAST-Jammu to study the effect of foliar application of nutrients on crop performance, economics, resource use efficiency and soil properties in wheat (*Triticum aestivum*. L). The experiment comprising seven treatments (viz. control, 0.5% K foliar spray ($KNO_3$), 0.5% K foliar spray ($KNO_3$) + 0.5% N foliar spray (Urea), 0.5% K foliar spray (KCl), 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), 0.5% N foliar spray (Urea), foliar spray of water) was laid out in randomized block design with three replications. Results revealed that all yield attributes, viz. plant height, number of tillers/m row, spike length, 1000 grain weight were significantly higher with foliar application than the other treatments. Highest grain (2198 kg/ha) and straw yield (3430 kg/ha) were obtained with foliar application of 0.5% K (KCl) + 0.5% N (urea) in addition to 100% RDF soil application (T5). Similarly, the maximum build up of soil organic carbon, available nitrogen, phosphorus and potassium, nutrient uptake, net return (₹ 29008 kg/ha) and B:C ratio (2.45) were recorded in T5 treatment. Significantly higher RWUE (19.49 kg/ha-mm), agronomic use efficiency (21.64 and 65.47) and apparent recovery of nitrogen and potassium (0.74 and 2.22) were observed in T5. The foliar application of 0.5% K (KCl) + 0.5% N (urea) in addition to 100% RDF had pronounced effect on soil properties, resource use efficiency, economics and crop performance of wheat under rainfed conditions.

**Key words**: Foliar, Nitrogen, Potassium, Rainfed, Resource use efficiency, Wheat

The productivity of rainfed crops is primarily affected by the distribution of crop seasonal rainfall received from sowing to harvesting (Abrol *et al*. 2008), soil fertility and applied fertilizer nutrients (Abrol *et al*. 2015). Wheat (*Triticum aestivum* L.) is the predominant rainfed *rabi* crop grown in foothills of Shivaliks but crop yield remains stagnant due to low moisture retention, high evaporation and nutrient deficiencies in these light textured soils (Sharma *et al.* 2011). The situation is further aggravated by occurrence of recurring dry spells during critical stage of crop growth period which leads to substantial loss of crop productivity.

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The soil application of nutrients carries a risk of over-fertilization leading to substantial economic loss with concomitant deterioration of soil fertility. Reports indicate that foliar spray of nitrogen may enhance the growth and yield of wheat crop. Besides, reduction of common nitrogen losses like denitrification, leaching and immobilization in the soil (Gooding 2005), foliar applications of nutrients in addition to soil application resulted in improved productivity and quality of crops (Rehman *et al*. 2014, Kumar *et al*. 2015). Apart from nitrogen, potassium greatly improves the quality and quantity of productivity especially under rainfed conditions due to regulatory role of potassium in opening and closing of stomata. However, information regarding effect of foliar spray of nitrogen and potassium alone and in combination through different sources on wheat growth, yield and resource use efficiency in rainfed conditions is scanty. Therefore, the present study was thus carried to study the effect of foliar spray of nutrients on crop performance, economics, soil properties and resource use efficiency in wheat grown under rainfed conditions.

## MATERIALS AND METHODS

Field experiment was conducted on wheat during

*rabi* 2015–16 to 2017–18 under rainfed conditions at research farm of Advanced Centre for Rainfed Agriculture Research-All India Coordinated Research Project on Dryland Agriculture (ACRA-AICRPDA), Rakh Dhiansar, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu. The experimental site experiences sub-humid climate and was located at latitude of 32°39" N and longitude of 74° 53" E, at 332 m above mean sea level. Annual rainfall of the region is 1152 mm out of which 75-80% is received from July to September and *rabi* season is characterized by scanty rainfall with intermittent prolonged dryspells. Initial soil sample at the start of the study was sandy loam in texture, low in soil organic carbon (0.26 %), available nitrogen (169 kg/ha), available potassium (98 kg/ha) and medium in available phosphorus (13 kg/ha) with neutral pH (6.6). The experiment having plot size of 5 m × 3 m (15 $m^2$) was laid out in a randomized complete block design with three replications. The seven treatments consisted, viz. T1: control (unfertilized, without foliar spray), T2: 0.5% K foliar spray ($KNO_3$), T3: 0.5% K foliar spray ($KNO_3$) + 0.5% N foliar spray (Urea), T4: 0.5% K foliar spray (KCl), T5: 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), T6: 0.5% N foliar spray (Urea), T7: foliar spray of water, were applied to the same plots every year. All treatments received 100% recommended dose of fertilizers of NPK (100:66:35) soil application in addition to foliar sprays as per treatments except in control. Wheat crop was sown with recommended seed rate of 100 kg/ha with row to row spacing of 22.5 cm. Recommended cultural practices of growing wheat were followed and the plant samples of one-meter row were taken at random from the middle rows of each plot from the three replicates to measure plant height (cm), number of tillers/m row length, spike length (cm), test weight of 1000 grain (g) at the harvest of crop. The soil and plant samples were sampled every year after harvest and analyzed for N, P and K using standard procedures. The data of three years were pooled and statistically analyzed using analysis of variance (ANOVA) for Randomized Complete Block Design. The treatment means were tested for significance at P = 0.05.

The resource use efficiency indices were calculated as:

Agronomic use efficiency (AUE) = (Grain yield in fertilized – Grain yield in unfertilized)/Nutrient applied (1)

Apparent recovery efficiency (ARE) = (Nutrient uptake of nutrient in fertilized-Nutrient uptake of nutrient in unfertilized)/Nutrient applied (2)

Rainwater use efficiency (RWUE, kg/ha-mm) = Grain yield (kg/ha)/Crop seasonal rainfall(mm) (3)

## RESULTS AND DISCUSSION

*Yield attributes, plant uptake of nutrients, crop productivity and economic returns*

Foliar application of nutrients significantly influenced the yield attributes of wheat (Table 1). The highest plant height, number of tillers/meter row, spike length and test weight were observed with foliar feeding of 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), T5 followed by 0.5% K foliar spray ($KNO_3$) + 0.5% N foliar spray (Urea), T3 . Lowest values of the entire yield attributing characters were recorded with control. Increase in the crop growth attributes by by foliar urea and potassium was also observed by Abad *et al*. (2004), Kousar *et al*. (2015), Gul *et al*. 2011). Khan *et al*.( 2009) also reported that crop readily absorbs more nutrients through foliar application which in turn produced more tillers. In addition, Khaled *et al*. (2006) mentioned that, adequate K result in superior of water use efficiency and mention a normal balance between carbohydrates and protein results in stronger wheat straw and assist in grain filling. Yildirim *et al*. (2007) reported

Table 1 Effect of foliar fertilizer treatments on yield attributes, total nutrient uptake, yield and economics of wheat (pooled mean of three years)

| Treatment | Plant height (cm) | No of tillers/m row length | Spike length (cm) | Test weight (g) | Total uptake (kg/ha) | | | Yield (kg/ha) | | Economics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Nitrogen | Phospho-rus | Potassi-um | Grain yield | Straw yield | Net returns (₹/ha) | B:C ratio |
| T1 | 76.4 | 65.5 | 6.1 | 30.61 | 28.02 | 7.11 | 24.63 | 889 | 1945 | 3902 | 1.22 |
| T2 | 92.8 | 88.7 | 8.9 | 34.25 | 55.94 | 15.95 | 47.60 | 1772 | 3087 | 20587 | 2.02 |
| T3 | 100.3 | 109.3 | 9.6 | 36.75 | 67.34 | 18.53 | 53.70 | 2043 | 3264 | 25630 | 2.27 |
| T4 | 94.2 | 98.7 | 8.6 | 36.71 | 58.06 | 15.64 | 51.51 | 1850 | 3122 | 22081 | 2.10 |
| T5 | 102.8 | 112.4 | 9.8 | 37.25 | 72.69 | 21.22 | 62.37 | 2198 | 3430 | 29008 | 2.45 |
| T6 | 93.2 | 94.9 | 9.0 | 35.27 | 60.78 | 16.70 | 50.48 | 1920 | 3223 | 23614 | 2.18 |
| T7 | 86.3 | 82.1 | 7.8 | 34.17 | 49.92 | 13.44 | 42.29 | 1604 | 2799 | 16916 | 1.85 |
| CD (P=0.05) | 5.9 | 2.5 | 0.47 | 1.12 | 5.79 | 2.01 | 4.28 | 217 | 277 | 3888 | 0.19 |

T1: control (without foliar spray), T2: 0.5% K foliar spray ($KNO_3$), T3: 0.5% K foliar spray ($KNO_3$) + 0.5% N foliar spray (Urea), T4: 0.5% K foliar spray (KCl), T5: 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), T6: 0.5% N foliar spray (Urea), T7: foliar spray of water. * Foliar application of nutrients was in addition to 100% recommended dose of fertilizers (60:30:20) except control.

that this increment may be due to the stimulating effect of urea that improve the physiological performance of plants and foliar application improved the efficiency and rapidity of utilization of a nutrient urgently required by the plant for maximum growth and yield. Significantly higher grain weight (37.25 g) was found in treatment T5 and this could be ascribed to the provision of nutrients at later stages which might have enhanced accumulation of assimilates in the grains of wheat. The similar findings had also been reported by Amal *et al*. (2011), Khan *et al*. (2009) and Arif *et al*. (2006).

Results presented in Table 1 show that foliar application of nutrients had a significant effect on nutrient uptake. The highest uptake of N, P and K were recorded in T5 which was at par among the other treatments except control. Lowest value of N, P and K uptake were recorded with control. The magnitude of increase in N, P, K uptake were 159 %, 198 % and 153.2 % with T5, respectively over the control. This might be attributed to combined foliar spray of N and K which led to increase in grain and straw production with their increased concentration in plant system. These results corroborate the findings of Arif *et al.* (2006). Further, significantly superior phosphorus in treatments receiving foliar nitrogen might be due to close interrelationship between nitrogen and phosphorus metabolism in plant cell. Similar results were obtained by Kumar *et al.* (2015).

The highest average grain (2198 kg/ha) and straw yield (3430 kg/ha) was recorded with T5 which showed statistical parity by T3 and both these treatments proved significantly superior to other treatments (Table 1).The grain yield was 2.5 and 2.3 times higher in T5 and T3, respectively, over control owing to better nutrition (Gholami *et al*. 2011), availability of nutrients at vital growth period (Javad *et al*. 2013) and synthesis of carbohydrates and their translocation (Rahman *et al*. 2014) with foliar spray which in turn increased the crop yield. Arif *et al*. 2019 also recorded higher grain and straw yields significantly influenced by foliar spray. Foliar spray of water recorded 1.80 and 1.43 times, increase in grain and straw yield respectively, over the control. However increase was less as compared to foliar N and K treatments.

Foliar management of nutrients recorded significantly higher net monetary returns (₹ 29008 kg/ha) and benefit:cost ratio (2.45) in treatment T5 which registered (7.43 and 1.71) times and (2.02 and 1.32) times higher net returns and benefit:cost ratio over control and water spray, respectively. The lowest net returns and benefit:cost ratio were obtained in control. It is obvious because of higher grain and straw yield obtained under treatment T5 as compared to other treatments which consequently resulted in higher net returns and benefit:cost ratio. Arif *et al*. (2019) and Meena *et al*. (2017) also reported higher monetary returns with foliar management of nutrients.

*Soil properties and resource use efficiency*

Foliar application of nutrients showed significant increase in organic carbon and available N,P,K over control and application of 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), T5 resulted in maximum values of all soil properties (Table 2). Highest build up of organic carbon, available nitrogen, phosphorus and potassium by 1.52, 1.30, 1.37 and 1.35 times, respectively was found relative to control. Further, the maximum build up of soil available nitrogen, phosphorus and potassium to the tune of 17.1, 19.2 and 17.3 %, respectively over their initial values was also observed in T5 treatment which might be attributed to additional supply of N and K through foliar sprays that increased root biomass which on mineralization improved soil nutritional status (Saeed *et al*. 2012, Njuguna *et al*. 2012). The highest increase in organic carbon in T5 with respect to control and initial values substantiate our findings (Table 2).

Rain water use efficiency (RWUE) attained by fertilizer

Table 2 Effect of foliar fertilizer treatments on soil properties and resource use efficiency after the harvest of wheat crop (pooled mean of three years)

| Treatment | pH (1:2.5) | Organic carbon (%) | Available nutrients (kg/ha) | | | Rain water use efficiency (kg/ha-mm) | Resource use efficiency | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Agronomic use efficiency (AUE) | | Apparent recovery efficiency (ARE) | |
| | | | N | P | K | | Nitrogen | Potassium | Nitrogen | Potassium |
| T1 | 6.64 | 0.23 | 153.9 | 11.3 | 85.2 | 8.10 | - | - | - | - |
| T2 | 6.61 | 0.29 | 179.8 | 13.4 | 105.1 | 15.62 | 14.73 | 43.10 | 0.47 | 1.36 |
| T3 | 6.62 | 0.33 | 189.2 | 15.0 | 110.7 | 18.05 | 19.09 | 56.33 | 0.65 | 1.92 |
| T4 | 6.57 | 0.26 | 183.9 | 15.4 | 108.8 | 16.33 | 16.02 | 46.89 | 0.50 | 1.47 |
| T5 | 6.56 | 0.35 | 198.0 | 15.5 | 115.0 | 19.49 | 21.64 | 65.47 | 0.74 | 2.22 |
| T6 | 6.53 | 0.28 | 187.2 | 15.3 | 106.9 | 16.89 | 17.05 | 51.59 | 0.54 | 1.64 |
| T7 | 6.57 | 0.28 | 177.6 | 14.0 | 104.7 | 14.15 | 11.92 | 35.75 | 0.37 | 1.10 |
| CD (*P*=0.05) | NS | 0.06 | 22.4 | 2.3 | 16.4 | 1.99 | 1.26 | 3.78 | 0.04 | 0.14 |

T1: control (without foliar spray), T2: 0.5% K foliar spray ($KNO_3$), T3: 0.5% K foliar spray ($KNO_3$) + 0.5% N foliar spray (Urea), T4: 0.5% K foliar spray (KCl), T5: 0.5% K foliar spray (KCl) + 0.5% N foliar spray (Urea), T6: 0.5% N foliar spray (Urea), T7: foliar spray of water

treatments ranged from 8.1 to 19.49 kg/ha-mm (Table 2) and the highest RWUE of 19.49 kg/ha-mm was obtained in T5 and the lowest (8.1 kg/ha-mm) in control. Thus T5 treatment was the most efficient in utilization of rain water with maximum increase of 140.6% while the treatment T3 was the 2nd best treatment with 122.8 % increase over control. The combined foliar spray of 0.5% N (urea) + 0.5% K either through KCl or $KNO_3$ were found to be superior in utilization of nitrogen and potassium in comparison to sole application of N or K and water spray. The highest agronomic use efficiency (AUE) and apparent recovery (AR) of nitrogen was recorded in T5 which registered 82 and 102 % increase while the corresponding lowest values were recorded with water spray. Similar trend was observed in AUE and AR of potassium. Significantly higher resource use efficiency of rain water complemented in improving AUE and AR in treatment T5 which could be attributed to better assimilation of nutrients applied through foliar application. Mengel (2002) ascribed that K acts as a catalyst for enzyme activation in plant, protein synthesis, starch formation and translocation of proteins as well as the regulation of water use (osmoregulation) in the plant.

The study concluded that foliar feeding of potassium and nitrogen in wheat crop is an efficient method of maximizing yield, improving profitability, resource use efficiency and soil fertility in rainfed wheat.

## REFERENCES


Abad A, Livoberas J and Michelena A. 2004. Nitrogen fertilization and foliar urea effects on durum wheat yield and quality on residual soil nitrate in irrigated Mediterranean conditions. *Field Crops Research*, **87** (2-3): 257-269.

Abrol V, Sharma P, Maruti Sankar G R, Sharma Manish, Chandra Ramesh and Sharma Vikas. 2015. Soil management effects on soil quality and crop performance in dry sub humid Inceptisols of India. *Indian Journal of Soil Conservation* 43(1): 47-57

Abrol Vikas, Maruti Sankar G R, Sharma P, Singh M. 2008. Optimization of organic and inorganic nitrogen for rainfed maize (Z) in dry sub-humid Inceptisols. *Indian Journal of Agronomy* **53**(3): 178-83.

Amal G Ahmed, M M Tawfik and Hassanein M S. 2011. Foliar feeding of potassium and urea for maximizing wheat productivity in sandy soil. *Australian Journal of Basic and Applied Sciences* **5**(5): 1197-1203.

Arif M, Dashora L N, Choudhary J, Kadam S S and Mohsin M. 2019. Effect of nitrogen and zinc management on growth, yield and economics of bread wheat (*Triticum aestivum*) varieties *Indian Journal of Agricultural Sciences* **89** (10): 1664–8

Arif M, Chohan M A, Ali S, Gul R and Khan S. 2006. Response of wheat to foliar application of nutrients. *Journal of Agriculture and Biological Sciences* **1**(4): 30-34.

Gholami A, Akhlaghi S, Shahsavani S and Farrokhi N. 2011. Effects of urea foliar application on grain yield and quality of winter wheat. *Soil Science and Plant Analysis* **42** (6): 719-727.

Gooding M J. 2005. Foliar urea fertilisation and the management of yield and quality in wheat. *International Fertilizer Society Proceedings* **573**. http://www.fertiliser-society.org/Proceedings/US/Prc573.HTM.

Gul H, Said A, Saeed B, Mohammad F and Ahmad I. 2011. Effect of foliar application of nitrogen, potassium and zinc on wheat growth. *Journal of Agriculture and Biological Science* **6**(4):56-9.

Javad A, Maryam N and Reza S A. 2013. Effects of foliar nitrogen and foliar feeding on Vegetative growth, yield and quality of cucumber cultivars in autumnal sowing superdaminu. *International Journal of Agriculture and Crop Sciences* **5**(6):646-650.

Khalid N, Amanullah A and Saad A. 2006. Response of wheat to farm yard manure, potassium and zinc under rained cropping pattern. (one line). *Middle East Journal of Science and Research* **1**(1): 1-9.

Khan P, MY Memon, M Imatiaz and M Aslam.2009. Response of wheat to foliar and soil application of urea at different growth stages. *Pakistan Journal of Botany* **41**(3): 1197-04

Kousar P, Ali L, Raza A, Maqbool A, Maqbool S, Rasheed S and Irum N. 2015. Effect of different levels of nitrogen on the economic yield of wheat (*Triticum aestivum* L.) variety Aas-11. *International Journal of Agronomy and Agricultural Research* **6**(3): 7–11.

Kumar P, Ali L, Raza A, Maqbool A, Maqbool S, Rasheed S and Irum N. 2015. Effect of nitrogen and potassium on nutrient content, uptake and grain yield of wheat. *International Journal of Agricultural Sciences* **9**(2): 575-78.

Meena S K, Prasad S K and Singh M K. 2017. Effect of nitrogen levels and zinc fertilizer scheduling on economic of wheat (*Triticum aestivum* L.) production in Varanasi district of Uttar Pradesh. *International Journal of Plant and Soil Science* **17**(6): 1–8.

Njuguna M, Macharia N M, Akuja T E, Waweru J K and Kamwaga J N. 2012. Effect of foliar fertilization on wheat *Triticum aestivum* (l) in marginal areas of Eastern Province, Kenya. *Journal of Animal and Plant Sciences* **9**(2):1161- 1182.

Rehman M Ataur, Rahman M M, Hasan M M, Farida Begum and Sarker M A Z. 2014. Effects of foliar application of potassium orthophosphate on grain yield and kernel quality of wheat (*Triticum aestivum*) under terminal heat stress. *Bangladesh Journal of Agricultural Research* **39**(1): 67-77

Saeed B, Gul H, Khan A Z, Parveen L, Badshahand N L, Khan A. 2012. Physiological and quality assessment of wheat (*Triticum aestivum* L.) cultivars in response to soil and foliar fertilization of nitrogen and sulphur. *ARPN Journal of Agricultural and Biological Sciences* **7**(2): 1990-6145.

Sharma Peeyush, Abrol Vikas and Sharma R K. 2011. Impact of tillage and mulch management on economics, energy requirement and crop performance in maize–wheat rotation in rainfed subhumid Inceptisols. India *European Journal of Agronomy* **34**: 46–51

Yildirim E, Guvenc M, Turan M and Karatas A. 2007. Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L. var. italica). *Plant Soil Environment* **53**(3): 120-8.