

Original Research Article

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Influence of Foliar Fertilization of Nutrients on Growth, Yield and Economics of Wheat Under Sub-Tropical Rainfed Conditions

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ABSTRACT

A field experiment was conducted from 2015 to 2016 to determine the effect of foliar application of nutrients on growth, yield and economics of wheat (*Triticum aestivum* L). The study was conducted at research farm of Advanced Centre for Rainfed Agriculture under AICRPDA, Rakhdhiansar, SKUAST-Jammu. Seven treatments viz: T₁: Control (No spray), T₂: Foliar spray of 0.5% K solution in water (KNO₃), T₃: T₂ + Foliar spray of 0.5% N solution in water (Urea), T₄: Foliar spray of 0.5% K solution in water (KCl), T₅: T₄ + Foliar spray of 0.5% N solution in water (Urea), T₆: Foliar spray of 0.5% N solution in water (Urea), T₇: Foliar spray of water were replicated thrice in a randomized complete block design (RCBD). The data of two 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 results revealed that foliar application of nutrients resulted in significant effect on wheat grain and straw yield. Significantly higher wheat grain yield of 2224 kg ha⁻¹ was obtained in combined foliar spray of 0.5% N (urea) + 0.5% K (KCl) and it was statistically at par with the combined foliar spray of 0.5% N (Urea) + K (KNO₃) with grain yield of 2007kg ha⁻¹. The lowest grain yield (944 kg ha⁻¹) was found in control. Similar trend was observed in yield contributing plant attributes. Significantly highest uptake N, P and K was recorded with the combined foliar spray of 0.5% N (urea) + 0.5% K (KCl) followed by T₃ and T₆ which were statistically at par. The highest gross return and net returns of Rs49430 and Rs 29576ha⁻¹, respectively were obtained in foliar spray of 0.5% N (urea) + 0.5% K (KCl) with highest benefit:cost ratio while the lowest gross return and net returns to the tune of Rs 23992 and Rs6087 ha⁻¹ were recorded in unfertilized control. The highest agronomic use efficiency (AUE) and apparent recovery (ARE) of nitrogen and potassium were recorded in T₅. The study concluded that foliar application of 0.5% N (urea) + 0.5% K (KCl) played complementary role in improving crop productivity of wheat grown in rainfed conditions.

Keywords

Foliar, nitrogen, potassium, rainfed, wheat

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Introduction

Wheat (*Triticum aestivum* L.) is the most important food crop of the world and increasing wheat productivity is a national priority to bridge the gap between production and consumption. Wheat is the predominant *rabi* crop grown in foothills of Shivaliks (Jamwal, 2000). Production constraints like scarcity of soil moisture during most of the crop growth periods, high erodibility (Abrol *et al.*, 2019), low and erratic rainfall from sowing to harvesting (Abrol *et al.*, 2008), low soil fertility (Abrol *et al.*, 2015) high runoff water losses and high evaporation in these light textured soils results in stagnant wheat yield in rainfed areas of Jammu (Sharma *et al.*, 2011). Among the essential nutrients needed by the plant, nitrogen and potassium play an important role as adequate supply of these nutrients greatly improves the quality and quantity of productivity especially under rainfed conditions due to regulatory role of potassium in opening and closing of stomata.

Besides soil application of nutrients, the alternative approach is to apply nutrients as foliar spray has become an established technology to enhance yield and improve quality of crop products. Foliar application also improves nutrient utilization and lower environmental pollution through reducing the amount of fertilizers added to soil (Yaseen *et al.*, 2011). Moreover, foliar applications of nutrients in addition to basal applications are proved to be judicious, efficient and economical perspective for some crops (Gholami *et al.*, 2011). The rainfed farming of wheat carries a risk of over-fertilization that leads to substantial economic loss with concomitant deterioration of soil fertility.

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.

We hypothesized that sole or combined foliar spray of growth promoting nitrogen and osmoregulatory controlling potassium might offset the deleterious effect of dry spells during crop growth period. An investigation was undertaken to determine the influence of foliar application of nutrients on wheat crop under sub-tropical rainfed conditions of Jammu region.

Materials and Methods

Experimental details

The field experiments were conducted at the research farm of Advanced Centre for Rainfed Agriculture Research of the Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during year 2015 - 2016 under rainfed conditions. The experimental site is representative of the rainfed ecology of foothills of Shivaliks, located at a latitude of 32° 39' North and longitude of 74° 53' East, at 332 m above mean sea level. The region experiences sub-humid climate with 1152 mm precipitation wherein about 75% of total precipitation occurs in the summer season from July to September. May and June are the driest period for crop growth and little precipitation occurs during the winter months of December and January. The taxonomical soil unit is an Inceptisol with a sandy loam texture. The analysis of initial soil samples taken from the experimental site at the start of the study in 2015 indicated that the surface soil from 0-15 cm depth had a pH 6.6, soil organic carbon (SOC) content 2.6 g kg⁻¹, soil N 169 kg ha⁻¹, P 13 kg ha⁻¹ and K 98 kg ha⁻¹. The field experiments were conducted by superimposing six foliar fertilizer treatments with an unfertilized control to the same plots every year. The treatments T₁: Control (No spray), T₂: Foliar spray of 0.5% K solution in water (KNO₃), T₃: T₂ + Foliar spray of 0.5% N solution in water (Urea), T₄: Foliar spray of 0.5% K solution in water (KCl), T₅: T₄ +

Foliar spray of 0.5% N solution in water (Urea), T₆: Foliar spray of 0.5% N solution in water (Urea), T₇: Foliar spray of water. The sources of nitrogen, and potassium were urea and murate of potash, respectively. Foliar application of nutrients was done during real time dry spells experienced during crop growth period in addition to 100% recommended dose of fertilizers (100:66:35) except in control. The sole water spray was carried with deionized water to simulate rain water quality. The experimental plots were laid-out in a randomized block design with 3 replications having plot size of 5 m × 3 m (15 m²). Wheat crop was sown with recommended seed rate of 100 kg/ha with row to row spacing of 22.5 cm. Among fertilizer doses, 100% of P and K doses were applied at the time of sowing, while N was applied in three splits i.e., 2/3 rd of N at the time of sowing as basal dose and the remaining 1/3 rd nitrogen as top dressing before boot stage in all treatments except control. Soil nutrients, available N was determined by alkaline KMNO₄ method (Subbaiah and Asija, 1956), P was extracted from soil by 0.5 M NaHCO₃ (pH 8.5) as per the method of Olsen *et al.*, (1954) and available K was extracted by 1N CH₃COONH₄ (pH 7.0) as proposed by Merwin and Peech (1951); SOC content was estimated by wet digestion method of Walkley and Black (1934). 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⁻¹ row length, spike length (cm), test weight of 1000 grain (gm) at the harvest of crop. The plant samples were sampled every year after harvest and uptake of N was determined by modified microkjeldhal method, P by Vanadomolybdo Phosphoric acid yellow colour (Jackson, 1973) and K by Ammonium acetate method (Jackson, 1973). The uptake of nutrients was calculated by multiplying their respective

nutrient contents with plant dry matter. Three foliar sprays as per treatments were applied (with 500 L water/ha) at crown root initiation, booting and milking stages. The data 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 nutrient 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)

Results and Discussion

Yield attributing components and plant uptake of nutrients

The analysis of variance (Table 1) revealed that plant height was significantly affected by foliar application of water, N and K solutions. Maximum plant height (103.90 cm) was recorded in those plots which were sprayed with 0.5% N (urea) + 0.5% K (KCl), while minimum plant height (76.16 cm) was recorded in control (no spray) plots. This might be attributed to foliar application of N and K solution which increased the stem length which in turn resulted in maximum plant height in treated plots. These results are in conformity with Gul *et al.*, (2011) and Rogalski (1994) who reported higher length of wheat with combined foliar spray of N and K. The foliar application of N and K solutions had significant effect on the number of tiller m⁻¹row length with maximum value (111.67) recorded in plots sprayed with 0.5% N (urea)

+ 0.5% K (KCl) while minimum number of tiller m^{-1} (65.12) were recorded in control (no spray) plots. This might be due to the fact that crop readily absorbs more nutrients through foliar application which in turn produced more tillers m^{-1} . These results are in the conformity with those of Dafen *et al.*, (1999), who reported that number of tillers m^{-1} increased with foliar application of potash. Narimani *et al.*, (2010) have also reported increased the number of productive tillers with foliar spray of urea. The pooled data obtained for mean spike length per plant revealed that combined foliar application of N and K treatments were found to be significantly superior to the other treatments. Maximum mean value was recorded from combined foliar application of 0.5% N (urea) + 0.5% K (KCl) which was 1.25 and 1.60 times higher than water spray and control respectively. The results are in accordance with those of Wagan *et al.*, (2017) and Jamal (2007). Analysis of the data revealed that foliar application of nutrients solution resulted in a significant increase in thousand grains weight. The combined foliar spray of 0.5% N (urea) + 0.5% K (KCl) resulted in significantly heavier grains (36.95 g) which was statistically at par with foliar spray of 0.5% N (urea) + 0.5% K (KNO_3) and foliar spray of 0.5% K (KCl) with grain weight of 36.39 g and 36.12 g respectively while control treatment produced grains with least weight (30.33 g). This may be due to the provision of nutrients at later stages which might have enhanced accumulation of assimilates in the grains thus resulting in heavier grains of wheat. The results are in line with Amal *et al.*, (2011), Khan *et al.*, (2009) and Arif *et al.*, (2006) who reported significant increase in thousand grains weight with foliar application of nutrients.

The uptake values obtained with combined foliar spray of N and K were almost similar however significant differences were observed when compared with sole application of N, K,

water spray and control (Table 1). On average total N, P and K uptake ranged from 30.36 to 73.18, 8.04 to 22.36 and 28.74 to 65.67 $kg\ ha^{-1}$ respectively. The combined foliar spray of 0.5% N (urea) + 0.5% K (KCl) recorded maximum uptake of nutrients over water spray and 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 interrelation ship between nitrogen and phosphorus metabolism in plant cell. Similar results were obtained by Kumar *et al.*, (2015).

Crop productivity, economic returns and resource use efficiency

Grain and straw yield of wheat was significantly affected by foliar application of nutrients and water (Table 2). The highest average grain (2224 $kg\ ha^{-1}$) and straw yield (3667 $kg\ ha^{-1}$) was recorded with combined foliar spray of 0.5% N (urea) with 0.5% K (KCl) which showed statistical parity by combined foliar spray of 0.5% N (urea) with 0.5% K (KNO_3) and these treatments proved significantly superior to rest of the treatments. Strong (1982) and Gooding and Devies (1992) also reported increased grain yield for foliar application of N and K individually or in combinations. It might be due to beneficial effect of foliar spray of N and K that controlled their losses from the soil and facilitated easily availability to the plant which manifested in increased yield and quality of wheat grain. Further it could be attributed to better availability of nutrients at vital growth period and synthesis of carbohydrates and their translocation. Rehman *et al.*, (2014) also reported increased grain yield for foliar application of N and K, individually or in combination.

Table.1 Effect of foliar fertilizer treatments on yield attributes and nutrient uptake in wheat (pooled mean of two years)

Treatments	Plant height (cm)	Tillers m ⁻¹ row length	Spike length (cm)	Spikelet /Spike	Test weight (g)	Uptake N kgha ⁻¹			Uptake P kgha ⁻¹			Uptake K kgha ⁻¹		
						2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
T1	76.16	65.12	6.19	5.85	30.33	30.58	30.14	30.36	8.18	7.90	8.04	26.41	31.08	28.74
T2	92.57	88.62	9.09	11.08	33.56	49.88	61.64	55.76	14.31	18.58	16.44	43.71	56.29	50.00
T3	101.94	108.78	9.72	12.02	36.39	59.29	71.62	65.45	16.59	20.06	18.33	49.46	59.37	54.41
T4	93.44	97.72	8.79	10.78	36.12	52.59	63.16	57.87	14.27	18.06	16.17	48.77	60.13	54.45
T5	103.90	111.67	10.04	12.52	36.95	67.70	78.67	73.18	20.32	24.40	22.36	61.01	70.33	65.67
T6	92.74	93.70	9.11	10.63	34.64	54.11	68.22	61.17	14.92	19.80	17.36	46.99	60.62	53.81
T7	85.91	81.57	7.97	9.52	33.72	44.43	55.50	49.97	12.03	15.76	13.90	38.60	50.81	44.70
CD (P<0.05)	6.51	12.94	1.71	0.71	1.12	11.46	7.67	9.56	2.45	1.73	2.09	6.83	6.68	6.76

T₁: Control (No spray), T₂: Foliar spray of 0.5% K solution in water (KNO₃), T₃: T₂ + Foliar spray of 0.5% N solution in water (Urea), T₄: Foliar spray of 0.5% K solution in water (KCl), T₅: T₄ + Foliar spray of 0.5% N solution in water (Urea), T₆: Foliar spray of 0.5% N solution in water (Urea), T₇: Foliar spray of water.

Table.2 Effect of foliar fertilizer treatments on grain and straw yield of wheat at harvesting

Treatment	Grain Yield kgha ⁻¹			Straw Yield kgha ⁻¹		
	2015	2016	Mean	2015	2016	Mean
T1	1055	833	944	2209	2472	2341
T2	1614	1928	1771	3214	3461	3338
T3	1819	2194	2007	3408	3417	3413
T4	1708	2000	1854	3361	3444	3403
T5	2044	2403	2224	3756	3597	3677
T6	1742	2111	1927	3383	3694	3539
T7	1475	1736	1606	3039	3125	3082
CD (P<0.05)	290	410	226	555	432	109

Table.3 Effect of foliar fertilizer treatments on gross returns, net returns and benefit:cost ratio of wheat

Treatment	Gross returns (Rs ha ⁻¹)			Net returns (Rs ha ⁻¹)			B:C ratio		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
T1	25192	22792	23992	7392	4782	6087	1.42	1.27	1.35
T2	37871	43725	40798	18120	23574	20847	1.92	2.17	2.05
T3	41835	47681	44758	22043	27488	24766	2.11	2.36	2.24
T4	39924	44778	42351	20287	24741	22514	2.03	2.23	2.13
T5	47228	51632	49430	27591	31560	29576	2.41	2.57	2.49
T6	40529	47500	44015	20857	27488	24173	2.06	2.37	2.22
T7	35018	39410	37214	15447	19439	17443	1.79	1.97	1.88

Fig.1

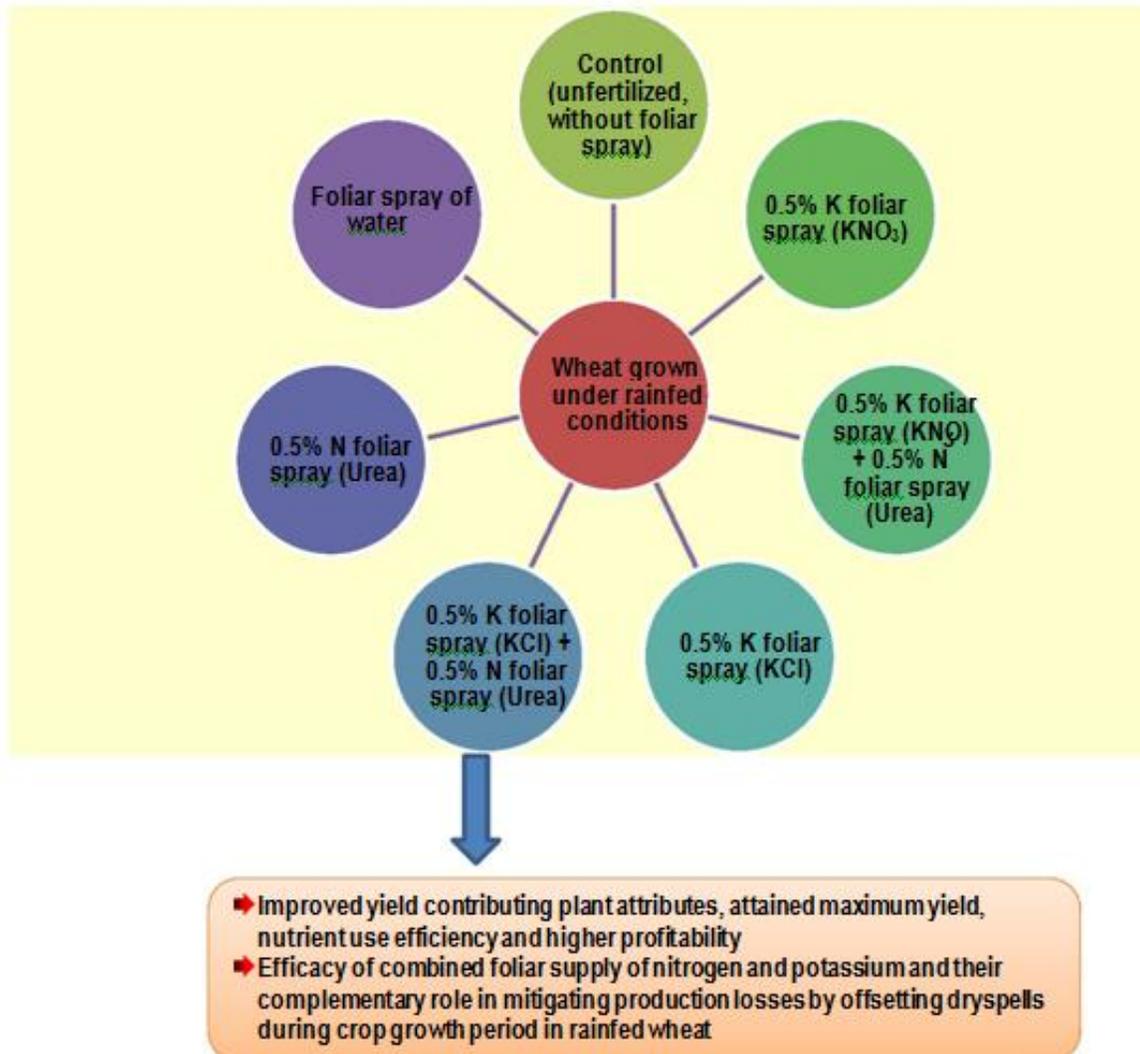
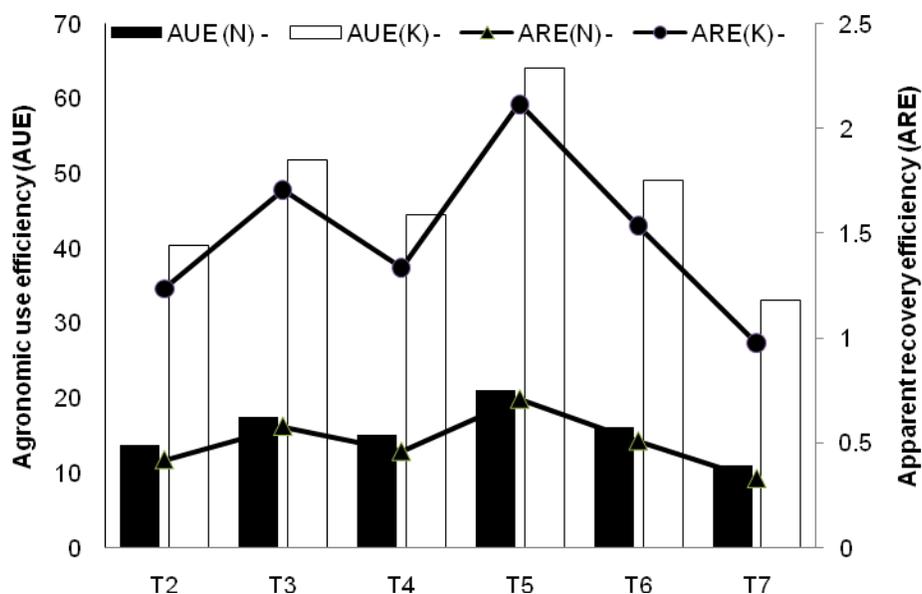


Fig.2 Effect of foliar fertilizer treatments on agronomic use efficiency (AUE) and apparent recovery efficiency (ARE) of nitrogen and potassium



Pooled data of two years showed that combined foliar spray of 0.5% N (urea) with 0.5% K (KCl) gave remarkably higher net monetary returns (29576 Rs ha⁻¹) and benefit: cost ratio (2.49) followed by combined foliar spray of 0.5% N (urea)+0.5% K (KNO₃), and the lowest B:C ratio was recorded in control (Table 3). It is obvious because of higher grain and straw yield obtained under treatment, 0.5% N (urea) +0.5% K (KNO₃) 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.

The highest agronomic use efficiency (AUE) and apparent recovery (ARE) of nitrogen was recorded in T5 which registered 1.92 and 2.15 times higher over water spray followed by T2. Similar trend was observed in AUE and ARE of potassium. This could be due to better assimilation of nutrients applied through foliar application which complemented in improving AUE and ARE. 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 confirmed the complementary role of foliar supply of mineral nutrition for improving wheat yield, net monetary benefits and use efficiency of applied nutrients under rainfed conditions.

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