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RESEARCH ARTICLE

COMPARATIVE RESPONSE OF TWO WHEAT VARIETIES TO BASAL AND SPLIT POTASSIUM NUTRITION UNDER FIELD CONDITIONS

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ABSTRACT

Potassium (K) is an essential plant nutrient. Several research studies are available on the basal application of K concerned with yield and quality of wheat (*Triticum aestivum* L.). Conversely, very limited studies are available on the split application of K. During 2018-2019, a field experiment was performed at the Southern Wheat Research Station, Agriculture Research Institute, Tandojam, Pakistan to determine the importance of the right time for K fertilization in wheat. The experiment included 18 plots, each having an area of $12m^2$ ($4m \times 3m$) involving two cultivars of winter wheat, viz. *Benazir* and *Sindhu*, sown in two-factor Randomized Complete Block Design, arranged in a split pattern (main plots = varieties, sub plots = treatments). Three K fertilization levels were tested, i.e. T_1 = No K fertilization, T_2 = 50 kg K_2O ha^{-1} applied at the time of sowing, T_3 = two splits of K, i.e. 25 kg K_2O ha^{-1} applied at sowing and 25 kg K_2O ha^{-1} applied at grain filling stage (top dressing). According to results, the yield components showed a positive enhancement upon split application of K as compared to basal application in terms of significantly higher ($p<0.05$) number of tillers (10.1 against 8.18), number of grains per plant (548.0 against 374.2), 1000 grain weight (44.7 against 41.9 g), grain yield (4.5 against 4.2 Mg ha^{-1}) and straw yield (8.5 and 8.3 Mg ha^{-1}), and K concentration in grain (0.38 against 0.32%) and straw (0.44 against 0.40%) was recorded for *Sindhu* and *Benazir*, respectively. The varietal interaction revealed that *Sindhu* was significantly different as compared to *Benazir*. These results advocate that the split application of K is better for obtaining the higher yield of wheat, especially *Sindhu*.

Keywords: Cereal, Fertilization methodology, Modern cultivars, yield constraints, K-splits

1. INTRODUCTION

Potassium (K) is an essential plant nutrient which plays pivotal roles in plant growth, metabolism and contributes remarkably to the survival of plants. There are various stresses that plants are subjected to both biotically and abiotically [1]. It improves crop resistance to stress in low-moisture soils by inducing deeper rooting, higher absorption surfaces and increased water maintenance in plant tissues. The use of K-fertilizer worldwide is increasing, but its efficiency is declining due to the introduction of high-yielding varieties under intensive farming. The soil K reserves had already begun to deplete, which in turn resulted in reduced crop yields and high economic losses for farmers [2]. In general, crops take more K from soil~~s~~ than the amount available in it, as it is a water soluble and highly exchangeable element [3]. Potassium deficiency may result in more damaging physiological stress for plants in terms of frost damage. When plants are drought-stricken, they remain flaccid while moisture-logged conditions cause them to wilt for longer periods of time. Moreover, crops will become more prone to diseases and pests, especially where nitrogen (N) and K imbalances exit, leading to weaker growth. Interestingly, the amount of K taken up by crops from the soil is almost equal or even greater ~~to~~ than that of N [4]. Applied K significantly affected the uptake of N and P in straw and wheat grain [5]. In plants, the high intake of nitrate ions (NO_3^-) during vegetative growth is usually matched by an equivalent consumption of positively charged potassium ions (K^+), which maintains electrical neutrality Therefore, sufficient potash is crucial for the quality production of wheat [6]. The yield increment of wheat is directly related to kernel weight which is increased with K fertilization [7]. There are several

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studies reported to advocate the positive impacts of K nutrition on wheat yield as a basal application, nonetheless, the results vary from one study to another [8,9].

The use of a single dose of K at sowing time increases the risk of its fixation and consequently the plant is unable to absorb it properly [10]. During the growth period, split applications of K have been found to be beneficial in that they simultaneously reduce the loss of K due to leaching and boost the efficient use of K fertilizers [11]. In addition, K applications in splits together with improved yield can also improve wheat crop quality [12]. Prevention of K losses through split application of K fertilizer can increase the sucrose supply, encourage starch accumulation in grains and consequently increase grain yield [13]. Additionally, split applications of K increase protein and wet gluten content in wheat grains more than basal applications alone [14]. Scientific community carries a difference of opinion regarding the method of K application. Very little is known about the single and split application of K fertilizers. We conducted this study to investigate the comparative response of two newly developed wheat cultivars, viz. *Benazir* and *Sindhu* (indigenous high-yielding modern wheat varieties of Sindh, Pakistan) in terms of growth and yield under basal and split K nutrition with these specific objectives; 1) to examine the comparative response of two wheat varieties under basal and split fertilization of K nutrition in terms of growth and yield and 2) to evaluate K accumulation by grain and straw of two wheat varieties under basal and split K nutrition.

2. MATERIALS AND METHODS

2.1. Experimental Setup and Treatment Details

This field experiment was conducted using a two-factor RCBD, with split-plot arrangement (main plot=varieties, sub plots=treatments), in three replications. The experimental site was located at 25°25′12"N 68°32′49"E Sindh, Pakistan, during winter 2018-19. The treatments involved were: T_1 = No K application, T_2 = K application at 50 kg K_2O ha^{-1} at the time of sowing, T_3 = K applications in two splits, i.e., 25 kg K_2O ha^{-1} at sowing and 25 kg K_2O ha^{-1} at the grain filling stage (same three treatments for each variety). Each treatment also received a blanket recommended dose of P_2O_5 in the form of single super phosphate [$Ca(H_2PO_4)_2$] applied at the rate of 90 kg ha^{-1} and N in the form of Urea [$CO(NH_2)_2$] at the rate of 120 kg ha^{-1} [15]. A piece of 216m^2 land was selected for this experiment. The area was divided into 18 equal experimental units of 12m^2 (4m × 3m).

2.2. Sowing and Harvesting of Wheat

To prevent winter injuries, wheat seeds were sown using drills at the recommended seed rate of 125 kg ha^{-1}. It is imperative to seed wheat in a moist, firm seedbed prior to planting. All the recommended cultural and management practices were followed during the early growth stages. Canal water from the River Indus was used for irrigation. Total six irrigations were recommended; initial irrigation was applied after 20 days of sowing and the subsequent irrigations were set as 5 irrigations at 15 days intervals. Precise agronomic observations were recorded at the time of maturity, number of tillers plant^{-1}, number of grain plant^{-1}, 1000 grain weight (g), grain yield (kg ha^{-1}), and straw yield (kg ha^{-1}). Wheat with its two local genotypes was sown on the 3rd of December 2018 and harvested at maturity after 140 days.

2.3. Soil and Plant Analysis

Soil was analyzed (samples collected from 0-30 cm depth randomly to produce representative soil samples). Soil was silty clay containing sand 0.38%, silt 41.37% & clay 58.32%, deficient in N (0.40 g kg^{-1}) and organic matter (6.98 g kg^{-1}). The extractable K was found to be 115 mg kg^{-1} determined by the AB-DTPA method. The soil under study was alkaline in reaction (pH 7.89), non-saline (EC 0.14 dS cm^{-1}) and moderately calcareous in nature ($CaCO_3$-74.0 g kg^{-1}) [16]. The plant analysis was done for K concentration in grains and straw. Plant (grain and straw) samples were collected as per treatment (five samples per replication), washed with tap water followed by deionized water, and then oven dried at 65°C for 24 hours. Samples were ground in a Wiley Mill and analyzed by the wet acid digestion method [16]. The concentration of K^+ in plant samples was calculated by the following formulae:

Potassium = GR X volume made/weight of plant material

2.4. Statistical Analysis

This field study was conducted in a Randomized Complete Block Design (RCBD) involving two factors, viz. three K application treatments with two varieties, and three replications. Based on this design the Analysis of Variance was done using Statistix ver. 8.1. The treatment means were separated using the Least Significant Difference (LSD) test at alpha 0.05.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The results in relation to growth attributes of wheat and varietal differences as affected by K mode of application are shown in Table-1&2. The number of tillers due to different K modes and its interaction on two varieties was found significant ($p \leq 0.05$). The maximum numbers of tillers per plant were recorded in plants which received 50 kg K_2O ha^{-1} in two splits followed by 50 kg K_2O ha^{-1} as a basal application once only while the minimum numbers of tillers were observed in control. According to varietal differences the maximum number of tillers per plant in two splits, were measured in variety *Sindhu* (12.13) while (10.31) in *Benazir*, followed by 50 kg K_2O ha^{-1}. However, the minimum number of tillers per plant (7.71 and 6.10) was recorded at 0 kg K_2O ha^{-1} (control) in *Sindhu* and *Benazir* respectively. The same trend was seen in the number of grains per plant. The maximum number of grains per plant was noted in plants that received K in two doses followed by basal application. In contrast, the minimum number of grains per plant was recorded in the control. Varietal difference was significant ($p \leq 0.05$) as *Sindhu* (611.75) and *Benazir* (475.30) responded by producing more grains after split K fertilization, in comparison to basal K application. It was found that both cultivars responded positively where K was applied in two equal splits, at planting time (25) and during active tillering (25) as compared to K applied as a basal. The application of K in 2 equal splits is an indication of more K availability and less transformation into a non-exchangeable pool, which regulates cells and tissue growth in a right manner with a continuous process [17]. In addition, K application at once may result in cation imbalances, in particular Ca and Mg, due to the long lifecycle of the crop (120 days). It has been highlighted in the literature that the single application of K fertilizers may not necessarily be helpful for plants to complete their growth and-development properly [18]. The role of K in plants is sugar translocation and starch biosynthesis [19]. Generally, K is associated with membrane permeability, opening and closing of stomata (as K is low, plants would be unable to open stomata). Stomatal closing causes a lower input of carbon dioxide and thereby lowers photosynthetic activity [20]. The split K application provides better results than the one-go and less available K (basal application). Several biochemical and physiological processes rely on K as a "quality element" and K is required at higher concentrations for better growth [21].

Table 1. Growth attributes of two wheat cultivars towards different K applications time.

Treatments (kg K_2O ha^{-1})	*Sındhu* No. of tillers $plant^{-1}$	*Benazir* No. of tillers $plant^{-1}$	*Sindhu* No. of grains $plant^{-1}$	*Benazir* No. of grains $plant^{-1}$
Control (0)	7.71 c	6.10 c	466.30 c	306.70 c
K1 (50 as basal)	10.33 b	8.13 b	566.00 b	340.70 b
K2 (50 two splits)	12.13 a	10.31 a	611.75 a	475.30 a
SE±	0.65		5.8	
LSD 0.05	0.29		2.6	

Means with different letters are significantly different from each other at LSD <0.05

Table 2. Response of Two wheat cultivars towards different K applications time

Growth parameters	Interaction of varieties *Sındhu*	*Benazir*	SE± (T*V)	LSD 0.05 (T*V)
No. of tiller $plant^{-1}$	10.06 A	8.18 B	0.91	0.41
No. of grains $plant^{-1}$	548.02 A	374.23 B	8.21	3.68

3.2. Yield Parameters

The yield parameters affected by different K application timings were significant ($p<0.05$). Likewise, the interaction of two wheat cultivars was significant too (Table 3-4). The maximum seed index (1000 grain weight) was recorded in plants that received 50 kg K_2O ha^{-1} in two splits. In both varieties, *Sindhu* (51.60 g) and *Benazir* (48.30 g), split K application performed better than basal K application; however, a minimum seed index was observed in the control. According to the findings, maximum grain yields of 4.8 and 4.0 Mg ha^{-1} were received in *Sindhu* and *Benazir* respectively in plants using 50 kg K_2O applied in two splits. Straw yields had a similar pattern. Potassium enhances physiological activities, which was reflected in an increase in yield attributes. As a result of physiological activities, including photosynthesis, translocation, and assimilation of photosynthates, and spikelet initiation, spikelet numbers increased. In addition, abundant K availability resulted in a faster photosynthetic rate and improved material transition in the phloem, which culminated in a substantial number of grains filled.
Results are in line with Zhao et al. [22], who have noted similar enhancement by applying K in different modes. These results confirm the findings of Lu et al. (2014), who observed that K application in splits can improve the yield parameters significantly. Since K is its own element and can contribute in many uncertainties (as mentioned earlier), its application in parts eliminates the risk of K losses. Increasing wheat yield under current research is consistent with Corrêa et al. [23]. They obtained the most effective results when K is applied 50% at planting and 50% at topdressing.

Table 3. Yield attributes of two wheat cultivars towards different K applications time

Treatments (kg K_2O ha^{-1})	*Sindhu* Grain yield (Mg ha^{-1})	*Benazır* Grain yield (Mg ha^{-1})	*Sindhu* Straw yield (Mg ha^{-1})	*Benazir* Straw yield (Mg ha^{-1})	*Sindhu* Seed index (g)	*Benazir* Seed index (g)
Control (0)	3.5 c	3.1 c	8.9 a	8.5 a	37.10 c	35.70 c
K1 (50 as basal)	4.1 b	3.6 b	8.4 b	8.1 b	45.30 b	41.70 b
K2 (50 two splits)	4.8 a	4.0 a	8.2 c	8.3 c	51.60 a	48.30 a
SE±	0.4		0.3		0.08	
LSD 0.05	0.02		0.23		0.03	

Means with different letters are significantly different from each other at LSD <0.05

Table 4. Response of Two wheat cultivars towards different K applications time

Growth parameters	Interaction of varieties *Sındhu*	*Benazir*	SE± (T*V)	LSD 0.05 (T*V)
No. of tiller plant^{-1}	10.06 A	8.18 B	0.91	0.41
No. of grains plant^{-1}	548.02 A	374.23 B	8.21	3.68

3.3. Potassium Concentration in Grain and Straw

The data in Table 5 display the results in relation to the average K concentration (%) in grains and straw. Moreover, the data in Table 6 display the results in relation to the interaction between varieties in grains and straw both. The different methods used for applying K to grains and straw resulted in a significant difference in K concentrations ($p \leq 0.05$). It was found that split K application was associated with a significant difference in the K concentration in grains (*Sindhu* 0.54%; *Benazir* 0.51%) and straw (*Sindhu* 0.65%; *Benazir* 0.63%) in plots where K was applied in two splits followed by basal K application. Control grain and straw were also found to contain the lowest K concentration.

Table 5. K-concentration in grains and straw towards different K applications time

Treatments (kg K_2O ha^{-1})	*Sindhu* Grains %	*Benazır* Grains %	*Sindhu* Straw %	*Benazir* Straw %
Control (0)	0.20 c	0.16 c	0.23 c	0.21 c
K1 (50 as basal)	0.41 b	0.40 b	0.43 b	0.40 b
K2 (50 two splits)	0.54 a	0.51 a	0.65 a	0.63 a
SE±	0.01		0.16	
LSD 0.05	7.42		0.07	

Means with different letters are significantly different from each other at LSD <0.05

Table 6. Response of Two wheat cultivars towards different K applications time

K concentration	Interaction of varieties *Sındhu*	*Benazir*	SE± (T*V)	LSD 0.05 (T*V)
K concentration in Grains	0.38 A	0.32 B	0.02	0.01
K concentration in Straw	0.44 A	0.40 B	0.22	0.1

There was a substantial difference in response between *Sindhu* and *Benazir*. Therefore, topdressing with 50% of the seed and planting with 50% of the seed gave the most promising results. According to Kang et al. [24], excessive K can lead to soil salinization and imbalance in the absorption of other nutrients, such as N, Ca, and Mg; thus, impairing the formation of roots. Thus, it is believed that the supply of K only at planting allows leaching losses [23].

4. CONCLUSION

The study concluded that K application in two equal splits, each at planting and topdressing, was significantly better than the single application of K. Moreover, the wheat variety *Sindhu* performed significantly better as compared to *Benazir* in terms of growth and yield attributes. Further research is warranted on this subject to reduce the luxury consumption of K and the input cost of farmers on K fertilizers.

CONFLICT OF INTEREST

The authors stated that there are no conflicts of interest regarding the publication of this article.

AUTHORSHIP CONTRIBUTIONS

Saima Kalsoom Babar: Writing original draft, conceptulization, supervision. **Tarique Ali Jatoi:** Formal analysis, Investigation, visualization**. Zia-ul-Hassan Shah:** supervision, conceptulization.

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