Research Article

Evaluation of Temporal and Differential Fertilizer Application on Growth, Yield and Quality of Wheat

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Abstract | Pakistani soils are very poor in organic matter content; therefore, fertility status of soils is very low. Farmers apply fertilizer but below the recommended doses. As we know that for the better quality and yield of crops, time and method of fertilizers application are the most important factors. Some growth stages are very sensitive, at those stages of growth; the addition of fertilizers is more responsive than others. In order to nutrients to become available when the plant needs them and to make maximum benefits, fertilizers should be applied at the right time. In this experiment, impact of fertilizer applying methods for nitrogen and potash at different times was investigated on wheat crop. Wheat was sown as a test crop with six different fertilizer application methods at varying times under RCBD arrangement with three replications. The experimental soil was high in pH, low in fertility status and free from salinity and sodicity hazards. Wheat grains were analyzed for mineral contents. The results revealed that maximum grain yield was obtained from treatment T_6 (Half N at sowing time + spray of 2% N after 30 & 45 DAS + half K at sowing time + spray of 2% K after 30 & 45 DAS) as compared to other treatments. Furthermore, the chemical analysis showed the maximum quantity of N, P and K in wheat grains obtained from T_6. This study concluded that split application of fertilizer at various stages of wheat crop produced better yield as well as wheat quality. The joined addition of NPK at sowing time along with 2% spray of N and K after 30 and 45 days of sowing is the best approach for the increase in wheat growth and yield.

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Introduction

Food security is a global issue of developing world for the ever-increasing population, while the natural resources are the same. Healthy and nutrient enriched food through proper management practices of nutrients are necessary for a healthy generation and maintenance of successful life and social growth (Nazir *et al.*, 2016). For healthy crops, different fertilizer application strategies are being used such as seed coating, soil application *etc.*, while, foliar fertilization is considered better for the maximizing quality and yield of crops. The nutrients through this method are readily available to plant because it is independent of

soil-water availability and root activity factors. In areas where saline and drought conditions prevail, the foliar application showed the best results as compared to soil application. In such situations, the required nutrients are rapidly absorbed because they are supplied to the leaves and absorbed directly. It has shown to be a good method for increasing N, P, K requirements for critical growth periods of a crop (Amanullah *et al*., 2013). A sufficient supply of nutrients is essential to obtain the maximum yield potential of crops.

Among all nutrients, nitrogen has prime importance to achieved successful plant growth of any crop because nitrogen is required for protein manufacturing that is an integral component of chloroplast and protoplast (Alam *et al*., 2010). In the soil, nitrogen is lost by many mechanisms including: denitrification, leaching, volatilization and runoff hence, nitrogen use efficiency reduces in the rhizosphere (Qadri *et al*., 2015).

The importance of potassium (K) in plants is well documented, it is involved in enzyme activation (Abid *et al*., 2016), various metabolic activities in plants such as cation-anion balance, stomatal conductance, photosynthesis, energy transfer, osmoregulation, phloem transport, protein synthesis, carbohydrate translocation in plants and meristematic growth etc. It is well known fact that potassium is famous for its impacts on metabolism of vitamins, formation of nucleic acids, generation of many substances essential for plant development as well as synthesis of proteins. It is known as a key active cation of the plant cell. It also enables the plant to resist against pests and diseases, and also improves the synthesis of fats and carbohydrates. In the growth and development of plants as well as many growth regulating mechanisms within the plant, role of potassium is self-explanatory (Bukhsh *et al*., 2012). Potassium has major part in refining plant acceptance under anxiety circumstances (Khan *et al*., 2014). K is tangled in meristematic tissue's development, cell turgor pressure, quality determination and crop productivity (Gul *et al*., 2011; Dewdar and Rady, 2013).

Foliar applied fertilizers, alone or in combination with pesticides reduced the environmental threat of pollution by decreasing the amount of nutrients and increasing the economic effects of nutrients (Kalinova *et al*., 2014). When soil moisture is limited then foliar application of N is useful for improving grains protein and plant productivity. Plant's lodging risk can also be reduced by the late addition of N in foliar mode. However, weight per grain was increased by its application during and after the anthesis stage (Woolfolk *et al*., 2002). In some cases, foliar applied nitrogen showed a better response than granular applied nitrogen. In wheat crop, foliar N application during anthesis and milking stage increased grain protein. After the late milky-ripe stage, foliar applied N is not taken up by plant. At these timings, carbohydrate accumulation is reduced and ultimately plants show no response in terms of yield (Baloch *et al*., 2019).

Combine usage of fertilizers in foliar and soil mode has been evaluated better to enhance growth components and maize grain yield (Asumadu *et al*., 2012). Foliar usage of nutrients surges vegetative as well as crop attributes of wheat in comparison to soil addition. Because of interfering of many edaphic factors like loss of nutrients due to leaching, deficiency of soil water and less temperature in the soil, roots are incapable of nutrient absorption. In such situations, foliar application is very useful (Rahman *et al*., 2014). In most cases, foliar feeding is less costly and more effective, and gives better response than soil application (Jamal *et al*., 2006). Keeping in view the low fertility status of Pakistani soils and low fertilizer use efficiency, current trial was performed to evaluate the impacts of temporal and fertilizer usage on various wheat parameters like crop quality and development.

Materials and Methods

This research experiment was done at AARI, Faisalabad, Punjab, Pakistan during 2017-2019. Wheat seeds were sown in the soil on November 20, 2017 and crop after maturity was harvested in April 24, 2018 for the first time and this same practice was followed for 2nd year of experimentation.

Experiment Setup, Treatments and Measurements

Soil samples were collected for determination of different characteristics (physical and chemical) before starting this trial.

Six treatments with three replications were tested by using RCBD design of statistics. Experiment comprised of the following treatments:

T_1 = N, P AND K as recommended dose (RD).
T_2 = K as RD + half N at sowing time + spray of 2% N after 30 & 45 DAS.
T_3 = N as RD + half K at sowing time + half K after

30 DAS.

T_4 = N as RD + half K at sowing time + spray of 2% N after 30 & 45 DAS.

T_5 = Half N at sowing time + spray of 2% N after 30 & 45 DAS + half K at sowing time + half K after 30 DAS.

T_6 = Half N at sowing time + spray of 2% N after 30 & 45 DAS + half K at sowing time + spray of 2% K after 30 & 45 DAS.

Urea, SSP and K_2SO_4 remained respective sources for N, P and K and were applied to all pots as per treatment plant. These fertilizers were added at the rate of 120 N-90 P-60 K for kg/ha. These fertilizers were applied to all plots as per action proposal. Wheat variety Faisalabad-2008 was sown. All agronomic practices were carried out for optimum growth and yield of wheat. Soil samples were examined for different properties *i.e.*, EC and pH (Richards, 1954), and organic matter (Walkley, 1947). Fertility status of soil was determined by measuring extractable K (Richards, 1954) and Olsen P (Olsen, 1954). Hydrometer method was used for textural class determination (Bouyoucos, 1962). Wheat grain and straw yield were measured along with other growth parameters.

Chemical analysis of grains

Grain samples were taken at harvesting and oven dried at 70°C, ground, digested and analyzed for concentration of nitrogen, phosphorus and potassium. Digestion of these samples was done in tri-acid mixture of H_2SO_4-$HClO_4$-HNO_3 (George *et al.*, 2013). Metavanadate colour method was applied for P-estimation (Jackson, 1979) with Spectrophotometer IRMECO model U-2020, whereas flame spectrophotometry method was used for potassium determination in plant samples (Chapman and Pratt, 1961). N was analyzed by applying protocols of Bremner (1996). The quality parameter i.e., crude protein remained estimated by multiplying N concentration by 6.25 (Fujihara *et al.*, 2008).

Statistical analysis

Entirely composed data were exposed to analysis of statistics using RCBD. Mean comparison was carried out according to the LSD test, at $p \leq 0.05$ probability level (Steel *et al.*, 1997).

Results and Discussion

Basic soil analysis indicated that the experimental site had sandy clay loam texture and free from salinity and sodicity, low in organic matter and available phosphorus while sufficient in available potassium. The chemical analysis of the experimental soil is mentioned in Table 1.

Table 1: *Soil physico-chemical properties before experimentation.*

Parameters	Units	Depth (cm)			
		0-15	15-30	0-15	15-30
		2018		2019	
EC	dS m^{-1}	1.11	1.00	1.31	1.11
pH	-	7.62	6.65	7.53	7.66
Organic Matter (OM)	%	0.99	0.68	0.75	0.43
Available P	ppm	7.6	5.4	6.9	4.3
Available K	ppm	188	149	116	68
Texture		Sandy clay loam			

Table 2: *Various yield parameters as affected by N and K application through different modes.*

Treatments	Plant height (cm)	Number of tillers/ plant	Number of spikes/ plant	Number of spikelet/ spike	Grain/ spike	1000-grain weight (g)
T_1	98 b	11 a	10 a	19 a	57 ab	41.00 ab
T_2	103 ab	9 bc	9 a	20 a	57 ab	44.33 a
T_3	104 ab	9 bc	9 a	19 a	53 ab	39.33 b
T_4	105 a	10 b	9 a	20 a	54 ab	40.33 b
T5	104 ab	7 d	7 b	19 a	65 a	42.67 ab
T6	100 ab	9 c	9 a	19 a	48 b	42.67 ab
LSD	5.83	1.00	1.96	1.45	14.09	3.78

All the values are means of triplicates ± SD. Letters in a column are not significantly ($p \leq 0.05$) dissimilar rendering to Fishers least significant difference (LSD).

Wheat growth attributes

The results showed that split application of fertilizer, significantly increased the plant height and maximum plant height (105 cm) was recorded in treatment where RD of N + ½ K at sowing + 2% spray of K at 30 and 45 DAS were applied, while, minimum plant height (98 cm) was observed in T_1 where RD of N, P and K was applied while other treatments were statistically remained at par (Table 2). Maximum number of tillers (11 tillers/plant) was obtained in T_1 where RD of N, P and K was applied followed by T_4 (10 tiller/plant) where RD of N + ½ K at sowing + 2% spray of K at 30 and 45 DAS was applied. Minimum number of spikes/plant (7) was found in T_5 treatment while all other treatments were statis-

tically at par with each other. Non-significant effect of all treatments was observed in the case of number of spikelets /spike. The number of grains/spike is also significant parameter to predict the yield of wheat grain. The highest number of grains/spike (65) was found in treatment T_5 where ½ N at sowing + 2% spray of N at 30 and 45 DAS + ½ K at sowing + ½ K at 30 DAS were applied. On the other hand, maximum 1000 grain weight (44.33 g) was found in T_2 treatment followed by T_5 and T_6 treatment (42.67 g).

Wheat yield attributes

Two years data (Figure 1) showed that soil and foliar applied N and K (urea and K_2SO_4) significantly affect grain yield of wheat. The maximum grain yield was recorded from T_4 (4.11 tons ha^{-1}) and T_6 (3.88 tons ha^{-1}) treatments respectively. However, both treatments showed statistically non-significant results. Higher straw yield 7.08 tons ha^{-1} and 7.09 tons ha^{-1} was recorded in T_1 and T_3 (Figure 2).

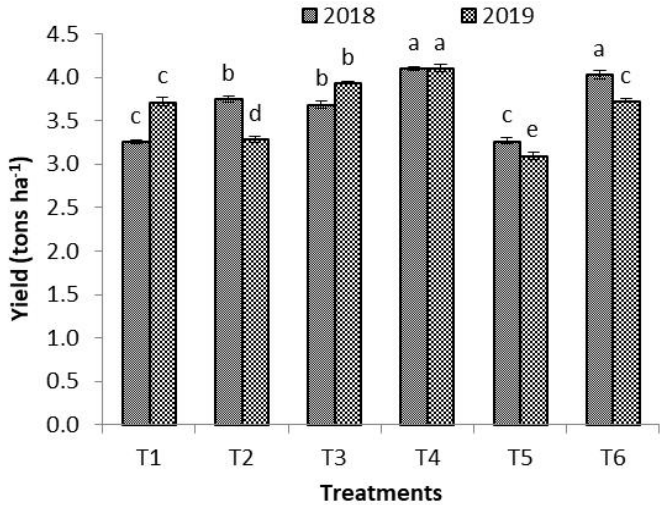

Figure 1: *Wheat yield as affected by N and K application through different modes.*

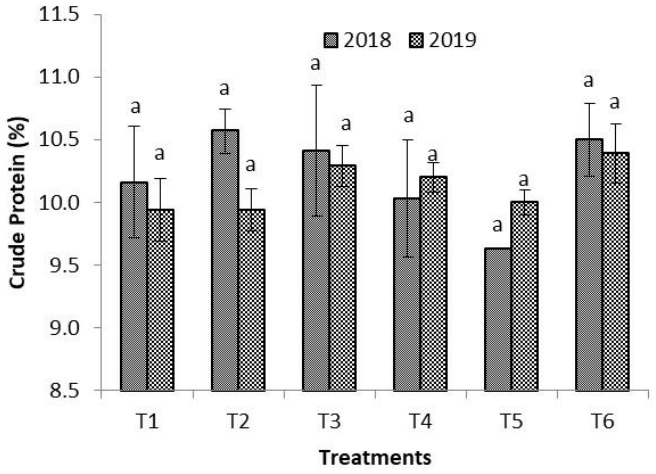

Figure 2: *Wheat straw yield as affected by N and K application through different modes.*

Quality parameters

Data related to quality parameters were given in Figure 3 and 4. During year 2018-2019 maximum crude protein (10.45%) was found in treatment T_6 and minimum was found in treatment T_5. Maximum crude fiber was found in treatment T_1 where recommended NPK was applied, while all other treatments were at par with each other.

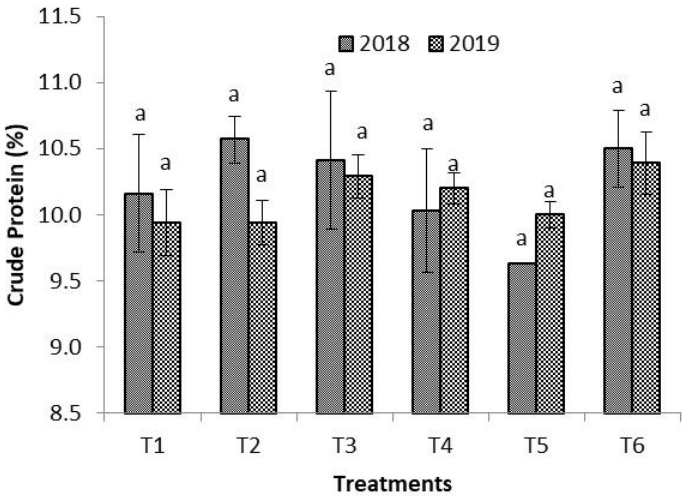

Figure 3: *Crude Protein as affected by N and K application through different modes.*

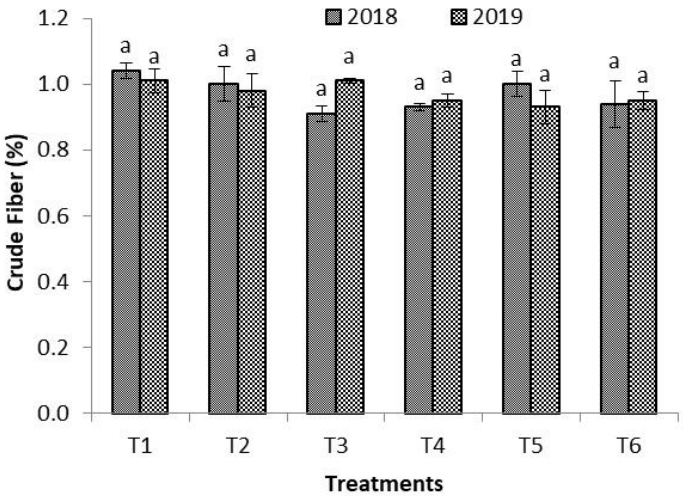

Figure 4: *Crude Fiber as affected by N and K application through different modes.*

Nutrient concentration in wheat grains

The N, P and K concentration were evaluated and results presented in Table 3. The nitrogen contents in grain showed that all treatments were statistically similar. On the other hand, maximum phosphorus content was observed in T_4, while the maximum K was observed in T_6, which were 92 and 74% increase respectively as compared to their respective controls.

Kenbaev and Sade (2002) reported that foliar spray of

nutrients in combination or alone enhance the plant height. Previous studies also indicated that foliar application of potassium improves plant height in wheat when sprayed under drought conditions at vegetative stage than at flowering or at grain filling stages (Aown *et al*., 2012). Arif *et al*. (2010) reported that increased number of tillers was observed due to foliar application of K. The number of grains/spikes is also significant parameter to predict the yield of wheat grain. Parvez *et al*. (2009) described that number of grains/spike was significantly increased with foliar spray of urea. Guenis *et al*. (2003) and Soylu *et al*. (2005) reported that 1000 grain weight was significantly improved with nutrient foliar application. Foliar and soil applied N and P also improved the grain yield of wheat. Arif *et al*. (2009) described that foliar applied N ensures the sufficient availability of nutrients to crops for obtaining higher yield. Another study indicated that potato yield was also improved by K sprays on weekly basis (Fageria *et al*., 2009). Foliar spray 1.5% K_2SO_4 improved straw and paddy yield as compared to KCl and KNO_3 (Ali *et al*., 2005). This might be due to suitable concentration of K_2SO_4 for foliar application which produced high yield. Maize grain yield was much improved by urea spray of 7 kg N ha^{-1}. Plants cannot consume urea N when its foliar application was done after anthesis stage because it prolongs the dry matter accumulation in plants (Singh, 2003). John and Lester (2011) described that foliar applied potassium increased crude protein in grains due to the better accessibility of nutrients to cereals. Dekov (2004) described that nitrogen spray after flowering stage increased the seed protein.

Table 3: *Nutrient contents of wheat grains as affected by N and K application through different modes.*

Treatments	N (%)	P (%)	K (%)
T_1	1.62 a	0.38 ab	0.46 c
T_2	1.69 a	0.40 ab	0.54 abc
T_3	1.66 a	0.40 ab	0.49 bc
T_4	1.61 a	0.42 a	0.48 bc
T_5	1.54 a	0.38 ab	0.57 ab
T_6	1.68 a	0.38 b	0.62 a
LSD	0.15	0.04	0.10

All the values are means of triplicates ± SD. Letters in a column are not significantly ($p \leq 0.05$) dissimilar rendering to Fishers least significant difference (LSD).

Conclusions and Recommendations

This study concluded that split and foliar application of N and K improved the plant height, grain yield and straw yield. The N, P and K contents of wheat grain also increased by split and foliar application while quality parameters (protein and crude fiber) remained unaffected.

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Novelty Statement

Wheat growth and yield was improved by N and K application through split and foliar mode.

Author's Contribution

Raheela Naz: Basic Researcher.
Ana Aslam, Qudsia Nazir and Asifa Naz: Preparation of graphs on excel.
Abid Niaz: Complete direction, supervision of paper preparation.
Sarfraz Hussain and Ghulam Sarwar: Proof read and edited for English language.
Farah Rasheed, Amina Kalsom and Nisa Mukhtar: Contributed in laboratory analysis.
Sadia Sultana and Ifra Saleem: Elaborated results and discussion.
Muhammad Aftab and Arfan ul Haq: Participated in materials and methodology portion.
Muhammad Arif and Muhammad Adnan Rafique: Contributed to introduction section.
Aamer Sattar: Analysis of research data for statistics.

Conflict of interest
Authors declare that they have no conflict of interest.

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