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A study on wheat crop for estimation of potassium efficiency, effect on growth, potential yield under agricultural and botanical practices

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Abstract

Wheat (*Triticum aestivum L.)* is one of the important crops of human diet around the globe. Purify flour of wheat contains less vitamins and causes constipation and malnourishment. The experiment was designed to study on wheat crop, botanical and agricultural parameters and advances in plant sciences and accomplished in Randomized Complete Block Design. Sowing was done in field with plot size of 216 m^2. LAI is very crucial growth index which directly controls the interception of solar radiation and consequently dry matter production and accumulation. The LAD exhibits the tenacity of leaves to remain photo synthetically active during the growth season of a crop. The NAR indicates the dry matter accumulation in plants per unit canopy area. Recorded data was subjected to analysis of variance by using Statistix 8.1 software. It presented mean values of all treatments for crop growth rate. Maximum results for CGR observed under T_3 with 14.3 mean values. While minimum observations had been shown by T_1 that is 13.4. It showed mean values for all applied treatments and wheat showed maximum value of leaf area index of (3.3367) under treatment (T_4) and minimum value of leaf area index that is 3.0233 was shown by plants under treatment (T_7). Maximum results for flag leaf area observed under T_4 with 114.73 mean values. While minimum observations had been shown by T_1 that is 88.03. It is recommended that the farmers should use split dose of potassium fertilizer for better growth and yield of wheat and it may also be helpful in future prospects.

Keywords: Wheat, agriculture, botanical, crop sciences, sustainable development.

INTRODUCTION

Cereals play a substantial role in consumption patterns of the world. In most of the countries cereal crops are the basis of agricultural production. Wheat (*Triticum aestivum L.)* is one of the important parts of human diet around the globe. Among cereals the worldwide highly distributed food is wheat which has the largest planting area. Wheat is used to feed more than 35 percent of the world's population [1, 2]. That's why it plays a vital role in global food security and its stipulation coming from developing countries especially. Among cereals wheat has been placed at top of the list for holding greater than 66 percent of annual harvesting area. It is grown annually and four wheat species are grown globally for wheat production from which *Triticum aestivum* occupies 95 % of wheat cultivated area of world and 5% is occupied by the species *Triticum durum* and remaining two species *Triticum polonicum* and *Triticum spelta* grown on small areas of world[3-5].

In cereals, wheat is an essential major crop that supplies twenty percent of the calories worldwide. Primarily, it is used for making bread, chapati and biscuits. Human beings depend on plants to get their food. Wheat is a major crop because its consumption is 120 kg per person. In many countries, wheat is a staple food and 1/3 world population feeds on this crop because approximately half of protein is obtained from it. The demand of wheat may increase till 2050 up to 750 million tons. Wheat belongs to family Poaceae because it is used as principal food globally it has great importance. Now days wheat is cultivated over 18% of cultivable area, 35% world population use it as a staple food globally, it provides 20% basic need of daily use of protein and a big source of other nutrients of diet. Wheat grain is rich in starch and contains 60-68 % of it [1, 3, 6]. Other nutrients such as cellulose (2-2.5%) fats (1.5 -2%) and minerals (1.8%) are also present in wheat grain. Wheat is considered as a big source of calories because it contains such a great percentage of starch 65-75 % in white flour and 60 to 70 % in whole grain. Ingredients derived from wheat are used as raw assets for many industrial food makings. Several kinds of animal's feeds are also obtained from by-products of wheat. Because wheat can be cultivated in different environmental condition and it is recognized as high yield crop and used as natural resource for several food products, it is considered as a successful crop [6-8].

Wheat gives large quantity of carbohydrates, energy and many other elements that are crucial and useful for fitness, like protein, vitamins (particularly B), fiber and chemical substances. Fiber lowers the danger of heart disease, non-insulin-dependent diabetes and cancer particularly colon cancer. Wheat has gluten protein, so it is used to make bread. Due to gluten, bread mixture binds together and becomes capable of absorbing gas. Purify flour of wheat contains less vitamins and causes constipation and malnourishment. The whole grain of wheat contains bran and wheat germ and protects from, heart problem, weight gain and appendix [9-11].

Wheat yield is affected by a variety of biotic and abiotic stressors. The abiotic factors that affect the wheat yield include insufficient water or nutrients, climatic conditions etc. Plant diseases and insects are the biotic factors that cause yield losses in wheat. During different phonological periods, the required growth factors for wheat are different and therefore it is sensitive to ecological factors which fluctuate during the expansion period. Many studies have shown that the influence of increasing air pollution on wheat productivity should not be underestimated. For instance, the elevation in the intensity of atmospheric particulate matters whose diameter ($PM_{2.5}$) which is less than 2.5 µm puts eloquent antagonistic effect on the regular production of wheat. Critical haze can reduce surface air temperature by reducing sun radiation, which can affect wheat growth [12-14].

Potassium is commonly titled as "poor-man's irrigation" as it helps crops to attain yield efficiently. Demand of Potassium differs in different plants and plant groups. Such as, wheat needs Potassium for ideal development although proper Potassium contributes to good standard of entire plant because of greater capability of photosynthesis, higher opposition for few diseases, efficacy of higher water utilization, and supports to regulate a proper equilibrium within protein and carbohydrates. Adequate Potassium gives powerful husk of wheat and helps in ripening [15, 16].

Varieties Ufaq-2002 and Inqlab-91 were provided with control, 30 Kg, 60 Kg and 90 Kg of potassium per hectare. Grain yield, 100 grain weight, fertile tillers and grains per spike were significantly increased with the increasing supply of potassium. It was observed that the productivity was highest where 90 Kg of potassium was supplied and 60 Kg of potassium per hectare also gave better results. In Inqlab-91 variety the productivity was more increased by increasing potassium level than Ufaq-2002.

MATERIALS AND METHODS

The experiment was designed to observe Potassium use efficiency as influenced by prevailing temperature and its effect on growth and yield components of wheat (*Triticum aestivum* L.)

Experiment site and condition

The experiment was performed on variety (Punjab 2011) during Rabi season, in Research Field of Plant Physiology Section, Ayub Agricultural Research Institute, Faisalabad.

Experimental Design

The experiment was accomplished in Randomized Complete Block Design (RCBD). Three replications were managed to investigate the experiment. Sowing was done in field with plot size of 216 m^2. The plot was further divided into 8 small plots with size of 3m×9m. Each small plot was contained 10 rows with row-to-row distance of 23 cm. The fertilizer 115, 85 N.P kg/ha was applied. Seed rate was used 125 kg/ha. Agronomic practices like drill sowing, irrigations (according to rainfall) and chemical weed control were performed uniformly. Following treatments were applied.

Leaf Area Index (LAI)

LAI is very crucial growth index which directly controls the interception of solar radiation and consequently dry matter production and accumulation. The LAI was computed by the formula written below [16].

$$\text{LAI} = \frac{\text{leaf area}}{\text{land area}}$$

CGR (Crop0growthjrate) (g m^{-2} day^{-1})

The CGR indicates the dry matter production by plants per unit land area. This also reveals the progress or advancement in the growth of plants. Crop growth rate (CGR) was measured by formula which was suggested by hunt [17].

$$CGR = \frac{W_2 - W_1}{t2 - t1}$$

Where, W_1 and W_2 are total dry weights harvested at time t_1 and t_2, respectively.

LAD (Leaf area duration) (days)

The LAD exhibits the tenacity of leaves to remain photo synthetically active during the growth season of a crop. The LAD was computed by the equation [18].

$$LAD = \frac{(LAI1 + LAI2)(t2 - t1)}{2}$$

Where, LAI_1 and LAI_2 are the leaf area indices at time t_1 and t_2, respectively.

NAR (Net assimilation rate) (g m^{-2} day^{-1})

The NAR indicates the dry matter accumulation in plants per unit canopy area. This also shows the net progress in dry matter assimilation in plants after respiratory loses. The NAR was calculated with the help of formula suggested [19].

$$NAR = \frac{TDM}{LAD}$$

TDM= Total dry matter, and LAD= Leaf area duration

STATISTICAL ANALYSIS

Recorded data was subjected to analysis of variance by using Statistix 8.1 software. A suitable comparison test was used to determine the differences among treatments under controlled and potassium used treatments.

RESULTS AND DISCUSSIONS

Crop growth rate (g m^{-2} day^{-1})

Analysis of variance for crop growth rate of wheat (Punjab 2011) is shown in table1.1. Significant outcomes observed for this parameter under different treatments of recommended potassium (K) dose. It presented mean values of all treatments for crop growth rate. Maximum results for CGR observed under T_3 with 14.3 mean value. While minimum observations had been shown by T_1 that is 13.4.

Table-1.1: Analysis of variance for crop growth rate of wheat plant

Source	df	SS	MS	F	P
Replication	2	0.00392	0.00196		
Treatment	7	1.96973	0.28139	18909.4**	0.0000
Error	14	0.00021	0.00001		
Total	23	1.97386			

**Highly significant at $P < 0.05$/ * Significant at $P < 0.05$/ ^{NS} Non-significant @ $P > 0.05$

Grand Mean = 14.181 CV = 0.03

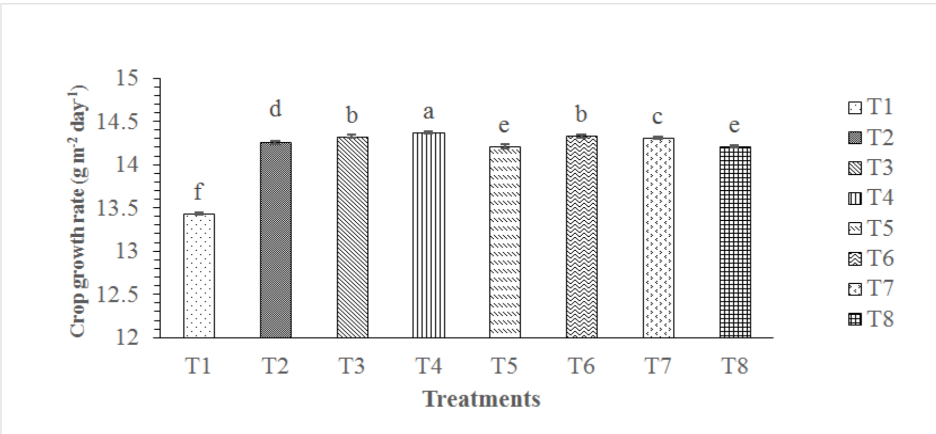

Fig-1.1: Graph presenting crop growth rate of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed

+ 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

Leaf area index (LAI) (%)

Table 1.2 showed the results of analysis of variance of wheat (Punjab 2011) under different treatments of potassium (K) at various growth stages. All treatments showed significantly different values. It showed mean values for all applied treatments and wheat showed maximum value of leaf area index of (3.3367) under treatment (T_4) and minimum value of leaf area index that is 3.0233 was shown by plants under treatment (T_7).

Table-1.2: Analysis of variance for leaf area index of wheat plant

Source	df	SS	MS	F	P
Replication	2	0.00231	0.00115		
Treatment	7	0.22172	0.03167	382.82**	0.0000
Error	14	0.00116	0.00008		
Total	23	0.22518			

**Highly significant at P < 0.05/ * Significant at P < 0.05/ ^{NS} Non-significant @ P > 0.05
Grand Mean = 3.1992 CV = 0.28

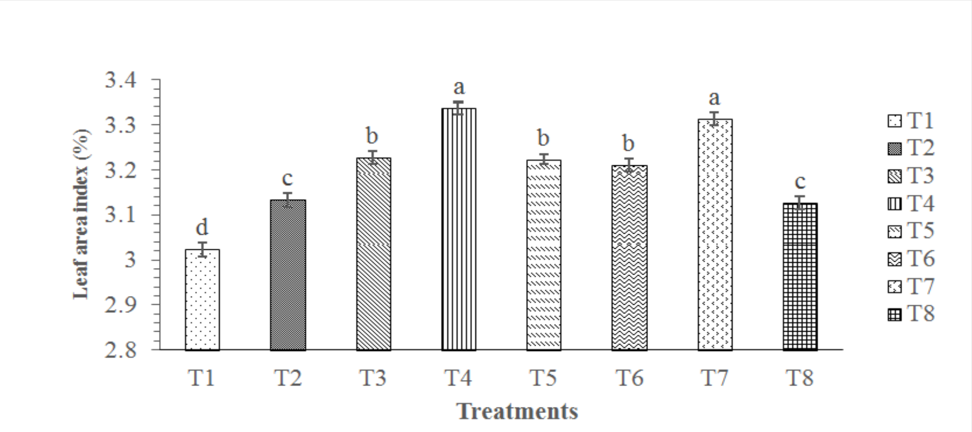

Fig-1.2: Graph presenting leaf area index of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed + 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

Flag leaf area (cm^2)

Analysis of variance for flag leaf area of wheat (Punjab 2011) is shown in table 1.3 Significant results observed for this parameter under different treatments of recommended potassium (K). It presented mean values for all treatments. Maximum results for flag leaf area observed under T_4 with 114.73 mean value. While minimum observations had been shown by T_1 that is 88.03.

Table-1.3: Analysis of variance for flag leaf area of wheat plant.

Source	df	SS	MS	F	P
Replication	2	39.28	19.641		
Treatment	7	2065.99	295.141	94.47**	0.0000
Error	14	43.74	3.124		
Total	23	2149.01			

**Highly significant at P < 0.05/ * Significant at P < 0.05/ ^{NS} Non-significant @ P > 0.05
Grand Mean = 99.990 CV = 1.77

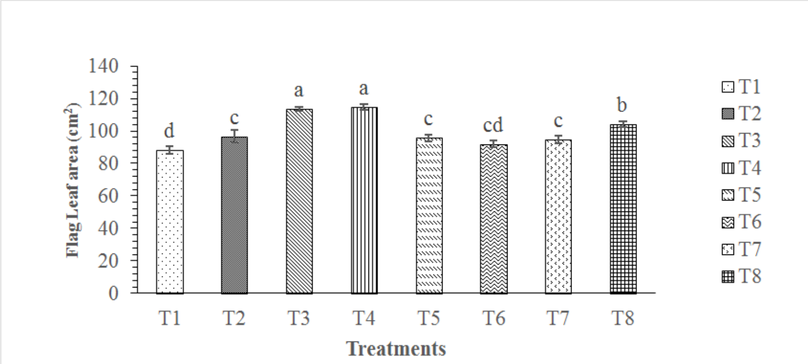

Fig-1.3: Graph presenting flag leaf area of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed + 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

Total dry matter (%)

Table 1.4 showed the results of analysis of variance of wheat (Punjab 2011) under different treatments of potassium (K) at various growth stages. All treatments showed significantly different values. It showed mean values for all applied treatments and wheat showed maximum value of total dry matter of (1166.0) under treatment (T_4) and minimum value of total dry matter that is 936.7 was shown by plants under treatment (T_1).

Table-1.4: Analysis of variance for total dry matter of wheat plant

Source	df	SS	MS	F	P
Replications	2	508	254.0		
Treatment	7	103593	14799.0	1699.41**	0.0000
Error	14	122	8.7		
Total	23	104223			

**Highly significant at $P < 0.05$/ * Significant at $P < 0.05$/ ^{NS} Non-significant @ $P > 0.05$

Grand Mean = 1086.3 CV = 0.27

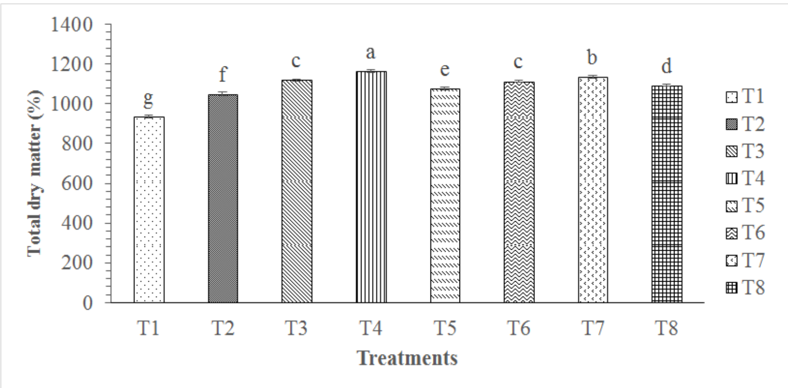

Fig-1.4: Graph presenting total dry matter of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed + 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

Net assimilation rate (g m^{-2} day^{-1})

Table 1.5 showed the results of analysis of variance of wheat (Punjab 2011) under different treatments of potassium (K) at various growth stages. All treatments showed significantly different values. It showed mean values for all applied treatments and wheat showed maximum net assimilation rate of (4.4233) under treatment (T_4) and minimum net assimilation rate that is 3.3867 was shown by plants under treatment (T_7).

Table-1.5: Analysis of variance for net assimilation rate of wheat plant.

Source	df	SS	MS	F	P
Replication	2	0.00461	0.00230		
Treatment	7	2.52293	0.36042	19532.4**	0.0000
Error	14	0.00026	0.00002		
Total	23	2.52780			

**Highly significant at P < 0.05/ * Significant at P < 0.05/ ^{NS} Non-significant @ P > 0.05
Grand Mean = 4.1379 CV = 0.10

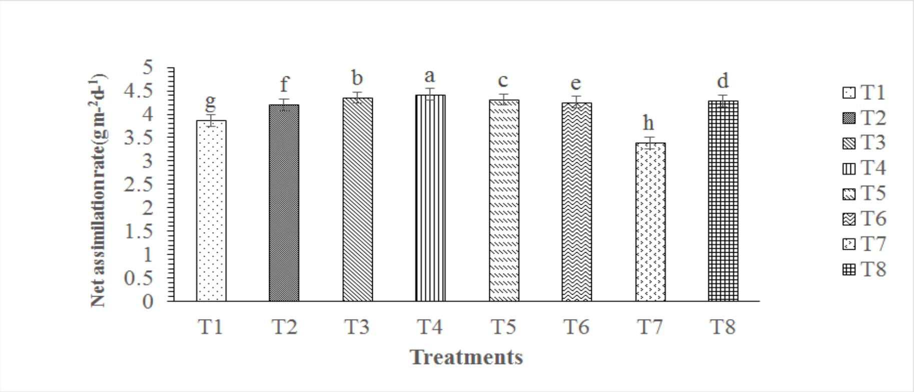

Fig-1.5: Graph presenting net assimilation rate of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed + 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

Leaf area duration (LAD)(days)

Table 1.6 showed the results of analysis of variance of wheat (Punjab 2011) under different treatments of potassium (K) at various growth stages. All treatments showed significantly different values. It showed mean values for all applied treatments and wheat showed maximum leaf area duration of (321.82) under treatment (T_4) and minimum leaf area duration that is 248.02 was shown by plants under treatment (T_1).

Table-1.6: Analysis of variance for leaf area duration of wheat plant

Source	df	SS	MS	F	P
Replication	2	119.4	59.69		
Treatment	7	11157.6	1593.94	1297.82**	0.0000
Error	14	17.2	1.23		
Total	23	11294.2			

**Highly significant at P < 0.05/ * Significant at P < 0.05/ ^{NS} Non-significant @ P > 0.05 Grand Mean = 299.80 CV = 0.37

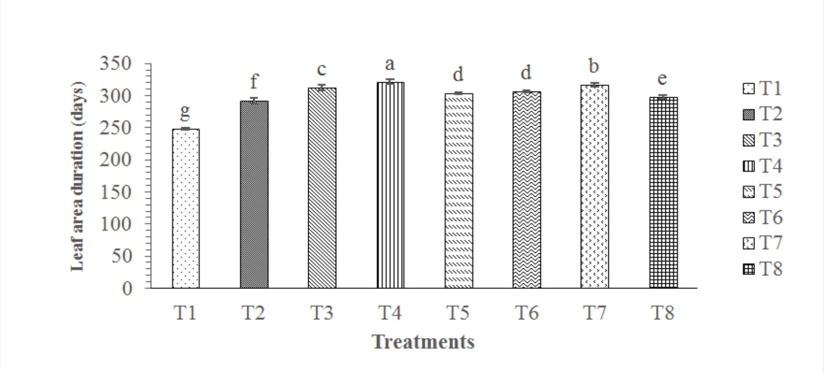

Fig-1.6: Graph presenting leaf area duration of wheat under potassium (K) treatments.

T_1: Control (No potash fertilizer application), **T_2**: K recommended dose (60 kg/ha) during preparation of seed bed, **T_3**: K recommended dose during preparation of seed bed + foliar application of K (2% KNO_3 solution at booting stage), **T_4**: K during preparation of seed bed + foliar application of K at grain filling stage, **T_5**: K during preparation of seed bed + foliar application of K at booting and grain filling stages, **T_6**: 1/2 dose K during preparation of seed bed + 1/2 dose at the time of booting stage, **T_7**: 1/2 dose of K during seed bed + 1/2 dose at the time of grain filling stage, **T_8**: 1/3 dose of K during preparation of seed bed + 1/3 dose **at** booting stage + 1/3 dose at grain filling stage.

The experiment was conducted to observe Potassium use efficiency as influenced by prevailing temperature and its effect on growth and yield components of wheat (*Triticum aestivum* L.). The experiment was performed on variety (Punjab 2011) during Rabi season (2020-21), in research field of Plant Physiology Section, Ayub Agricultural Research Institute, Faisalabad.

The experiment was laid out in Randomized Complete Block Design (RCBD). Three replications were used to conduct the experiment. The fertilizer 115, 85 N.P kg/ha was applied. Seed rate was used 125 kg/ha. Agronomic practices like drill sowing, irrigations (according to rainfall) and chemical weed control were performed uniformly. Following treatments were applied.

The data was recorded on different parameters, all the results after statistical analysis differs significantly. Analysis of variance for crop growth rate of wheat (Punjab 2011) is showed significant difference. Significant outcomes observed for this parameter under different treatments of recommended potassium (K) dose. Maximum results for CGR observed under T_3 (K recommended dose during preparation of seed bed + foliar application of K (2% KNO3, solution at booting stage) with 14.3 mean value. While minimum observations had been shown by T_1 (Control (No potash fertilizer application) that is 13.4. It is noted that significance differences in crop growth rate of wheat crop. Present study observations are also in accordance with results for crop growth rate and various other traits. Presence of variations in various treatments of potassium for crop growth rate in wheat were highly significant [20-22].

The analysis of variance for leaf area index showed highly significant results. All the treatments showed significantly different values. The T_4 (K during preparation of seed bed + foliar application of K at grain filling stage) increases most the leaf area index. Its findings are in accordance with the present study results for leaf area index in wheat after different treatments of potassium and they also found the significant difference for leaf area index. It is reported the significant difference for leaf area index in wheat.

The flag leaf area is the growth parameter in wheat, the significant results were observed under different treatments of recommended potassium (K). The T_4 (K during preparation of seed bed + foliar application of K at grain filling stage) effects most on flag leaf area. It is reported significant results with flag leaf area in wheat crop also contributed to describing significant valuable results in flag leaf area also reported homogenous results [23-25].

CONCLUSION

It is determined from this research experiment that split dose of potassium plays a noteworthy the development and seedling processing for the enhancement of overall developmental growth of wheat. It is recommended that the farmers should use split dose of potassium fertilizer for better growth and yield of wheat and it may also be helpful in future prospects.

REFERENCES

1. Ahanger, M. A., & Agarwal, R. M. (2017). Potassium up-regulates antioxidant metabolism and alleviates growth inhibition under water and osmotic stress in wheat (Triticum aestivum L). *Protoplasma*, *254*(4), 1471-1486.

2. Hadis, M., Meteke, G., & Haile, W. (2018). Response of bread wheat to integrated application of vermicompost and NPK fertilizers. *African Journal of Agricultural Research*, *13*(1), 14-20.
3. Khan, M. Z., Muhammad, S., Naeem, M. A., Akhtar, E., & Khalid, M. (2006). Response of some wheat (Triticum aestivum L.) varieties to foliar application of N & K under rainfed conditions. *Pakistan Journal of Botany*, *38*(4), 1027.
4. Ponkia, H. P., Vekaria, L. C., Ramani, V. B., Sakrvadia, H. L., Polara, K. B., & Babaria, N. B. (2018). Potassium and Sulphur Fertilization of Wheat (Triticum aestivum L.) in Medium Black Calcareous Soils of Saurashtra Region of Gujarat. *International Journal of Pure & Applied Bioscience*, *6*, 1634-1640.
5. Zheng, Y., Xu, X., Simmons, M., Zhang, C., Gao, F., & Li, Z. (2010). Responses of physiological parameters, grain yield, and grain quality to foliar application of potassium nitrate in two contrasting winter wheat cultivars under salinity stress. *Journal of Plant Nutrition and Soil Science*, *173*(3), 444-452.
6. Tariq, M. U. H. A. M. M. A. D., Saeed, A., Nisar, M., Mian, I. A., & Afzal, M. (2011). Effect of potassium rates and sources on the growth performance and on chloride accumulation of maize in two different textured soils of Haripur, Hazara division. *Sarhad J. Agric*, *27*(3), 415-422.
7. Kubar, G. M., Talpur, K. H., Kandhro, M. N., Khashkhali, S., Nizamani, M. M., Kubar, M. S., & Kubar, A. A. (2019). 27. Effect of potassium (K+) on growth, yield components and macronutrient accumulation in Wheat crop. *Pure and Applied Biology (PAB)*, *8*(1), 248-255.
8. Dinçsoy, M., & Sönmez, F. (2019). The effect of potassium and humic acid applications on yield and nutrient contents of wheat (Triticum aestivum L. var. Delfii) with same soil properties. *Journal of Plant Nutrition*, *42*(20), 2757-2772.
9. Ashraf, M. Y., Rafique, N., Ashraf, M., Azhar, N., & Marchand, M. (2013). Effect of supplemental potassium (K+) on growth, physiological and biochemical attributes of wheat grown under saline conditions. *Journal of Plant Nutrition*, *36*(3), 443-458.
10. Ur Rehman, A., & Ishaque, M. (2011). Potassium application reduces bareness in different maize hybrids under crowding stress conditions. *Pak. J. Agri. Sci*, *48*(1), 41-48.
11. Liang, X., & Yu, Z. (2004). Effect of potassium application stage on photosynthetic characteristics of winter wheat flag leaves and on starch accumulation in wheat grains. *Ying Yong Sheng tai xue bao= The Journal of Applied Ecology*, *15*(8), 1349-1352.
12. Liu, Y., Chen, Q., Ge, Q., Dai, J., Qin, Y., Dai, L., ... & Chen, J. (2018). Modelling the impacts of climate change and crop management on phenological trends of spring and winter wheat in China. *Agricultural and Forest Meteorology*, *248*, 518-526.
13. Raza, M. H., Bakhsh, A., & Kamran, M. (2019). Managing climate change for wheat production: An evidence from southern Punjab, Pakistan. *Journal of Economic Impact*, *1*(2), 48-58.
14. Wang, Y., & Wu, W. H. (2013). Potassium transport and signaling in higher plants. *Annual review of plant biology*, *64*, 451-476.
15. Ye, Y., Wang, G., Huang, Y., Zhu, Y., Meng, Q., Chen, X., ... & Cui, Z. (2011). Understanding physiological processes associated with yield–trait relationships in modern wheat varieties. *Field Crops Research*, *124*(3), 316-322.
16. Zaman, U., Ahmad, Z., Farooq, M., Saeed, S., Ahmad, M., & Wakeel, A. (2015). Potassium fertilization may improve stem strength and yield of Basmati rice grown on nitrogen-fertilized soils. *Pakistan Journal of Agricultural Sciences*, *52*(2).
17. Singh, P., Agrawal, V. K., & Singh, Y. V. (2019). Effect of potassium and FYM on growth parameters, yield and mineral composition of wheat (Triticum aestivum L.) in alluvial soil. *Journal of Pharmacognosy and Phytochemistry*, *8*(3), 24-27.
18. Rabbani, M., Hosseini-Mokhallesun, S. A. A., Ordibazar, A. H., & Farrokhi-Asl, H. (2020). A hybrid robust possibilistic approach for a sustainable supply chain location-allocation network design. *International Journal of Systems Science: Operations & Logistics*, *7*(1), 60-75.
19. Farooq, M. S., Chaudhry, A. H., Shafiq, M., & Berhanu, G. (2011). Factors affecting students' quality of academic performance: a case of secondary school level. *Journal of quality and technology management*, *7*(2), 1-14.
20. Farooq, M. S., Chaudhry, A. H., Shafiq, M., & Berhanu, G. (2011). Factors affecting students' quality of academic performance: a case of secondary school level. *Journal of quality and technology management*, *7*(2), 1-14.
21. Alam, M. R., Ali, M. A., Molla, M. S. H., Momin, M. A., & Mannan, M. A. (2009). Evaluation of different levels of potassium on the yield and protein content of wheat in the high Ganges river floodplain soil. *Bangladesh Journal of Agricultural Research*, *34*(1), 97-104.
22. Chen, X. P., Z. L. Cui, M. S. Fan, P. Vitousek, M. Zhao, W. Q. Ma, Z. L. Wang, W. J. Zhang, X. Y. Yan, J. C. Yang, X. P. Deng, Q. Gao, Q. Zhang, S.W. Guo, J. Ren, S. Q. Li, Y. L. Ye, Z. H. Wang, J. L. Huang., & Y. Q. Tang. (2014). Producing more grain with lower environmental costs. Nature, 514-486.

23. Brar, M. S., & Tiwari, K. N. (2004). Boosting seed cotton yields in Punjab with potassium: A review. *Better Crops*, *88*(3), 28-31.
24. Hasanuzzaman, M., Bhuyan, M. H. M., Nahar, K., Hossain, M. D., Mahmud, J. A., Hossen, M., & Fujita, M. (2018). Potassium: a vital regulator of plant responses and tolerance to abiotic stresses. *Agronomy*, *8*(3), 31.
25. Guo, J., Jia, Y., Chen, H., Zhang, L., Yang, J., Zhang, J., & Zhou, Y. (2019). Growth, photosynthesis, and nutrient uptake in wheat are affected by differences in nitrogen levels and forms and potassium supply. *Scientific reports*, *9*(1), 1-12.