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Effect of potassium application on growth, yield and nutrients uptake of wheat crop in Alluvial soil

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Abstract

A field experiment was conducted at Raja Balwant Singh College Research farm Bichpuri, Agra during rabi season of 2017-18 to study the effects of potassium levels on the growth, yield and uptake of wheat. The treatments comprised of five potassium levels viz. 0, 30, 60, 90 and 120 kg K ha^{-1}. The results revealed that the significant effect was limited to potassium application up to 90 kg $K_2$0 ha^{-1}, beyond which the response was not significant in yield of wheat crop. However, the higher plant height, number of tillers, yield attributing characters, grain yield, straw yield, crude protein, protein yield was found in 120 kg K ha^{-1} treatment. The nutrient uptake was recorded highest in the treatment 120 kg K ha^{-1} and lowest in the control. It can be suggested that farmers can be used 90 kg K ha $^{-1}$ for better growth and yield and nutrient uptake of wheat.

Key words: Potassium, Wheat, Growth, Yield, Crude Protein, Nutrient uptake

Introduction

Potassium is one of the three major essential nutrient elements required by plants, unlike nitrogen and phosphorus, potassium does not from bonds with carbon or oxygen, so it never becomes a part of protein and other organic compounds. Although, K is not a constituent of any plant structures or compounds, it is involved in nearly all processes needed to sustain the plant life, Potassium in cell sap is involved in enzyme activation, photosynthesis, transport of sugars, protein and starch synthesis, it is known to help crop to perform better under water stress through the regulation of the rate at which plant stomata open and close. It is also known for its role to provide lodging resistance and insect / disease resistance to plants. Since Potassium is involved in many metabolic pathways that affect crop quality, it is often called as “the quality element”. Potassium as a macro element plays an important role in quantity and quality of crop production. Wheat is the most important staple food grain crop in Indian diet and main source of protein and calories for a large section of population. By 2020, India will have a population of about 1.3 billion and there will be a substantial pressure on land to produce more food. Stagnation in wheat production, lower productivity and inferior quality of the Produce is due to various constraints including inadequate and imbalanced nutrient application. To enhance productivity of wheat, use of balanced fertilization by potassium application is of great significance so as to attain maximum economic yield without any deleterious effect on soil properties or ecological balance. Crops

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differ in their responsiveness to applied potassium and therefore crop specific potassium management would help a great deal in maintaining soil fertility besides achievement the goal of higher yield. Although K deficiency is not as widespread as that of N and P, many recent research data reveal that soils which were initially rich in K (based on soil test) have become K deficient due to heavy removal of K by harvested crops and inadequate K application (Tiwari, 2002). Crops, in general, remove as much or more K than they remove N but average consumption of K_20 ha^{-1} is still 8.7 kg while that of N is 58.7 kg ha^{-1} resulting in a highly unbalanced N : K_2O ratio 7 : 1. In the long-term fertilizer experiments, there are indications that when exchangeable K is not rapidly replenished, crops start drawing on the non-exchangeable K, resulting in soil mining and depletion of soil K reserves. The present study was, therefore, undertaken to find out the effect of different rates of potassium on the growth, yield and nutrient uptake of maize.

Materials and Methods

A field experiment was conducted at Raja Balwant Singh College Research farm Bichpuri, Agra during rabi season of 2017-18. The experiment was laid out in randomized block design with three replications on sandy loam soils. The soil had EC-0.14 dSm^{-1}, pH-8.00, organic carbon 3.3 g kg^{-1}, available N-162 kg ha^{-1}, P-11.5 kg ha^{-1}, K-110.3 kg ha^{-1} and S-8.2 kg ha^{-1}. The treatments comprised of five potassium levels viz. 0, 30, 60, 90 and 120 Kg K ha^{-1}. The control plots received no potassic fertilizer**.** The wheat crop (var. PBW 343) were sown at the rate 100 kg ha^{-1} in furrows during rabi season on Nov 20, 2017. Recommended doses of N (150 kg ha^{-1}) and P (60 kg P_2O_s ha^{-1}) for wheat were applied at the time of sowing. Nitrogen was applied in the form of urea. Diammonium phosphate was used as a source for P_2O_5. Potassium as per treatments was applied in the form of muriate of potash at sowing. Intercultural operations were done as and when necessary. Five hills from each plot were randomly selected and uprooted after sowing for taking data on growth parameters like plant height, tillers/running meter. The crop was harvested at physiological maturity and grain and straw yields were recorded. The grain, leaf, shoot samples are collected and analyzed nutrient uptake. These observations on growth, yield attributes and nutrient uptake were recorded at harvest. The collected data were analyzed statistically.

Results and Discussion

Plant height

A study of kg Table 1 reveals potassium fertilization (30, 60 and 90 Kg K_2O ha^{-1}) in wheat that significantly increased. The plant height over no potassium treatment. The plant height was further increased non-significantly with 120 kg K_20 ha^{-1} over 90 kg K20 ha^{-1}. The tallest plants were produced by wheat crop with 120 kg K_2O ha^{-1} application. The plant height increased from 83.7 cm at control to 91.0 cm at 120 kg K_20 ha^{-1}. An improvement in plant growth by potassium application might be owing to its role in the formation of protein, vitamins and chlorophyll. Therefore, due to differences in availability of potassium at graded levels of fertilization significant differences in wheat plant growth were observed. These results confirm the findings of Singh et al. (2016).

Number of tillers

A further study of Table 1 reveals that the

Table 1: Effect of potassium levels of growth and yield attributes of wheat

Potassium levels	Plant height (cm)	Tillers/running meter	Ear length (cm)	No. Grain/ear	Test weight (g)
0	83.7	79.0	7.7	42.6	45.7
30	85.0	81.7	7.8	43.2	46.2
60	87.8	85.0	8.2	44.4	47.7
90	90.2	89.2	8.7	44.9	48.4
120	91.0	90.5	8.8	45.0	49.0
SEm$\pm$	1.37	1.20	0.05	0.54	0.22
CD (P=0.05)	2.94	2.57	0.10	1.17	0.45

increasing levels of potassium increased the number of tillers per running meter significantly over control. Application of 90 kg K_2O ha^{-1} produced significantly higher number of tillers (89.2) over other treatments. However, maximum number of tillers (90.5) was noted with 120 kg K_2O ha^{-1}. Tillering capability is genetically controlled but also much dependent on the nutrition and environmental factors. Among various plant hormones, cytokinins have been known to play an important role in the growth of buds and tillers. Therefore, better potassium nutrition in fertilized plots resulted in significant increase in the number of tillers. Singh et al. (2000) and Singh et al. (2016) reported similar results.

Yield attributing characters

Data on yield attributes of wheat recorded at harvest are presented in Table 1. The ear/plant, grain/ear and 1000 grains weight of wheat increased significantly with potassium application over control. The maximum values of ear length (8.8 cm), grains/ear (45.0) and 1000 grains weight (49.0 g) were recorded at 120 kg K_2O ha^{-1}. However, significant increase in these yield attributes was recorded up to 90 kg K_20 ha^{-1}. This might be on account of better translocation of Photosynthates from source to sink and its involvement in protein and fat synthesis. This results in formation of bold grain by increasing the size and weight of grain. The possible reason of increase in these yield attributes could be that growth was much influenced by potassium application, which, later on, got converted in to reproductive phase. The favorable effect of K addition on yield attributes might be probably due to the fact that potassium is well known for its role in various metabolic processes. These findings endorse the results of Singh et al. (2000) and Singh et al. (2016).

Grain yield

The yield has been expressed in terms of grain and straw. The data pertaining to yield studies as affected by potassium levels are summarized in Table 2. The grain yield of wheat increased significantly with potassium application. The increase in yield of wheat crop was significant for each levels of potassium as compared to no potassium treatment (control). The significant effect was limited to potassium application up to 90 kg K_20 ha^{-1}, beyond which the response was not significant in yield of wheat crop. The increases in grain yield of wheat due to 30, 60, 90 and 120 kg K_20 ha^{-1} over control were 5.1, 17.1, 25.8 and 29.2 per cent, respectively. The beneficial results in respect of yield of wheat crop were mainly due to increased availability of K as a result of potash application, which enhanced physiological and biochemical activities. The increase in grain yield with K levels may be due to its role in improving the utilization of N which directly plays a role in cellular metabolism and reflected in improved grain production. Response of wheat to potassium application was also reported by Tomar and Singh (1994), Singh and Singh (2009), Khare and Dixit (2011), Yadav et al. (2012), Singh et al. (2016) and Singh (2018).

Straw yield

Potassium levels had significant beneficial effect on the straw yield of wheat significantly over control and maximum wield of straw was recorded under 120 kg K_2O ha^{-1} treatments Table 2. The increases in straw yield of wheat due to 30, 60, 90 and 120 kg K_2O ha^{-1} over control were 5.2, 15.0, 26.2 and 28.7 per cent, respectively. Thus,

Table 2: Effect of potassium levels on crop yield and protein yield (kg ha^{-1}) of wheat crop

Potassiuml evels	Yield (kg ha^{-1})		% response		Protein (%)		Protein yield
	Grain	Straw	Grain	Straw	Grain	Straw	(kg ha^{-1})
0	41.50	60.87	-	-	12.0	3.3	498.0
30	43.62	64.06	5.1	5.2	12.1	3.4	527.8
60	48.60	71.00	17.1	15.0	12.3	3.5	597.7
90	52.23	76.85	25.8	26.2	12.5	3.6	626.7
120	53.61	78.38	29.2	28.7	12.7	3.7	680.6
SEm±	1.30	2.11	-	-	0.07	0.03	14.52
CD (=0.05)	2.70	4.36	-	-	0.15	0.06	30.05

Table 3: Effect of potassium levels on nitrogen and phosphorus uptake in wheat grain and straw

Potassium Levels	N uptake (kg ha^{-1}) Grain	N uptake (kg ha^{-1}) Straw	P uptake (kg ha^{-1}) Grain	P uptake (kg ha^{-1}) Straw
0	80.1	32.3	8.7	6.1
30	81.0	35.2	9.6	7.0
60	96.2	40.5	11.2	8.5
90	105.0	46.1	13.0	10.7
120	109.4	48.6	13.9	11.7
SEm±	2.21	1.37	0.45	0.49
CD (P=0.05)	4.58	2.84	0.94	0.01

application of potassium brought about a significant improvement in the straw yield of wheat. Similar results were reported by Meel et al. (1994), Singh et al. (2009), Singh et al. (2016) and Singh (2018).

Qualitative studies

Crude protein

The data on protein content in wheat crop are presented in Table 2. It is evident from the data that the crude protein in wheat crop increased significantly with potassium application. As compared to control, almost all the higher levels of potassium were significantly superior in respect of protein content in wheat crop. The plants grown in control treatment had minimum protein percentage in their grain and straw. The maximum percentage of crude protein (12.7 % in grain and 3.7 % in straw) was recorded at 120 kg K_2O ha^{-1} dose. Since, potassium has vital role in the synthesis of protein in the plants, it greatly contributes to the quality of the crops. The increase in protein content due to potassium application might be due to increase in the synthesis of effective ribosome's, aminoacyl t RNA'S, peptide bond synthesis etc, during protein synthesis. The increase in the crude protein content with potassium application has been reported in cereals (Singh and Singh 2002). Sahu and Singh (2009) and Singh et al. (2016).

Protein yield

The data on protein yield of the crop are presented in Table 2. The study reveals that the increasing level of potassium from 0 to 120 kg ha^{-1} significantly increased the protein production in the crop and maximum protein yield in wheat crop was recorded under 120 kg K_20 ha^{-1}. The protein yield increased from 498 kg ha^{-1} at control to 680.6 kg ha^{-1} at 120 kg K_20 ha^{-1}. This increase in protein yield may be attributed to greater production of grain and straw of wheat and improvement in protein percentage. The highest level of 120 kg K_20 ha^{-1} could not improve significantly the protein production over 90 kg K_20 ha^{-1}. It has been the increase in protein yield with potassium Hadwani application and Gundalia reported by Singh and Singh (2002), Singh et al. (2016) and (2005) Singh and Singh (2009).

Uptake studies

Nitrogen

The N uptake data in Table 3 indicated that the uptake of nitrogen by the crop significantly increased with every increase in the level of potassium supply over control. A consistent and significant increase in N uptake by grain and straw of wheat was recorded up to 90 kg K_20 ha^{-1} application. The higher level of K (120 kg K_2O ha^{-1}) could not increase the nitrogen uptake by grain and straw over 90 kg K_20 ha^{-1}. Higher values of N uptake with increasing levels of potassium addition are apparently the result of favorable effect of this element on N absorption coupled with greater grain and straw production. Similar results were obtained Sharma et al. (2003),

Phosphorus

The data on P uptake by the wheat crop as affected by K levels are given in Table 3. The results reveal that the increased yields due to potassium fertilization of the crop resulted in increased phosphorus removal by the crop; it increased from 8.7 to 13.9 and 6.1 to 11.7 kg ha^{-1} in grain and straw of wheat as the dose of potassium was increased from 0to 120 kg K_20 ha^{-1}. However, the difference in phosphorus uptake by grain and straw due to 90/ 120 kg K_20 ha^{-1} statistically non-significant. The changes in P uptake by wheat grain and straw brought about by potassium fertilization were pronounced and significant up to 90 kg K_2O ha^{-1}.

Potassium

A study of Table 4 reveals that the progressive increase in potassium levels gradually increased the uptake of potassium by the wheat grain and straw over control. Highest uptake of potassium by the crop was recorded for the treatment producing higher yields. Higher uptake of K might

Table 4: Effect of potassium levels on potassium, sulphur and zinc uptake in wheat grain and straw

Potassium levels	Potassium uptake (kg ha^{-1})		Sulphur uptake (kg ha^{-1})		Zinc uptake (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
0	23.2	104.0	8.3	5.5	120.3	133.9
30	25.7	112.8	9.1	6.4	128.7	142.8
60	31.1	129.2	11.2	8.5	149.2	163.3
90	35.5	144.4	12.5	10.0	167.1	183.6
120	38.0	152.8	12.3	9.4	166.2	180.3
SEm_+	0.71	2.87	0.39	0.21	2.57	3.14
CD(P=0.05)	1.71	5.94	0.81	0.43	5.31	6.49

be due to higher yields of the wheat crop as the differences in percent K content were significant. In all the cases, the uptake of potassium under 30, 60, 90 and 120 kg K_20 ha^{-1} was significantly more than the control treatment. However, the maximum values of K uptake by the crop were recorded at 120 kg K_2O ha^{-1} treatment. Similar results were obtained by Singh et al. (1997) Singh and Pathak (2002) and Singh and Singh (2002) and Singh (2018).

Sulphur

Data on sulphur uptake by grain and straw of wheat as affected by k levels are presented in Table 4. A further study of reveals that the sulphur uptake by the wheat crop increased significantly with increase potassium application over control. The sulphur uptake by wheat grain and straw increased from 8.3 to 12.5 and 5.5 to 10.0 kg ha^{-1}, respectively. The increased S uptake following K application might have been contributed by increased sulphur concentration and reproductive yields of the wheat crop. Similar trend was reported by Singh et al. (1997) and Chauhan et al. (2017).

Zinc

The data on zinc content in wheat grain and straw as affected by K application are presented in Table 4. The uptake of Zn by the wheat crop increased significantly with potassium application over control. The uptake of zinc by grain and straw ranged from 120.3 to 167.1 and 133.9 to 183.6 g hai1, respectively. The maximum value of zinc uptake by wheat crop was recorded with 90 kg ha^{-1}. The increase in Zn uptake may be attributed to higher yield of the crop as well as improvement in zinc content due to potassium addition. Similar results were reported by Khare and Dixit (2011).

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