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Optimization of Potassium Fertilization for Maize (*Zea mays* L.) in New Alluvial Zone of West Bengal

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A B S T R A C T

A field experiment was conducted during *kharif* season of 2018 at District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, and West Bengal, India on sandy clay loam soil having neutral in reaction with the objective of optimization of potassium fertilization for maize in new alluvial zone of West Bengal. The experiment was laid out in Randomized Block Design having four replications with six treatments (T) comprising different potassium levels as 0 (T_1), 30 (T_2), 60 (T_3), 90 (T_4), 120 (T_5) and 150 (T_6) kg K_2O ha^{-1} with recommended dose of nitrogen and phosphorus (120:60 N: P_2O_5 kg ha^{-1}). Application of 150 kg K_2O ha^{-1} resulted in higher plant height (304.23 cm), LAI (6.71) grain yield (7.86 t/ha), stover yield (9.12 t/ha), net return (Rs. 59019.33/-) which were statistically at par with 120 kg K_2O ha^{-1} treated plots and 90 kg K_2O ha^{-1} treated plots. Highest B: C (2.11) ratio was observed in T_5 treatment which was statistically at par with T_6 treatment (2.10) and T_4 treatment (2.04). The results showed that increase in all growth, yield, net return and B: C ratio of crop was more pronounced up to 90 kg K_2O ha^{-1}, but there was no significant increase in all growth, yield, net return and B: C ratio of crop when potash level was increased above 90 kg K_2O ha^{-1}. So, it could be concluded that application of 90 kg K_2O ha^{-1} is the optimum level of potassium for maize to obtain higher yield and profitability.

Keywords

Maize, Potassium, Yield, Net return and B: C ratio

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Introduction

Maize is an important grain crop of the world and it ranks 3rd after wheat and rice in area basis and total production (FAOSTAT, 2013). The importance of corn is due to its wide diversity of uses. Globally, maize is grown in 184 M ha across 165 countries, with total production of 1016 Mt and average productivity of 5.52 t/ha (FAOSTAT, 2014). Its production is increasing at twice the annual rate of rice and three times that of wheat (Fischer *et al.,* 2014). India produces about 2% the world's maize produce. Karnataka is the leading producer of maize in India producing around 16% of India's total Maize production and followed by Telangana & Bihar which together contribute 20% to India's maize production basket. Maharashtra, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Rajasthan and Uttar Pradesh are other maize producing states of India. Maize is also gaining importance in West Bengal. The area of cultivation of this crop is increasing year after year. In the year 2015-16 maize was cultivated in 0.156 M ha and recorded production of 0.720 Mt of maize grains. The state's contribution to national production was about 2.74%. However, average productivity (4615 kg/ha) was much higher as compared to national average of 2632 kg/ha (more than 165%).

Potassium is the major nutrient required for a variety of crops along with nitrogen and phosphorus for their normal growth and development. Potassium acts as macro-nutrient in plant growth and crop production. It plays role in cell expansion and maintains turgidity. It helps in osmo- regulation of plant cell, assists in opening and closing of stomata, more than 60 enzymes are activated by potassium. Promotive effect has been observed on growth, development and grain yield in maize. It regulates photosynthesis, protein synthesis and starch synthesis (Mengel and Kirkby, 1996). Thus, maize requires K as high as that of nitrogen and for about 6 metric tons production, maize removes 120 kg N, 50 kg P and 50 kg K ha^{-1} from soil.

Numerous studies on soil potassium have been carried out in the past. But there is enough scope to study the availability of soil potassium for plant growth. The fertilizer use efficiency of maize crop with respect to individual elements is affected by its proportion in soil. Maize genotypes respond to potassium application contrarily due to modification in its uptake, translocation, accumulation, growth and utilization. Application of K has primitive effect on growth and development (Bukhsh *et al.*, 2011) and grain yield in maize (Bukhsh *et al.*, 2009). It not only affects the rate of photosynthesis but also regulates transport of assimilates in maize. So, the present experiment was conducted to study the effect of different levels of potassium on growth, yield attributes, yields and economies of maize crop.

Materials and Methods

The field study was carried out during *kharif* season of 2018 at District Seed Farm (AB-Block) of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, and West Bengal. The experimental farm is situated at $22^0 57'$ N latitude and $88^0 20'$ E longitude with an average altitude of 9.75 m above the mean sea level, having neutral pH (7.2) with 253, 11.48 and 179.42 kg ha^{-1} of available N, P and K, respectively. The experiment was laid out in Randomized Block Design having four replications and six treatments comprising different potassium levels (T) as 0 (T_1), 30 (T_2), 60 (T_3), 90 (T_4), 120 (T_5) and 150 (T_6) kg K_2O ha^{-1} with recommended dose of nitrogen and phosphorus (120:60 N: P_2O_5 kg ha^{-1}). Potassium applied in two split doses, one basal and one in knee height stage and total P was applied as basal and N was applied as 3 split doses (1/3 at basal, 1/3 at knee height stage and 1/3 at tasseling stage). The plot size of 5 m x 3 m ($15m^2$) with row to row distance of 60 cm and plant to plant distance 20 cm and COH (M) 8 maize variety were used.

Fertilizers were applied as per treatments; six different doses of K_2O, N and P_2O_5 were applied in the form of MOP, Urea and SSP, respectively. Data were recorded on growth parameters (plant height, LAI) and post-harvest parameters (length and girth of cob, grain yield and stover yield) and economic parameter (net return, B: C). Height of the plant was recorded from 5 marked plants from each plot and their average (treatment-wise) was calculated. LAI of maize is calculated by using the following formula:

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

Length of the cobs of five labelled plants were measured from base to the tip of the cob after de-husking and the mean value of five randomly selected cob was worked out to expressed in centimetre (cm). The girth of five labelled cob was measured with the help of vernier calliper and the mean value was expressed in cm. The grain yield was recorded from net plots at 120 DAS from each plot. Cobs were collected, grains were separated and weighed, the total weight was recorded and expressed in kg ha^{-1} and the stover weight was recorded from net plots after sun drying and was expressed in kg ha^{-1}.

Treatment wise cost of cultivation of maize of one-hectare area was calculated. Cost of cultivation included land preparation cost, labour cost, irrigation cost, cost of fertilizers and cost for intercultural operation. Net return is the difference between the gross return and the cost of cultivation. Net return was calculated and recorded for each treatment combination and the benefit: cost ratio is the ratio of gross return and cost of cultivation. Benefit: cost ratio of different treatment of the crop was computed by following formula:

$$B: C = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Results and Discussion

Effect of potassium on growth attributes

Potash (K) application significantly affected plant heights and LAI at 90 DAS. Long stature plants (304.23 cm) were produced at 90 DAS when potash was applied at the rate of 150 kg K_2O ha^{-1} which was statistically similar to 120 kg K_2O ha^{-1} applicator plots (302.06 cm) and 90 kg K_2O ha^{-1} applicator plots (299.98 cm). The increase in plant height with higher K doses might be attributed to the fact that higher potassium doses promoted plant growth, increased the number and length of the internodes due to more cell division and cell elongation which in turn resulted higher plant height. Findings of this study are in line with Ayub *et al.*, (2002), Hussain *et al.*, (2011), Bukhsh *et al.*, (2011) and Aslam *et al.*, (2004) who also found improvement in growth parameters in different cultivars of maize with the application of potash. Statistical analysis of the recorded data showed that potash (K) application significantly affected on leaf area index (LAI). Highest LAI (6.71) at 90 DAS were obtained at T_6 treatment, where potash was applied at the rate of 150 kg K_2O ha^{-1} which was statistically similar to 120 kg K_2O ha^{-1} treated plots (6.60) and 90 kg K_2O ha^{-1} treated plots (6.57). The increase of LAI with increasing level of K application could be due to the increased photosynthetic activity of plants and more no of leaves per plant. Amanullah *et al.,* (2016) reported that maximum leaf area index was recorded for the plots treated with the highest K level (90 kg ha^{-1}).

Effect of different treatments on yield attributes and yield

Yield attributes

From the Table 1 it may be stated that different level of potassium did not significantly influenced the length of cob and cob girth. However maximum cob length (15.30 cm) was observed at T_5 treatment (120 kg K_2O ha^{-1}.). Highest cob girth (13.86 cm) was obtained when potash was applied at the rate of 150 kg K_2O ha^{-1}. The mean data revealed that cob length and cob girth increase with increased different potassium levels. Similar result was obtained by Hussain et al., (2019) and Amanullah *et al.*, (2016).

Table.1 Plant height, LAI, length of cob, girth of cob of maize as affected by different treatments

Treatments	Plant height at 90 DAS (cm)	LAI at 90 DAS	Length of cob (cm)	Girth of cob (cm)
T1- RDF of nitrogen and phosphorus + 0 kg potassium per ha	283.33	5.25	12.22	12.54
T2 -RDF of nitrogen and phosphorus + 30 kg potassium per ha	279.13	5.44	13.77	13.08
T3 - RDF of nitrogen and phosphorus + 60 kg potassium per ha	284.66	5.51	13.49	13.00
T4 - RDF of nitrogen and phosphorus + 90 kg potassium per ha	299.98	6.57	14.30	13.32
T5 - RDF of nitrogen and phosphorus + 120 kg potassium per ha	302.06	6.60	15.30	13.08
T6 - RDF of nitrogen and phosphorus + 150 kg potassium per ha	304.23	6.71	15.23	13.86
Sem ±	2.12	0.22	1.09	0.42
CD at 5%	6.69	0.70	NS	NS

Table.2 Grain yield, Stover yield, Net Return and B: C of maize as affected by different treatments

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Net Return (Rs ha^{-1})	B:C
T1- RDF of nitrogen and phosphorus + 0 kg potassium per ha	5.253	6.863	27202.67	1.55
T2 -RDF of nitrogen and phosphorus + 30 kg potassium per ha	5.947	7.416	35843	1.71
T3 - RDF of nitrogen and phosphorus + 60 kg potassium per ha	6.575	7.977	43691	1.85
T4 - RDF of nitrogen and phosphorus + 90 kg potassium per ha	7.397	8.711	54226.83	2.04
T5 - RDF of nitrogen and phosphorus + 120 kg potassium per ha	7.782	8.948	58515.33	2.11
T6 - RDF of nitrogen and phosphorus + 150 kg potassium per ha	7.861	9.125	59019.33	2.10
Sem ±	0.199	143.69	2517.27	0.05
CD at 5%	0.628	452.79	7932.07	0.16

Yield (t ha^{-1}) as affected by different potassium levels

Statistical analysis of the data showed that potash (K) application significantly affected grain and stover yield. The higher grain yield (7.86 t ha^{-1}) and stover yield (9.12 t ha^{-1}) was obtained with 150 kg K_2O ha^{-1} which were statistically similar to 120 kg K_2O ha^{-1} (7.78 t ha^{-1} of grain and 8.948 t ha^{-1} of stover yield, respectively**)** and 90 kg K_2O ha^{-1} (**7**.39 t h^{-1} of grain and 8.71 t ha^{-1} of stover yield, respectively). The results showed that increase in grain yield was more pronounced up to 90 kg K_2O ha^{-1}, but there was no significant increase in grain yield of crop when potash level was increased above 90 kg K_2O ha^{-1}. Increased level of potassium up to 90 kg K_2O ha^{-1} significantly improve grain yield by providing a better source sink relationship enabling greater synthesis and translocation of metabolites to reproductive organs resulting in improved yield attributing characters, grain and Stover yield of maize. The results are in agreement with the findings of Bereez *et al.*, (2005), Choudhary and Malik (2000).

Effect of potassium levels on net return and B: C ratio

The potassium levels significantly influenced the net return and B: C ratio of maize. Maximum net return (59,019.33/- ha^{-1}) obtained fromT_6 treatment which was statistically at par with treatments T_4 and T_5 treatment and B: C ratio (2.11) was obtained in T_5 treatment. Which was statistically at par with treatments T_4 and T_6 treatment? The mean data revealed that net return and B: C ratio increased significantly with the increase in potash level up to 90 kg K_2O ha^{-1}. This might be due to higher grain and stover yield of maize under these treatments.

In conclusion from the experimental results, it could be concluded that application of 90 kg K_2O ha^{-1} is the optimum level of potassium for obtaining higher grain yield, economic benefit of maize and supplementing balance nutrition to the maize during *Kharif* season under new alluvial zone of West Bengal.

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