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Effect of Different Potassium Management Practices on Growth, Yield And Economics Of Maize (*Zea Mays* L.)

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ABSTRACT
A field experiment was conducted during kharif season of 2014 and 2015 at Zonal Agricultural and Horticultural Research Station, Navile Shivamogga under rainfed situation to study the effect of different potassium management practices on growth and yield of maize.Among different potassium management practices, application of 150 % RDK (60 kg K_2O ha^{-1}) in split doses along with foliar fertilization of potassium sulphate (0:0:50) at 60 DASrecorded the highest grain yield of 7693 kg ha^{-1}. Higher gross returns (` 1,01,730 $ha^{-1}$) and net returns (` 64,897 ha^{-1}) were recorded with application of 60 kg K_2O ha^{-1} in two splits along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS. However, higher BC ratio (2.77) was recorded with application of 100 % RDK (40 kg K_2O ha^{-1}) in two splits along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS.
Key words: *foliar fertilization, levels of potassium, potassium sulphate,Split application.*

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INTRODUCTION

Among cereals, maize (*Zea mays* L.) is an important food and feed crop ranked third after wheat and rice both in India and as well as world. In India, crop is being cultivated in an area of 9.43 million hectares with total annual production of 24.35 million tonnes accounting for an average yield of 2583 kg ha^{-1} [1]. The productivity is tremendously lower than other maize growing countries of the world (5160 kg ha^{-1}). There are many reasons for low productivity, among them drought and mismanagement of plant nutrition are important because the crop is predominately grown under *rainfed* situation [2]. Hence, there is a need to evolve best nutrient management strategies to enhance the yield and production of maize under rainfed situation. Among the major nutrients proper management of potassium plays important role while growing maize in rain fed situation. Potassium is involved in many physiological processes, its impact on water relations, photosynthesis, assimilate transport, and enzyme activation has direct consequences on crop productivity [3]. Along with quantity of potassium to be applied, its time of application also plays an important role in determining the yield of maize. Most of potassium is taken up during the vegetative growth and developmental stages of crop, when roots are more active than in reproductive growth stages [4]. Similarly, developing fruits are stronger sinks for photoassimilates than roots and vegetative tissues. This competition for photoassimilates reduces root growth energy supply for nutrient uptake including K [4]. Therefore during later stages of crop growth providing potassium has advantage. In case of light textured soils split application of potassium is recommended as the potassium holding capacity of these soils is low [5]. Hence, time of application of potassium is an important aspect for maize production in crop grown under light textured soil. By considering these points inorder to standardize the potassium management practice for maize grown under *rainfed* condition an experiment was conducted at Zonal Agricultural and horticultural Research Station, Navile, Shimoga during *kharif* season of 2014 and 2015.

MATERIAL AND METHODS

A field experiment was conducted in 2014 and 2015 during *kharif* at Zonal Agricultural and Horticultural Research Station, Navile Shivamogga under rainfed situation to study the **"**Effect of different potassium management practices on growth and yield of maize". The soil of experimental site was slightly acidic in reaction (pH 6.40) with a normal electrical conductivity of 0.25 d Sm^{-1} and low in organic carbon (4.2 g kg^{-1}), low in available nitrogen (194 kg ha^{-1}), high in available phosphorus (64 kg ha^{-1}) and medium in available potassium status (244 kg ha^{-1}).The experiment was laid out in randomized block design with nine treatments and replicated thrice with gross plot size of 4.5X4.5 m. The treatment details are T_1- 100 per cent recommended dose of potassium as basal application, T_2- 125 per cent recommended dose of potassium as basal application, T_3- 150 per cent recommended dose of potassium as basal application, T_4- 100 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS), T_5- 125 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS), T_6- 150 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS), T_7- 100 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS)+ foliar spray of potassium sulphate at 60 DAS, T_8- 125 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS)+ foliar spray of potassium sulphate at 60 DAS, T_9- 150 per cent recommended dose of potassium (50 % as basal + 50 % at 30 DAS)+ foliar spray of potassium sulphate at 60 DAS. Recommended dose of potassium is 40 kg K2O ha^{-1}. Foliar spray of potassium sulphate was done the concentration of one per cent.

Fifty per cent of N and entire dose of P was applied at the time of sowing in the form of urea and di-ammonium phosphate, respectively based on the nutrient combinations. The remaining 50% N was top dressed at 30 days after sowing in the form of urea. The potassium was supplied in the form of muriate of potash as per the treatments. The maize hybrid Hema was sown with a spacing of 45×30 cm. All agronomic practices were carried out as per the schedule.

A total rainfall of 1766.2 and 1232.8 mm was received during 2014 and 2015, respectively, as against normal of 877.1 mm. The rainfall during the year 2014 was exceeded by 101 per cent of normal rainfall of station. In the succeeding year also the trend remained same, in that rainfall exceeded by 40 per cent of normal. In the year 2014, the crop was sown on second week of July and the excessive rains occurred during July (429.2 mm) and August (480.2 mm) month has severely affected the early growth of crop and enhanced the leaching of nutrients. Upto 60 days after sowing the number of rainy days was 44. However, in 2015 the crop was sown on second week of June and the month recorded 294.8 mm rainfall. During 2015 also early stage of crop suffered due to excess rainfall but it was recovered due to optimum rainfall received in July and August (121.0 and 83.2 mm, respectively) and number of rainy days remained 30 during first two month of crop growth

The data on growth parameters were recorded at 30, 60, 90 and at harvest. Yield attributes and yield observations were recorded at harvest and subjected to statistical analysis. The economics of the system was worked out considering the prevailing cost of inputs and price of output. All the results were then analyzed statistically for drawing conclusion using Analysis of Variance (ANOVA) procedure [6].

RESULTS AND DISCUSSION

Growth Parameters

Pooled data at harvest indicated that significantly higher plant height (199.7 cm, respectively) and total dry matter production (303.9 g $plant^{-1}$) was recorded with application of 150 per cent RDK in two equal splits along with foliar fertilization of sulphate of potash at 60 DAS as compared to entire basal application of 100, 125 and 150 per cent RDK. Higher dry matter production with split application of 150 per cent RDK along with foliar fertilization of sulphate of potash could be owing to significantly higher crop-growth rate. Higher crop growth rate was achieved due to higher leaf area, leaf area index and leaf area duration achieved in treatment which received potassium in split doses along with foliar fertilization at 60 DAS.Persistence of the assimilatory area is the pre-requisite for prolonged photosynthetic activity and ultimately crop productivity. In the present investigation, higher values of leaf area index and extended periods of leafiness (LAD) was associated with application of 150 per cent RDK in two splits along with foliar fertilization at 60 DAS. Application of potassium (K) at the highest rate (60 kg ha^{-1}) improved photosynthetic apparatus such as number of leaves $plant^{-1}$ (Table 1) and mean leaf area and LAI of maize (Table 1). According to Akhtar *et al.* [7] and Asif *et al.* [8], the main reason for improved mean leaf area at higher K level could be attributed to the activation of several enzymes, increase in protein synthesis, N uptake and utilization that resulted in the normal growth of maize and hence leaf number and area was increased.

Yield and Yield parameters

The study revealed that significantly the higher grain yield (7693 kg ha^{-1}) was recorded with application of 150 per cent RDK (60 kg K_2O ha^{-1}) in two equal splits (basal+ 30 DAS) along with foliar fertilization at 60 DAS as compared to basal application of 100, 125 and 150 per cent RDK (6532, 6593 and 6614 kg ha^{-1}, respectively) (Table 2). This was closely followed by 125 per cent and 100 per cent RDK in two splits along with foliar fertilization at 60 DAS (7676 and 7620 kg ha^{-1}, respectively). Treatments comprising split application of potassium without foliar fertilization *viz*. T_6, T_5 and T_4 (7404, 7351 and 7314 kg ha^{-1}, respectively) also recorded on par yield with best treatment. Maize responded more positively to split application of potassium rather than only basal application. Due to split application of potassium the maize plants have absorbed more K with the passage of time during their growth period and hence both leaf number and area was increased [9]. The single application of K at early growth stages on the other hand caused the plants to be under K stress and did not provide sufficient amount of K to be available for the plants at different growth stages which decreased photosynthesis. Potassium is one of the principle plant nutrients determining yield and quality of the crop. While involved in many physiological processes, potassium impact on water relations, photosynthesis, assimilate transport and enzyme activation can have direct consequences on crop productivity [10]. Potassium deficiency in entire basal application treatment may lead to a reduction in both the number of leaves produced and leaf area. Coupling this reduced amount of photosynthetic source, reduction in photosynthetic rate per unit leaf area caused overall reduction in the amount of photosynthetic assimilates available for growth. Further, reduced assimilate transport out of the leaves to the developing fruit due to potassium deficiency greatly contributes to the negative consequences on yield and quality production [3]. This mechanism also most likely took place in maize where grain yield responded strongly to the application of potassium in split doses along with foliar fertilization at later stages (T_7-T_9). Grain yield increased as the level of K_2O application increased up to 150 per cent RDK (60 kg K_2O ha^{-1}), which was statistically similar to application of 100 per cent RDK (40 kg K_2O ha^{-1}). Chaudhary and Mallik [11] and Asif Iqbal *et al.* [12] also reported non significant yield response to different levels of potassium. There was a significant effect due to split application of potassium on biomass yield also. Although significantly higher grain yield was obtained with 150 per cent RDK in split doses along with foliar fertilization at 60 DAS the highest stover yield was obtained with application of 150 per cent RDK in split doses without foliar fertilization at 60 DAS (9547 kg ha^{-1}). Because at later stages contribution of foliar fertilization towards leaf longevity and dry matter accumulation in reproductive parts was much more. This may be due to higher harvest index as a result of better translocation of photosynthates to sink (Table 2). Minimum stover yield was observed in the low rate basal application of potassium resulting in an overall reduction in the amount of photosynthetic assimilates available for growth [3]. One of the more visually obvious consequences on plant growth from insufficient levels of plant potassium is a reduction in plant stature. It was reported that insufficient K levels reduced leaf area expansion leading to reduced photosynthesis in maize [13]. Application of 150 per cent RDK in two splits along with foliar fertilization at 60 DAS resulted in a 17.7 per cent increase in yield over basal application of 100 per cent RDK. This is due to cumulative effect of split application of potassium and foliar fertilization at 60 DAS. Data indicates that the cumulative effect of yield-contributing characters, such as cob length (18.43 cm), number of grains per cob (482.9), 100 grain weight (31.6 g) and grain weight per plant (131.9 g) contributed positively to higher grain yield obtained when 150 per cent RDK was applied in split doses along with foliar fertilization at 60 DAS. In the treatment which received 100 per cent RDK as basal the growth and development of plants were hampered due to an imbalance uptake of essential elements which resulted lesser cob length (14.78 cm), less number of grains per cob

(390.8), 100 grain weight (27.5 g) and grain weight per plant (131.9 g). which ultimately gave the lowest grain Yield (6532 kg ha^{-1}). The present findings of increase in grain yield was in accordance with the research findings of Reyhaneh *et al.* [14], Ali Rahimi [15], Sarkaut *et al.*[16].

Economics

Significantly higher gross and net returns (` 1,01,730 $ha^{-1}$ and ` 64,897 ha^{-1}, respectively) were recorded with treatment which received 150 per cent RDK in split doses along with foliar fertilization at 60 DAS as compared to basal application treatments (T_1, T_2 and T_3) and on par with rest of the treatments. Both individual as well as pooled data followed same trend. However, significantly higher B:C ratio of 2.77 was recorded with 100 per cent RDK in split doses along with foliar fertilization at 60 DAS compared to only basal application of potassium (T_1, T_2 and T_3). However, it was on par with rest of the treatments during both years as well as pooled over years.

Table.2: Yield parameters, yield and economics of maize cultivation as influenced by different potassium management practices(pooled data of two years)

Treatments	Length of Cob (cm)	Grains per cob	Test Weight (100 grain weight in g)	Grain weight (g $plant^{-1}$)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)	Gross Returns (` ha^{1})	Net Returns (` ha^{1})	B:C
T_1	14.78	390.8	27.5	107.1	6532	8785	42.5	86703	51916	2.49
T_2	14.97	399.4	28.0	109.3	6593	8886	42.5	87536	52436	2.49
T_3	15.13	403.7	27.8	113.2	6614	8984	42.3	87810	52416	2.47
T_4	16.97	408.7	28.8	121.9	7314	9285	44.0	96747	61568	2.74
T_5	17.08	453.7	29.1	124.1	7351	9423	43.7	97249	61770	2.73
T_6	17.22	454.6	30.1	125.6	7404	9547	43.6	97995	62206	2.73
T_7	17.80	460.8	31.1	129.3	7620	9223	45.1	100671	64440	2.77
T_8	18.27	480.0	31.5	129.9	7676	9373	44.9	101458	64816	2.76
T_9	18.43	482.9	31.6	131.9	7693	9516	44.6	101730	64897	2.75
S.Em.±	0.51	23.4	0.95	3.6	148	99	0.4	1925	1852	0.05
CD (P=0.05)	1.54	70.2	2.83	10.8	444	297	1.3	5771	5553	0.15

Table 1: growth parameters of maize as influenced by different potassium management practices (pooled data of two years).

Treatments	Plant height (cm)	Number of leaves at 60 DAS	Number of leaves at 90 DAS	LAI at 60 DAS	LAI at 90 DAS	CGR (30-60 DAS)	CGR (60-90 DAS)	LAD (30-60)	LAD (60-90)	Total dry matter (g $plant^{-1}$)
T_1	175.1	10.41	6.92	3.14	2.45	20.5	30.5	59.45	83.82	251.4
T_2	178.2	10.69	7.00	3.45	2.51	20.9	33.4	64.46	89.37	258.8
T_3	179.5	10.92	7.18	3.49	2.85	21.4	33.1	65.51	95.06	265.3
T_4	187.6	11.93	7.70	3.84	3.02	25.9	31.0	65.99	102.93	280.8
T_5	188.7	12.02	7.80	4.02	3.10	25.9	32.4	69.69	106.72	282.8
T_6	193.0	12.20	7.81	4.13	3.30	25.6	33.3	73.81	111.40	278.7
T_7	196.4	11.81	7.38	3.83	3.47	26.5	35.0	65.26	109.48	294.3
T_8	197.6	12.06	7.99	3.92	3.55	25.5	36.9	68.37	112.02	303.7
T_9	199.7	12.28	8.89	4.00	3.59	25.6	37.7	71.02	113.90	303.9
S.Em.±	3.8	0.39	0.26	0.13	0.19	1.2	1.6	1.94	3.40	6.8
CD (P=0.05)	11.2	1.16	0.83	0.39	0.56	3.6	4.8	5.80	10.20	20.5

DAS- Days after sowing, LAI- Leaf Area Index, CGR- Crop growth rate, LAD- Leaf area duration

CONCLUSION

The highest grain yield of 7693 kg ha^{-1} was obtained with application 150 % RDK (60 kg K_2O ha^{-1}) in split doses along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS. It was closely followed by the application of 100 % RDK(40 kg K_2O ha^{-1}) in split doses along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS (7620 kg ha^{-1}). Higher gross returns (` 1,01,730 ha$^{-1}$) and net returns (` 64,897 ha^{-1}) were recorded with application of 60 kg K_2O ha^{-1} in two splits along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS. However, higher BC ratio (2.77) was recorded with application of 40 kg K_2O ha^{-1} in two splits along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS. From economic point of view applying 40 kg K_2O ha^{-1} in split doses along with foliar fertilization of potassium sulphate (0:0:50) at 60 DAS is optimum for obtaining higher economic yield of maize under rainfed condition.

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