Original Research Article

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Effect of Potassium and Sulphur Levels on Yield and Yield Attributes of Popcorn (*Zea mays* Var. *Everta*)

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ABSTRACT

Keywords

Rabi popcorn, Potassium levels, Sulphur levels, Dry matter yield, Yield and yield attributes.

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A field experiment was conducted during 2013-14 *rabi* season, at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh to assess response of popcorn (*Zea mays* L. *everta* Sturt) to four levels each of potassium viz., 0, 30, 60 and 90 kg K₂O ha⁻¹ and sulphur viz., 0, 20, 40, 60 kg S ha⁻¹. The results of different potassium and sulphur levels depicted that application of potassium @ 60 kg K₂O ha⁻¹ as well as sulphur @ 40 kg S ha⁻¹ significantly increased the dry weight of leaves, shoot, root and total plant, at 30, 60 DAS and at harvest, cob girth, cob length, number of cobs per plant, number of grains per cob, grain rows per cob, 100 seed weight, seed weight per cob, dry weight of cob, seed yield & fodder yield.

Introduction

Maize is one of the most important cereal crop next to rice, wheat and jowar in respect of area and production in India. Maize cultivated over an area of 9.3 million hectares with production of 24.2 million tonnes and average yield of 2602 kg/ha in the country (FAO STAT, 2014). Gujarat occupies an area of 5.59 lakh hectares, with production of 7.86 lakh tonnes and productivity of 1953 kg /ha (DOA, 2013). According to the character of the kernels, it is classified in various groups among which “popcorn” is major one. Popcorn (*Zea mays* L. var. *everta* Sturt) also known as popping corn is popular and nutritious snack food in many parts of World. All parts of corn such as grain,

branches and leaves, even corn cob and corn silk is used numerously in human nutrition, fed livestock and poultry and pharmaceutical industry. The kernels of teosinte are readily “popped” for human consumption like modern popcorn. It has tremendous potentiality because, it gives more remuneration to the farmer. Potassium and sulphur play a vital role in the nutrition of plants. Fertility analysis of Indian soils has indicated that the soils are deficient in sulphur and medium to low in the potash. In fact, these nutrients are lacking mostly in the soils of Saurashtra region. Therefore, application of chemical fertilizers becomes essential to raise the crop yield. Potassium is an essential

element for plant growth and development and is the most abundant cation in plants, making up 3-5% of a plant's total dry weight. Sulphur plays an important role in enhancing the productivity of pop corn crop.

Materials and Methods

The experiment was conducted during *rabi* season 2013-14 in D-5 plot of Instructional Farm at Krushigadh, College of Agriculture, Junagadh Agricultural University, Junagadh. It is Geographically Junagadh is situated at 21.5° N latitude and 70.5° E longitude with an altitude of 60 m above the mean sea level. The experiments were laid out in Factorial Randomized Block Design having 16 treatments with three replications. The gross and net plot sizes were 5.0 m X 3.6 m and 4.2 m X 2.4 m, respectively. The experiment consisted of 4 levels of potassium (0, 30, 60 and 90 kg K₂O ha⁻¹) and 4 levels of sulphur (0, 20, 40, 60 kg S ha⁻¹).

The soil of the experimental field was medium black calcareous soil with pH 7.9 and EC 0.35 dS m⁻¹. The crop was fertilized with potassium and sulphur as per treatment allotted to each plot in the form of MOP and Cosavet fertis. WG. (90%) in basal application and nitrogen and phosphorus in the form of urea, dammonium phosphate in the furrows, respectively 1/3rd nitrogen applied before sowing, 1/3rd at 20 days after sowing and remaining 1/3rd at 40 days after sowing, and phosphorus applied as basal. Amber popcorn variety was used as planting material in this study. The seeds were dibbled at a spacing of 60 cm x 20 cm using a seed rate of 15 kg ha⁻¹ during the last week of November.

Five plants were selected at random from each plot to record dry matter production per plant and yield parameters, seed yield and fodder yield (kg ha⁻¹) by using standard

procedure. Similarly for grain yield, cobs of each plot after removing were shelled with the help of machine sheller and were weighed to have grain yield per plot. All other recommended agronomic practices and plant protection measures were carried out to all treatments uniformly during the course of study.

Results and Discussion

Effect of Potassium

Dry matter yield

The dry weight of leaves, shoot, root and total plant were significantly recorded higher with 60 kg K₂O ha⁻¹ (K₃) at 30, 60 DAS and leaves, shoot, root, seed and total plant at harvest (Table 1). The leaves were remain at par with 90 kg K₂O ha⁻¹ (K₄) at 30, 60 DAS and 30 kg K₂O ha⁻¹ (K₂) and 90 kg K₂O ha⁻¹ (K₄) at harvest. Shoot was remain at par with 30 kg K₂O ha⁻¹ (K₂) and 90 kg K₂O ha⁻¹ (K₄) at 30 DAS and at harvest, the root was remain at par with 90 kg K₂O ha⁻¹ (K₄) at harvest, seed was at par with 30 kg K₂O ha⁻¹ (K₂) and 90 kg K₂O ha⁻¹ (K₄) at harvest, while total plant was at par with 90 kg K₂O ha⁻¹ (K₄) at 30 DAS and harvest.

The application of potassium was found to increase the shoot dry weight of maize which may be due to selective and adequate potassium uptake in plant tissue (Kaya *et al.*, 2009). The adverse effect of ammonium on root growth in Arabidopsis in absence of potassium (Cao *et al.*, 1993) and this harmful effect can be alleviated by potassium supply which activates the enzymes involved in ammonium assimilation (Hagin *et al.*, 1990) through which root dry weight increased in maize crop. Tacket and Pearson (1964) reported that potassium doubles the weight of roots at harvest.

It can be attributed to high capability of photosynthesis by increasing the capturing carbon and enzyme rubisco and encouraging synthesis and matter transport in developing plant which helps to increase the dry weight of leaves, shoot, root and total dry weight with potassium levels. These results are already in agreement with those reported by Kalpana and Krishnarajan (2002) and Maurya *et al.*, (2004)) for total dry matter, Bhatt and Jain (2012), Aslam *et al.*, (2013) for shoot dry weight.

Yield attributes

An examination of data (Table 2) showed that different levels of potassium exhibited their significant influence on yield attributes. Application of 60 kg K₂O ha⁻¹ (K₃) recorded significantly the higher cob girth (15.67 cm), cob length (18.61 cm), number of cobs per plant (1.47), number of grains per cob (250.41), grain rows per cob (14.83), 100 seed weight (23.11 g), seed weight per cob (57.97 g), dry weight of cob (32.0 g), whereas the lowest was observed with K₁ (control).

Potassium is essential for many physiological processes such as photosynthesis and formation of ferredoxin which functions as electron transporter in photosynthesis (Zehler *et al.*, 1981), translocation of photosynthates into sink, activation of enzymes and it increases the NUE increase the metabolites and nutrients to develop reproductive structures (Brar *et al.*, 2012) seems to have resulted in increased cob girth, cob length, number of cobs, number of grains per cob, grain rows per cob, 100 grain weight and seed weight. The findings are close agreement with those obtained by Tariq *et al.*, (2011) and Chaudari (2012).

Yield

A perusal of data (Table 2) revealed that different levels of potassium exerted their

significant influence on seed yield and fodder yield. Among various levels the K₃ (60 kg K₂O ha⁻¹) gave significantly higher seed yield and fodder yield with the value of 3677 kg ha⁻¹ and 6447 kg ha⁻¹, respectively, which were remained at par with K₄ (90kg K₂O ha⁻¹) with the value of 3558 kg ha⁻¹ and 5804 kg ha⁻¹, respectively.

The lowest seed yield (2979 kg ha⁻¹) and fodder yield (5025 kg ha⁻¹) was recorded under K₁ (control). Potassium due to its impact on many physiological processes plays an important role in water use by crop plants (Grzebisz *et al.*, 2013 and Oosterhuis *et al.*, 2013). A main function of K is unloading sugars from chloroplasts to phloem cells, and from phloem cells into storage cells such as grains, (Salisbury and Ross, 1978). Therefore, the availability of K during initial stage to until the end of grain filling increases the filled grain number in cob and grain weight, as observed in these studies. In addition, the presence of K is known to improve the N use efficiency in rice and maize, (Kanwar *et al.*, 1973 and Rao, 1985); it aids to uptake the other nutrients, (Wakeel *et al.*, 2002). K nutrition collectively added a higher yield potential to the popcorn crop. The results are also in conformity with Senaratne *et al.*, 2006.

Effect of sulphur

Dry matter yield

The dry weight of leaves, shoot, root and total plant were significantly recorded higher with S₃ (40 kg S ha⁻¹) at 30, 60 DAS and leaves, shoot, root, seed and total plant at harvest (Table 1; Figs. 1 and 2). The leaves were remain at par with S₄ (60 kg S ha⁻¹) at 30, 60 DAS and at harvest, shoot was remain at par with S₄ (60 kg S ha⁻¹) at 30DAS and at harvest, root and seed was at par with S₄ (60 kg S ha⁻¹) at harvest, while total plant at par with S₄ (60 kg S ha⁻¹) at 30 DAS.

Table.1 Effect of potassium and sulphur on dry matter yield of popcorn at 30 DAS, 60DAS and at Harvest

Treatments	Dry matter yield												
	30DAS				60DAS				Harvest				
	Leaves	Shoot	Root	Total plant	Leaves	Shoot	Root	Total plant	Leaves	Shoot	Root	seed	Total plant
Potassium levels (kg K₂O ha⁻¹)													
K ₁ -0	4.14	22.67	2.21	29.03	18.67	28.52	9.39	56.57	27.83	40.94	14.65	55.78	139.54
K ₂ -30	4.23	24.25	2.32	30.80	20.17	31.87	9.56	61.60	29.08	44.58	15.18	58.69	147.54
K ₃ -60	4.47	25.25	2.79	32.51	21.33	36.21	10.58	68.12	30.25	45.96	16.21	61.43	153.85
K ₄ -90	4.34	24.67	2.41	31.42	20.67	33.51	9.77	63.95	29.83	44.71	15.42	59.75	149.70
S.E.m. ±	0.07	0.44	0.06	0.45	0.36	0.72	0.18	0.71	0.42	0.78	0.30	1.05	1.50
C.D. (P=0.05)	0.19	1.28	0.18	1.31	1.03	2.07	0.51	2.05	1.21	2.26	0.87	3.02	4.33
Sulphur levels (kg S ha⁻¹)													
S ₁ -0	4.19	23.33	2.26	29.79	19.33	28.66	9.46	57.45	28.58	41.19	14.57	56.38	140.72
S ₂ -20	4.20	23.83	2.29	30.33	19.83	31.89	9.50	61.22	28.67	43.58	15.19	57.38	144.82
S ₃ -40	4.41	25.17	2.69	32.27	21.17	35.87	10.51	67.54	30.33	46.83	16.13	61.80	155.08
S ₄ -60	4.38	24.50	2.48	31.37	20.50	33.70	9.82	64.02	29.42	44.59	15.58	60.09	149.68
S.E.m. ±	0.07	0.44	0.06	0.45	0.36	0.72	0.18	0.71	0.42	0.78	0.30	1.05	1.50
C.D. (P=0.05)	0.19	1.28	0.18	1.31	1.03	2.07	0.51	2.05	1.21	2.26	0.87	3.02	4.33
KxS Interaction													
S.E.m. ±	0.13	0.89	0.12	0.91	0.71	1.43	0.35	1.42	0.84	1.56	0.61	2.09	3
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	5.33	6.53	8.67	5.07	6.11	7.63	6.24	3.92	4.96	6.14	6.83	6.16	3.51

Table.2 Effect of potassium and sulphur on yield and yield attributes of popcorn

Treatments	Cob girth (cm)	Cob length (cm)	Number of cobs per plant	Number of grains per cob	Grain rows per cob	100 seed weight (g)	Seed weight per cob (g)	Dry weight of cob (g)	Seed yield (kg/ha)	Fodder yield (kg/ha)
Potassium levels (kg K₂O ha⁻¹)										
K ₁ -0	12.33	14.58	1.16	236.18	12.58	18.10	42.76	18.73	2979	5025
K ₂ -30	14.08	16.45	1.32	242.97	14.00	20.70	50.35	25.08	3393	5323
K ₃ -60	15.67	18.61	1.47	250.41	14.83	23.11	57.97	32.00	3677	6447
K ₄ -90	15.00	17.21	1.38	245.32	14.50	21.69	53.25	28.08	3558	5804
S.E.m. ±	0.43	0.48	0.04	2.91	0.44	0.42	1.28	0.84	84.1	233.1
C.D. (P=0.05)	1.23	1.40	0.12	8.41	1.26	1.22	3.71	2.41	242.8	673.3
Sulphur level (kg S ha⁻¹)										
S ₁ -0	12.92	15.88	1.17	237.37	12.58	19.89	47.38	20.90	3182	4907
S ₂ -20	13.83	16.08	1.32	242.86	13.83	20.49	49.86	24.92	3308	5671
S ₃ -40	15.58	17.58	1.43	249.63	14.83	22.08	55.23	30.75	3628	6192
S ₄ -60	14.75	17.32	1.40	245.02	14.67	21.14	51.86	27.33	3489	5828
S.E.m. ±	0.43	0.48	0.04	2.91	0.44	0.42	1.28	0.84	84.1	233.1
C.D. (P=0.05)	1.23	1.40	0.12	8.41	1.26	1.22	3.71	2.41	242.8	673.3
KxS Interaction										
S.E.m. ±	0.86	0.97	0.09	5.83	0.87	0.85	2.57	1.67	168.1	466.3
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	10.38	10.02	11.22	4.14	10.82	7.00	8.71	11.14	8.56	14.29

Fig.1 Dry weight of leaves, shoot, root and seed (g plant⁻¹) within plant at different growth stages under different potassium levels

Fig.2 Dry weight of leaves, shoot, root and seed (g plant⁻¹) within plant at different growth stages under different sulphur levels

Fig. 3 Effect of K and S on cob girth and cob length (cm) of popcorn

Fig. 4 Effect of K and S on number of cobs/plant, grain number/cob, grain

The application of 40 kg S ha⁻¹ significantly increased the uptake of nutrients by plant parts, improved the yield attributes, growth parameters, ultimately resulted in higher dry matter per plant (leaf, stem, root and seed). The similar findings were also recorded by Dechassa *et al.*, (2013) and Nanthakumar *et al.*, (2014) (Fig. 3).

Yield attributes

An appraisal of data (Table 2) showed that various levels of sulphur exerted their significant effect on yield attributes. Application of 40 kg S ha⁻¹ (S₃) recorded significantly the maximum cob girth (15.58cm), cob length (17.58 cm), number of cobs per plant (1.43), number of grains per cob (249.63), grain rows per cob (14.83), 100 seed weight (22.08 g), seed weight per cob (55.23g), dry weight of cob, whereas the lowest was observed with S₁ (control). S improved the nutritional environment and favorably influenced the carbohydrate metabolism due to role of S in energy transformation and activation of enzymes. Rise in different yield attributing characters were also recorded by Dechassa *et al.*, (2013) and Nanthakumar *et al.*, (2014). More number of bigger sized cobs per plant might have accommodated more number of grains providing sufficient space for development of an individual grain, leading to higher 100-grain weight, seed weight per cob and dry weight of cob (Mahmood *et al.*, 1994 and Grobler *et al.*, 1999) (Fig. 4).

Yield

The data presented in table 2 indicated that various levels of sulphur manifested their significant influence on seed yield and fodder yield. Application of 40 kg S ha⁻¹ (S₃) recorded significantly the higher seed yield (3628 kg ha⁻¹) and fodder yield (6192 kg ha⁻¹), seed yield was remained at par with S₄

(3489 kg ha⁻¹) and fodder yield was remained at par with S₄ (5828 kg ha⁻¹) and S₂ (5671 kg ha⁻¹). The lowest seed yield and fodder yield were observed under S₁ (control). As these growth and yield attributes as well as nutrients uptake showed significant increase in grain and fodder yields with sulphur fertilization. The similar observations were also recorded by Bhatt and Jain (2012), Sutar (2012), Ahmad *et al.*, (2013) and Nanthakumar *et al.*, (2014).

Based on the experimental results, it can be concluded that significantly the higher seed and fodder yield, yield attributes were obtained from *rabi* popcorn (cv. Amber) by fertilizing the crop with potassium 60 kg K₂O ha⁻¹ (K₃) and sulphur up to 40 kg S ha⁻¹ (S₃) in medium black calcareous soils of South Saurashtra region of Gujarat.

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