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Effect of potassium and sulphur on yield of and nutrient uptake by pearl millet (*Pennisetum glaucum*) in alluvial soil

T.M. CHAUHAN[1], RAM LAKHAN AND VINAY SINGH

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra (U.P.) - 283105

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ABSTRACT

A field experiment was conducted during Kharif season of 2013 and 2014 on sandy loam soil of a farmer field at Panwari (Agra) to study the effect of graded levels of K and S on growth, yield, quality and nutrient uptake of pearl millet (Pennisetum glaucum). The experiment was laid out in randomized block design with four levels each of K (0, 30, 60 and 90 kg K_2O ha^{-1}) and S (0,20, 40 and 60 kg S ha^{-1}) and three replications. The results revealed that growth and yield parameters of pearl millet increased significantly with increasing levels of K up to 90 kg K_2O ha^{-1}. The mean grain (35.66 q ha^{-1}) and stover (88.84 q ha^{-1}) yields with 60 kg K_2O ha^{-1} were 21.5 and 22.0% higher than the control, respectively. However, the maximum grain and stover yields were recorded with 90 kg K_2O ha^{-1}, but it was at par with 60 kg K_2O ha^{-1}. Increasing sulphur levels up to 20 kg S ha^{-1} showed significant improvement in plant height, ear length and test weight over the control. Similarly, application of 20 kg S ha^{-1} resulted in 20.6% higher grain yield (36.64q ha^{-1}) than the yield obtained in the control (30.38q ha^{-1}). Similar increase in stover yield was recorded with 20 kg S ha^{-1} by 21.0% over control. The uptake of N, P, K and S in pearl millet crop increased significantly with increasing levels of potassium. The content and yield of protein in pearl millet grain increased significantly with the addition of K up to 90 kg K_2O ha^{-1} and sulphur up to 20 kg S ha^{-1}. The nutrient uptake in pearl millet increased significantly with increasing levels of S and maximum values of nutrient uptake were recorded with 20 kg S ha^{-1}.

Keywords: Pearl millet, nutrient uptake, potassium, sulphur, quality, yield.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*), is an important Kharif crop of Agra region of Uttar Pradesh. The productivity of this crop is very low, mainly because of its cultivation on marginal land under reduced rate of fertilizer. Among the several constraints, improper nutritional management is an important impediment for increasing the productivity of pearl millet. A cereal crop like pearl millet has a high potassium (Singh *et al.* 2016) and sulphur (Singh *et al.,* 2014) requirement due to their many functions in plant growth. Potassium is important for growth and development of plants. The quantity of K absorbed by roots is second to that of nitrogen for most of the cultivated plants. Due to intensive cropping, continuous manuring and limited or no use of K fertilizers, the available K status of the soils has depleted. Soils have begun to show response to K application particularly under intensive use of N and P fertilizers. Sufficient amounts of K is required for improving the yield and quality of different crops because of its effect on photosynthesis, water use efficiency and plant tolerance to diseases, drought and cold as well for making the balance between proteins and carbohydrates. Sulphur plays an important role in growth and development of crops. It plays an important role in the formation of S-containing amino acids like cystine (27% S), Cysteine (26% S), methionine (21% S), which act as building blocks in the synthesis of proteins. It has role to play in increasing chlorophyll formation and aiding photosynthesis. Sulpher also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. In recent years, an increased frequency of sulphur deficiency has been observed in crops and S may become a factor limiting yield and quality of crops. Pearl millet, one of the important kharif crop, is sensitive to the deficiencies of potassium and sulphur. So far, inadequate information is available regarding the effect of K and S on pearl millet in Agra condition. This study was, therefore conducted to evaluate the effect of K and S on the yield, nutrient uptake and quality of pearl millet.

MATERIALS AND METHODS

The present investigation was carried out at Panwari village of Agra district (U.P.) during Kharif season of 2013 and 2014. The soil of the experimental field was sandy loam in texture having pH 7.9, organic C 2.7 g kg^{-1}, available N 155 kg ha^{-1}, available P 8.0 kg ha^{-1}, available K 106 kg ha^{-1} and available S 16 kg ha^{-1}. The sixteen treatment combinations which were tried in pearl millet consisted of potassium as muriate of potash at four levels viz. 0, 30, 60 and 90 kg K_2O ha^{-1} and sulphur as elemental sulphur at three levels viz. 0, 10, 20 and 40 kg S ha^{-1}. The experiment was laid out in randomized block design with three replications. A basal dose of 100 kg N and 60 kg P_2O_5 ha^{-1} for pearl millet was applied uniformly in all the plots. Nitrogen supplied by diammonium phosphate was compensated. Full dose of P was applied at the time of sowing. Potassium and sulphur were applied as per treatments at the time of sowing. Pearl millet was sown on July 1, 2013 and July 4, 2014 and harvested on October 3, 2013 and October 7, 2014. Grain and stover yields of the crop were recorded at maturity. The growth and yield attributes were also recorded at harvest. The grain and stover samples were wet digested in HNO_3 and $HClO_4$ mixture and analyzed for P by vanadomolybdate yellow colour method (Jackson 1973), K by flame photometer, S by turbidimetric method (Chesnin and Yien 1951). Nitrogen content in grain and straw of the crop was determined by Kjeldahl method (Jackson 1973). The uptake of nutrients was calculated by multiplying nutrient content values with the yield data.

RESULTS AND DISCUSSION

Growth and yield attributes

All the growth and yield attributing characters were affected significantly by different levels of K and S (Table 1) over control. The significantly taller plants (194 cm), higher ear length (24.1), and test weight (10.9 g) were recorded at 90 kg K_2O ha^{-1} followed by 30, 60 kg K_2O ha^{-1} and control. Both the higher levels of K (60 and 90 kg K_2O ha^{-1}) were statistically at par with respect to these growth parameters. Potassium plays a crucial role in meristematic growth through its effect on the synthesis of phyto hormones. Among various plant hormones, cytokinin plays an important role in growth of plant. Beneficial effects of K on growth and yield attributes have been reported by Yadav *et al.* (2012) and Singh *et al.* (2016). Application S increased the plant height, significantly over the control. This increase may be due to involvement of S in bio synthesis of Indole 3 acetic acid. The maximum value of ear length (24.0), and test weight (10.6 g) were recorded with 20 kg S ha^{-1}. These increases in yield attributes may be attributed to increased growth of plants with S application which later on get converted in to reproductive phase (Singh *et al.* 2014).

Table 1: Effect of potassium and sulphur on growth, yield attributes and yield of pearl millet (mean of two years)

Treatment	Plant height (cm)	Ear/ Length (cm)	Test wt. (g)	Yield (t ha^{-1})		Protein (%)	Protein yield (kg ha^{-1})
				Grain	Straw	Grain	
Potassium (kg ha^{-1})							
0	181	19.5	9.0	29.34	72.29	9.2	270.0
30	185	21.0	9.7	31.30	76.61	9.4	294.2
60	190	23.2	10.4	35.66	88.24	9.5	338.8
90	194	24.1	10.9	38.27	95.36	9.7	371.2
SEm$\pm$	1.16	0.38	0.15	0.82	2.40	0.021	5.70
CD (P=0.05)	4.03	1.29	0.51	2.84	8.34	0.072	19.79
Sulphur (kg ha^{-1})							
0	182	20.0	9.2	30.38	74.31	9.3	282.5
20	185	20.5	9.8	33.03	83.61	9.4	310.5
40	192	24.0	10.6	36.64	89.89	9.5	348.0
60	191	23.3	10.4	34.25	85.48	9.7	332.2
SEm $\pm$	1.18	0.38	0.15	0.82	2.40	0.021	5.70
CD (P=0.05)	4.03	1.29	0.51	2.84	8.34	0.072	19.79

Yield

Grain and stover yield of pearl millet increased significantly with potassium application over the control. The mean yield of pearl millet grain increased by 21.5 and 30.4% over control owing to addition of 60 and 90 kg K_2O ha^{-1}, respectively. The corresponding increases in stover yield were 22.0 and 31.9%. As K is essential for grain development, the favourable effect of high doses of K on growth and yield attributes of pearl millet was mainly responsible for higher grain and stover yields. The results confirm the finding of Yadav *et al.* (2012) and Singh *et al.* (2016).With successive increase in S levels, grain and stover yields of pearl millet increased significantly up to 20 kg S ha^{-1}. The highest grain and stover yields were recorded with 20 kg S ha^{-1}, which registered 20.6 and 21.0% higher grain and stover yield over the control. The increase in yield owing to S application may be ascribed to improved growth and yield attributes and yield is directly related to these attributes. Increase in yield with S application is quite obvious as the soil under study was deficient in available Singh *et al.* (2014) and Pandey Chauhan (2016) also reported similar results.

Quality

Increasing levels of K and S significantly increased the protein content in pearl millet grain from 9.2 to 9.7% with 90 kg K_2O ha^{-1}. The corresponding increase in protein content in grain with 40 kg S ha^{-1} was from 9.3 to 9.7%. The increase in protein content owing to S addition might be attributed to its involvement in amino acid synthesis. Singh *et al.*(2014) also reported an increase in protein content in pearl millet with S application. Corresponding application of K and S also increased the protein yield from 270.0 to 371.2 and 282.5 to 348.0 kg ha^{-1}, respectively. The increases in protein yield were significant up to 60 kg K_2O and 20 kg S ha^{-1} over the control. Protein yield is the function of protein content and grain yield. Since, variation in protein content has genetic and bio-chemical limitation, the protein yield is more influenced by grain yield and thus followed almost trend similar to grain yield. Singh *et al.* (2014) and Singh *et al.* (2016) also reported similar results.

Table 2: Effect of potassium and sulphur on uptake of N,P,K,S (kg ha^{-1}) AND Zn (g ha^{-1}) by grain and stover of pearl millet (mean of 2 years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Potassium (kg ha^{-1})								
0	46.6	35.4	6.2	7.9	17.6	137.3	5.6	9.4
30	50.7	39.8	7.2	9.9	20.0	154.0	6.3	10.7
60	58.4	47.6	8.9	12.3	24.2	186.1	7.8	13.2
90	64.0	53.4	9.9	12.8	27.5	206.0	8.8	15.2
SEm$\pm$	0.52	0.51	0.19	0.29	0.33	3.61	0.18	0.15
CD (P=0.05)	1.80	1.77	0.66	1.06	1.14	12.52	0.62	0.55
Sulphur (kg ha^{-1})								
0	48.6	35.7	6.1	8.2	19.4	150.8	5.5	8.9
20	53.5	42.6	7.6	10.0	21.1	170.6	6.6	11.7
40	60.0	48.5	9.5	12.5	24.2	184.2	8.0	13.4
60	57.1	47.8	9.2	12.8	22.9	176.0	8.2	14.5
SEm$\pm$	0.52	0.51	0.19	0.29	0.33	3.61	0.18	0.16
CD (P=0.05)	1.80	1.77	0.66	1.06	1.14	12.52	0.62	0.55

Nutrient uptake

The N uptake by pearl millet grain and stover increased significantly over control due to 60 and 90 kg K_2O ha^{-1}, (Table 2). This increase in N uptake by pearl millet grain and stover may be ascribed to higher grain and stover production due to K addition. Yadav *et al.* (2011) and Singh *et al.* (2016) observed the same trend of results in pearl millet and oat, respectively. The N uptake by pearl millet grain and stover increased significantly with sulphur application which is apparently the result of favourable effect of this element on N absorption coupled with greater pearl millet grain and stover production. Singh *et al.*(2014) also indicated an increase in N uptake by pearl millet, due S application. Application of K resulted in significant increase in P uptake due to 60 and 90 kg K_2O ha^{-1} over the control. The results indicated a beneficial effect of K on the obsorption of phosphorus by the crop. Singh *et al.* (2016) also reported an increase in P uptake with K application. The phosphorus uptake by pearl millet grain and stover tended to increase with sulphur application over control. Singh *et al.* (2014) also reported similar results. The K uptake by the pearl millet grain and stover increased from 17.6. to 27.5 and from 137.3 to 206.0 kg ha^{-1}, respectively as the dose of K was increased from 0 to 90 kg K_2O ha^{-1}. This increase in K uptake may be ascribed to higher grain and straw production and K content in pearl millet due to K application Yadav *et al.* (2011) and Singh *et al.* (2016). The addition of 5 also increased K uptake by grain and straw from 19.4 to 24.2 and from 150.8 to 184.2 kg ha^{-1} as the dose of S was increased from 0 to 20 kg S ha^{-1}. Higher uptake of K might be due to higher grain and stover yield as the differences in percent K content were only marginal in all the cases (Pandey and Chauhan 2016, Singh *et al.* 2014). Sulphur uptake by grain and stover increased significantly with the increasing levels of K up to 90 kg K_2O ha^{-1} over the control and the increases were 57.1 and 61.7% due to 90 kg K_2O ha^{-1}, respectively. The increases in S uptake by stover were also significant over control. Kumar *et al.* (2015) and Singh *et al.* (2015) also reported similar results. The S uptake by grain and stover increased from 5.5 to 8.2 and from 8.9 to 14.5 kg ha^{-1} with 40 kg S ha^{-1}. This increase in S uptake may be ascribed to the higher grain and stover production as well as improvement in S content with its addition (Singh *et al.* 2014).

It may be concluded from the results that, in light textured soils deficient in K and S, application of K and S are required to harvest optimum crop yield, nutrient uptake and quality of produce. Application of 60 kg K_2O and 20 kg S ha^{-1} was found optimum for maintaining higher pearl millet yield and quality in sandy loam soil of Agra region of Uttar Pradesh.

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