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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Response of *kharif* Sorghum to Yield, Variation of N P K Content and Uptake by Soil and Foliar Application of Micronutrients

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ABSTRACT: *Improving forage yield and quality remains a major concern of the producer. Among the various ways of supplying nutrient to the crops, the efficient utilization of nutrients by the plants is made through foliar application. Application methods of micronutrients are very important to attain the best absorption. To understand the effects of application of micronutrients an experiment was carried out during kharif 2011 to study the response of kharif sorghum to soil and foliar application of micronutrient. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and three replications. Results revealed that the grain yield of kharif sorghum significantly affected due to micronutrients. Treatment T_7 significantly recorded highest sorghum grain yield (20.58 q ha^{-1}) followed by T1 and significantly superior over control (7.50 q ha^{-1}). Nitrogen concentration in fodder was markedly increased after addition of recommended dose of fertilizer along with micronutrients. It was less at flowering stage than harvest and varied from 0.23 to 0.52 per cent at flowering and 0.23 to 0.65 per cent at harvesting stage, respectively. At flowering stage, the N concentration (0.52%) was highest in treatment T_7 and it was found at par with T_1 (048%), T_2 (0.46%), T_4 (0.42%). At harvest stage, N concentration was ranged from 0.23 to 0.65 per cent. The treatment T_7 showed significantly more N concentration (0.65%) followed by T_1 (0.62%) which was at par with treatment T_7.*

Key words: *kharif sorghum, Micronutrients, N P K uptake.*

INTRODUCTION

Sorghum is the principle dry land cereal crop grown adopted in the region of low rainfall in India for food, feed and fodder. It ranks third after rice and wheat. In addition, the fodder and stover is fed to millions of animals providing milk and meat for man and also being used as industrial raw material in various industries in the USA and other developed countries. Sorghum grain contains 10-12% proteins, 3% fat and 70% carbohydrates. India has the largest share (32.3%) of world's area under sorghum and rank second in production after the United States. At present Maharashtra is largest producer of sorghum in India accounting for 50 per cent of the total area i.e. 50.10 lakh hectares with a production of 28.90 lakh tonnes and productivity was about 657 kg ha^{-1} as reported by Awaghad *et al.* (2010). Availability of micronutrients is influenced by their distribution in soil and other physicochemical properties of soil. Field crops are generally sensitive to micronutrient stress and suffer due to hidden hunger of multi micronutrient deficiencies. Therefore correction of hidden hungers or deficiencies of micronutrients are necessary for balanced nutrient to get higher yield of crops on sustainable basis. Quantum of micronutrient deficiencies of Zn (49%), B (37%), Fe (12%), Mn (4%) and Cu (30%), respectively in Indian soils as given by Singh, (2009). Integrated use of all potential sources of plant nutrients seems to be the only option to maintain soil fertility and crop productivity. Therefore, the purpose of this research is to understand the effects of application of micronutrients as foliar application on forage sorghum.

MATERIALS AND METHODS

The experiment was laid out in a randomized block design with 3 replications. Ten treatment combinations involving standard micro-fertilizers ferrous sulphate, zinc sulphate were tried involving soil and foliar applications, namely **T1-**RDF + 25kg $ZnSO_4$ ha^{-1} , **T2-** RDF+ 25kg $FeSO_4$ ha^{-1} ,**T3-** RDF + 0.2% $ZnSO_4$ foliar at 15 &30 DAS, **T4-**RDF + 0.5% $FeSO_4$ foliar at 15 &30 DAS, **T5-**RDF + 15 kg $ZnSO_4$ + 0.2% $ZnSO_4$ foliar at 15 & 30 DAS, **T6-**RDF + 15kg

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$FeSO_4$ + 0.5% $FeSO_4$ at 15 & 30 DAS, **T7-** RDF + 15 kg $ZnSO_4$ + 15 kg $FeSO_4$ ha^{-1}, **T8-** RDF + foliar appl. (0.2% $ZnSO_4$ + 0.5% $FeSO_4$) at 15 & 30 DAS, **T9-** RDF alone and **T10**- Control (Native fertility). The sowing was done by dibbling two seeds at each plot spaced at 45 x 15 cm^2 apart and seed were covered with soil. PVK-809 variety of *kharif* sorghum selected. Soil samples were collected before sowing and at harvesting stage of crop treatment wise randomly from 0-15 cm depth from each net plot. The collected soil samples were processed. The plant samples at flowering and harvest of crops had analyzed.

RESULTS AND DISCUSSION

Effect of soil and foliar application of micronutrients on yield of *kharif* sorghum

(i) Grain yield (q ha^{-1}):

The grain yield of *kharif* sorghum significantly affected due to soil and foliar application of micronutrients. Treatment T7 significantly recorded highest sorghum grain yield (20.58 q ha^{-1}) followed by T1 and significantly superior over control (7.50 q ha^{-1}). Higher grain yield recorded under micronutrient application could be attributed to early bloom and bold seeds i.e. higher 1000 grain weight. Arbad *et al.* (2008) reported that grain yield of sorghum significantly improved with the application of inorganic fertilizer at 50% RDF + vermi compost and micronutrients (Zn and Fe) with seed treatment of biofertilizers.

Table 1
Yield (qha^{-1}) of *kharif* sorghum as influenced by soil & foliar application of micronutrients

Treat. code	*Treatments*	*Grain yield*	*Fodder yield*	*Total Biomass*
T1	RDF + 25kg$ZnSO_4$ ha^{-1}	19.70	28.58	48.28
T2	RDF + 25kg$FeSO_4$ ha^{-1}	19.36	27.75	47.11
T3	RDF + 0.2% $ZnSO_4$ foliar at 15 &30 DAS	16.20	24.12	40.32
T4	RDF + 0.5% $FeSO_4$ foliar at 15 &30 DAS	17.80	24.76	42.56
T5	RDF + 15 kg $ZnSO_4$ + 0.2% $ZnSO_4$foliar at 15 & 30 DAS	18.57	26.37	44.94
T6	RDF + 15kg $FeSO_4$ + 0.5% $FeSO_4$ at 15 & 30 DAS	18.32	26.31	44.63
T7	RDF + 15 kg $ZnSO_4$ + 15 kg $FeSO_4$$ha^{-1}$	20.58	28.69	49.27
T8	RDF + foliar appl. (0.2% $ZnSO_4$ + 0.5% $FeSO_4$) at 15 & 30 DAS	17.26	24.48	41.74
T9	RDF alone	15.80	22.52	38.32
T10	Control (Native fertility)	7.50	12.40	19.90
	SE $\pm$	0.85	1.51	2.34
	CD at 5%	2.54	4.49	6.20

(ii) Fodder yield (q ha^{-1}): The fodder yield of *kharif* sorghum due to treatment T_7 were higher (28.69 q ha^{-1}) and it was at par with all other treatments except T_9 and T_{10}. Verma *et al.* (2005) reported that application of nitrogen and zinc produced significantly higher green forage. Increase in herbage yield with the increase in N and Zn rate may be combined effect of more number of plants per unit area, taller plants and higher leaf area index and dry matter accumulation resulting in better plant growth and ultimately resulted in higher yield of sorghum. Similar results were also reported by Sumeriya and Singh (2008), Syed Ismail *et al.* (2001).

(iii) Total biomass: Highest total biomass of *kharif* sorghum (49.27 q ha^{-1}) was obtained with treatment T_7 followed by T_1 and T_2 recorded 48.28, 47.11 q ha^{-1} total biomass, respectively.

Effect of soil and foliar application of micronutrients on nutrient concentration and nutrient uptake of *kharif* sorghum (At flowering and harvesting stage)

(A) N concentration and N uptake in sorghum

(i) N concentration in fodder: Nitrogen concentration in fodder was markedly increased after addition of recommended dose of fertilizer along with micronutrients. N concentration was less at flowering stage than harvest. It varied from 0.23 to 0.52 per cent at flowering and 0.23 to 0.65 per cent at harvesting stage, respectively. At flowering stage, the N concentration (0.52%) was highest in treatment T_7 and it was found at par with T_1 (048%), T_2 (0.46%), T_4 (0.42%) whereas lowest N concentration (0.23%) was found in T_{10} (control). At harvest stage, N concentration was ranged from 0.23 to 0.65 per cent. The treatment T_7 showed significantly more N concentration (0.65%) followed by T_1 (0.62%) which was at par with treatment T_7

(ii) N concentration in grain: N concentration in grain was as influenced by the different soil and foliar application of micronutrients was presented in Table 2 and 3. The concentration of N in grain (1.55%) found superior in significant in treatment $T_{7.}$ The treatment T_1, T_2 recorded 1.52, 1.50 per cent N in grain respectively. As regards the N concentration in sorghum grains it found greater than that of fodder, similar results were reported by Dhamak *et al.* (2010).

(iii) N uptake: N uptake of sorghum (Table 2 and 3) revealed that N uptake ranged from 1.0 to 5.29 kg ha^{-1} at flowering stage and 12.35 to 50.9 kg ha^{-1} at harvesting stage, respectively it indicates that N uptake were found more at harvest compared to

Table 2
Nutrient content and uptake of macro and micronutrients in *kharif* sorghum fodder as influenced by soil and foliar application of micronutrients at flowering stage

Tr. No.	Treatments	Nutrient content in sorghum fodder N (%)	P (%)	K (%)	Nutrient uptake by sorghum fodder N(kg ha^{-1})	P(kgha^{-1})	K(kgha^{-1})
T1	RDF+ 25kg$ZnSO_4$ ha^{-1}	0.48	0.38	0.78	4.56	3.59	7.65
T2	RDF+ 25kg$FeSO_4$ ha^{-1}	0.46	0.38	0.78	4.42	3.55	7.22
T3	RDF+ 0.2% $ZnSO_4$ foliar at 15 &30 DAS	0.32	0.30	0.59	2.65	2.63	4.64
T4	RDF + 0.5% $FeSO_4$ foliar at 15 &30 DAS	0.37	0.34	0.70	3.12	3.25	5.94
T5	RDF + 15 kg $ZnSO_4$ +0.2% $ZnSO_4$foliar at 15 & 30 DAS	0.42	0.37	0.75	4.08	3.39	6.96
T6	RDF+ 15kg $FeSO_4$ + 0.5% $FeSO_4$ at 15 & 30 DAS	0.40	0.37	0.73	3.66	3.37	6.55
T7	RDF + 15 kg $ZnSO_4$ + 15 kg $FeSO_4$$ha^{-1}$	0.52	0.39	0.78	5.29	3.82	7.80
T8	RDF + foliar appl. (0.2% $ZnSO_4$ + 0.5% $FeSO_4$) at 15 & 30 DAS	0.34	0.31	0.62	2.94	2.92	5.18
T9	RDF alone	0.25	0.29	0.56	2.49	2.26	4.32
T10	Control (Native fertility)	0.23	0.26	0.50	1.00	1.14	2.16
SE $\pm$		0.04	0.009	0.01	0.61	0.361	0.70
CD at 5%		0.12	0.028	0.03	1.81	1.07	2.10

Table 3
Nutrient content and uptake of NPK of *kharif* sorghum as influenced by soil and foliar application of micronutrients at harvest

Treat. code	Treatments	Nutrient content of kharif sorghum grain and fodder: N (%) grain	N (%) fodder	P (%) grain	P (%) fodder	K (%) grain	K (%) fodder	Nutrient uptake N(kgha1)	P(kgha1)	K(kgha1)
T1	RDF + 25kg$ZnSO_4$ ha^{-1}	1.52	0.62	0.74	0.47	0.39	0.80	47.86	28.46	30.78
T2	RDF + 25kg$FeSO_4$ ha^{-1}	1.50	0.53	0.72	0.46	0.38	0.78	43.00	26.53	27.90
T3	RDF + 0.2% $ZnSO_4$ foliar at 15 &30 DAS	1.29	0.30	0.65	0.32	0.27	0.67	29.53	19.22	20.52
T4	RDF + 0.5% $FeSO_4$ foliar at 15 &30 DAS	1.40	0.43	0.68	0.34	0.30	0.72	35.35	20.93	23.17
T5	RDF + 15 kg $ZnSO_4$ + 0.2% $ZnSO_4$foliar at 15 & 30 DAS	1.48	0.50	0.71	0.45	0.35	0.76	39.31	25.50	26.72
T6	RDF+ 15kg $FeSO_4$ + 0.5% $FeSO_4$ at 15 & 30 DAS	1.43	0.44	0.70	0.38	0.32	0.74	37.23	22.61	24.07
T7	RDF + 15 kg $ZnSO_4$ + 15 kg $FeSO_4$$ha^{-1}$	1.55	0.65	0.88	0.49	0.41	0.82	50.79	31.85	32.29
T8	RDF + foliar appl. (0.2% $ZnSO_4$ + 0.5% $FeSO_4$) at 15 & 30 DAS	1.32	0.43	0.67	0.33	0.29	0.70	34.51	19.98	22.18
T9	RDF alone	1.27	0.25	0.60	0.31	0.24	0.63	25.82	17.50	18.20
T10	Control (Native fertility)	1.23	0.23	0.57	0.28	0.23	0.61	12.35	7.97	9.33
SE $\pm$		0.018	0.02	0.01	0.001	0.004	0.006	1.65	0.931	1.22
CD at 5%		0.056	0.08	0.04	0.005	0.014	0.017	4.91	2.764	3.64

flowering stage. At flowering stage, N uptake (5.29 kg^{-1}) found highest in treatment T_7 and it was at par with T_1, T_2, T_5 and T_6 recorded 4.56, 4.42, 4.08 and 3.66 kg ha^{-1} N uptake at flowering, respectively.

The lower uptake (1.00 kg ha^{-1}) at flowering stage of *kharif* sorghum was recorded in T_{10} (control). At harvesting stage, total uptake of nitrogen (50.79 kg ha^{-1}) was found highest in treatment T_7. Whereas lowest in control (12.35 kg ha^{-1}), the treatment T_1 also showed better N uptake (47.86 kg ha^{-1}) which was at par with treatment T_7 kg ha^{-1} and found significantly superior over rest of treatments. Verma *et al.* (2005) also reported that nitrogen uptake increased significantly with nitrogen and zinc application at 120 kg ha^{-1} and 5 kg ha^{-1}. This might be due to higher nitrogen and Zn content in plant tissues and higher dry matter yield.

(B) P concentration and P uptake in sorghum

(i) Phosphorus content in fodder of *kharif* sorghum: Phosphorus at flowering and at harvest stage varied from 0.26 to 0.39% and 0.28 to 0.49%, respectively with increased at harvesting stage than that of flowering stage of fodder. Phosphorus content at flowering stage (0.39%) found highest in treatment T_7 which were at par with T_1 (0.38%), T_2 (0.038%), T_5

(0.371), T_6 (0.37%) and lowest (0.26%) in treatment T_{10} (control). Similarly phosphorus at harvesting stage of crop was highest in treatment T_7 (0.49%) and lowest (0.28%) in T_{10}

(ii) P concentration in grain (%): Generally high phosphorus content was observed in grain than fodder of sorghum. Data presented in Table 3 indicated that the grain P concentration varied from (0.57 to 0.88%). The treatment T_7 showed highest phosphorus content (0.88%) and treatment T_{10} in phosphorus content (0.57%) were found lowest. Dhamak *et al.* (2010) reported that the phosphorus concentration were highest in grain at harvest of crop.

(iii) Phosphorus uptake -The P uptake significantly increased with application of NPK along with micronutrient (Table 2 and 3). At harvest stage the treatment maximum uptake of phosphorus (31.85 kg ha^{-1}) recorded in T_7. Similar results observed at flowering stage Nataraja *et al.* (2005) reported that the application of 100% P_2O_5 of RD registered maximum P uptake. This was mainly attributed to better nutrient utilization by more healthy and vigor plants under recommended level results in higher dry matter accumulation, which ultimately increased the total uptake of P as compare to control.

(C) K concentration and K uptake in sorghum

(i) K concentration in fodder: The potassium concentration in fodder as influenced by combined application of NPK and micronutrients are presented in Table 2 and 3. The potassium concentration is increased at harvesting stage as compared to flowering stage. At flowering stage, potassium concentration in plant varied from 09.50 to 0.78 per cent. Highest potassium content (0.78%) was found in treatment T_7 and lowest potassium content (0.50%) was found in control. At harvesting stage of crop maximum K content (0.82%) found in treatment T_7 followed by treatment T_1 (0.80%). Lowest K content (0.61%) obtained in T_{10} (control).

(ii) K concentration in grain: K concentration in matured harvested grain ranged from 0.23 to 0.39 per cent. K concentration (0.41%) was found maximum in T_7 followed by T_1 (0.39) which were at par with T_7. Lowest K concentration (0.23%) was recorded in T_{10}. It is found that the K concentration is maximum in fodder of sorghum than that of grains.

(iii) K uptake of sorghum: At flowering stage of crop, potassium uptake was varied from 2.16 to 7.80 kg ha^{-1}). Highest P uptake (7.80 k ha^{-1}) was found in T_7 followed by T_1 (7.65), T_2 (7.22), T_4 (5.94) and T_5 (6.96), T_6 (6.55 kg ha^{-1}), respectively. Lowest uptake of K (1.16 kg ha^{-1}) was recorded in control. Similarly at harvesting stage of crop, highest potassium uptake (32.29 kg ha^{-1}) was recorded in treatment T_7 While, lowest (9.33 kg ha^{-1}) in control.

CONCLUSIONS

Micronutrients are required by plants in minute quantities, although these are very effective in regulating plant growth as they form a part of the enzyme system and thus regulate plant life Application methods of micronutrients are very important to attain the best absorption. The results of this study demonstrated that, foliar application of Fe, Zn had positive effect on yield and quality of *kharif* sorghum. The highest N P and K concentration in grain and fodder was obtained by foliar application of Fe, Zn. So, on the basis of the results, it seems that foliar application of Zn + Fe was suitable to gain high yield with maximum nutrient uptake in *kharif* sorghum.

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