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RESEARCH ARTICLE

Response of finger millet (*Eleusine coracana* L.) cultivated on steep hill slopes to foliar nutrition

■ **A.V. Bulbule, P.N. Gajbhiye and C.T. Kumbhar**

SUMMARY

Field experiments were conducted at Zonal Agricultural Research Station, Shenda Park Farm, Kolhapur on Entisol, Sub-montane Zone of Maharashtra during the *Kharif* seasons of 2014 to 2016 to study the response of finger millet crop to foliar nutrition of nitrogen, phosphorus and potassium. The finger millet was transplanted and fertilized by basal general recommended dose of fertilizer (45 kg N: 22.5 kg P_2O_5: 00 kg K_2O through briquettes) + FYM @ 5 t ha^{-1}. Foliar spray was applied at 50 days after transplanting. The fertilizers used for spray were urea, di-ammonium phosphate, muriate of potash, complex 19-19-19 and calcium nitrate applied @ 2 % foliar spray while combination treatment of urea, di-ammonium phosphate and muriate of potash @ 0.5 % each was applied to the experimental plots.The findings of the field experiments revealed that the application of foliar spray increased the yields of finger millet crop. The highest yield was recorded by the treatment foliar spray of 19-19-19 @ 2% (22.68 q ha^{-1}) over the recommended dose of fertilizer (17.75 q ha^{-1}). It was followed by the treatment urea spray applied @ 2 % (20.86 q ha^{-1}), DAP @ 2.0 % (19.85 q ha^{-1}) and at par with rest of the treatments on foliar nutrition while it was superior over water spray (17.94 q ha^{-1}). The similar trend was observed by straw yield of finger millet crop to that of grain yield. The data on plant uptake revealed that the treatment of foliar spray 19-19-19 @ 2% recorded higher uptake of N, P and K as compared to no foliar spray application. The application of foliar spray 19-19-19 @ 2% recorded significantly highest B:C ratio (1.46). The soil analyses after harvest of the crop revealed that the nitrogen, phosphorus and potassium contents in the soil after harvest of the crop did not differ amongst the different treatments.

Key Words : Foliar, Finger millet, Nutrient, Rice, Yield

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MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
A.V. Bulbule, Zonal Agricultural Research Station, Sub-montane Zone, Shenda Park, Kolhapur (M.S.) India

Address of the Co-authors:
P.N. Gajbhiye and C.T. Kumbhar, Zonal Agricultural Research Station, Sub-montane Zone, Shenda Park, Kolhapur (M.S.) India

Under conditions of heavy rainfall finger millet is widely grown on steep hill slopes. The crop tolerates the heavy rains and is a sustenance food in the diets of farmers (Malinda *et al.*, 2015). The crop is starved of nutrition due to the constraints which can limit potential (Rao *et al.*, 2012). One of the major constraint is that the farmer is unable to fertilize the crop.

The fertilizers applied to the crop on sloppy terrains are lost as run off losses along with rain water. The situation gets more complicated due to continuous high intensity rains received on hilly slopes during the month of July-August. The period is critical since the crop is transplanted during this period as well as it is active growth period of the crop. The prevailing condition, therefore, discourages the resource constraint farmers of hilly and sloppy regions to application of chemical fertilizers.

Fertilization of crops is an important input to boost the crop yields. Among methods of fertilization, foliar nutrition is one of the most efficient way of fertilizer application (Fageria *et al.,* 2009; Hoytova, 2013 and Stanislaw, 2014) as it facilitates rapid nutrient uptake by penetrating through the leaf cuticle (Oosterhuis, 2009). Foliar application is also most effective when the crop is incapable of absorbing required amounts of nutrients from soil due to prevailing constraints such as nutrient fixation, lack of soil moisture, losses due leaching and low soil temperature etc. The studies on foliar nutrition of finger millet were not attempted earlier. The literature is not available on the crop response to foliar nutrition of finger millet in the regions and also elsewhere. Considering the problems faced by farmers attempts were made to study the effect of foliar application on finger millet with the objectives to study the response of finger millet to major nutrients applied through foliar spray and to study the effect on uptake of nutrients.

MATERIAL AND METHODS

The experiments were conducted during the *Kharif* seasons at Zonal Agricultural Research Station, Shenda Park Farm, Kolhapur on Entisol, Sub-montane Zone of Maharashtra of 2014 to 2016 to study the response of finger millet crop to foliar nutrition of nitrogen, phosphorus and potassium. The finger millet (variety Phule Nachani) was transplanted and fertilized through general recommended dose of fertilizer (45 kg N: 22.5 kg P_2O_5: 00 kg K_2O through briquettes) + FYM @ 5 t ha^{-1}. The briquettes were hand placed after transplanting. The foliar spray was applied at 50 days after transplanting. The fertilizers used for spray were urea, di-ammonium phosphate, muriate of potash, complex 19-19-19 and calcium nitrate applied @ 2 % foliar spray while combination treatment of urea, di-ammonium phosphate and muriate of potash @ 0.5 % each was applied to the experimental plots. The crop was harvested at maturity and the soil and plant samples were processed for analysis of nutrients in soil and plant samples.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Yields:

The pooled results on grain yield, straw yield and nutrient uptake by finger millet crop are presented in Table 1. The data revealed that application of foliar spray 19:19:19 @ 2 % at 50 DAT recorded significantly highest grain yield of finger millet (22.68 q ha^{-1}) over urea spray @ 2 % (20.86 q ha^{-1}). The urea spray @ 2 % was followed by DAP spray @ 2 % (19.85 q ha^{-1}) and at par with rest of the treatments on foliar nutrition while it was superior over water spray (17.94 q ha^{-1}) and recommended dose of fertilizers (17.75 q ha^{-1}). The straw yield of finger millet crop followed similar trend to that of grain yield. Similarly Mudalagiriyappa *et al.* (2016) also observed that foliar spray of 19-19-19 significantly increased growth attributes, yield and benefit cost ratio in chickpea. The leaves absorb nutrients from inorganic or organic sources. Small pores within leaf cuticles can take up the nutrients like urea, ammonium and nitrate etc. These pores are lined with negatively charged molecules. Therefore, the uptake of cations such as ammonium is comparatively faster than anions. The uptake of small uncharged molecules like urea is also fast. Thus, absorption of nutrients like urea, ammonium and other positively charged particles are rapid when applied as foliar spray. While the other anions take very long time for its absorption. The response of foliar application of 19:19:19 and urea appears to be relatively higher than other sources since the crop requirement of nitrogen could be higher. Also the nutrient is rapidly absorbed by the leaves as it is uncharged. The source DAP provides relatively lower contents of nitrogen while the sources like $Ca(NO_3)_2$ were providing nitrogen in anionic form. Similar findings was reported by Stevens (1994) and Oosterhuis (2009).

Nutrient uptake:

The nitrogen uptake (pooled means) by finger millet crop revealed that the application of foliar spray 19:19:19 @ 2 % at 50 DAT recorded significantly higher uptake of nitrogen (57.5 kg ha^{-1}), phosphorus (25.4 kg ha^{-1}) and

potassium (50.3 kg ha^{-1}) when compared to urea spray @ 2 % (51.8 kg ha^{-1}), (21.5 kg ha^{-1}) and (47.9 kg ha^{-1}), respectively. Ullasa *et al.* (2016) who reported higher nitrogen uptake for maize with 100 per cent RDF over foliar spray treatments of urea and 19:19:19.

Nutrient use efficiency:

The nutrient use efficiency of N, P and K was computed (Table 2) by using the formula as under and presented in table (Sheorana *et al.*, 2016)

$$\text{Nutrient use efficiency (NUFE) kg kg}^{-1} = \frac{Yf}{F_{appln}}$$

Yf =Grain yield (kg ha^{-1}) produced per unit of Nutrient

F_{appln} =Quantity (kg) of nutrient applied

Amongst the different treatment of nutrient management, the highest nutrient use efficiency (kg grain kg^{-1} nutrient applied) of N (31.11), P_2O_5 (56.14) and K_2O (59.84) was recorded by treatment GRDF + 19:19:19 spray @ 2 % whereas, the lowest nutrient use efficiency N (25.0), P_2O_5(46.1), K_2O (49.3) was observed in treatment GRDF.

Economics:

The pooled data on economics applied to finger millet crop is presented in Table 3. The gross monetary return finger millet crop revealed that significant returns were recorded for treatment foliar spray 19:19:19 @ 2% at 50 DAT (52,599 Rs. ha^{-1}) over rest of the treatments of foliar nutrition while it was at par with urea spray @ 2% (48,500 Rs. ha^{-1})

The treatment foliar spray 19:19:19 @ 2% at 50 DAT recorded highest net returns of 16942 Rs. ha^{-1} while urea spray @ 2% recorded the net returns of 13918 Rs. ha^{-1}. The lowest net returns was recorded by the treatment recommended dose of fertilizers (6927 Rs. ha^{-1}).

The benefit cost ratio (B:C) for treatment foliar spray 19:19:19 @ 2% at 50 DAT was 1.46 while it was followed by urea spray @ 2 % (1.39). Saleem *et al.*

Table 1 : Grain yields, straw and nutrient uptake by finger millet crop yields as influenced by different treatments (pooled mean values)

Sr. No.	Treatments	Grain yield	Straw yield	Nutrient uptake		
				N	P	K
		(q ha^{-1})		(kg ha^{-1})		
T_1	Absolute control	10.02	13.64	23.8	8.8	23.9
T_2	General recommended dose (45.0:22.5 N: P_2O_5 kg ha^{-1})	17.75	24.29	46.1	16.6	40.4
T_3	GRDF + Water spray	17.94	24.69	46.1	16.5	38.6
T_4	GRDF + Urea spray @ 2 %	20.86	28.28	51.8	21.5	47.9
T_5	GRDF + DAP spray @ 2 %	19.85	27.24	49.4	19.6	47.0
T_6	GRDF + MOP spray @ 2 %	18.66	25.23	45.9	17.4	41.3
T_7	GRDF + Urea @ 0.5 % + DAP @ 0.5 % + MOP spray @ 0.5 %	18.38	25.24	45.8	18.0	44.0
T_8	GRDF + 19:19:19 spray @ 2 %	22.68	31.88	57.5	25.4	50.3
T_9	GRDF + Calcium Nitrate spray @2 %	18.69	26.27	47.0	19.3	43.0
	S.E. $\pm$	0.824	1.219	1.22	1.14	2.45
	C.D. (P=0.05)	2.470	3.655	3.66	3.41	7.36

Table 2 : Nutrient use efficiency (NUE kg grain kg^{-1} nutrient applied) as influenced by different treatments

Sr. No.	Treatments	Nutrient applied (kg)			Grain yield (kg ha^{-1})	Nutrient use efficiency (kg grain yield kg^{-1} nutrient applied)		
		N	P_2O_5	K_2O		NUE	PUE	KUE
T_1	Absolute control	0	0	0	1002	-	-	-
T_2	GRDF	71.0	38.5	36.0	1775	25.00	46.10	49.31
T_3	GRDF + WS	71.0	38.5	36.0	1794	25.27	46.60	49.83
T_4	GRDF + Urea@ 2 %	75.6	38.5	36.0	2086	27.59	54.18	57.94
T_5	GRDF + DAP@ 2 %	72.8	43.1	36.0	1985	27.27	46.06	55.14
T_6	GRDF + MOP@ 2 %	71.0	38.5	42.0	1866	26.28	48.47	44.43
T_7	GRDF + Urea@0.5 % + DAP@0.5 % +MOP@ 0.5 %	72.6	39.7	37.5	1838	25.32	46.36	49.01
T_8	GRDF + 19:19:19@2%	72.9	40.4	37.9	2268	31.11	56.14	59.84
T_9	GRDF + $Ca(NO_3)_2$ @2 %	72.5	38.5	36.0	1869	25.78	48.55	51.92

Table 3 : Economics of finger millet crop after three years as influenced by different treatments (pooled mean values)

Sr. No.	Treatments	Grain yield	Straw yield	Cost of cultivation	Monetary returns	Net returns	B:C
		(q ha^{-1})		----------Rs. ha^{-1}----------			
T_1	Absolute control	10.02	13.64	27596	21665	-5931	0.81
T_2	General recommended dose (45.0:22.5 N: P_2O_5 kg ha^{-1})	17.75	24.29	33898	40825	6927	1.21
T_3	GRDF + Water spray	17.94	24.69	34524	41291	6767	1.20
T_4	GRDF + Urea spray @ 2 %	20.86	28.28	34582	48500	13918	1.39
T_5	GRDF + DAP spray @ 2 %	19.85	27.24	34772	45987	11215	1.31
T_6	GRDF + MOP spray @ 2 %	18.66	25.23	34689	43034	8346	1.24
T_7	GRDF + Urea @ 0.5 % + DAP @ 0.5 % + MOP spray @ 0.5 %	18.38	25.24	34643	42088	7445	1.23
T_8	GRDF + 19:19:19 spray @ 2 %	22.68	31.88	35658	52599	16942	1.46
T_9	GRDF + Calcium Nitrate spray @2 %	18.69	26.27	35424	42739	7315	1.22
	S.E. $\pm$	0.824	1.219		2323.6		
	C.D. (P=0.05)	2.470	3.655		6965.5		

Table 4 : Soil properties and available nutrient status as influenced by different treatments after harvest of finger millet crop

Sr. No.	Treatments	pH	EC dSm^{-1}	OC (%)	Available nutrients (kg ha^{-1})		
					N	P	K
T_1	Absolute control	7.1	0.14	0.58	230	30.3	235
T_2	General recommended dose (45.0 22.5 N: P_2O_5 kg ha^{-1})	7.1	0.14	0.61	255	31.2	239
T_3	GRD + Water spray	7.0	0.14	0.60	251	32.0	235
T_4	GRD + Urea spray @ 2 %	7.1	0.13	0.60	251	31.9	235
T_5	GRD + DAP spray @ 2 %	7.1	0.14	0.61	255	31.9	235
T_6	GRD + MOP spray @ 2 %	7.1	0.14	0.59	259	32.3	239
T_7	GRD + Urea @ 0.5 % + DAP @ 0.5 % + MOP spray @ 0.5 %	7.1	0.14	0.59	255	32.0	235
T_8	GRD + 19:19:19 spray @ 2 %	7.1	0.14	0.60	259	32.6	235
T_9	GRD + Calcium Nitrate spray @2 %	7.1	0.14	0.61	255	32.3	239
	Initial soil test values	7.0	0.13	0.58	230	30.5	241
	S.E. $\pm$	0.03	0.007	0.022	9.9	0.79	10.1
	C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS=Non-significant

(2013) reported that the application of 2 % urea spray at tillering and booting stage recorded higher net returns.

Soil properties:

The pH, EC and organic carbon did not differ due to different treatments after harvest of the finger millet crop (Table 4). Similarly the available nitrogen, phosphorus and potassium contents also did not differ among the different treatment whereas numerical highest values of available N and available P were recorded by treatment foliar spray 19:19:19 @ 2%. This higher values recorded could be due to balanced fertilization by the treatment. The favourable crop growth also had favourable effect on the microbial activity resulting in higher values recorded by the treatment.

Conclusion :

Amongst the different treatments of foliar nutrition, the highest significant grain yield and straw yield was recorded by 19: 19: 19 @ 2 % sprayed at 50 DAT over rest of the treatments of foliar nutrition. It also recorded highest gross monetary returns, net profit and B:C ratio. It was observed to be superior source of fertilizer for foliar nutrition as compared to the other sources used in present investigation.

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