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Concentration and Uptake of Major Nutrients as Influenced by Varieties and Different Levels of NPK Nutrients of Finger Millet (*Eleusine coracana* L.)

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A B S T R A C T

A field experiment was conducted during *kharif*, 2018 at Agricultural College Farm, Mahanandi to assess “concentration and uptake of major nutrients as influenced by varieties and different levels of NPK nutrients in finger millet (*Eleusine coracana* L.)”. The experiment was laid out in randomized block design with factorial concept (FRBD) having twelve treatments and three replications. The results revealed that higher concentration and uptake of major nutrients were observed in the treatment V_2 *i.e.*, VR-847 variety over (VR-762, Vakula and PPR-1012) and at higher NPK fertilizer levels in the treatment F_3 *i.e.*, 120-60-40 N, P_2O_5 and K_2O kg ha^{-1}at all the stages of crop growth.

Introduction

Finger millet (*Eleusine coracana* L.) is important small millet grown in India and has the pride of place with highest productivity among millets. It is also known as Ragi, African millet and Bird’s foot millet. In India, it is cultivated in Andhra Pradesh, Karnataka, Tamil Nadu, Orissa, Jharkhand, Uttaranchal, Maharashtra and Gujarat with cultivated area around 1.01 million ha, production of 1385.11 tonnes and productivity is 1363 kg ha^{-1}. In Andhra Pradesh, the total cultivated area is 0.032 million ha, production is 350 tonnes and productivity is 1094 kg ha^{-1}.

Majority of the finger millet varieties developed in the recent years are with wide adaption, easy cultivation, free from major pests and diseases and drought tolerance which made this crop an indispensable component of dry farming system. Often in the lands where finger millet crop is raised, no other crop worth mentioning can give reasonable harvest. To improve productive potential, nutrient management is an important practice. Fertilizer application not only influences the economic return of the investment through optimized yield and quality but also cause minimum level of environmental hazards. This calls for adoption of nutrient management practices which aims at efficient and judicious use of the major sources of plant nutrients to get maximum economic yield without any deleterious effect on physico-chemical and biological properties of the soil. In this context, the experiment is proposed to find out the "Response of Finger Millet (*Eleusine coracana* L.) Varieties to different Levels of Nutrients".

Materials and Methods

A field experiment was conducted at Agricultural College Farm, Agricultural College, Mahanandi of Acharya N.G. Ranga Agricultural University during *kharif* season from August to November, 2018 to evaluate the response of finger millet (*Eleusine coracana* L.) varieties to different levels of nutrients. The experiment comprised four finger millet varieties *viz.*, V_1: VR-762, V_2: VR-847, V_3: Vakula and V_4: PPR-1012 and three fertility levels *viz.*, F_1: 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, F_2: 90-45-30 N, P_2O_5 and K_2O kg ha^{-1} and F_3: 120-60-40 N, P_2O_5 and K_2O kg ha^{-1}. The experiment was laid out in randomized block design with factorial concept (FRBD) having twelve treatments and three replications. The experimental site was sandy loam and it was slightly alkaline in reaction with a pH of 8.08, EC of 0.21 ds m^{-1}, medium in organic carbon (0.59%) and low available nitrogen (137.98 kg N ha^{-1}), low in available phosphorous (39.9 kg P_2O_5 ha^{-1}) and high in available potassium (615.14 kg K_2O ha^{-1}).The fertilizers such as urea, single super phosphate and muriate of potash were supply of NPK as per the treatments and the entire quantity of phosphorous as basal and potassium and nitrogen were applied in three equal splits *i. e.*, at the time of sowing, 30 DAS and 60 DAS and other agronomical operations were carried out as per recommendation. The growth, yield attributes and yield were recorded at the time of harvest of crop.

After recording the dry matter production, the grain and straw samples were grounded in a willey mill and were analyzed for the concentrations of major nutrients as per the procedures laid out lined by Tandon (1993). The uptakes of major nutrients were computed with using the formula:

$$\text{Uptake of N, P and K (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (per cent)} \times \text{Weight of dry matter (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Drymatter production

Drymatter production recorded at different stages of crop growth is presented in Table 1. At 30 DAS, higher drymatter production was noticed with the finger millet variety of VR-847 (885.5 kg ha^{-1}) which was statistically found to be at par with the finger millet variety of VR-762 (863.7 kg ha^{-1}) when compared over other varieties of finger millet, whereas, lower drymatter production was recorded with the Vakula variety (744.5 kg ha^{-1}).

At 60 DAS, the finger millet variety of VR-847 (12418.5 kg ha^{-1}) recorded the higher drymatter production and found significantly superior to all other varieties tried in the study. However, lower drymatter production was observed in Vakula (9708.8 kg ha^{-1}) variety.

At harvest, significantly higher drymatter production was observed in VR-847 (15572.4 kg ha^{-1}) variety when compared with other varieties. The lower drymatter production was registered in Vakula (12694.1 kg ha^{-1})variety. It denotes that the drought tolerant capability of these varieties as they maintained higher physiological activity in terms of higher growth parameters, thus sustained higher total plant dry weight. These results were in collaboration with the findings of Sarawale*et al.*, (2016) and Aparna and Bhargavi (2017).

Increasing levels of fertilizers significantly and progressively influenced the drymatter production at all the stages of crop growth. Application of 120-60-40 kg N, P_2O_5, K_2O ha^{-1} (960.6, 12295.7 and 15194.7 kg ha^{-1}, respectively) recorded the higher drymatter production at 30 DAS, 60 DAS and at harvest and found significantly superior to other levels of nutrients tried in the experimentation. This might be due to increase in the availability of nutrients which was responsible for higher plant height, profused tillering, hence higher drymatter accumulated. Such increase in drymatter production with increased levels of nutrients was also reported by Narayan *et al.*, (2018) and Prakash *et al.*, (2018)

Regarding the interaction effect the combination of 120-60-40 kg N, P_2O_5, K_2O ha^{-1} with variety VR-847 produced highest drymatter at 30 DAS, 60 DAS and at harvest. The lowest drymatter was produced with application of the treatment 60-30-20 kg N, P_2O_5, K_2O ha^{-1} with Vakula variety at all growth stages of the crop.

Table.1 Dry matter production at different growth stages of finger millet as influenced by varieties and different levels of NPK nutrients

Treatment	**Drymatter production (kg ha^{-1})**		
	30DAS	**60 DAS**	**At harvest**
VARIETIES			
V_1	863.70	11971.85	14673.74
V_2	885.59	12418.52	15572.43
V_3	744.59	9708.89	12694.11
V_4	794.17	10087.37	13366.05
SEm ±	**7.70**	**111.11**	**99.79**
CD (P=0.05)	**22.60**	**325.84**	**292.65**
FERTILIZER LEVELS (NPK)			
F_1	717.01	9324.50	12906.88
F_2	788.37	11519.76	14128.18
F_3	960.67	12295.73	15194.71
SEm ±	**6.67**	**96.22**	**86.42**
CD (P=0.05)	**19.57**	**282.19**	**253.44**
V X F			
SEm ±	**13.35**	**192.44**	**172.84**
CD (P=0.05)	**39.15**	**564.38**	**506.89**

Varieties
V_1: VR-762
V_2: VR-847
V_3: Vakula
V_4: PPR-1012

N, P and K levels
F_1: 60-30-20 N,P_2O_5 and K_2O kg ha^{-1}
F_2: 90-45-30 N,P_2O_5 and K_2O kg ha^{-1}
F_3: 120-60-40 N,P_2O_5 and K_2O kg ha^{-1}

Table.2 N, P and K concentrations at different growth stages of finger millet as influenced by varieties and different levels of NPK nutrients

Treatment	N concentration (%)				P concentration (%)				K concentration (%)			
	30 DAS	60 DAS	At harvest		30 DAS	60 DAS	At harvest		30 DAS	60 DAS	At harvest	
			Straw	Grain			Straw	Grain			Straw	Grain
VARIETIES												
V_1	2.59	1.64	1.09	1.33	0.30	0.24	0.18	0.21	3.65	2.24	2.04	0.59
V_2	2.70	1.68	1.13	1.35	0.33	0.27	0.20	0.23	3.70	2.34	2.14	0.63
V_3	2.43	1.58	1.03	1.32	0.27	0.21	0.16	0.20	3.37	2.15	1.95	0.57
V_4	2.38	1.54	1.01	1.30	0.25	0.19	0.15	0.19	3.32	2.11	1.91	0.54
SEm ±	**0.01**	**0.005**	**0.005**	**0.002**	**0.006**	**0.006**	**0.004**	**0.003**	**0.01**	**0.009**	**0.009**	**0.009**
CD 5%	**0.02**	**0.01**	**0.01**	**0.006**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**	**0.02**	**0.02**	**0.02**
FERTILIZER LEVELS												
F_1	2.30	1.51	0.94	1.27	0.23	0.17	0.15	0.18	3.28	1.94	1.74	0.49
F_2	2.54	1.63	1.06	1.34	0.29	0.23	0.18	0.21	3.45	2.24	2.04	0.63
F_3	2.75	1.70	1.21	1.37	0.35	0.29	0.20	0.25	3.81	2.46	2.26	0.65
SEm ±	**0.008**	**0.005**	**0.005**	**0.002**	**0.005**	**0.005**	**0.004**	**0.003**	**0.01**	**0.008**	**0.008**	**0.008**
CD 5%	**0.02**	**0.01**	**0.01**	**0.006**	**0.01**	**0.01**	**0.01**	**0.009**	**0.03**	**0.02**	**0.02**	**0.02**
V X F												
SEm ±	**0.01**	**0.009**	**0.009**	**0.004**	**0.01**	**0.01**	**0.008**	**0.006**	**0.02**	**0.01**	**0.01**	**0.01**
CD 5%	**0.04**	**0.02**	**0.02**	**0.01**	**NS**	**NS**	**NS**	**NS**	**0.07**	**0.04**	**0.04**	**NS**

Table.3 N, P and K uptake at different growth stages of finger millet as influenced by varieties and different levels of NPK nutrients

Treatment	N uptake (kg ha^{-1})				P uptake (kg ha^{-1})				K uptake (kg ha^{-1})			
	30 DAS	60 DAS	At harvest		30 DAS	60 DAS	At harvest		30 DAS	60 DAS	At harvest	
			Straw	Grain			Straw	Grain			Straw	Grain
VARIETIES												
V_1	22.63	197.72	161.22	37.83	2.65	29.39	26.87	6.11	31.98	272.08	301.54	16.88
V_2	24.12	210.01	178.06	38.71	2.98	34.09	31.31	6.79	33.19	292.53	335.71	18.20
V_3	18.26	154.55	132.41	35.75	2.07	21.20	21.36	5.56	25.19	211.53	250.45	15.47
V_4	19.12	157.49	136.17	33.46	2.08	20.54	20.68	4.94	26.46	216.17	257.79	14.05
SEm ±	**0.08**	**0.62**	**0.76**	**0.06**	**0.05**	**0.66**	**0.61**	**0.09**	**1.11**	**0.99**	**1.30**	**0.24**
CD 5%	**0.24**	**1.82**	**2.22**	**0.18**	**0.14**	**1.94**	**1.80**	**0.27**	**0.34**	**2.92**	**3.84**	**0.72**
FERTILIZER LEVELS												
F_1	16.55	141.84	121.30	33.26	1.67	16.19	19.79	4.66	23.57	182.52	226.30	12.83
F_2	20.07	188.14	150.08	36.69	2.27	26.46	24.97	5.78	27.26	258.03	287.86	17.09
F_3	26.48	209.87	184.52	39.38	3.41	36.28	30.42	7.12	36.81	303.70	344.98	18.54
SEm ±	**0.07**	**0.53**	**0.65**	**0.05**	**0.04**	**0.57**	**0.53**	**0.08**	**1.10**	**0.86**	**1.13**	**0.21**
CD 5%	**0.21**	**1.57**	**1.92**	**0.16**	**0.12**	**1.68**	**1.56**	**0.23**	**0.29**	**2.53**	**3.32**	**0.62**
V X F												
SEm ±	**1.14**	**1.07**	**1.31**	**1.10**	**0.08**	**1.14**	**1.06**	**0.16**	**0.20**	**1.72**	**2.27**	**0.42**
CD 5%	**0.42**	**3.15**	**3.85**	**0.32**	**0.25**	**3.36**	**NS**	**NS**	**0.58**	**5.06**	**6.65**	**NS**

Concentration and uptake of nutrients

Nitrogen

Concentration and uptake recorded at different stages of crop growth is presented in Table 2 & 3. Both finger millet varieties and fertilizer levels showed significant influence on concentration and uptake of nitrogen. The interaction effect between these two factors was found to be statistically significant. At 30 DAS, the concentration and uptake was significantly higher in VR-847 (24.12 kg ha^{-1}) variety followed by VR-762, PPR-1012 and Vakula (22.63, 19.12 and 18.26 kg ha^{-1}) varieties.At 60 DAS, higher concentration and uptake were produced in VR-847 (210.01 kg ha^{-1}) variety when compared over rest of the varieties. The lower concentration and uptake were observed in Vakula (154.55 kg ha^{-1}) variety. At harvest (straw and grain), significantly higher nitrogen uptake was observed in VR-847 (178.06 kg ha^{-1} in straw and 38.71 kg ha^{-1} in grain) variety compared with VR-762, Vakula and PPR-1012 (161.22, 132.41 and 136.17 kg ha^{-1} in straw and 37.83, 35.75 and 33.46 kg ha^{-1} in grain) varieties.

Nitrogen uptake showed increasing trend with the advancement of age of crop and reached maximum at harvest. Increasing fertilizer levels application significantly influenced the nitrogen uptake at all stages of crop growth. Application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1}at30 DAS (26.48 kg ha^{-1}), 60 DAS (209.87 kg ha^{-1}) and at harvest (184.52 kg ha^{-1}in straw and 39.38 kg ha^{-1} grain), respectively was found significantly superior in nitrogen uptake by the crop at all stages when compared with other treatments.

With regard to the interaction effect, the combination of the finger millet variety VR-847 with the application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1} recorded higher nitrogen uptake at all stages of crop growth. The lower nitrogen uptake was recorded with the Vakula variety along with application of 60-30-20 N, P_2O_5 and K_2O kg ha^{-1} at all crop growth stages.

The higher nitrogen uptake might be due to better availability of nutrients that to increase uptake of nutrients. These results were in conformity with the findings of Nigade and More (2013), Saraswathi *et al.,* (2017) and Sandhya Rani *et al.,* (2017). The higher nitrogen uptake in grain is due to increased availability of nutrients in the crop root zone that resulted in increased absorption of the elements by the plants as well as higher drymatter production. Similar results were also reported by Vajantha *et al.,* (2017) and Prakasha *et al.,* (2018).

Phosphorous

Concentration and up take of phosphorous (Table 2 and 3) were differed significantly by finger millet varieties and with the application of various fertilizer levels at all growth stages of crop. The interaction effect between varieties and different fertilizer levels was statistically found to be significant at30 DAS and 60 DAS, but at harvest (straw and grain) it is found to be non-significant. At 30 DAS, higher concentration and uptake of P was observed with finger millet variety VR-847 (2.98 kg ha^{-1}) when compared to other varieties. However, the PPR-1012 (2.08 kg ha^{-1}) was statistically at par with Vakula (2.07 kg ha^{-1}) variety. At 60 DAS, phosphorous uptake was higher with finger millet variety of VR-847 (34.09 kg ha^{-1}) whereas, the variety Vakula (21.20 kg ha^{-1}) was statistically at par with PPR-1012 (20.54 kg ha^{-1}) variety. At harvest (straw and grain), phosphorous uptake was higher with finger millet variety of VR-847 (31.31 kg ha^{-1} in straw and 6.79 kg ha^{-1} in grain) whereas, the Vakula variety (21.36 kg ha^{-1}) was statistically at par with the PPR-1012 (20.68

kg ha^{-1}) at harvest in straw. Increasing fertilizer doses significantly increased the phosphorous uptake up to the highest level of the fertilizer. Phosphorous uptake increased with the application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-}at 30 DAS (3.41 kg ha^{-1}), 60 DAS (36.28 kg ha$^{-1)}$ and at harvest (30.42 kg ha^{-1} in straw and 7.12 kg ha^{-1} grain), respectively when compared with the application of 90-45-30 N, P_2O_5 and K_2O kg ha^{-1} and 60-30-20 N, P_2O_5 and K_2O kg ha^{-1},respectively at all the stages of the crop growth.

With regard to interaction effect, the combination of VR-847 variety with the application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1} was recorded higher concentration and uptake of P at 30 DAS and 60 DAS. The lower phosphorous uptake by straw was observed in Vakula at 30 DAS and in PPR-1012 at 60 DAS with the application of 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, respectively. Higher phosphorous uptake by the crop was attributed to higher solubility, even distribution of nutrients throughout root zone and higher efficiency of applied fertilizers. Similar results were reported by Saravanane *et al.*, (2011), Sandhya Rani *et al.*, (2017) and Saraswathi *et al.*, (2017). The higher P uptake in grain might be due to increased drymatter production in reproductive parts (panicles) and nutrient content which was due to favorable environment and increased fertilizer levels made sufficient quantity of P available in the rhizosphere which in turn helped the plants to uptake more nutrients. These results were in collaboration with the findings of Vajantha *et al.*, (2017) and Prakasha *et al.*, (2018).

Potassium

Concentration and uptake of K (Table 2 and 3) of finger millet measured at different growth stages differed due to different finger millet varieties and different fertilizer levels. The potassium uptake of finger millet increased steadily up to harvest (straw and grain) and their interaction effect was found to be significant throughout the growth period. Among the finger millet varieties, higher potassium uptake was recorded with VR-847 (33.19 kg ha^{-1}) variety at 30 DAS, when compared rest of the varieties. However, lower potassium uptake was observed in Vakula (25.19 kg ha^{-1}) variety. At 60 DAS, potassium uptake was higher in VR-847 (292.53 kg ha^{-1}) variety which was superior over rest of the treatments. Whereas, lower uptake of potassium was observed in Vakula (211.53 kg ha^{-1}) variety.At harvest (straw and grain), potassium uptake was higher in the treatment VR-847 (335.71 kg ha^{-1} in straw and 18.20 kg ha^{-1} in grain) when compared to other treatments. Regarding the fertility levels, application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1} was found significantly superior in potassium uptake at all the crop growth stages *viz.*, 30 DAS (36.81 kg ha^{-1}), 60 DAS (303.70 kg ha^{-1}) and at harvest (344.98 kg ha^{-1}) in straw and 18.54 kg ha^{-1} in grain), when compared to 90-45-30 and 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, respectively.

With regard to interaction effect, the combination of the VR-847 variety along with the application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1} recorded higher concentration and uptake of K at all the growth stages of the crop. The lower potassium uptake was observed in Vakula variety with the application of 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, respectively. The increase in concentration and uptake of potassium might be due to direct fertilizer application, which solubilize the native *i.e.*, fixed and non-exchangeable form of potassium ions at later stages of crop growth that caused higher potassium uptake in straw. These results were in conformity with the findings of Nigade and More (2013) and Saraswathi *et al.*, (2017).

The higher potassium uptake by grain might be due to increased growth parameters and yield parameters, due to favorable environment and increased fertilizer levels available throughout the root zone and helped to uptake more nutrients. These results were in conformity with the findings of Shankar *et al.,* (2014) and Vajantha *et al.,* (2017).

Concentration of N, P and K nutrients in finger millet was the highest at the younger stage (30 DAS) and gradually declined thereafter mainly due to dilution as the drymatter accumulated (Table 2). Concentration of K was the highest, followed by that of N, while the concentration of P was the lowest at all the stages. At harvest the concentration of N and P in grain higher than concentration of N and P in straw. This could be expected because both N and P were involved in protein synthesis and were also part in proteins and therefore accumulated in grain. On the other hand, the concentration of K in straw was higher than concentration in grain. Similar reports were observed in rice crop was reported by Sivajyothi *et al.*, (2014).

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