Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 557-560
Received: 01-07-2019
Accepted: 03-08-2019

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Effect of nutrient management in finger millet in red sandy loam soils of North Coastal zone

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Abstract
Finger millet (*Eleusine coracana* (L.) Gaertn) is a staple food crop grown by subsistence farmers in red sandy loam soils of North Coastal Zone and scarce rain fall zone of Andhra Pradesh. It is commonly called as "Nutricereal" as it is nutritionally superior to many cereals and containing proteins, minerals, calcium and vitamins in abundance and is highly valued by traditional farmers as it is nutritious, drought tolerant, short duration and requires low inputs. High yielding varieties of finger millet require comparatively large quantities of both macro and micronutrients and are expected to respond favourably to their application. A field experiment was conducted on *kharif*, 2018-19, to study the yield response of finger millet to graded doses of fertilizers at Agricultural Research Station, Vizianagaram, Andhra Pradesh. The experiment consisting of eleven treatments, three replications with RBD design. The experimental results indicated that significantly higher grain and straw yields of finger millet were recorded in the treatment with 150% RDF (30.5q/ha and 79.5q/ha respectively). The highest available soil macronutrients and uptake of plant macronutrients was also found in the same treatment.

Keywords: Finger millet, nutrient management, soil available nutrients, plant uptake

Introduction
Finger millet or Mandua or Bird's foot millet commonly known as Ragi [*Eleusine coracana* (L.) Gaertn.] is an important small millet crop ranked third in India with respect to area, production and has the pride of place in having the highest productivity among the millets (Seetharam and Krishnegowda, 2007) [12]. It is also a staple food crop in many hilly regions of the country. It is grown both for grain and fodder purposes and is cultivated up to an altitude of 3000 metres above MSL. The crop is well adapted to very poor and marginal uplands where other crops cannot be grown successfully (AICSMIP, 2014) [1]. In India, it is an extensively grown crop over an area of 1.26 M ha with a production of 1.89 M t and a productivity of 1.48 t ha^{-1}. In Andhra Pradesh, finger millet is grown in an area of 7.88 lakh ha, with an annual production of 12.72 lakh tonnes and productivity of 1871 kg ha^{-1}. Finger millet is the staple food grain for majority of the population in India since it is economically and highly nutritious. Dietary fiber protects against hyper glycemia, phytates against oxidation stress by chelating iron and some phenolic and tannins act as antioxidants (Antony, 1998) [2]. In south India, finger millet is used in many food preparations like cakes, porridge and sweetmeat. Sprouted grains are malted and fed to infants also. It is also good for pregnant women. The finger millet flour is consumed by mixing with milk, boiled water or yoghurt. It is non-acid forming food and easy to digest. It is considered to be one of the least allergic and most digestible foods over the last three decades, there has been decline in area and production of finger millet due to low price in the market which forced the farmers to shift to cash crop cultivation and the trend is towards growing cash crops rather than ensuring our own food security. However, there is every need to increase the productivity of finger millet to meet the needs of ever increasing population in India. Major constraint in finger millet production is lack of suitable crop management practices. The productivity of finger millet is low due to unfavourable weather, late transplanting and faulty methods of cultivation. It has been reported in Karnataka, the average yield of finger millet is more under good fertilizer management practices of young seedlings (Kalaraju *et al.*, 2011) [7].

Material and Methods
A field experiment was conducted during *Kharif,* 2018-19 at Agricultural Research Station, ANGRAU, Vizianagaram, Andhra Pradesh. The soil of the operational site was sandy loam in texture, low in organic carbon, available nitrogen and high in available phosphorus and medium in available potassium. The experiment was laid down in randomised block design with eleven treatments replicated thrice. T_1: Control (0% RDF N, P, K), T_2: 100% RDF N

alone, T_3: 100% RDF P alone, T_4: 100% RDF K alone, T_5: 100% RDF N and P, T_6: 100% RDF N,P and K, T_7: 150% RDF N alone, T_8: 150%RDF P alone, T_9: 150% RDF K alone, T_{10}: 150% RDF N and P and T_{11}: 150% RDF N,P,K. The recommended dose of nutrients (R.D.F.) was 60 kg N, 40 kg P_2O_5 and 30 kg K_2O ha^{-1} which was applied in the form of urea, DAP and muriate of potash. Fertilizer nitrogen was applied as per treatments in two equal splits, half at transplanting and half at 30 days after transplanting. Phosphorus and potash were applied basally, at transplanting as per the treatments. Uniform cultural practices were carried out in all the experimental plots of 3 X 3 m^2 and healthy seeds were sown with a spacing of 30X10cm^2 in all the plots. Required population of finger millet crop of released variety VR-847 was maintained by thinning and gap filling whenever required.

Growth parameters *viz*., plant height, no. of productive tillers, leaf length, leaf width, ear head length, no. of fingers/ear, straw and grain yields were recorded at the time of harvest. The initial soil samples before sowing of the crop and post-harvest soil samples were analysed for pH, EC, OC, available N, P_2O_5, K_2O and available micronutrients *viz*., Zn, Fe, Cu and Mn as per the standard procedures. The plant samples of both the grain and straw of both the varieties of finger millet were prepared and analysed for both macro and micronutrient uptake.

Results and Discussion

Yield and yield attributing parameters

The growth characters, yield attributes, soil and plant quality were significantly influenced with different nutrient management practices. The plant height was found highest with 150% RDF and lowest was observed with control. However which was statistically non-significant. Increase in plant height with increasing levels of nitrogen was reported by Gupta *et al*. (2012) and Tenywa *et al*. (1999) [6, 16] found that application of P fertilizer (40 kg P ha^{-1}) increased the growth and yield of finger millet compared to the no fertilizer under row planting conditions. The boot leaf length (Table 1) was found highest with 150% RDF (T_{11}) and it was on par with 150% RDF N and P (T_{10}). The No. of productive tillers per plant (Table 1) were highest in 150% RDF (T_{11}), which was on par with 150% RDF N and P (T_{10}), 100% RDF N,P and K (T_6) and 100% RDF N and P (T_5). The ear head length and fingers/ear were also found highest with treatment T_{11} which was found on par with 150% RDF N and P (T_{10}), 150% RDF N alone (T_7), 100% RDF N,P and K (T_6), 100% RDF N and P (T_5) and 100% RDFN alone (T_2). Similar results were recorded by Sankar *et al*. (2011) [11] who obtained the highest number of effective tillers with 50 kg N ha^{-1}. The highest grain yield (30.5q ha^{-1}) (Table 1) was obtained with 150% RDF (T_{11}) followed by 150% RD N and P (T_{10}). Increase in grain yield due to increasing levels of nutrients has also been reported by Dubey and Shrivas (1999), Chakraborty *et al*. (2002) and Tetarwal and Rana (2006) [5, 3, 17]. Maximum straw yield (78.1q ha^{-1}) (Table 1) was recorded in 150% RDF (T_{11}) followed by 150% RD N and P (T_{10}). Varied responses in straw yield due to levels of nutrients have also been reported by Singh (1999) [13] (75% of 50-40-25 kg N, P, K ha^{-1}), Sunitha *et al*. (2006) [15] (100% N through fertilizer) and Chavan *et al*. (1995) [4] (120 kg N). The physicochemical properties (pH and E.C) have not been significantly influenced with the application of different nutrient management practices (Table 4). The organic carbon percentage of the soil was also not significantly influenced by various treatments (Table 4). The soil available Nitrogen, Phosphorus and Potassium (Table 4) were significantly high in 150% RDF (T_{11}) compared to the rest of the treatments. The least soil available nitrogen, phosphorus and potassium were recorded in control treatment. In the soil available micronutrients (Table 4), available Fe and Cu were significantly influenced by various treatments of nutrient management except control, soil available Fe was statistically similar in all treatments. Similar results were reported by Rangaraj *et al*. (2007) [9]. The uptake of macronutrients (N, P and K) (Table 2) were found highest in the treatment 150% RDF (T_{11}) which was found on par with 150% RDN and P (T_{10}) 100% RDF N and P (T_5), 100% RDF N,P and K (T_6) and 150% RDF N alone (T_7). Increased uptake of N with increased levels of N application has been reported by Sudhakara Rao *et al.* (1991) [14] while increase in N uptake by grain and straw of pearl millet due to increased levels of nitrogen has been reported by Tetarwal and Rana (2006) [17]. The uptake of micronutrients (Zn and Fe) (Table 3) was found highest with the treatment 150% RDF (T_{11}) which was found on par with the treatments 150% RDN and P (T_{10}), 100% RDF N,P and K (T_6) and 100% RDF N alone (T_2). The lowest uptake of micronutrients was recorded with control (T_1). Similar results were recorded by Rao *et al*. (2012) and Ramachandrappa *et al*. (2014) [10, 8].

Table 1: Effect of nutrient management on yield and yield attributes in finger millet

Treatments particulars	Plant height (cm)	Productive Tillers/ plant	Boot leaf Length (cm)	Boot leaf Width (cm)	Ear head length (cm)	No. of Fingers/ ear	Grain yield (q/ha)	Straw yield (q/ha)
T1 Control (no N,P,K)	115.7	1.7	29.7	0.6	6.9	7.0	17.8	43.5
T2 100% N alone	123.5	2.8	33.3	0.7	8.1	7.7	23.8	55.6
T3 100% P alone	121.0	2.4	31.7	0.7	7.6	7.5	22.2	53.1
T4 100% K alone	120.0	1.9	30.7	0.6	7.2	7.3	21.1	46.9
T5 100% N and P	126.4	3.1	36.0	0.7	8.3	7.7	25.9	65.7
T6 100% N,P and K	127.7	3.3	37.3	0.7	8.5	7.7	26.6	67.7
T7 150% N alone	123.3	2.9	34.3	0.7	8.3	7.5	25.2	60.2
T8 150% P alone	121.4	2.6	32.3	0.7	7.8	7.5	23.4	56.1
T9 150% K alone	120.9	2.2	30.7	0.7	7.3	7.5	21.7	50.8
T10 150% N and P	132.6	3.2	40.7	0.8	9.0	7.9	29.4	74.0
T11 150% N,P,K	134.2	3.5	42.0	0.9	9.4	7.8	30.5	79.5
Sem±	3.8	0.1	1.9	0.04	0.2	0.3	1.0	2.2
CD (0.05)	NS	0.4	5.7	0.1	0.7	NS	3.2	6.4
CV (%)	5.3	9.5	9.8	12.6	5.2	7.3	7.8	6.4

Table 2: Effect of N, P, K nutrients management on nutrient content (%) of finger millet

Treatments	N (%)	P (%)	K (%)	Zn (ppm)	Fe (ppm)
T_1 Control (no N,P,K)	0.87	0.27	0.75	4.11	28.75
T_2 100% N alone	1.08	0.34	0.96	4.02	28.12
T_3 100% P alone	1.02	0.32	0.90	4.04	28.26
T_4 100% K alone	0.93	0.29	0.81	3.90	27.32
T_5 100% N and P	1.18	0.37	1.06	3.30	23.12
T_6 100% N,P and K	1.19	0.37	1.07	3.26	22.82
T_7 150% N alone	1.13	0.35	1.01	3.34	23.36
T_8 150% P alone	1.05	0.33	0.93	3.22	22.56
T_9 150% K alone	0.99	0.31	0.87	3.28	28.04
T_{10} 150% N and P	1.22	0.38	1.10	3.36	23.52
T_{11} 150% N,P,K	1.25	0.39	1.13	3.25	21.92
Sem±	0.05	0.0155	0.05	0.10	0.76
CD (0.05)	0.14	0.04	0.15	0.30	2.25
CV (%)	7.91	6.71	8.90	5.04	5.24

Table 3: Effect of N, P, K nutrients management on uptake (kg ha^{-1}) by finger millet

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Zn uptake (g/ha)	Fe uptake (g/ha)
T_1 Control (no N,P,K)	38.0	11.9	32.8	178.9	1252.5
T_2 100% N alone	60.1	18.8	53.5	223.4	1563.5
T_3 100% P alone	54.4	17.0	48.0	214.6	1502.4
T_4 100% K alone	43.9	13.7	38.2	183.2	1282.7
T_5 100% N and P	77.8	24.3	69.9	217.4	1522.1
T_6 100% N,P and K	80.8	25.3	72.7	220.8	1545.3
T_7 150% N alone	67.9	21.2	60.7	200.9	1406.1
T_8 150% P alone	59.1	18.5	52.4	180.9	1266.1
T_9 150% K alone	50.6	15.8	44.5	166.5	1424.6
T_{10} 150% N and P	90.1	28.2	81.2	248.6	1740.4
T_{11} 150% N,P,K	99.7	31.2	90.2	258.7	1739.8
Sem±	3.87	1.21	3.68	10.12	71.52
CD (0.05)	11.42	3.56	10.88	29.86	210.97
CV (%)	10.21	10.21	10.91	8.41	8.38

Table 4: Soil fertility status of post-harvest soil samples as influenced by nutrient management in finger millet

Treatment particulars	pH (1:2.5)	EC (dS m^{-1})	OC (%)	Av. N (kg/ha)	Av.P_2O_5 (kg/ha)	Av. K_2O (kg/ha)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
T_1 Control (no N,P,K)	6.61	0.15	0.37	242	31	235	1.83	4.5	2.7	0.30
T_2 100% N alone	6.64	0.16	0.46	275	40	248	2.02	5.8	3.0	0.40
T_3 100% P alone	6.81	0.15	0.42	269	59	252	2.60	5.9	3.1	0.40
T_4 100% K alone	6.70	0.14	0.40	258	45	271	1.56	6.0	3.0	0.30
T_5 100% N and P	6.76	0.16	0.47	282	63	262	1.67	6.2	3.1	0.37
T_6 100% N,P and K	6.80	0.19	0.48	284	68	283	2.69	6.3	3.3	0.33
T_7 150% N alone	6.69	0.16	0.49	288	47	265	1.55	5.8	3.0	0.42
T_8 150% P alone	6.89	0.21	0.45	277	75	267	1.60	6.0	3.1	0.40
T_9 150% K alone	6.91	0.19	0.45	275	53	293	1.55	5.8	2.9	0.33
T_{10} 150% N and P	6.92	0.19	0.50	296	77	271	1.58	6.2	3.0	0.30
T_{11} 150% N,P,K	6.95	0.19	0.51	303	85	316	1.64	6.2	3.1	0.33
Sem±	6.78	0.17	0.45	287.56	58.17	269.36	0.58	5.87	3.02	0.35
CD (0.05)	0.15	0.01	0.03	5.43	3.63	8.30	0.04	0.20	0.21	0.03
CV (%)	NS	0.03	NS	16.04	10.71	24.50	NS	0.61	NS	0.08
T_1 Control (no N,P,K)	3.96	12.93	11.44	3.27	10.81	5.34	10.01	6.15	12.05	13.71
Initial soil analysis	6.73	0.28	0.44	265	40.6	208	1.7	5.1	3.7	1.4

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