Indian Journal of Agronomy **65** (3): 372–376 (September 2020)

Research Communication

Effect of nutrient-management practices on yield, nutrient uptake and economics in finger millet (*Eleusine coracana*) and pearl millet (*Cenchrus americanus*)

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Received: May 2020; Revised accepted: September 2020

ABSTRACT

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture Jobner, Jaipur (Rajasthan) during the rainy (*kharif*) season of 2018, to study the comparative response of finger millet (*Eleusine coracana* Gaertn.) and pearl millet (*Cenchurs americanus* (L.) Morrone; syn *Pennisetum glaucum* (L.) R.Br.] to applied nutrients under semi-arid conditions of Rajasthan. The experiment, consisting of 8 fertilization levels (control, N, P, Zn, N+P, N+Zn, P+Zn and N+P+Zn), to each finger millet and pearl millet were tested in randomized block design with 3 replications. Results showed that the apparent values of yield-attributing characters of both the crops *viz.* effective tillers/plant, grains/ear and test weight, increased with application of plant nutrients either alone or in combination. Significantly higher values were obtained with combined application of N + P + Zn. The same treatment resulted in statistically higher yields of grain and stover as well as uptake of N, P and Zn in both the crops. It resulted in the grain and stover yields of 2006 and 3,304 kg/ha in finger millet and 2024 and 5,317 kg/ha in pearl millet, being 40 and 29% higher in finger millet and 69 and 46% higher in pearl millet over the control, respectively. However, the same treatment was found at par with that against N+P. The harvest index in grains remained unaffected due to application of any nutrient applied alone or in combination. Fertilization with N+P+Zn significantly improved the net returns from finger millet (₹57,178/ha) and pearl millet (₹48,717/ha) over rest of the treatments. A comparison between yield and economic from both the crops proved superiority of finger millet which gave approximately ₹8,400/ha higher than pearl millet. Finger millet proved to be more economic, as its benefit: cost ratio ranged between 2.59 and 3.26/₹ invested in its cultivation than the corresponding figures for pearl millet 1.80 and 2.81.

Key words: Finger millet, Grain yield, Nitrogen, Nutrients, Pearl millet, Phosphorus, Zinc

Millets are the group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. Millets are important crops in the semiarid tropics of Asia and Africa, with 97% of millet production in developing countries. Most of millet crops are native of India and are popularly known as Nutricereals, as they provide most of the nutrients required for normal functioning of human body (Dinesh *et al.*, 2019). Finger millet is an important small millet crop, as it accounts for about 85% of production in India among total minor millets. The production area of finger millet in India stands sixth after wheat, rice, maize, sorghum and pearl millet. Pearl millet is one of the important millet crops for arid and semi-arid climatic condition, is endowed with greater ability to withstand and yield under harsh climatic conditions. It is one of the most important cereal crops of India and rank fourth in area after rice, wheat and sorghum. In India, it is grown in an area of 7.46 million hectare with the production of 9.73 million tonnes with an average productivity of 1305 kg/ha. (DAC, MoA, 2017). It is nutritionally better than many cereals, as it is a good source of protein having higher digestibility (12.1%), fat (5%), carbohydrate (69.4%) and minerals (2.3%). Pearlmillet is taken mostly as rainfed crop on marginal and sub marginal land; poor in organic matter, low in available nitrogen, phosphorus and zinc, which result in low yield. In the present system of intensive agriculture, most of the farmers are using exhaustive high-yielding varieties of the crops, therefore led to heavy withdrawal of nutrients from the soil during past few years and fertilizer consumption remained much

Based on a part of M.Sc. thesis of the first author, submitted to Sri Karan Narendra Agriculture University, Jobner, in 2019 (unpublished)

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below compared to removal. So, the mineral fertilization is one of the most important ways to improve the crop yield qualitatively and quantitatively, and its quality can be improved by adequate soil nutrient and crop-management practices. The degree of response of the crop to fertilizer application depends on fertility status of the soil, nutrient acquisition power of the crop as well as management factors for crop production. The low profit from pearl millet crop is causing concern to both farmers and government. Crop diversification or crop substitution may yield expected results if tried. Experience shared by local farmers revealed that, finger millet might be an option. If the new crop succeeds, its complete package of practices will have to be standardized under local conditions. Hence, there is a need to divert our research efforts towards crop diversification or substitution ensuring higher income to the growers or finding out alternatives for efficient use of resources and maintaining soil health. Therefore, our research effort should be diverted to remove the constraints that are responsible for its poor yield in Rajasthan. Hence the present investigation was conducted with the objective to find out the comparative response of finger millet and pearl millet to applied nutrients under semi-arid conditions of Rajasthan for achieving high yield, better nutrient uptake and economics.

The experiment was conducted during the rainy (*kharif*) season of 2018 at Agronomy farm, College of Agriculture, Sri Karan Narendra Agriculture University, Jobner (26° 05' N and 75° 28' E with altitude of 427 m above the mean sea-level) Jaipur, Rajasthan. The area falls in agro-climatic zone-IIIa, i.e. semi-arid eastern plain zone of Rajasthan. The annual rainfall of site received during south west monsoon season (July to September). During summers, the temperature may go as high as 48 °C while in winter, and it may fall as low as –1.5°C. The relative humidity fluctuates between 43 and 87%. The total rainfall received during the crop season was 398.6 mm but the distribution was erratic. There was a dry spell of 2 weeks during 27 July–9 August 2018. The soil of the experimental field was loamy sand in texture, alkaline (*p*H 8.2), poor in organic carbon (0.21%), low in available nitrogen (121.7 kg/ha) and medium in phosphorus (16.12 kg/ha) and potassium (153.24 kg/ha). The experiment consisting of 8 fertilization levels (control, N, P, Zn, N+P, N +Zn, P+Zn and N+P+Zn kg/ha) to each finger millet and pearl millet were tested in randomized block design with 3 replications. The plot size was 4.0 m × 3.0 m. Recommended doses of nutrients for pearl millet at 60, 20 and 5 kg/ha of N, P and Zn through urea, single superphosphate and zinc sulphate, respectively, were equally applied to both the crops. The recommended dose of 20 kg P_2O_5/ha through single superphosphate, 5 kg/ha through zinc sulphate (heptahydrate) and one-third dose of nitrogen was drilled as basal, 10 cm deep, at the time of sowing and the remaining nitrogen was top-dressed in 2 splits through urea–at the time of first and second irrigation. The seeds of finger millet variety 'GPU 28' @ 6 kg/ha and pearl millet variety 'RHB 177' @ 4 kg/ha were sown on 2nd July 2018 in the rows, spaced at 30 cm apart, with the help of hand-operated 'desi' plough with 'pora' attachment. Thinning, hoeing and weeding were done 20 days after sowing to maintain spacing (30 cm row-to-row and intra-row spacing of 10 cm), proper aeration and weed-free field. Five plants were selected randomly from each plot and tagged permanently. Pearl millet was harvested on 25th September 2018 and finger millet on 20th October 2018 after leaving 2 border rows on each side of plot along the length on both sides, a net area of 3.0 m × 2.4 m was harvested and threshed manually. Sample was taken from the produce of each of the plot harvested and weight of 1,000-seeds were recorded. The clean grain obtained from individual plot was weighed separately and weight recorded as grain yield (kg/plot). The straw yield (kg/plot) was obtained by subtracting the grain yield from biological yield recorded earlier. Harvest index was computed by using the formula given by Singh and Stoskopf (1971). The total uptake of N, P and Zn was computed from N, P and Zn concentration in grain and stover at harvesting stage. To find out the most profitable treatment, economics of different treatments were worked out in terms of net returns (₹/ha) on the basis of the prevailing market rate and benefit cost ratio for each treatment was calculated to ascertain economic viability of the treatment.

The result related to number of effective tillers/plant, grains/ear, 1000-grains weight, grain and stover yield presented in Table 1 indicated that each nutrient has significant effect on the yield attributes and yield of both the crops. Significantly higher values of effective tillers/plant, grains/ear and 1000-grain weight in both the crops were recorded under treatment N, P and Zn over the control. Further, the treatment N + P + Zn exhibited significantly higher values of effective tillers/plant, grains/ear and 1000-grain weight of finger millet crop over rest of the treatments. The same treatment when applied to pearl millet crop resulted in statistically higher values of effective tillers/plant, grains/ear and 1000-grain weight over the other treatments and remained at par with that against N + P. The grain and stover yields of both the crops improved significantly with the application of N + P over the control and Zn (Table 1). Application of N + P to finger millet resulted in increase of grain yield (1,825 kg/ha) and stover yield (3,095 kg/ha) with a remarkable enhancement of 27.6 and 20.8% in grain and 20.9 and 18.3% in stover over the control and zinc, respectively, and showed at par with that against N and P. Same treatment N + P provided the grain

yield (1,814 kg/ha) and stover yield (4,827 kg/ha) in pearl millet which registered a notable increase of 51.1, 40.5 and 28.9% in grain and 32.1, 26.6 and 19.1% in stover over the control, Zn and P, respectively, and shows statistically equivalence with N. Data presented in Table 1 indicated that grain and stover yields of both the crops were also influenced significantly by the combined application of N + P + Zn. Significantly higher grain and stover yields of 2,006 and 3,304 kg/ha in finger millet and 2,024 and 5,317 kg/ha in pearl millet were recorded under treatment N + P + Zn, showing a notable increase of 22 and 20.2% (grain) and 20.8 and 19.3% (stover) in finger millet and 27 and 23.9% (grain) and 24.8 and 23.8% (stover) in pearl millet over P + Zn and N + Zn respectively. However, the same treatment was statistically at par with N + P. The increment in grain and stover yields of both the crops with these treatments was also owing to improvement in harvest index that showed great partitioning of the plant assimilates towards the sink. Khinchi *et al.* (2017) reported the highest total green fodder yield (392.91 q/ha) in pearl millet under combined application of N and Zn treatment compared to N and Zn. Harvest index of both the crops did not differ significantly due to various nutrients (Table 1). However, the highest harvest index was recorded in the treatment N + P + Zn and lowest in the control.

Total N uptake in both the crops significantly increased with application of nutrients either alone or in combination. Since the uptake of nutrients in grain and stover is a function of their concentration and yield, the increase in grain and stover yield coupled with increased nutrient concentration also resulted in higher total uptake of N. Data further revealed that, application of N + P resulted in significant improvement in N uptake over the control, N, P and Zn (Table 2). Significantly higher uptake of 40.48 kg N/ha in finger millet and 69.96 kg N/ha in pearl millet was recorded under treatment N + P + Zn, indicating an increase of 74.5 and 128.2% over the control, respectively, but the same treatment was found at par with N + P. The increased availability of nitrogen in the root zone coupled with increased metabolic activity at cellular level might have increased the nutrient uptake and their accumulation in the vegetative plant parts. These results are in close conformity with those of Divyashree *et al.* (2018) in finger millet.

The total P uptake in both the crops was increased significantly with the application of nutrients either alone or in combination (Table 2). Data further revealed that, application of N + P results in significant improvement in phosphorus uptake (14.95 kg P/ha in finger millet and 11.99 kg P/ha in pearl millet) over the control, N, P and Zn respectively. Significantly higher uptake of 16.77 kg P/ha in finger millet and 13.83 kg P/ha in pearl millet was recorded under combined application of N + P + Zn indicating an increase of 74.7 and 95.8% over the control, respectively, and remained at par with that N + P. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of these nutrients to reproductive organs of crop and ultimately increased the contents at different growth stages and in seed and stover at harvest. Similar findings with the application of phosphorus were also reported by Singh *et al.* (2017) in pearl millet.

Critical perusal of data presented in the Table 2 showed that the Zn uptake in both the crops increased significantly owing to application of nutrients either alone or in combination. Data further revealed that application of N + Zn resulted in significant improvement in zinc uptake (112.2 g Zn/ha in finger millet and 177 g Zn/ha in pearl millet)

Table 1. Effect of nutrients on yield attributes, grain and stover yield, harvest index in finger millet and pearlmillet

Treatment	Finger millet						Pearlmillet					
	Effective tillers/ plant	Grains/ ear	1000-grain weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Effective tillers/ plant	Grains/ ear	1000-grain weight(g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
N	2.13	1,088	1.78	1,614	2,705	37.4	1.17	811	4.30	1,569	4,231	26.9
P	2.03	1,055	1.74	1,586	2,668	37.3	1.10	799	4.20	1,407	4,053	25.7
Zn	1.97	1,034	1.70	1,510	2,617	36.5	1.07	773	4.15	1,291	3,813	25.4
N+P	2.63	1.205	2.00	1,825	3,095	37.1	1.47	888	4.93	1,814	4,827	27.4
N+Zn	2.33	1,175	1.94	1,669	2,770	37.8	1.37	850	4.64	1,633	4,293	27.7
P+Zn	2.23	1,139	1.85	1,645	2,734	37.6	1.23	828	4.45	1,594	4,260	27.3
N+P+Zn	2.93	1,350	2.23	2,006	3,304	37.9	1.57	1004	5.46	2,024	5,317	27.7
Control	1.83	1,019	1.66	1,430	2,560	35.7	1.03	755	4.12	1,200	3,653	24.8
SEm±	0.11	53	0.09	97	167	1.7	0.06	40	0.21	102	335	1.3
CD (P=0.05)	0.33	160	0.26	295	507	NS	0.18	122	0.65	312	1,019	NS

NS, non-significant

Details of treatments are given under Materials and Methods

Table 2. Effect of nutrients on nitrogen, phosphorus and zinc uptake, net returns ($\times 10^3$ /ha) and benefit: cost (B:C) ratio in finger millet and pearl millet

Treatment	Finger millet			Pearl millet			Finger millet		Pearl millet	
	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total Zn uptake (g/ha)	Total N uptake (kg/ha)	Total P uptake (g/ha)	Total Zn uptake (g/ha)	Net returns ($\times 10^3$ /ha)	B:C ratio	Net returns ($\times 10^3$ /ha)	B : C ratio
N	34.0	10.9	74.5	46.5	8.9	128.9	44.5	2.80	36.1	2.31
P	31.1	11.9	71.3	37.5	8.9	118.6	43.3	2.70	31.9	2.01
Zn	29.2	10.1	82.3	33.4	7.6	124.8	41.1	2.60	28.6	1.83
N+P	42.4	14.9	86.2	60.8	11.9	152.2	51.6	3.07	42.9	2.59
N+Zn	35.8	11.6	112.3	50.4	9.4	177.1	45.7	2.75	36.9	2.26
P+Zn	32.9	12.5	94.7	42.0	9.9	150.9	44.6	2.66	35.8	2.16
N+P+Zn	47.9	16.8	141.1	69.9	13.8	217.0	57.2	3.26	48.7	2.81
Control	27.5	9.6	64.5	30.7	7.1	102.9	39.2	2.59	26.8	1.80
SEm±	1.9	0.7	4.1	3.9	0.8	9.9	1.9	0.14	2.3	0.13
CD (P=0.05)	5.7	1.9	12.3	9.9	2.3	30.3	5.9	0.42	7.1	0.39

Details of treatments are given under Materials and Methods

over the control, N, P and Zn. Significantly higher uptake of 141.13 g Zn/ha in finger millet and 217.04 g Zn/ha in pearl millet was recorded under treatment N + P + Zn, indicating an increase of 118.7 and 111% over the control respectively. It might be because of the fact that zinc is recognized as an essential component in several hydrogenases, proteinases and peptidases and plays an important role in auxin formation and other enzyme system. Zinc plays a pivotal role in regulating the auxin concentration in plant and nitrogen metabolism and might have improved the nutrient uptake. Thus, the favourable effect of zinc on photosynthesis and metabolic processes augmented the production of photosynthates and their translocation to different plant parts including seed, which ultimately increased the concentration of nutrients in the seed and stover. Singh *et al.* (2017) also reported similar findings owing to application of zinc in pearl millet.

Economics is the major consideration for the farmers while taking a decision regarding the adoption of any technology. Net returns were significantly influenced by different nutrients (Table 2). Significantly higher net returns in both the crops was recorded under treatment N, P and Zn over the control. Finger millet and pearl millet planted under treatment, (N + P + Zn) fetched significantly higher net returns of (₹57,178) and (₹48,717) compared to rest of the treatment thereby increasing net returns by 28.1 and 25.1% in finger millet and 34.9 and 31.8% in pearl millet over P + Zn and N + Zn respectively (Table 2). However, this treatment was at par with N + P. Higher net returns under treatment (N + P + Zn) might be owing to more returns from higher grain yield as compared to cost involved under this treatment. As net return is calculated by multiplying grain and stover yields by their sale prices and subtracting the total cost of cultivation including treatment cost, it seems to be directly associated with significantly higher grain and stover yields obtained under these superior treatments as well as comparatively lower additional cost of cultivation over control in comparison to added output. Also, the benefit: cost (B : C) ratio in both the crops were significantly influenced to a great extent due to different nutrients (Table 2). The higher benefit: cost ratio was recorded under treatment N + P + Zn (3.26) in finger millet and (2.81) in pearl millet (Table 2) compared to rest of the treatment, registering an increase of 25.8 and 56.1% in finger millet and pearl millet over control, respectively, and remained at par with N + P. Similar observation was also made by Rani *et al.* (2017) in finger millet.

On the basis of the findings of the present investigation, it can be concluded that finger millet, a non-traditional crop does well under loamy sand soils of semi-arid eastern plain zone (III A) of Rajasthan. Finger millet may be an alternative nutri-cereal crop for this region. A comparison between yield and economics from both the crops proved superiority of finger millet which gave approximately ₹8,400/ha higher than pearl millet. Both the crops responded to nutrients applied alone or in combination. Finger millet proved to be more economic as its benefit: cost ratio was higher than pearl millet.

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