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Impact of nitrogen management on yield and economics of *kharif* pearl millet

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Abstract
A field experiment was carried out during the *kharif* seasons of the year 2021 and 2022 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, with a view to study the effect of nitrogen management on growth, yield and economics of *kharif* pearl millet. The experiment was laid out in a Randomized Block Design with six treatments and four replications. The results revealed that the yield parameters *viz*., total tillers and effective tillers, length of ear head, grain yield, straw yield, harvest index, test weight and economic parameter *viz*., gross realization were recorded higher in treatment with 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium. Treatment with 100% RDN through urea was found superior by recording maximum net return and BCR followed by treatment with 75% RDN through urea + Bio NPK consortium.

Keywords: Pearl millet, RDN, castor cake, bio NPK consortium

Introduction
Globally, nearly 800 million people do not have enough food to meet their basic nutritional needs. Demand is rising. Set against a background of population growth, conflict, migration and climate change, it is more important than ever to find innovative and sustainable ways to help vulnerable communities achieve food and nutrition security. Now a days Government of India (GoI) focusing on food securities along with nutritional security and proposed 2023 as International Year of Millets (IYoM) to United Nations and it was supported by United Nation's General Assembly (UNGA) and 72 countries and declared year 2023 as International Year of Millets on 5th March, 2021. Further, GoI has decided to celebrate IYoM, 2023 to make it people's movement so that the Indian millets, recipes, value added products are accepted globally. India as the global hub for millets. 'Millets' were among the first crops to be domesticated in India with several evidence of its consumption during the Indus valley civilization.

Pearl millet (*Pennisetum glaucum* L.) is quantitatively the most important millet, with a world annual production of 15-25 million tonnes (Mt). In India, it is the second most important millet and have fifth place among the cereals next to rice, wheat, maize and sorghum.

Pearl millet is commonly known as Bajari or Bajra in India and other names *viz*., candle millet, cattail millet, bulrush millet in other parts of the world. Pearl millet is gaining importance as a climate-resilient and health-promoting nutritious crop. It is the most drought tolerant crop among cereals and millets and low water requirement. It is traditionally an indispensable component of dry-farming system and is considered as more efficient in utilization of soil moisture with higher level of heat tolerance than sorghum and maize (Chaudhary and Gautam, 2007) [4]. Pearl millet has inimitable photosynthesis mechanism owing to the C_4 mechanism. It is a miracle crop. It has a higher level of industrial utilization than any other cereal grains as of its diversified by-products, higher production potential and wider adaptability.

The energy level of 361 k cal is the highest among the grain cereals. Pearl millet grain is gluten-free and thus is the only grain that retains its alkaline properties after being cooked which is ideal for people with gluten allergies (Khairwal *et al*., 2007) [5]. It is nutritionally healthier than many cereals as it is a good source of protein having higher digestibility (12.1%), minerals (2.0-

3.5%) particularly iron (284 mg/kg), fats (4-8%) and carbohydrates (69.4%). Pearl millet grains have higher protein content (10.5-14.5%) with higher levels of essential amino acids. In India, it is annually grown on 76.52 lakh ha. area producing 108.63 lakh tonnes of grains with productivity of 1420 kg/ha (Anon., 2021-22). India is the second-largest producer of pearl millet after China both in term of area and production. Out of the total area under pearl millet, nearly 92% lies in the Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. Rajasthan is a largest producing state in India having 51% area under cultivation of pearl millet followed by Maharashtra 15.3%, Gujarat 10.6%, Uttar Pradesh 9.2% and Haryana 6.2%.

Gujarat occupies an area of 4.60 lakh ha. and production of 10.08 lakh tonnes with productivity of 2192 kg/ha (Anon., 2021-22). Kutch, Banaskantha, Sabarkantha, Patan, Bhavnagar, Mehsana, Kheda, Anand and Gandhinagar are major pearl millet growing district.

Nutrient management through chemical fertilizers and organic sources in pearl millet play very important role in boosting grain yield, it includes nutrients fixed by bio-fertilizers and organic sources such as castor cake, vermicompost, farm yard manure, biocompost, compost, animal refuse and crop residues. This concept is gaining attention in recent years in the perspective of sustainable soil productivity. Use of nutrient management system will not only reduce the heavy load of catering of chemical fertilizers but also balanced use of organic with inorganic fertilizers to supply all essential nutrients and assurance of quality apart from maintaining soil fertility (Srivatsava *et al*., 2015) [13].

Materials and Methods

A field experiment was carried out during the *kharif* seasons of the year 2021 and 2022 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of experimental site was loamy sand in texture, having low in organic carbon (0.487%), available N (205.57 kg/ha), medium in available P_2O_5 (38.65 kg/ha) and available K_2O (265.48 kg/ha) with slightly alkaline condition (pH 8.01) with low EC (0.250 dS/m). The soil was free from any kind of salinity and sodicity hazard. Pearl millet variety Gujarat Hybrid Bajra 1225 (GHB 1225) was used as a test crop in the study. Crop was sown on 9th June, 2021 and 16th June, 2022, respectively. The experiment was arranged in randomized block design with four replications, consisting of six treatments *viz*., T_1 (100% RDN through urea), T_2 (100% RDN through castor cake), T_3 (75% RDN through urea + Bio NPK consortium), T_4 (75% RDN through castor cake + Bio NPK consortium), T_5 (50% RDN through urea + 75% RDN through castor cake) and T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium), each plot being 3.6 m × 6.0 m. Inorganic sources of N and P is urea and SSP, respectively. Whereas, organic sources are castor cake and Bio NPK consortium. Application of Bio NPK consortium as seed treatment (5 mL/kg) at the time of sowing and soil drenching of Bio NPK consortium (1 L/ha) of water at 31 and 38 DAS during the year 2021 and 2022, respectively. The crop was harvested on 3rd September, 2021 and 6th September, 2022, respectively. The ring lines were harvested first and aloofed from the experimental plots.

Results and Discussion

Effect on Yield Attributes and Yield

Total tillers per meter row length

Total number of tillers differed significantly due to different treatments. Treatment T_6 recorded significantly higher number of total tillers. It was at par with treatments T_5, T_2 and T_4 during the first year and at par with treatment T_5 during the second year while, significantly lower number of total tillers were recorded under treatment T_3.

The higher total tillers may be due to the positive effects of application of castor cake which had accelerated various metabolic processes and resulted in increasing vegetative growth. Increase in the total tillers was quite obvious due to supply of adequate nutrients through organic source along with Bio NPK consortium conjunctive with inorganic fertilizers, which improve soil physical and biological properties and increase the availability of nutrients and solubilizing them. Thus, favourable influence of nutrients to produce larger cells with thinner cell walls and its contribution in cell division and cell elongation which improved vegetative growth and ultimately increase total tillers of pearl millet. The results are in corroboration with those of Yadahalli *et al*. (2014) [15] and Bana *et al*. (2016) [2].

Effective tillers per meter row length

Effective tillers per meter row length recorded maximum under treatment T_6 which was remained at par with treatments T_5 and T_2 during the year 2021 and at par only with treatment T_5 during the year 2022 as well as in pooled analysis. The minimum number of effective tillers was recorded under the treatment T_3.

It might be due to that, pearl millet plant required adequate N at early and mid-tillering stage to maximize the number of effective tillers. Combined application of organic manures, Bio NPK and inorganic fertilizer might have brought better mobilization of nutrients towards effective tillers. The results are in validation with those of Minz *et al*. (2021) [9] and Nikhitha *et al*. (2021) [10] in pearl millet.

Length of ear head (cm)

Length of ear head not found significantly influenced due to various nitrogen management treatments during both the years (2021 and 2022) as well as on pooled basis.

Test weight (g)

The results pertaining that different treatments did not show their significant influence on test weight.

Grain yield (kg/ha)

Higher grain yield was recorded in treatment T_6 and it was remained at par with the treatments T_5 and T_2 during both the years while, treatment T_5 was recorded at par on pooled basis. However significantly lower seed yield was recorded under treatment T_3.

This might be due to the fact that, increased absorption of nutrient and their assimilation by supply of N in balanced quantity enabled the pearl millet plant to assimilate adequate photosynthetic products and thus increased the dry matter accumulation. With increased dry matter and photosynthetic products, which coupled with efficient translocation of nutrients results in production of a greater number of fertile grains and resulted in higher grain yield. The increased grain yield can also be ascribed as the effect of adequate availability of macro and micronutrient through castor cake in soil solution may upsurge in root growth, thereby increasing uptake of nutrients. Higher yield due to collective application of inorganic fertilizers, organic manures and Bio NPK consortium might have attributed to sustained nutrient supply and also as a result of better utilization of applied nutrients. The other reason might be that, better grain yield was obtained under combination of inorganic

fertilizer and organic manure, improved physical condition of soil by improving the efficacy in utilization of native as well as applied nutrients. Castor cake act as a store house for macro and micro nutrient which may enhanced the metabolic process vice versa enlarged source and sink capacity ultimately increased grain yield of pearl millet. The same results were also reported by Bhargavi *et al*. (2020) [3] and Maharana and Singh (2021) [8] in pearl millet.

Straw yield (kg/ha)

Significantly maximum straw yield was obtained under the treatment T_6, whereas treatment T_5 found statistically at par during both the years and in pooled analysis. The lowest straw yield was observed in treatment T_3.

The positive response of real time N through chemical fertilizer enhanced the straw yield significantly as against integration of inorganic and organic nitrogen sources which might be credited due to quicker conversion of available N to pearl millet plants easily during the first year and better performance of organic and inorganic fertilizer application in second year and on pooled base can also be ascribed to the effect of adequate availability of NPK in soil solution, may increase in root growth, thereby increasing uptake of nutrients and higher straw yield. Utilization of applied nutrients through improved micro-environmental conditions, especially the activities of soil micro-organisms involved in nutrient transformation and fixation. Similar results have also been reported in previous studies on pearl millet by Kumar *et al*. (2017) [6] and Parameswari *et al*. (2020) [11].

Harvest index (%)

Maximum harvest index was recorded with treatment T_1. It was statistically at par with treatments T_3 during the both years as well as in pooled analysis whereas, lower harvest index recorded under treatment T_5 during the year 2021 while, in treatment T_6 during the year 2022 and on pooled basis.

It might be due to the increased yield attributes and yield resulting in favourable environment for vegetatively as well as reproductively from initial growth stage to harvest, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which consequently caused significant increase in photosynthesis and dry matter accumulation, which resulted in higher grain and straw yield of pearl millet and harvest index was directly related to grain and straw yield of crop. The results are in confirmation with those reported by Maharana and Singh (2021) [8] and Patel *et al*. (2021) [12] in pearl millet.

Effect on economics of *kharif* pearl millet

Gross realization (₹/ha)

Data presented in Table 2 revealed that the highest net realization of ₹ 66583/ha was incurred with application of treatments T_6 and it was closely followed by treatment T_5 with ₹ 63446/ha. However, the lowest net realization of ₹ 46949/ha was recorded under the treatment T_3.

Net realization (₹/ha)

Data presented in Table 2 revealed that the highest net realization of ₹ 31426/ha was incurred with application of treatments T_1 and it was closely followed by treatment T_3 with ₹ 25152/ha. However, the lowest net realization of ₹ 9325/ha was recorded under the treatment T_2.

Benefit Cost Ratio (BCR)

In case of benefit cost ratio, the highest benefit cost ratio of 2.45 was recorded in treatment T_1 and it was followed by treatment T_3 with a benefit cost ratio of 2.15. Whereas, treatment T_3 registered the lowest benefit cost ratio of 1.19 as compared to all other treatments.

Table 1: Total tillers, effective tillers, length of ear head and test weight of pearl millet as influenced by various nitrogen management treatments

Treatments		Total tillers/m			Effective tillers/m			Length of ear head (cm)			Test weight (g)		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	100% RDN through urea	30.75	30.58	30.66	20.67	20.17	20.42	23.50	23.70	23.60	12.03	12.10	12.06
T_2	100% RDN through castor cake	32.25	31.33	31.79	25.50	24.62	25.06	23.95	24.06	24.01	12.32	12.45	12.38
T_3	75% RDN through urea + Bio NPK consortium	25.42	27.00	26.20	16.33	17.41	16.87	23.33	23.46	23.40	11.93	11.97	11.94
T_4	75% RDN through castor cake + Bio NPK consortium	31.92	30.67	31.29	23.98	23.41	23.69	23.62	23.89	23.76	12.16	12.23	12.19
T_5	50% RDN through urea + 75% RDN through castor cake	32.50	33.17	32.83	26.25	27.01	26.62	24.17	24.47	24.32	12.62	12.65	12.63
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium	36.59	37.09	36.83	27.96	28.88	28.41	24.42	24.51	24.46	12.89	12.98	12.93
S. Em. ±		1.61	1.47	1.09	1.16	1.08	0.79	1.03	0.98	0.71	0.36	0.39	0.27
C. D. at 5%		4.85	4.45	3.15	3.52	3.28	2.30	NS	NS	NS	NS	NS	NS
Interaction (Y × T)		-	-	NS	-	-	NS	-	-	NS	-	-	NS
C. V. (%)		10.20	9.34	9.78	9.96	9.23	9.60	8.66	8.23	8.45	5.98	6.41	6.20

Table 2: Grain yield, straw yield, harvest index and economics of pearl millet as influenced by various nitrogen management treatments

Treatments		Grain yield (kg/ha)			Straw yield (kg/ha)			Harvest index (%)			Economics		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	GR	NR	BCR
T_1	100% RDN through urea	2245	2295	2270	4693	4814	4754	32.62	32.28	32.44	53066	31426	2.45
T_2	100% RDN through castor cake	2431	2378	2405	5378	5340	5359	31.12	30.80	30.96	57511	9325	1.19
T_3	75% RDN through urea + Bio NPK consortium	1967	2023	1995	4200	4311	4256	31.88	31.94	31.91	46949	25152	2.15
T_4	75% RDN through castor cake + Bio NPK consortium	2342	2307	2325	5210	5225	5218	31.00	30.63	30.81	55747	14040	1.33
T_5	50% RDN through urea + 75% RDN through castor cake	2532	2576	2554	6284	6285	6284	28.72	29.14	28.93	63446	21329	1.50
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium	2702	2659	2681	6676	6508	6592	28.84	29.00	28.91	66583	24029	1.56
S. Em. ±		99	102	71	289	255	193	0.44	0.28	0.26	-	-	-
C. D. at 5%		298	307	205	872	767	557	1.35	0.85	0.76	-	-	-
Interaction (Y × T)		-	-	NS	-	-	NS	-	-	NS	-	-	-
C. V. (%)		8.34	8.58	8.46	10.70	9.40	10.07	2.93	1.84	2.44	-	-	-

Where, GR = Gross realization, NR = Net realization, BCR = Benefit: Cost ratio

Conclusion

It was concluded from the two years of experimentation that the yield and economics of *kharif* pearl millet in terms of number of total and effective tillers, grain yield, straw yield and harvest index can be improved significantly by application of 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium. Thus, increment in growth and development was inturn enhance the yield and productivity of *kharif* pearl millet crop.

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