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Effect of Different Nutrient Management Practices on Growth, Yield Attributes and Yield of Transplanted Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Field experiment was conducted to evaluate the effect of fertility management on growth, yield attributes and yield of pearlmillet in a Randomized Block Design (RBD) with ten treatments and four replications during summer, 2019 at Anand, Gujarat. The experiment comprises of different nutrient management practices including 100% and 75% RDF with 15 t and 10 t FYM along with Bio NP consortia. A significant higher growth and yield parameters enhancement with the application of 100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia was recorded in plant height, number of tillers, length of ear head, protein content and biological yield. The treatment T5 produced maximum (91.5 q ha^{-1}) biological yield and statistically it was on par with T9 and T5. However, the lowest biomass production (73.0 q ha^{-1}) was reported in treatment T1. Results of different nutrient management practices on days to 50% flowering, days to maturity, ear head girth and test weight were found non-significant. Protein content of pearlmillet was increased from 7.5% to 9.06% under different nutrient management practices.

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Keywords: Bio NP consortia; Nutrient management practices; growth; yield attributes.

1. INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is one of the world's hardiest warm season cereal crops [1]. The common name of pearl millet in most part of India is bajra or bajri, which is low price food grain crop. Pearl millet belongs to the poaceae family. Pearl millet is an indispensable arid and semi-arid crop of India [2] cultivated as a dual-purpose (food and feed) crop in over 8.3 m ha ranking fourth among total cereals [3]. It is one of India's most important cereal crops and ranks 4th in area after rice, wheat, and sorghum, grown in arid and semi-arid regions. In India, pearl millet production is 9.25 million tonnes. The share of pearl millet in total food grain production is 10.7 percent. Pearl millet is the most widely cultivated cereal crop in India. It is grown on more than 8.39 m ha with current grain production of 9.15 MT and productivity of 1091 kg ha^{-1} during the summer season [4]. The average composition of the edible portion is 12.4 per cent moisture, 11.6% protein, 3-5% fat, 67% carbohydrates, 1.5 to 3% fiber and 2.7% minerals [5]. Pearl millet grain contains high nutritious sources and is also used in livestock and poultry farms for feed. It is also rich in vitamins, thiamine and riboflavin contents and imparts substantial energy to the body with easy digestibility [6]. India's major pearl millet growing states are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, and Haryana, accounting for more than 90% of pearl millet acreage in the area in the country. Further, the nutritional value of these crops offers much scope to the development of value-added products in new health-conscious consumer segments [4] as it contains more fiber and is suitable for diabetic and heart patients.

Farmers are using excess and imbalance chemical fertilizer, which leads to nutrient deficiency other than applied and declined organic carbon levels. An Indiscriminate use of chemical fertilizer spoils the structure and texture of the soil. Therefore, use of chemical fertilizer alone may not keep pace with time in maintenance of soil health for sustaining the productivity. So, adequate and balanced use of manure and fertilizer is essential for better soil health. The concept of Integrated Nutrient Management (INM) is a continuous improvement of soil productivity on long term basis through appropriate use of fertilizers, organic manures along with biofertilizers for optimum growth, yield and quality of different crops and cropping systems in specific agro-ecological situations. Fertilization of crops enhances water use efficiency, controlling soil erosion by promoting rapid and vigorous crop growth to check runoff and increases the soil's water-holding capacity. The application of nitrogen helps in better vegetative growth of plants, phosphorous for better proliferation, which extracts moisture from the deep layers of the soil, particularly during moisture stress conditions. Potassium increases the potential and improving the quality of grains. The concept of conjunctive application plant nutrient through all possible sources aimed to reduce non-renewable energy in the form of fertilizer use. This concept has assumed greater importance in our ecological situation. Keeping in this view an experiment was conducted to assess the effect of fertility on the growth, yield attributes and yield of pearl millet.

2. MATERIALS AND METHODS

A field experiment was conducted during summer season 2019 at the Agronomy Farm of Anand Agricultural University, Anand, Gujarat, India. The experimental site is located at 22^{0}35$'$ N and 72^{0}55$'$ E with an elevation of 45.1 meters above mean sea level (MSL) experiencing semi–arid subtropical with hot summer and cool winter. The characteristics of the experimental soil was loam sand in texture, very deep and moisture retentive, belongs to the soil order Inceptisols (*Typic Ustochrept*), slightly alkaline with pH 8.16, Bulk density 1.4 Mg m^{-3},organic carbon 0.28%, water holding capacity 28.5%, cation exchange capacity 11.3 [C mol (P$^+$) kg^{-1}] available nitrogen 188 kg ha^{-1}, Olsen's phosphorus 23.4 kg ha^{-1} , available potassium 537 kg ha^{-1}. The experiment was laid out in a Randomized Block Design with each plot measuring 3.6 × 4.8 m consisting of ten treatments and four replications. The treatments consisted of control received only 100% RDF (T_1), 100 % RDF + 10 t FYM ha^{-1} (T_2), 100 % RDF + 10 t FYM ha^{-1} + Bio NP Consortia (T_3), 100 % RDF + 15 t FYM ha^{-1}(T_4), 100 % RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_5), 75% RDF + 10 t FYM ha^{-1}(T_6), 75% RDF + 10 t FYM ha^{-1} + Bio NP Consortia (T_7), 75% RDF + 15 t FYM ha^{-1}(T_8), 75% RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_9), 15 t FYM ha^{-1} + 5.0 t Vermicompost ha^{-1} + Bio NP Consortia (T_{10}). Recommended dose of fertilizers (RDF) for pearl millet was 120: 60: 0 kg ha^{-1} of nitrogen phosphorus and potassium, respectively.

3. RESULT AND DISCUSSION

3.1 Growth attributes

The plant population at 15 DATP and at the time of harvest of pearlmillet was found non-significant influenced by the application of farmyard manure and bio-fertilizer applied in conjunction with fertilizers.

The plant population was gradually decreased from initial to harvest might be due to biotic and abiotic stress during crop growth period. Similar findings were also reported by [7]. Application of organic manures along with fertilizer increased the availability of nutrients and showed higher plant population as compared to application of inorganic fertilizers. A similar finding of higher final plant population at harvest observed due to integrated nutrient practices by [8,9]. The data showed that plant height gradually increased at all the stages of crop and reached maximum at maturity. The plant height at various growth stages was found significant due to different INM treatments in terms of plant height. At 30, 60 DATP and harvest significantly higher plant height was observed with100 % RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_5). The increased in plant height due to T_5 was to the tune of 31, 24 and 19 per cent at 30, 60 DATP and at harvest respectively over control. However plant height at 30 DATP with100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_5) was at par with 100 % RDF + 15 t FYM ha^{-1} (T_4), 75% RDF + 10 t FYM ha^{-1} + Bio NP Consortia (T_7), 75% RDF + 15 t FYM ha^{-1}(T_8) and 75% RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_9). Whereas, plant height at 60 DATP and at harvest T_5 remained at par with100 % RDF + 10 t FYM ha^{-1} + Bio NP Consortia (T_3), 100 % RDF + 15 t FYM ha^{-1} (T_4), 75% RDF + 10 t FYM ha^{-1} + Bio NP Consortia (T_7), 75% RDF + 15 t FYM ha^{-1}(T_8) and 75% RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_9).

The application of 100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T_5) proved superior because inorganic fertilizer along with FYM and bio-fertilizer application improve the soil-physical properties, hydraulic conductivity, released the mineral nutrients probably at faster rate and enriched the soil owing to supply sufficient amount of nutrients that are essential to various metabolic processes. This resulted in better mobilization and synthesized carbohydrates in the amino acids and proteins, which in turn stimulated rapid cell elongation and cell division, facilitated the faster vegetative growth and lead to higher inter nodal elongation and finally enhanced the plant height. The higher plant height in integrated nitrogen management systems can also be attributed to increased solar radiation harvesting energy as reflected by increased leaf area index and dry matter production and also probably by promoting greater photosynthetic and meristermatic activities of pearl millet crop. Similar finding were reported by [10, 11, 12].

Table 1. Direct effect of nutrient management practices growth and yield attributes of transplanted pearlmillet

Treatment	Plant population (m^{-1} row length)		Plant height (cm)			Tillers per plant		Ear head length (cm)	Ear head girth (cm)
	15 DATP	Harvest	30 DATP	60 DATP	Harvest	Total	Effective		
T_1	7.35	7.15	56.9	110.5	126.2	4.75	4.65	17.4	8.61
T_2	7.45	7.25	63.4	123.9	137.9	6.25	6.15	20.2	9.43
T_3	7.55	7.30	67.3	127.6	142.5	6.25	6.05	20.8	9.47
T_4	7.55	7.30	69.1	129.7	144.4	6.35	6.05	22.4	9.64
T_5	7.55	7.40	75.2	137.2	150.5	7.10	6.80	23.7	10.13
T_6	7.35	7.30	65.7	123.2	137.5	5.65	5.60	19.3	8.81
T_7	7.55	7.40	68.7	125.6	139.7	6.00	5.80	19.5	8.96
T_8	7.75	7.50	69.8	125.6	142.3	6.10	5.60	21.2	9.32
T_9	7.65	7.45	70.8	130.9	147.7	6.55	5.55	21.3	9.38
T_{10}	7.45	7.25	65.1	121.0	137.0	6.15	5.95	20.1	9.40
SEm ±	0.16	0.10	2.31	4.54	4.32	0.25	0.35	0.34	0.12
LSD (P<0.05)	NS	NS	6.70	13.18	12.52	0.72	1.01	1.02	NS
CV (%)	4.38	2.80	6.86	7.24	6.14	8.09	11.90	7.11	6.45

DATP- days after transplanting

Table 2. Direct effect of nutrient management practices on flowering, maturity, test weight, harvest index, protein content and biological yield of transplanted pearlmillet

Treatment	Days to 50% Flowering	Days to Maturity	Test Weight (g)	Harvest Index (%)	Protein (%)	Biological Yield (q ha^{-1})
T_1	53.3	87.2	8.14	34.81	7.50	73.0
T_2	54.3	90.2	8.43	33.96	7.63	79.9
T_3	54.4	90.5	8.33	33.15	8.06	85.1
T_4	55.2	92.6	8.48	33.23	8.94	87.0
T_5	56.1	93.0	8.99	33.94	9.06	91.5
T_6	53.2	90.4	8.47	33.55	8.75	77.1
T_7	53.5	91.2	8.49	32.66	8.88	83.3
T_8	53.5	92.1	8.52	33.07	8.88	85.1
T_9	54.1	92.3	8.39	33.56	8.94	87.5
T_{10}	53.4	91.3	8.36	34.48	8.50	79.7
SEm ±	0.17	0.24	0.16	1.27	0.36	2.1
LSD(P<0.05)	NS	NS	NS	NS	1.05	6.09
CV (%)	6.77	6.65	3.78	7.55	8.52	5.10

Table 3. Pearson's correlation matrix for growth, yield attributes and biological yield

	PH- 30 days	PH-60 days	PH- harvest	Total tillers	Eff. tillers	EH length	EH girth	DF	DM	Test weight	Biomass yield
PH- 30 days	**1.000**	0.954**	0.963**	0.886**	0.723*	0.886**	0.744*	0.623^{NS}	0.937**	0.818**	0.940**
PH-60 days	0.954**	**1.000**	0.986**	0.945**	0.817**	0.928**	0.830**	0.765**	0.896**	0.801**	0.947**
PH- harvest	0.963**	0.986**	**1.000**	0.939**	0.747*	0.928**	0.817**	0.707*	0.923**	0.739*	0.963**
Total tillers	0.886**	0.945**	0.939**	**1.000**	0.889**	0.924**	0.917**	0.746*	0.890**	0.758*	0.905**
Effective tillers	0.723*	0.817**	0.747*	0.889**	**1.000**	0.815**	0.875**	0.756*	0.719*	0.791**	0.718*
EH length	0.886**	0.928**	0.928**	0.924**	0.815**	**1.000**	0.941**	0.849**	0.894**	0.791**	0.934**
EH girth	0.744*	0.830**	0.817**	0.917**	0.875**	0.941**	**1.000**	0.876**	0.765**	0.724*	0.843**
DF	0.623^{NS}	0.765**	0.707*	0.746*	0.756*	0.849**	0.876**	**1.000**	0.566^{NS}	0.708*	0.762*
DM	0.937**	0.896**	0.923**	0.890**	0.719*	0.894**	0.765**	0.566^{NS}	**1.000**	0.719*	0.888**
Test weight	0.818**	0.801**	0.739*	0.758*	0.791**	0.791**	0.724*	0.708*	0.719*	**1.000**	0.718*
Biomass yield	0.940**	0.947**	0.963**	0.905**	0.718*	0.934**	0.843**	0.762*	0.888**	0.718*	**1.000**

PH- Plant height, EH- Ear head, DF- Days to 50% flowering, DM- days to maturity

Table 4. Descriptive Statistics and results of different parameters of transplanted pearl millet

Character	N	Mean	Standard Deviation	Std. Error	Statistical result
PH- 30 days	10	67.200	4.908	0.599	Significant
PH-60 days	10	125.520	7.002	0.625	Significant
PH- harvest	10	140.570	6.728	0.567	Significant
Total tillers	10	6.115	0.610	0.247	Significant
Effective tillers	10	5.820	0.551	0.228	Significant
EH length	10	20.590	1.741	0.384	Significant
EH girth	10	9.315	0.434	0.142	Non-significant
DF	10	54.100	0.943	0.128	Non-significant
DM	10	91.080	1.674	0.175	Non-significant
Test weight	10	8.460	0.216	0.074	Non-significant
Biomass yield	10	82.920	5.504	0.604	Significant

3.2 Yield Attributes

The results revealed that total number of tillers (7.10) and effective tillers (6.80) were significantly higher due to application of 100% RDF + 15 t FYM ha^{-1} + Bio NP Consortia however, total tillers remained at par with T_9 whereas effective tillers were found at par with T_2 , T_3 , T_4 , T_7 , and T_{10}. The increase in number of total tillers plant^{-1} and effective tillers plant $^{-1}$ at harvest under, manure, fertilizer and bio-fertilizer combination might be due to increased

availability of nitrogen to plants initially through inorganic fertilizer and then by mineralization of FYM and supported by liquid bio-fertilizers which enhances the development of strong cell walls and therefore stiffer straw which might be resulted into profuse tillering.

The results revealed that differences in test weight and harvest index of pearl millet due to different INM treatments did not reached to the level of significance. These results are in close conformity with those of [13,14,15,16]. Earhead length (cm) was significantly highest under direct effect of application of 100 % RDF + 15 t FYM ha^{-1} + Bio NP Consortia followed by T_4 and T_9. Earhead girth was not significantly influenced due to different nutrient management practices though it was showed the positive response with increase in the fertility levels and organic manures. Days to flowering and days to maturity were delayed with increased in the levels of fertilizer and organic manures but not reached the level of significance, most delayed flowering and maturity were in cased of application of 100% RDF + 15 t FYM ha^{-1} + bio NP Consortia (T_5).

3.3 Yield and Protein Content

The grain plus straw yield (total biomass) of pearl millet was affected significantly due to different treatments of integrated nutrient practices. Significantly higher biomass yield (91.5 q ha^{-1}) was observed in the treatment of 100% RDF + 15 t FYM ha^{-1} + bio NP Consortia (T_5) followed by T_9 and T_4. The most important factor contributing to the biomass production is the allocation of dry matter into reproductive parts and vegetative part. Integrated application of organic manures and inorganic fertilizers along with bio-fertilizer significantly influenced the dry matter accumulation in reproductive parts. The increased dry matter in reproductive parts may be attributed to increase the rate of metabolic processes due to increased available nutrients [17]. Application of 100% RDF + 15 t FYM ha^{-1} + bio NP Consortia (T_5) recorded significantly higher protein content in grain (9.06 %), but it was statistically at par with all the treatments except T_2 (7.60%) and T_1 (7.53%). The enhanced in pearl millet grain protein due to INM might be because of increased nitrogen content in grain which may be the result of increased availability of nitrogen to plants.

Another possible reason for higher nitrogen content might be due to increased activity of nitrate reeducates enzyme. Higher nitrogen in grain is responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. Application of nitrogen induced vigorous growth of the plant; phosphorous enhances the root development and strength of the plant as well as formation of bold and viable seed in the ear which ultimately increase the ratio of grain and straw. The findings of present experiment are in agreement with those of [18, 19, 20,21] in pearl millet crop.

3.4 Inter Relationship between Growth, Yield Attributes and Yield

Correlation analysis was carried out using Pearson's correlation to determine the inter-relationship between growth, yield attributes and yield of pearlmillet. The highest positive coefficient of correlation (r = 0.963) of biomass yield of pearlmillet was observed with plant height at harvest followed by plant height at 60 days after transplanting (r = 0.947) and plant height at 30 days after transplanting (r = 0.940). It might have because of higher biomass production at later stages of growth and contributed to stover yield of pearlmillet. Correlation study between most of the attributes showed the positive effect with higher level of significance. However, relationship between days to maturity with days to 50% flowering, plant height at 30 days and days to 50% flowering, days to 50% flowering and days to maturity were showing non-significant relation.

4. CONCLUSION

Application of different nutrient management treatments showed the significant increase in the plant height, tillers, ear head length and protein content of pearlmillet growth and yield attributes showing the positive relation with total biomass yield. However, ear head girth, days to 50% flowering, days to maturity not influenced significantly. Among the different nutrient management practices, application of 100 % RDF + 15 t FYM ha^{-1} + Bio NP Consortia (T5) showed the higher values of all the growth, yield attributes, protein content and biomass yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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