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Effect of nutrient management through organic and inorganic fertilizers on Productivity of Pearl millet

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Abstract
The field trial was carried out at Research farm of Suresh Gyan Vihar University, Jagatpura (Jaipur) to evaluate the effect of integrated N management through organic and inorganic fertilizers on pearl millet crop. The experiment was laid out in randomized block design using nine treatment combinations (Control, 100% RDF, 75% RDF + 25% N through FYM, 50% RDF + 50% N through FYM, 25% RDF + 75% N through FYM, 100% N through FYM, 75% RDF + 25% N through VC, 50% RDF + 50% N through VC, 25% RDF + 75% N through VC and 100% N through VC) and replicated thrice. The result showed that application of 75% RDF + 25% N through VC recorded the higher value of growth parameters (plant height, dry matter accumulation and chlorophyll content), yield parameters (number of effective tillers, earhead length and test weight) and yields (grain, stover and biological) of pearl millet and proved significantly superior to rest of the treatments. However, it remained at par with 50% RDF + 50% N through VC, 75% RDF + 25% N through FYM and 50% RDF + 50% N through FYM. Therefore, treatment 75% RDF + 25% N through VC is recommended for higher productivity of crop.

Keywords: RDF, vermicompost, FYM, DMA, Effective tillers

1. Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is the most important staple food of majority of poor and small land holders in Asia and Africa. In India, it is the fourth most widely cultivated food crop after rice, wheat and maize. India is the largest Pearl millet growing country contributing 42 per cent of production in the world. Pearl millet being grown in rainfed as well as in irrigated conditions in rainy (*kharif*) season crop in the state as staple food crop.

Pearl millet cultivation is mainly confined to semi-arid and arid region of India and covers an area of 6.70 million hectare with an average production of 9.62 million tonnes and productivity of 1436 kg/ha (Anonymous, 2023) [3]. The most important pearl millet growing states of India are Rajasthan (area of 3.74 million hectare, production 3.75 million tonnes with productivity of 1004 kg/ha), Uttar Pradesh, Maharashtra, Haryana, Gujarat, MP, Karnataka and in other states. Though, Rajasthan ranks first in area and production both, its cultivation is mainly confined to the arid (62% of total area) and semi-arid (12.60% of total area) regions. It is largely grown-up in Barmer, Nagaur, Jodhpur, Jalore, Churu, Jaipur, Alwar, Sikar and Jhunjhunu districts of Rajasthan.

Pearl millet performs better than other cereals due to its special characteristics: like more photosynthetic activity, high dry matter processing capability and the ability to thrive in the harsh agro-climatic conditions. Pearl millet has a higher mineral nutritional value, vitamins, thiamine, riboflavin contents and easily digestible than other cereals (Pal *et al*. 1996) [13]. It is a good source of energy, carbohydrate, fat (5-7%), ash, dietary fibre (1.2 g/100 g), protein (9-13%) and antioxidants such as coumaric acids with better digestibility (Kumari *et al*. 2018) [9]. It is gluten free grain and is the only grain that retains its alkaline properties after being cooked which is ideal for people with pearl millet allergy (Chauhan *et al*. 2015) [6]. Pearl millet is highly nutritious, healthful and resourceful grain that would be a worthy addition to anyone's diet but the bioavailability is low due to the presence of certain anti-nutritional factors like phytic acid, polyphenol etc. (Kumari *et al.* 2018) [9].

In present era, intensive agricultural, most of the farmers are using exhaustive high yielding crop varieties that have resulted in strong nutrient removal from the soil and fertilizer alone would not be enough to fullfil this gap between nitrogen removal and delivery. The productivity of pearl millet is very low in India mainly due to poor plant stand and less use of fertilizers. Pearl millet responds well to fertilizer application and the increase due to each successive level of fertilizer applied was significant for earhead length, earhead girth and test weight. The positive effect of fertilizer application on yield attributing characters of pearl millet seems to be due to cumulative effect on growth and vigour of plants.

Increased uses of chemical fertilizers without adequate organic recycling has not only aggravated multi-nutrients deficiencies in soil plant system but also deteriorated soil health and created environmental pollution. Efficiencies of organic manures like FYM, vermicompost not only for improving and building up of soil fertility but also increasing efficiency of chemical fertilizer. Vermicompost has been advocated as good organic manure for use in integrated nutrient management practices in field crops (Shroff and Devesthali, 1992) [21]. Now-a-days vermicompost is gaining more and more importance as a substitute of other organic manures due to its comparatively higher nutrient concentration with quick, release of nutrients and which are available mostly to the current crop. It also take part in improving the physical condition of the soil. Vermicompost is an eco-friendly and an effective way to recycle agriculture and kitchen waste. It can also call as biological manure and its application not only adds plant nutrients (macro and micro) and growth regulators but also increases soil water retention, nutrient content and organic carbon content of the soil. Vermicompost is a rich mixture of macro and micro plant nutrients. It also increases microbial availability of nitrogen and phosphorus and improves microbial action in the soil. Integration of organic manure and inorganic fertilizer has been found to be promising not only in maintaining higher productivity of crops but also for providing stability in crop production, besides improving soil physical conditions (Verma and Shete, 2012) [23]. The integrated nutrient supply system helps to produce higher yields and improve soil fertility (Gaur and Kumawat, 2000) [7]. Integrated chemical fertilizers with organic manure have been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production (Nambiar and Abrol, 1992) [12].

2. Materials and Methods

The field experiment on pearl millet crop was conducted during kharif season at Research farm of Suresh Gyan Vihar University Jagatpura (Jaipur) to evaluate the effect of integrated nitrogen management through organic and inorganic fertilizers on vegetative growth, yield attributes and yields of pearl millet crop. Geographically, site of field location comes under Agro-climatic Zone II A (Transitional plain of inland Draining) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during summers and cooler in winters. The experimental site was uniform in topography and loamy sand in texture with pH (8.3). The soil was low in fertility status with low organic carbon (0.13%) and available nitrogen (128.2 kg/ha), medium available phosphorus (16.9 kg/ha) and potassium (176.2 kg/ha). The experiment was laid out in randomized block design using nine treatment combinations (Control, 100% RDF, 75% RDF + 25% N through FYM, 50% RDF + 50% N through FYM, 25% RDF + 75% N through FYM, 100% N through FYM, 75% RDF + 25% N through VC, 50% RDF + 50% N through VC, 25% RDF + 75% N through VC and 100% N through VC) and replicated thrice. Fertilizers/manures were applied as per treatments before sowing. Pearl millet variety RHB-177 was sown at 45 cm X 15 cm row to plant spacing by *Kera* method using the recommended seed rate of 5 kg/ha. All agronomic practices were adopted as per recommendation of the zone. Observations on growth, yield attributes and yield of pearl millet were recorded.

The chlorophyll content of leaves at 50 DAS was determined by following the method suggested by Arnon (1949) [4] and calculated using the following formula.

$$\text{Total chlorophyll content (mg/g)} = \frac{\text{A (652) x 29 x Total volume (ml)}}{\alpha \text{ x 1000 x weight of sample (g)}}$$

Where, α is the path length = 1 cm and 29 is constant

Seed and stover yield were recorded per plot and converted into kg/ha. The observations recorded on different parameters were statistically analyzed using analysis of variance as suggested by Gomez and Gomez (1984) [8] for randomized block design to draw a valid conclusion. To evaluate the significant difference between treatment means, least significant difference (LSD) at 5 per cent level of significance was calculated.

3. Results and Discussion

3.1 Growth attributes

It is evident from the Table 1 that plant height, dry matter accumulation and chlorophyll content were significantly increased by integrated nitrogen management through organic fertilizers as compared to control. Application of 75% RDF + 25% N through VC recorded the maximum plant height (169.55 cm) and proved significantly superior to rest of the treatments. However, it remained at par with 50% RDF + 50% N through VC, 75% RDF + 25% N through FYM and 50% RDF + 50% N through FYM. The observed improvement in plant height might be due to an early and plentiful availability of macro and micro nutrients leading to better nutritional environment in the root zone for growth and development. As NPK are the major essential plant nutrients required for growth. Therefore, increased availability of these nutrients on poor soil might have increased cell number and cell size leading to better growth in terms of plant height, dry matter production, chlorophyll content and root growth. The findings of Senthilkumar *et al*. (2018) [19], Nalini *et al.* (2020) [11], Singh *et al*. (2020) [22], Yadav *et al*. (2021) [24] and Shiyal *et al*. (2023) [20] also supported.

With respect to dry matter accumulation (Table 1), similar trend was noted as in plant height. Application of 75% RDF + 25% N through VC recorded significantly maximum dry matter accumulation (177.34 g/metre row length) which proved superior over the rest of the treatments. However, treatment 75% RDF + 25% N through VC was remained at par with 50% RDF + 50% N through VC, 75% RDF + 25% N through FYM and 50% RDF + 50% N through FYM. The probable reason for higher dry matter production might be due the application of organic and inorganic fertilizer which contains most of the macronutrients and micronutrients in plant available form. Hence, availability of these nutrients to plants helps to enhance photosynthetic efficiency and higher dry matter accumulation in plant part as source that resulted in the higher dry matter

production in plants. Similar results are reported by Nalini *et al.* (2020) [11], Singh *et al.* (2020) [22], Yadav *et al.* (2021) [24], Amarghade and Singh (2021) [2] and Shiyal *et al.* (2023) [20].

The use of different nutrient management treatments to pearl millet significantly increased the total chlorophyll content in plant leaves at 50 DAS over control. Maximum value of chlorophyll content (2.94 mg/g fresh leaves) noted with 75% RDF + 25% N through VC that proved significantly superior by 20.99 per cent over control. However, all treatments remained at par with each other and significant over control. Nitrogen is a component of chlorophyll, it harnesses solar energy and fixes atmospheric CO_2 as carbohydrates and amino acids (Bequette *et al*., 1963). Thus, nitrogen application increased dry matter production. Similarly, increased supply of available phosphorus has long been considered as an essential constituent of all living organisms and plays an important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformations. The improvement in chlorophyll content in leaves might have also resulted in better interception and utilization of radiant energy leading to higher photosynthetic rate and finally more dry matter accumulation by crop (Balasubramanian *et al.*, 1999) [5]. The outcome is in the line of conformity by Polara *et al.* (2015) [14], Senthilkumar *et al.* (2018) [19], Ajeigbe *et al.* (2020) [1], Samruthi *et al.* (2020) [18] and Singh *et al.* (2020) [22].

Yield attributes

The data presented in table 2 showed that yield attributes like total number of effective tillers per plant, earhead length (cm) and test weight (g) of pearl millet crop were significantly improved with the use of different nutrient management practices. Application of 75% RDF + 25% N through VC being at par with 50% RDF + 50% N through VC, 75% RDF + 25% N through FYM and 50% RDF + 50% N through FYM recorded maximum number of effective tillers per plant (2.84), earhead length (26.61cm) and test weight (7.89g) which were found superior over test of the treatments. However, all other treatments were superior over control. Organic and inorganic fertilization stimulated seed setting and increased yield attributes of crop. The beneficial effect on yield attributes might also be due to the increased supply of all the essential nutrients by vermicompost and FYM that might have resulted in higher manufacture of food and its subsequent partitioning towards sink. Similar results were reported by Ram *et al.* (2015) [15], Senthilkumar *et al.* (2018) [19], Shiyal *et al.* (2023) [20] and Yadav *et al.* (2023) [25]

Yields

The perusal of data in table 3 showed that grain yield, stover yield and biological of crop was improved when different nitrogen management treatments applied. Application of 75% RDF + 25% N through VC recorded maximum seed yield (2276 kg/ha) which represented a significant increase of 47.22, 32.71, 26.72, 22.10, 16.96 and 13.23 per cent over control, 100% N through FYM, 100% RDF, 100% N through VC, 25% RDF + 75% N through FYM and 25% RDF + 75% N through VC, respectively. The increase in stover yield due to 75% RDF + 25% N through VC was 32.07, 13.75, 11.39, 8.63, 8.96 and 8.34 per cent over control, 100% N through FYM, 100% RDF, 100% N through VC, 25% RDF + 75% N through FYM and 25% RDF + 75% N through VC, respectively. Maximum biological yield (7588 kg/ha) of pearl millet obtained when 75% RDF + 25% N through VC applied. It registered an increase of 36.28, 18.86, 15.56, 12.55, 9.75 and 6.60 per cent over control, 100% N through FYM, 100% RDF, 100% N through VC, 25% RDF + 75% N through FYM and 25% RDF + 75% N through VC, respectively. However, treatment 75% RDF + 25% N through VC was at par with 50% RDF + 50% N through VC, 75% RDF + 25% N through FYM and 50% RDF + 50% N through FYM in respect to seed yield, stover yield and biological yield. All other treatments were significantly superior over control. Harvest index of pearl millet could not influence with the use of different nitrogen management treatments.

Grain yield is an ultimate end product of many yield-contributing components, physiological and morphological processes taking place in plants during growth and development. It is a well-known fact that grain yield is the function of more number of effective tillers per unit area, number of grains per earhead and test weight. As the yield is directly related to all the yield attributing characters which also showed increasing trend with this type of nitrogen management. Continuous supply of nutrients in balanced quantity throughout the growth stages by use of different organic and inorganic fertilizers enabled the plants to assimilate sufficient photosynthetic product causing increased dry matter accumulation and yield attributes. With increased dry matter and efficient photosynthetic products coupled with efficient translocation, higher number of effective tillers with test weight was produced which ultimately resulted in higher grain yield. The increased supply of major nutrients (NPK) and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased growth and yield parameters and resulted in increased grain and stover yields. Second reason for higher yield might be due to the higher values of yield attributes like effective tillers per plant, earhead length and test weight coupled with the higher crop dry matter observed with these treatments might have been the most probable reason of higher grain and stover yield. The biological yield is a function of seed and stover yields of crop. Thus significant increase in biological yield with the application of organic and inorganic fertilizers could be attributed owing to increased seed and stover yield. These results are corroborating the findings of Samruthi *et al.* (2019) [17] Rani *et al.* (2020) [16], Singh *et al.* (2020) [22], Yadav *et al.* (2021) [24], Margal *et al.* (2023) [10] and Shiyal *et al.* (2023) [20] and Yadav *et al.* (2023) [25].

Table 1: Effect of nutrient management on growth attributes of Pearl millet

Treatments	Plant height (cm)	DMA (g/metre row length)	Chlorophyll content (mg/g leaf weight)
T_0- Control	130.49	141.27	2.43
T_1- 100% RDF	148.33	155.58	2.70
T_2- 75% RDF + 25% N through FYM	163.91	167.91	2.87
T_3- 50% RDF + 50% N through FYM	159.11	165.87	2.85
T_4- 25% RDF + 75% N through FYM	155.66	161.08	2.77
T_5- 100% N through FYM	145.28	150.47	2.66
T_6- 75% RDF + 25% N through VC	169.55	177.34	2.94
T_7- 50% RDF + 50% N through VC	166.38	170.64	2.91
T_8-25% RDF + 75% N through VC	156.44	162.81	2.80
T_9- 100% N through VC	154.03	156.84	2.74

SE m(±)	4.51	4.96	0.10
CD (*P*=0.05)	13.03	14.34	0.29

Table 2: Effect of nutrient management on yield attributes of Pearl millet

Treatment	Yield attributes		
	No. of effective tillers/plant	Earhead length (cm)	Test weight (g)
T_0- Control	1.76	14.53	5.86
T_1- 100% RDF	2.49	21.41	6.77
T_2- 75% RDF + 25% N through FYM	2.78	26.21	7.63
T_3- 50% RDF + 50% N through FYM	2.73	25.18	7.44
T_4- 25% RDF + 75% N through FYM	2.55	23.67	7.01
T_5- 100% N through FYM	2.36	19.64	6.54
T_6- 75% RDF + 25% N through VC	2.84	26.61	7.89
T_7- 50% RDF + 50% N through VC	2.80	26.40	7.74
T_8-25% RDF + 75% N through VC	2.69	23.97	7.21
T_9- 100% N through VC	2.58	22.23	6.87
SE m(±)	0.05	0.81	0.19
CD (*P*=0.05)	0.14	2.33	0.56

FYM - Farm Yard Manure, VC- Vermicompost

Table 3: Effect of nutrient management on yields and harvest index of Pearl millet

Treatment	Yield (kg/ha)			HI (%)
	Seed	Stover	Biological	
T_0- Control	1546	4022	5568	0.28
T_1- 100% RDF	1796	4769	6566	0.28
T_2- 75% RDF + 25% N through FYM	2188	5143	7331	0.30
T_3- 50% RDF + 50% N through FYM	2114	5082	7216	0.29
T_4- 25% RDF + 75% N through FYM	1946	4890	6914	0.28
T_5- 100% N through FYM	1715	4670	6384	0.27
T_6- 75% RDF + 25% N through VC	2276	5312	7588	0.30
T_7- 50% RDF + 50% N through VC	2237	5207	7514	0.30
T_8-25% RDF + 75% N through VC	2010	4903	7052	0.28
T_9- 100% N through VC	1864	4875	6741	0.28
SE m(±)	87	140	177	0.18
CD (*P*=0.05)	251	404	512	NS

FYM - Farm Yard Manure, VC- Vermicompost, HI – Harvest index

Conclusion

Based on findings of experiment it might be concluded that application of 75% RDF + 25% N through VC was best suited for securing higher growth attributes, yield attributes, yields and economic returns from pearl millet under semi-arid condition of Rajasthan.

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