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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL NUTRIENTS STATUS OF SEMI-RABI PEARLMILLET (*PENNESETUM GLAUCUM* L.)

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ABSTRACT

An attempt has been made in the present investigation to study the effect of integrated nutrient management on soil nutrients status of semi-rabi pearl millet (*Pennisetum glaucum* L.) was carried out at Main Sugarcane Research Station, J.A.U., Kodinar during the semi-rabi season of the year 2022-23 & 2023-24. The study consisted the combination of different organic and inorganic sources of nitrogen to evaluate their effect on soil nutrient status of pearl millet. A field experiment comprised of integrated nutrient management viz., T₁ – Absolute Control, T₂ - 100% RDF, T₃ - 75% RDF + 25% RDN through vermicompost, T₄ – 50% RDF + 25% RDN through urban compost, T₅ - 75% RDF + 25% RDN through FYM and T₆ - 75% RDF + Bio fertilizer to pearl millet in semi-rabi season replicated four times in randomized block design. The result of experiment indicated that integrated application of 75% RDF + 25% RDN through vermicompost noted significantly higher organic carbon (0.96%), available nitrogen (239 kg/ha), phosphorus (64.39 kg/ha) and potassium (416 kg/ha) status in soil after harvest of pearl millet crop as compared to rest of integrated nutrient treatments combination.

Key words : INM, FYM, Vermicompost, Bio fertilizer, RDF, RDN, Organic carbon, Nitrogen, Phosphorus, Potassium, Pearl millet.

Introduction

Pearl millet (*Pennisetum glaucum* L.) is one of the fourth most important food crop in India after rice, wheat and sorghum and well adapted to drought, low soil fertility and acidic soil. Pearl millet is an allogamous crop belonging to family poaceae. The crop was introduced in India from West Africa around 2000 BC. Pearl millet is dual purpose crop. Its grain is used as food for human consumption and feed for cattle in hot arid regions of Africa and Asia. The main pearl millets growing countries are India, China, Nigeria, Pakistan and Sudan. Pearl millet (*Pennisetum glaucum* L.) is one of the important climate resilient millet crop which is mainly cultivated as a rain fed crop in dry land agriculture. It is also called as the “Power house of nutrients”. India holds position in the production of pearl millets in the world occupying about 7.37 million hectares with annual production of 10.72 million tons with

average productivity of 1453 kg ha⁻¹ (Centre for Monitoring Indian Economy, 2023-24).

Integrated nutrient management (INM) is one of the most important components of the agricultural production system to sustain higher crop yields vis-à-vis maintain soil health. The interactive advantages of combining organic and inorganic sources of nutrients in integrated nutrient management have shown additive effect in comparison to the use of each component separately (Palaniappan and Annadurai, 2007). Integrated use of chemical fertilizers with organic manures has been found to be quite promising in maintaining high productivity and providing greater stability to crop production (Patidar and Mali, 2004). FYM is used as a major source of organic manure in field crops. In view of poor efficiency of FYM, vermicompost has been advocated as a good source of organic manure along with inorganic source for field crops

(Roy and Singh, 2006). Even with the so called balance use of NPK fertilizers in long term studies, higher yield levels could not be maintained for years because of emergence of secondary and micro-nutrient deficiency and deterioration in the soil physical environment. Whereas, organic manure alone or in combination with inorganic fertilizers is known to have favourable effect on soil environment, correct the marginal deficiency of secondary and micro-nutrients and enhance the efficiency of applied nutrients.

The basic concept of integrated nutrient management (INM) is maintenance or adjustment of soil fertility and supply plant nutrients to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated way (Tondon, 1992). The response of N as chemical fertilizer generally increases when it is used in combination with FYM, vermicompost etc. and saves N fertilizer (Nambiar and Abrol, 1989). Organic N is slowly mineralized and about 30% N, 70% P_2O_5 and 75% K_2O is likely become available to the first crop and the rest of the nutrients to succeeding crops (Gour *et al.*, 2017).

Materials and Methods

The present investigation entitled “Effect of integrated nutrient management on soil nutrients status of semi-rabi pearlmillet (*Pennisetum glaucum* L.)” was carried out for two consecutive years during the semi-rabi seasons of 2022-23 and 2023-24 at Main Sugarcane Research Station, J.A.U., Kodinar, Gujarat. The experiment was carried out in Randomized Block Design with three replication. The treatments comprised were T_1 – Absolute Control, T_2 - 100% RDF, T_3 - 75% RDF + 25% RDN through vermicompost, T_4 – 50% RDF + 25% RDN through urban compost, T_5 - 75% RDF + 25% RDN through FYM and T_6 - 75% RDF + Bio fertilizer. The soil of the experimental plot was clayey in texture, high in organic carbon (1.05% and 1.23%), slightly alkaline in reaction with pH and EC with low inavailable nitrogen (230 and 231 kg/ha), medium in available phosphorus (51.3 kg/ha), medium in available potash (326 kg/ha). Representative sample for soil analysis taken up to 0-20 cm depth from each net plot after harvest of crop for analysis purpose of certain nutrients. Organic carbon (%) in the soil was estimated by rapid titration method as suggested by Walkley and Black (1934) and for estimation of available nitrogen was analysed by alkaline $KMnO_4$ method given by Subbiah and Asija (1956). Soil available phosphorus was extracted with 0.5 M sodium bicarbonate (1:20), as a Olsen’s method given by Olsen *et al.* (1954) while, available potassium determined by flame photometric method (Jackson, 1974). The required

quantities of 75% RDF (120 kg N ha^{-1}) and (60 kg P_2O_5 ha^{-1}) was applied to urea and DAP fertilizer while organic fertilizers farm yard manure, vermicompost, urban compost and bio fertilizer were applied in respective plots as per the treatments and incorporated into soil 15 days before sowing of the crop. Different soil nutrients status components were recorded after harvest of pearlmillet crop. The data were subjected to standard analysis of variance technique (Gomez and Gomez 1984). The mean treatment were compared at $P < 0.05$ level of significance.

Results and Discussion

Effect of integrated nutrient management on soil nutrients status

Organic carbon (%)

The data presented in Table 1 and Fig. 1 clearly indicate that the organic carbon (O.C) percentage in soil after harvest of pearlmillet was significantly influenced by the application of various integrated nutrient management (INM) treatments across both cropping seasons (2022–23 and 2023–24) as well as in the pooled mean.

Among all the treatments, the highest organic carbon content after harvest of pearlmillet was recorded under treatment T_3 (75% RDF + 25% RDN through vermicompost) with a value of 0.96%, in pooled results followed closely by T_5 (75% RDF + 25% RDN through FYM). These treatments were significantly higher than the rest, reflecting the beneficial effect of organic nutrient amendments in improving soil carbon status. T_4 (urban compost) also showed improved organic carbon levels (0.85% pooled), followed by T_6 (biofertilizer) and T_2 (100% RDF), which recorded 0.79% and 0.73%, respectively. The lowest O.C. value was noted in T_1 (absolute control) with a pooled mean of 0.62%, suggesting that the absence of nutrient application leads to gradual depletion of soil organic matter. Across both individual years, the trend remained consistent, treatment T_3 showing the highest organic carbon content (0.96% in 2022–23 and 0.97% in 2023–24).

The significant enhancement in soil organic carbon under vermicompost (T_3) and FYM (T_5) treatments can be attributed to the continued input of stable organic matter and microbial biomass, which improves soil aggregation, microbial proliferation, and carbon retention. Vermicompost contains humic substances and microbial metabolites that accelerate the build-up of soil organic matter. Likewise, FYM is rich in lignin and cellulose compounds that decompose slowly, thereby contributing to a sustained increase in soil carbon levels. In contrast, the limited increase in soil carbon under T_2 (100% RDF)

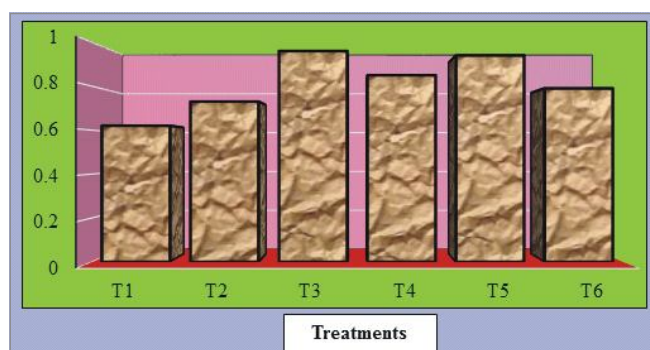


Fig. 1 : Effect of INM on organic carbon (%) in soil after harvest of pearl millet crop.

and T_6 (biofertilizer) suggests that inorganic fertilizers alone or microbial inoculants without sufficient carbon sources may not significantly enhance soil carbon pools. These findings support earlier studies which emphasize that the integration of organic amendments with mineral fertilizers not only improves nutrient availability but also enhances soil health and sustainability (Mandal *et al.*, 2007; Golada *et al.*, 2012 and Ogundijo *et al.*, 2015).

Available nitrogen (kg/ha) in soil

The data presented in Table 1 and Fig. 2 reveal that available nitrogen (N) in the soil after harvest of pearl millet was significantly influenced by various integrated nutrient management (INM) treatments across the years 2022–23 and 2023–24, as well as in pooled analysis.

In 2022–23, the significant higher mean value of available N (235 kg/ha) was recorded with T_5 (75% RDF + 25% RDN through FYM), which was at par with T_3 (232 kg/ha), and significantly higher than T_2 (207 kg/ha), T_4 (216 kg/ha), and T_6 (195 kg/ha). The lowest available N was observed in T_1 (absolute control) with value of 188 kg/ha. In 2023–24, a similar trend was observed where treatment T_3 (246 kg/ha) and T_5 (244 kg/ha) recorded the significantly highest available N in soil, followed by T_2 (235 kg/ha), T_6 (212 kg/ha), and T_4 (212 kg/ha). The lowest value again was in T_1 (199 kg/ha).

On the basis of pooled data, T_5 (239.49 kg/ha) and T_3 (239.26 kg/ha) were statistically at par and significantly superior to all other treatments, indicating their consistent effect in enhancing soil nitrogen availability. These were followed by T_2 (221 kg/ha), T_4 (214 kg/ha), and T_6 (204 kg/ha). The lowest pooled soil available N was recorded in T_1 (193.54 kg/ha). The increase in soil available nitrogen under treatments T_5 (FYM) and T_3 (vermicompost) may be attributed to the synergistic effect of organic manures with chemical fertilizers, which likely improved microbial activity, slowed nutrient leaching, and enhanced nutrient mineralization (Kumar *et al.*, 2021). FYM and vermicompost are well-known for their capacity

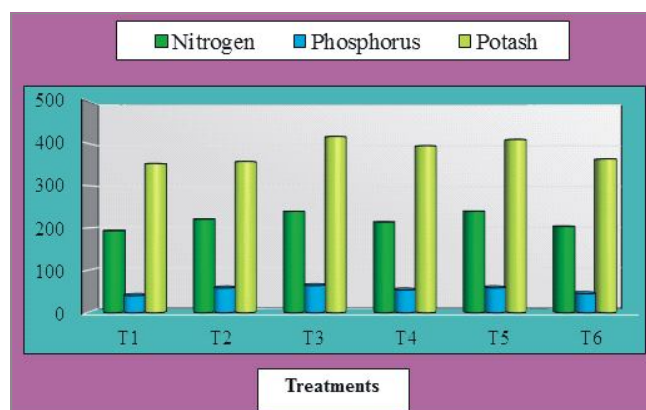


Fig. 2 : Effect of INM on available NPK in soil (kg/ha) in soil after harvest of pearl millet crop.

to gradually release nutrients and improve soil structure, contributing to better nitrogen retention and availability (Ladha *et al.*, 2016). Overall, the findings support the integration of 75% RDF with 25% RDN through FYM or vermicompost as an efficient INM practice to improve soil nitrogen status post-harvest, which is crucial for sustaining soil health and productivity.

Available phosphorus (kg/ha) in soil

The data revealed that integrated nutrient management treatments significantly influenced the available phosphorus (P_2O_5) content in the soil after harvest of pearl millet during both years and in pooled analysis (Table 2 and Fig. 2).

Among the treatments, T_3 (75% RDF + 25% RDN through vermicompost) consistently recorded the significantly higher available P_2O_5 , with values of 62.81 kg/ha in 2022–23, 65.96 kg/ha in 2023–24, and a pooled mean of 64.39 kg/ha, which was significantly superior to all other treatments. This was followed by T_5 (75% RDF + 25% RDN through FYM) with values of 58.39 kg/ha, 59.47 kg/ha, and 58.93 kg/ha and T_2 (100% RDF) with 57.11 kg/ha, 59.88 kg/ha and 58.49 kg/ha in respective years and pooled mean. Treatment T_4 (urban compost) recorded moderate values, while T_6 (biofertilizer) and T_1 (absolute control) showed the lowest available phosphorus, with pooled values of 45.05 kg/ha and 40.51 kg/ha, respectively. Statistically, T_6 was at par with T_1 .

The significant improvement in soil available phosphorus under vermicompost based INM (T_3) and FYM-based INM (T_5) treatments may be attributed to the organic acids released during the decomposition of organic manures, which help in solubilizing native and added phosphorus, thus enhancing its availability (Choudhary *et al.*, 2014). Vermicompost, in particular, is known for enhancing microbial activity and producing organic acids and phosphatases that mobilize fixed P

Table 1 : Effect of integrated nutrient management on O.C. content and available nitrogen content in soil after harvest of pearlmillet.

Treatments	O.C. % in soil			Available N (kg/ha) in soil		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁ : Absolute control	0.60	0.64	0.62	188	199	194
T ₂ : 100% RDF	0.72	0.74	0.73	207	235	221
T ₃ : 75% RDF + 25% RDN through vermicompost	0.96	0.97	0.96	232	246	239
T ₄ : 75% RDF + 25% RDN through urban compost	0.82	0.88	0.85	216	212	214
T ₅ : 75% RDF + 25% RDN through FYM	0.92	0.96	0.94	235	244	239
T ₆ : 75% RDF + Bio fertilizer	0.77	0.82	0.79	195	212	204
SEm±	0.04	0.04	0.03	11	11	8
CD (P=0.05)	0.13	0.13	0.09	32	33	22
CV (%)	10.42	10.45	10.44	10.13	9.74	9.93
Year (Y)						
SEm±	0.017				4	
CD (P=0.05)	NS				NS	
Interaction (Y × T)						
SEm±	0.043			11		
CD (P=0.05)	NS			NS		

Table 2 : Effect of integrated nutrient management on available phosphorus and potassium (kg/ha) in soil after harvest of pearlmillet.

Treatments	Available P ₂ O ₅ (kg/ha) in soil			Available K ₂ O (kg/ha) in soil		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁ : Absolute control	34.76	46.26	40.51	344	360	352
T ₂ : 100% RDF	57.11	59.88	58.49	351	363	357
T ₃ : 75% RDF + 25% RDN through vermicompost	62.81	65.96	64.39	410	423	416
T ₄ : 75% RDF + 25% RDN through urban compost	56.08	51.33	53.71	394	395	394
T ₅ : 75% RDF + 25% RDN through FYM	58.39	59.47	58.93	402	416	409
T ₆ : 75% RDF + Bio fertilizer	40.69	49.41	45.05	358	369	363
SEm±	3.61	4.08	2.72	16	16	11
CD (P=0.05)	10.87	12.29	7.86	48	48	33
CV (%)	13.97	14.73	14.39	8.53	8.20	8.36
Year (Y)						
SEm±	1.57			7		
CD (P=0.05)	NS			NS		
Interaction (Y × T)						
SEm±	3.85			16		
CD (P=0.05)	NS			NS		

(Sundara *et al.*, 2002). The lowest available P₂O₅ in absolute control (T₁) reflects the exhaustion of native phosphorus due to continuous crop uptake without replenishment. The moderate performance of urban compost (T₄) may be due to its variable quality and phosphorus content, while the relatively lower values in biofertilizer-based treatment (T₆) suggest that biofertilizers alone may not be sufficient to maintain high levels of available phosphorus in the short term.

Available potassium (kg/ha) in soil

The integrated nutrient management treatments had a significant effect on available potassium (K₂O) content in soil after harvest of pearlmillet in both years and in pooled data (Table 2 and Fig. 2).

The treatment T₃ (75% RDF + 25% RDN through vermicompost) recorded the highest available K₂O, with the value of 410 kg/ha in 2022–23, 423 kg/ha in 2023–24, and a pooled mean of 416 kg/ha, which was significantly

superior to all other treatments. This was closely followed by treatment T₅ (75% RDF + 25% RDN through FYM) with values of 402 kg/ha, 416 kg/ha, and 409 kg/ha, and T₄ (urban compost) with consistent values of 394 kg/ha in both years and in pooled mean. Moderate K₂O levels were recorded in T₂ (100% RDF) and T₆ (biofertilizer) with values of 357 kg/ha and 363 kg/ha, in pooled results respectively. The lowest K₂O content was found in T₁ (absolute control), with the value of 344 kg/ha in 2022–23, 360 kg/ha in 2023–24, and a pooled mean of 352 kg/ha.

The significantly higher potassium content in vermicompost (T₃) and FYM (T₅) treatments can be attributed to the mineralization of organic residues and enhanced microbial activity that improves nutrient cycling and availability of exchangeable potassium in the soil. Vermicompost is known to release K gradually and enrich the soil solution with soluble K forms, while FYM improves the soil's cation exchange capacity, which helps in better retention and release of K ions (Subba Rao *et al.*, 2007).

Conclusion

Based on two-years study, it is concluded that application of 75% RDF + 25% RDN through vermicompost significantly increased soil organic carbon, available N, P and potassium in soil after harvest of pearl millet crop as compared to other integrated nutrient treatments combination in medium black calcareous soil of south saurashtra zone-VIII in Kodinar Gujarat.

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