Impact of Integrated Nutrient Management Practices on Chemical Properties of Soil under Finger Millet Cultivation in Assam

ABSTRACT

A field experiment was carried out during the *rabi* season of 2022-2023 at Instructional-cum-Research Farm, Assam Agricultural University, Jorhat to evaluate the performance of different integrated nutrient management practices on chemical properties of soil under finger millet cultivation in rainfed upland condition. The design of the experiment was randomized block design (RBD) with three replications. Individual plot size was 4 m × 3 m. Total of 9 treatments were taken under consideration. The finger millet variety used for the experiment was AAU-GSG-Marua Dhan 1. Results revealed that available nitrogen in soil after harvest was found to be significantly higher under treatment T_3 (255.1 kg ha^{-1}) followed by T_4 (250.9 kg ha^{-1}). In case of phosphorus, available P_2O_5 in soil after harvest was found to be significantly higher under treatment T_3 (28.53 kg ha^{-1}) followed by T_4 (27.02 kg ha^{-1}) and T_2 (25.16 kg ha^{-1}). For potassium, available K_2O in soil after harvest was found to be significantly higher in T_3 (243.1 kg ha^{-1}) followed by (240.6 kg ha^{-1}) and T_2 (238.6 kg ha^{-1}). The lowest values for available N, P_2O_5 and K_2O in soil after harvest were observed in the control treatment.

Keywords: Finger millet, Nitrogen, Phosphorus, Potassium, Vermicompost

1. INTRODUCTION

Finger millet (*Eleusine coracana*), known as ragi in India, offers significant potential in climate-smart agriculture amidst global warming. As a low-nutrient-demanding C_4 plant, it shows resilience to various environmental stresses, both biotic and abiotic. Being tetraploid and self-pollinating, it falls under the category of minor millets. Finger millet stands out for its superior nutritional profile, containing high levels of essential nutrients such as iron, calcium, tryptophan, and methionine, and it is gluten-free with a lower glycemic index compared to other major cereals [1] Finger millet plays a significant dietary role in economically challenged regions of Asia and Africa, contributing 75% of the total calorie intake, second only to major cereal grains [2]. It is also utilized in gluten-free cereal products. They have become increasingly recognized for being gluten-free and are valued for their richness in polyphenols, antioxidants, and dietary fibres, which are crucial for promoting good health [3].
While crops like rice and wheat ensure food security, finger millet contributes to global nutritional security [4,5]. It is noteworthy that millets have shown remarkable productivity growth over the past five decades, contrasting with the variable productivity trends observed in major food crops [6].India holds the largest millet cultivation area globally, encompassing 26.6% of the total, with 83% of this area located in Asia [7]. Following wheat, rice, maize, sorghum, and pearl millet, finger millet ranks as the sixth most significant crop in India [8].

Finger millet holds the distinction of being the most widely cultivated minor millet in India, yielding 1.79 million tons from a total cropped area of 1.17 million hectares. Over 90% of the country's finger millet production comes from key states including Karnataka (58%), Uttarakhand, Maharashtra, Tamil Nadu, Odisha, and Andhra Pradesh [9]. In Assam, small millets and other cereals, excluding maize and wheat, are grown across 4,820 hectares. The total production from this cultivation amounts to 3,204 metric tons, achieving a productivity rate of 664 kg ha^{-1} [10]. Among various small millets, finger millet, known as Marua in Assam, has been gradually gaining popularity among the local population. The lower Assam region is renowned for its extensive cultivation of the inaugural promising variety of finger millet from Assam, AAU-GSG-Marua Dhan 1 (Gossaigaon Marua Dhan 1). Consequently, a research experiment was undertaken to systematically gather empirical evidence concerning the cultivation of finger millet under integrated nutrient management practices with relation to chemical properties of soil.

2. MATERIAL AND METHODS

A field experiment was carried out during the *rabi* season of 2022-2023 at Instructional-cum-Research Farm, Assam Agricultural University, Jorhat (26°47′ N latitude and 94°12′ E longitude) at an elevation of 86.6 m above msl in the Upper Brahmaputra Valley Zone of Assam. The total amount of rainfall received in the cropping period was 600.2 mm. The experimental site had sandy loam soil texture, with acidic pH (4.98), moderate organic carbon content (0.58%), low levels of available nitrogen (263.42 kg ha^{-1}) and available phosphorus (20.52 kg ha^{-1}), and moderate levels of available potassium (250.39 kg ha^{-1}). The design of the experiment was randomized block design (RBD) with three replications. Individual plot size was 4 m × 3 m. Treatments were as follows: control (T_1), recommended NPK (40-20-20 kg ha^{-1}) + FYM 1 t ha^{-1} (T_2), recommended NPK (40-20-20 kg ha^{-1}) + vermicompost @ 0.5 t ha^{-1} (T_3), recommended NPK (40-20-20 kg ha^{-1}) + poultry litter vermicompost @ 0.5 t ha^{-1} (T_4), FYM @ 1 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with quick lime @10 kg ha^{-1} (1000:10) at basal and 30 DAS (T_5), vermicompost @ 0.5 t ha^{-1} enriched with microbial consortia @ 0.2% w/w for 15 days (T_6), poultry litter vermicompost @ 0.5 t ha^{-1} enriched with microbial consortia @0.2% w/w for 15 days (T_7), vermicompost @ 0.5 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with 50% of the recommended dose of NPK applied as basal (T_8), poultry litter vermicompost @ 0.5 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with 50% of the recommended dose of NPK applied as basal (T_9). The finger millet variety used for the experiment was AAU-GSG-Marua Dhan 1. A raised seedbed measuring 3 x 1.5 m and elevated 10-25 cm was prepared with a 30 cm gap between each bed. Approximately 2-3 kg of dry cow dung were applied per bed and thoroughly mixed into the soil. For optimal seedling growth, 150 g of seed were sown, ensuring proper spacing. Farmyard manure (FYM), vermicompost, and poultry litter vermicompost were separately placed in sacks and thoroughly blended with nitrogen-fixing bacteria (*Azospirillum brasilense*) and phosphorus-solubilizing bacteria (PSB) at a rate of 0.2% (by weight). These mixtures were then incubated for 15 days, maintaining approximately 25% moisture content. Fertilizers and manures were applied as basal dose according to specific treatment combinations and evenly incorporated into the soil. The remaining FYM was incubated with a microbial consortium at 0.2% (by weight) for another 15 days and applied at 30 days after transplanting (DAT) following mixing with quick lime. After 30 DAS, seedlings were transplanted into pre-prepared moist beds, maintaining a spacing of 25 cm x 15 cm with one seedling per hill. Soil organic carbon was assessed using the wet digestion technique developed by Walkley and Black (1934) [11], while pH was measured using the glass electrode method detailed by Jackson (1973) [12]. The pH of the manure was determined using a pH meter, employing a 1:2.5 suspension of manure to water (Jackson, 1973) [12]. To estimate both NH_3-N and NO_3-N in manures, 10 grams of fresh samples of each manure were mixed with 200 ml of 2 N potassium chloride solution and shaken for 1 hr. The NH_3-N and NO_3-N levels in the resulting extract were then determined colorimetrically following the method outlined by Onken and Sunderman (1977) [13]. Three representative samples of each manure were analyzed, and the average gravimetric moisture content was calculated. Available nitrogen was determined using the alkaline permanganate oxidation method described by Subbiah and Asija (1956) [14]. Available phosphorus was quantified using Bray's I method with a colorimeter set at 470 nm wavelength, following the procedure outlined by Jackson (1973) [12]. Available potassium was extracted using neutral normal ammonium acetate, and potassium content in the solution was measured using flame photometry (Jackson, 1973) [12]. Experimental data were subjected to analysis of variance (ANOVA), and significance was assessed using Fisher's least significant difference test ($p = 0.05\%$).

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Table 1. Mechanical composition of soil

Sl. No	Soil Properties	Value	Method(s) followed
1	Sand (%)	67.07	International pipette Method (Piper,1966) [15]
2	Silt (%)	22.33	
3	Clay (%)	10.6	
4	Textural class	Sandy Loam	

Table 2. Initial chemical properties of soil (Before sowing)

SL. No.	Chemical properties	Value	Status	Method(s) followed
1	Soil reaction (pH)	4.98	Acidic	Glass electrode method (Jackson, 1973) [12]

2	Organic Carbon (%)	0.58	Medium	Wet digestion method (Walkley and Black, 1934) [11]
3	Available N (kg ha^{-1})	263.42	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [14]
4	Available P_2O_5 (kg ha^{-1})	20.52	Low	Bray's I Method, (Jackson, 1973) [12]
5	Available K_2O (kg ha^{-1})	250.39	Medium	Flame photometric method (Jackson,1973) [12]

3. RESULTS AND DISCUSSION

The results indicated that the pH of farmyard manure (FYM) was notably elevated at 7.61 compared to both poultry litter vermicompost and vermicompost. Vermicompost exhibited higher fractions of NH_3-N and NO_3-N, measured at 1445 mg kg^{-1} and 2497.33 mg kg^{-1} respectively, surpassing FYM and poultry litter vermicompost in this regard. Moreover, both vermicompost and poultry litter vermicompost demonstrated a higher NH_3-N to NO_3-N ratio compared to FYM. Numerous research studies have indicated that applying immature composts can lead to nutrient immobilization and potentially cause harm to plants [16]. The quality and stability of composts vary depending on the raw materials used in their preparation [17]. Assessing compost quality involves considering various parameters, with the ratio of ammonical nitrogen to nitrate nitrogen playing a crucial role. Also, compost becomes suitable for use when ammonical nitrogen levels decrease and nitrate nitrogen levels increase, indicating maturity and good quality. Monitoring the absence or reduction of ammonical nitrogen is a key indicator of compost maturity and readiness for application [18].

Table 3. pH, nutrient content and NH_3-N: NO_3-N of manures used

Manure	**pH**	**NH_3-N (mg kg^{-1})**	**NO_3-N (mg kg^{-1})**	**NH_3-N: NO_3-N**
FYM	7.61	1323.33	2334.33	0.57
Vermicompost	7.00	1445.00	2497.33	0.58
Poultry litter vermicompost	7.40	1389.33	2401.67	0.58

Table 4. Available N, P_2O_5 and K_2O (kg ha^{-1}) in soil after harvest

Treatment	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1: Control	201.5	19.20	224.8
T_2: Recommended dose of NPK (40-20-20 kg ha^{-1}) + FYM @ 1 t ha^{-1}	242.5	25.16	238.6
T_3: Recommended dose of NPK (40-20-20 kg ha^{-1}) + Vermicompost @ 0.5t ha^{-1}	255.1	28.53	243.1
T_4: Recommended dose of NPK (40-20-20 kg ha^{-1}) + Poultry litter vermicompost @ 0.5 t ha^{-1}	250.9	27.02	240.6
T_5: FYM @ 1 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with quick lime @ 10 kg ha^{-1} (1000:10) at basal and 30 DAT	220.4	21.11	227.3
T_6: Vermicompost @ 0.5 t ha^{-1} enriched with microbial consortia @ 0.2% w/w for 15 days	229.5	22.38	233.8
T_7: Poultry litter vermicompost @ 0.5 t ha^{-1} enriched with microbial consortia @ 0.2% w/w for 15 days	226.2	21.68	232.9
T_8: Vermicompost @ 0.5 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with 50% of the recommended dose of NPK applied as basal	235.8	24.24	236.0

T_9: Poultry litter vermicompost @ 0.5 t ha^{-1} (incubated with microbial consortia @ 0.2% w/w for 15 days) mixed with 50% of the recommended dose of NPK applied as basal	234.2	23.90	234.5
S. Em (±)	4.1	1.20	2.41
CD (P=0.05)	12.2	3.60	7.23

Where Here, T= Treatment, DAT = Days After Transplanting

The data pertaining to the available N in soil after harvest shows that there was a significant effect of the INM practices on the available nitrogen status of the soil at harvest. Available N was found to be significantly higher under treatment T_3 (255.1 kg ha^{-1}) followed by T_4 (250.9 kg ha^{-1}). However, T_4 was statistically at par with T_3. Meanwhile, control (T_1) recorded the lowest value (201.5 kg ha^{-1}) of available N in soil after harvest. In case of phosphorus, available P_2O_5 was found to be significantly higher under treatment T_3 (28.53 kg ha^{-1}) followed by T_4 (27.02 kg ha^{-1}) and T_2 (25.16 kg ha^{-1}). The treatments T_4, T_2 were statistically at par with T_3. Meanwhile, control (T_1) recorded the lowest value (19.20 kg ha^{-1}) of available P_2O_5 in soil after harvest. For potassium, available K_2O was found to be significantly higher in T_3 (243.1 kg ha^{-1}) followed by T_4 (240.6 kg ha^{-1}) and T_2 (238.6 kg ha^{-1}). Moreover, T_4, T_2, T_8 were statistically at par with T_3. Meanwhile, control (T_1) recorded the lowest value (224.8 kg ha^{-1}) of available K_2O in soil after harvest.

Application of recommended dose of NPK (40-20-20 kg ha^{-1}) + vermicompost @ 0.5 t ha^{-1} recorded the highest available N, P_2O_5, and K_2O in the soil (255.1, 28.53 and 243.1 kg ha^{-1}, respectively). The increased availability of nitrogen, phosphorus, and potassium can be attributed to using the full recommended amount of fertilizer combined with vermicompost, which contains higher levels of these nutrients compared to other organic fertilizers tested. Additionally, vermicompost releases nitrogen to plants more gradually compared to alternative organic sources [19]. The addition of urea alongside vermicompost likely decreased the C: N, accelerating decomposition and thereby enhancing nutrient availability for plants. During organic matter breakdown, organic acids released aided in solubilizing native phosphates, thereby increasing phosphorus accessibility to plants. The application of vermicompost may have coated sesquioxides, reducing soil's capacity to fix phosphates, a finding consistent with Gupta *et al*., 2006 [20]. Vermicompost also reduced potassium fixation, maintaining a balance between non-exchangeable and exchangeable forms of potassium throughout the growth phase.

According to Vidyavathi *et al*., 2011 [21], applying organic manure enhances potassium availability by promoting the action of organic acids released during decomposition and by increasing the organic manure's capacity to retain potassium in an accessible form. Also, vermicompost contributes a substantial amount of nitrogen to the soil, releasing it gradually over an extended period.

4. CONCLUSION

Application of recommended dose of NPK (40-20-20 kg ha^{-1}) + vermicompost @ 0.5 t ha^{-1} can enhance the presence of organic matter, nitrogen, phosphorus and potassium in the soil under finger millet cultivation. This leads to increased finger millet productivity while ensuring adequate soil nutrition, maintaining soil health, and enriching soil microorganisms, thereby promoting long-term sustainability of soil resources.

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