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Effect of different Composts on Crop Productivity and Soil Fertility under Maize-Mustard Cropping Sequence

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ABSTRACT

Field experiment was conducted for two consecutive year's viz. 2023-24 and 2024-25 (August-February) at School of Agricultural Sciences, Nagaland University to study the effect of different composts on productivity of crops and soil fertility under maize-mustard cropping sequence. Treatments consisted of sole application of inorganic fertilizers in different proportions (100% RDF, 50% RDF, 30% RDF); sole application of phospho-sulpho-nitro (PSN) compost and Azolla compost; integrated application of inorganic fertilizer in different proportions with composts. Two years pooled data on crop productivity revealed that integrated application of inorganic fertilizer with PSN compost and Azolla compost exhibited maximum grain yield, straw yield and nutrients uptake in maize. In case of mustard; the second crop in the sequence, integrated application of inorganic fertilizer and PSN compost exhibited 6.74% and 4.23% increase in grain and straw yield respectively over sole application of inorganic fertilizer (T_2: 100% RDF). Improvement in pH, organic carbon available N, P & K content was recorded in post-harvest soil. Increment of 42.78% and 38.18% in soil microbial biomass carbon compared to control in T_6 (50% RDF+PSN compost @2.5 t ha^{-1}) and T_9 (50% RDF+ Azolla compost @2.5 t ha^{-1}) respectively along with greater dehydrogenase and phosphatase enzyme activities also indicated the positive impact of integrated application of composts on soil biological properties. The findings of the present investigation revealed the prospects of locally produced composts in increasing crop productivity and soil fertility in a sustainable manner under hilly land condition of Nagaland.

Keywords: *Azolla* compost, crop productivity, maize, mustard, phosphor-sulpho -nitro compost, soil fertility

INTRODUCTION

Maize is the second most important crop, next to rice in the Northeastern Himalayan Region of India, which is mostly grown under rainfed hilly upland conditions. Maize production has a significant role in ensuring food security in the region, used both for direct consumption and as well as for second cycle produce in piggery and poultry farming (Ansari *et al.*, 2015). The average productivity of maize in the region is very low (<1.5 t ha^{-1}) in the coarse textured rain-fed upland acidic soils with high runoff and soil erosions (>80 t ha^{-1}) (Patiram, 2007) despite high annual rainfall (>2000 mm) and rich in soil organic carbon content (Choudhury *et al.*, 2013). Adoption of marginal to almost negligible external inputs in the form of fertilizers and other agrochemicals often compounded further reduction in productivity. Maize is the second largest cereal crop grown in Nagaland with the highest acreage (0.68 m ha) among the NEH state (Kumar, 2015) with productivity 2039 kg ha^{-1} (Anonymous, 2016). Next to food grains, oilseed crops play an important role in Indian agricultural economy in regard to area and production. Rapeseed and mustard were selected to popularize under National Mission on Oilseeds and Oil palm (NMOOP, 2015-16) being two important oilseed crops in Indian context. Exploitation of the domestic resources and practices may be helpful in maximizing the production and productivity which ensures edible oil security of the country. Researchers have reported that HYVs of maize with better management practices have immense potential to increase the existing production level by 2-3 times in the hilly ecosystem of Northeastern Hill Region.

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The negative effect of chemical fertilizers on soil health and fertility can be nullified by the utilization of resources available with farmers for crop production (Jatoliya *et al.*, 2019). Application of organic manures before sowing enhance maize productivity and profitability besides enhancing soil fertility by supplying vital macro and micro-nutrient for crop growth (Ansari *et al.*, 2015). Soils fertility under maize cultivation has to be improved not only by adding nutrients but also by other soil amendments, like organic matter for maintaining the activity of soil organisms (Ngosai *et al.*, 2018). Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combinations of different organic manures like green manures, compost/vermicompost etc. and inorganic fertilizers (Chandrasekhar *et al.*, 2000). Integrated nutritional management practices are essential for restoring soil fertility, improving maize yield, and ensuring sustainable agricultural development (Bhurtiya *et al.*, 2025). Compost, an organic amendment, can potentially save energy compared to using synthetic inorganic fertilizers (Cheptoek *et al.*, 2021). Utilization of composted organic materials can be the perfect way to boost organic matter content in soil, enhancing acquisition of nutrients by plants and improving activity of soil microorganisms. Use of compost is beneficial in amending soil characteristics and thus promotes crop production (Kimani *et al.*, 2021). Organic farming is spreading in hilly areas (Shahane and Shivay, 2022) in India, where composts can be considered as one of the important inputs for soil health management.

Agriculture in Nagaland is organic by default. Increasing crop productivity by using chemical fertilizers is not an effective venture as surface run-off due to sloppy land accelerated by heavy rainfall reduces fertilizer use efficiency. On the other hand, there is abundant availability of crop residues including rice, maize, pulses and oilseeds along with diverse weed species (Bujarbaruah, 2004). There is scope for utilization of abundant crop residues and weed biomass for production of quality compost in the North-East hill region (Chatterjee *et al.*, 2016). Inclusion of nutrient-enriched compost in the integrated nutrient management schedule was found to be effective in increasing the productivity of field crops and gradual improvement in soil quality parameters in Northeastern states like Nagaland and Meghalaya (Bordoloi *et al.*, 2019). Considering the above facts, the present investigation was carried out with the objective to study the productivity of crops and soil fertility upon application of different composts under maize-mustard cropping sequence.

MATERIALS AND METHODS

Composts *viz.* PSN (phospho-sulpho-nitro) enriched compost and *Azolla* compost were produced using locally available materials, *viz.* banana pseudo stem, mixed weed biomass, paddy straw, *Azolla Caroliniana* biomass and cow dung; widely available in and around the campus of School of Agricultural Sciences, Nagaland University. The composts were prepared well ahead of start of field experiment (March-July, 2023 and 2024). Urea, rock phosphate and sulphur powder were used as mineral additives in recommended proportion for enrichment during production of PSN compost. Well-decomposed cow dung was added to freshly collected *Azolla* biomass to prepare the *Azolla* compost. The mixture of *Azolla* + cow dung was kept for 1 month for curing. The mature composts were harvested in approximately 3.5 months ±10 days. Compost samples were analyzed for chemical constituents using standard procedures.

The field experiment was conducted during the month of August-February for two consecutive years *viz.* 2023-24 and 2024-25 at School of Agricultural Sciences, Nagaland University. Maize (var: RCM-76) and Mustard (var: TS-67) were grown in sequence as test crops with ten different treatments, each replicated thrice in randomized block design.

Grain and straw yield of test crops were recorded for individual treatments and expressed in q ha^{-1}. Plant samples were oven dried, grounded and analyzed for nutrient contents. The plant materials were digested with concentrated sulphuric acid in presence of digestion mixture. Nitrogen in digested plant samples were determined by kjeldhal method (Jackson, 1973). The phosphorus, potassium and sulphur content in plant samples was determined by wet digestion method. Plant samples were digested in di-acid mixture *i.e.* (HNO_3:$HClO_4$= 3:1). The phosphorus content in digested plant extract was determined by Vanadomolybdate yellow colour method, potassium content was determined by flame photometry (Jackson, 1973). Turbidimetric method was employed to determine sulphur content in digested plant extract (Chesnin and Yien, 1951). Nutrient uptake (kg ha^{-1}) in grain and straw samples was calculated by multiplying nutrient content (%) by yield (kg ha^{-1}) and dividing by 100.

Soil samples were collected in both the experimental years after harvest of the second crop in sequence i.e. mustard. Standard procedures were used for determination of soil properties after. Core method was used to determine the bulk density (Chopra and Kanwar, 1982). Pycnometer method was used to determine the particle density (Sharma, 2011). The porosity of the soils was calculated by using the formula, Porosity (%) = (1-bulk density/particle density) x 100. The water holding capacity was determined using Keen Raczkowski boxes (Piper, 1966). pH was determined in 1: 2.5 soil: water suspension using glass electrode pH meter (Jackson,1973). Organic carbon in soil was determined by wet oxidation method (Walkley and Black, 1934). Available nitrogen content in soil was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorus content in soil was determined by adopting Bray's and Kurtz No.1 method (Bray and Kurtz, 1945). Available potassium content in soil was determined by neutral normal ammonium acetate method (Jackson, 1973). Turbidimetric method was followed to determine the available sulphur content in the soil (Chesnin and Yien, 1951). Exchangeable calcium and magnesium content in soil was determined by Versenate method (Richards, 1954). Microbial biomass carbon content in soil was determined following the fumigation extraction method as described by Vance *et al.* (1987). Dehydrogenase enzyme activity (DHA) was determined by the 2-3-5-triphenyl tetrazolium chloride reduction technique (Casida, 1977) and acid phosphatase activity (PHA) was determined by the *p*-nitrophenyl phosphate method (Tabatabai and Bremner, 1969). Appropriate statistical methods were used for analyzing the data.

RESULTS AND DISCUSSION

Chemical constituents of compost

Chemical constituents of matured PSN and *Azolla* compost are presented in Table 1. Higher organic carbon was recorded in *Azolla* compost followed by PSN compost. PSN compost recorded substantial nitrogen content with higher phosphorus and potassium.

Table 1: Chemical constituents of matured compost

Compost	OC (%)	Total c(%)	Total n (%)	Total ph (%)	Total K (%)
PSN compost	12.90	18.66	2.00	0.59	1.9
Azolla compost	16.90	30.91	3.00	0.38	1.7

Yield of maize and mustard

Significant variation was recorded in the grain and straw yield of maize among different treatments. The maximum grain and straw yield were recorded in T_2 treatment with 100% RDF, which was at par with treatment T_6 with 50% RDF + PSN compost followed by treatment T_9 with integrated application of 50% RDF + *Azolla* compost. In case of mustard, the second crop in the sequence, integrated application of inorganic fertilizer and PSN compost (T_6) recorded significantly higher grain (11.87 q ha^{-1}) and straw yield (21.25 q ha^{-1}) compared to sole application of recommended fertilizers in different doses (Table 2). Significantly higher grain yield recorded in the treatment may be attributed to superior yield parameters *viz.,* cob length/ siliqua length and number of grain cob^{-1}/ $siliqua^{-1}$ as experienced during the investigation. Higher vegetative growth recorded by these treatments might have also helped the plant to assimilate more photosynthates from source to sink. Higher N, P, K content in grain and straw of maize and mustard in the PSN and *Azolla* compost treated

Table 2: Effect of integrated application of compost on yield of maize and mustard

Treatment	Maize yield (q ha^{-1})		Mustard yield (q ha^{-1})	
	Grain	Straw	Grain	Straw
T_1: Farmer's practice	$18.99^{f} \pm 1.13$	$38.68^{f} \pm 0.28$	$5.82^{h} \pm 0.24$	$14.11^{f} \pm 0.21$
T_2: 100% RDF	$32.39^{a} \pm 0.39$	$51.15^{a} \pm 0.15$	$11.12^{b} \pm 0.19$	$20.39^{b} \pm 0.20$
T_3: 50% RDF	$26.46^{c} \pm 0.46$	$46.24^{c} \pm 0.29$	$9.42^{d} \pm 0.44$	$19.57^{c} \pm 0.25$
T_4: 30% RDF	$22.13^{e} \pm 0.13$	$40.89^{e} \pm 0.14$	$6.99^{g} \pm 0.13$	$15.50^{e} \pm 0.22$
T_5: PSN compost	$23.89^{d} \pm 0.17$	$43.59^{d} \pm 0.42$	$7.29^{f} \pm 0.22$	$14.78^{f} \pm 0.25$
T_6: 50% RDF + PSN compost	$31.42^{a} \pm 0.46$	$50.00^{a} \pm 0.18$	$11.87^{a} \pm 0.19$	$21.25^{a} \pm 0.23$
T_7: 30% RDF + PSN compost	$25.00^{c} \pm 0.13$	$45.18^{c} \pm 0.20$	$7.54^{f} \pm 0.27$	$15.64^{e} \pm 0.16$
T_8: Azolla compost	$23.68^{d} \pm 0.28$	$43.43^{d} \pm 0.41$	$6.67^{g} \pm 0.24$	$14.85^{f} \pm 0.22$
T_9: 50% RDF + *Azolla* compost	$29.30^{b} \pm 0.29$	$48.46^{b} \pm 0.49$	$10.27^{c} \pm 0.22$	$19.89^{c} \pm 0.14$
T_{10}: 30% RDF + *Azolla* compost	$25.54^{c} \pm 0.49$	$45.75^{c} \pm 0.50$	$8.65^{e} \pm 0.11$	$16.87^{d} \pm 0.12$
CD (5%)	1.10	1.05	0.45	0.40

RDF= recommended dose of fertilizer, PSN compost= phospho sulpho nitro compost
The small letters superscripts are used to show the significant difference in mean values at 5% level

plots may also be attributed for higher grain and straw yield of the crops as nitrogen specifically stimulates photosynthetic capture, while phosphorus and potassium contribute to stronger stalks and improve stover yield. Singh and Sukul (2019) recorded the maximum grain yield in maize due to combined application of inorganic fertilizer, vermicompost, farmyard manure and fly ash. Composts mitigate soil pH variations and reduce nutrient leaching, creating stable environments conducive to growth of maize and mustard. In conformity with the present findings, Seleiman *et al.* (2022) reported optimal growth and the highest yield components of rice in combination of 40% NPK + 60% *Azolla* compost or 50% NPK + 50% *Azolla* compost. Moreover, compost contributes to the stabilization and increase crop productivity due to its multiple positive effects on the physical, chemical and biological soil properties (Adugna, 2016), which was evident in the present investigation.

Nutrient uptake by maize and mustard

Nitrogen uptake

Significantly higher N-uptake by maize grain was recorded in treatment T_2 (100% RDF) followed by treatment T_6 (50% RDF + PSN compost). On the other hand, maximum N-uptake by mustard grain and straw was recorded in treatments with combined application of 50% RDF+PSN compost (T_6) and 50% RDF+ azolla compost (T_9) (Table 3). Enriched compost application, which was fortified with urea might have made more nitrogen available in soil for easy uptake by plants and increasing its content in plant parts (1.65% and 1.09% in maize grain and straw respectively). High yield along with high nitrogen content in grain and straw for both maize and mustard in integrated application of PSN compost and inorganic fertilizer might have exhibited increased uptake of nitrogen in the treatment. Similar results were reported Baradhan *et al.* (2022). *Azolla* on the other hand, decomposes quickly and releases the fixed nitrogen quickly, facilitating good crop growth. Quick nitrogen release, easy accumulation of released nitrogen along with good grain yield may be accounted for high nitrogen uptake in treatment T_9. Similar results were reported by Thapa and Poudel (2021).

Phosphorus uptake

Significantly higher P-uptake by maize grain and straw was recorded in treatment T_2 (100% RDF) followed by treatment T_6 (50% RDF+ PSN compost) followed by treatment T_9 (50% RDF+ azolla compost). However, significantly higher grain and straw P-uptake in case of mustard was recorded in treatment T_6 with integrated application of PSN compost and inorganic fertilizer (Table 3). The high grain phosphorus uptake in treatment T_6 (50% RDF+ PSN compost) may be because of consistent supply of phosphorus by enriched compost where phosphorus enrichment was done by adding rock phosphate. Similar results were reported by Verma *et al.* (2018). Moreover, increased microbial activity in treatments with combined application of compost might have facilitated release of fixed phosphorus in soil and subsequent increased uptake. The results

Table 3: Effect of integrated application of compost on nutrient uptake by maize and mustard

Treatment	Maize						Mustard					
	Nutrient uptake (kg ha^{-1})											
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	25.10^{f} ±0.03	29.36^{f} ± 0.13	7.33^{f} ± 0.08	6.26^{f} ± 0.05	8.98^{f} ± 0.04	35.54^{f} ± 0.06	14.78^{f} ± 0.04	4.09^{f} ± 0.07	5.70^{f} ± 0.15	11.71^{f} ± 0.07	7.80^{f} ± 0.05	13.40^{f} ± 0.07
T_2	53.44^{a} ± 0.82	53.20^{b} ± 0.13	23.00^{a} ± 1.36	15.35^{a} ± 0.19	28.83^{a} ± 0.06	78.26^{a} ± 0.12	31.58^{b} ± 0.04	8.16^{b} ± 0.08	13.46^{b} ± 0.22	22.02^{a} ± 0.04	19.90^{b} ± 0.02	22.84^{a} ± 0.09
T_3	41.81^{c} ± 0.24	45.32^{c} ± 0.15	16.41^{c} ± 0.48	11.10^{c} ± 0.15	20.77^{c} ± 0.08	65.66^{b} ± 0.06	26.00^{c} ± 0.03	7.08^{c} ± 0.09	10.93^{c} ± 0.05	19.63^{b} ± 0.05	16.20^{c} ± 0.04	21.86^{b} ± 0.09
T_4	31.20^{e} ± 0.31	36.00^{e} ± 0.04	12.17^{e} ± 0.21	7.77^{e} ± 0.15	15.27^{e} ± 0.03	48.66^{e} ± 0.05	18.59^{e} ± 0.08	4.50^{e} ± 0.10	7.76^{e} ± 0.18	13.18^{e} ± 0.09	10.90^{e} ± 0.02	15.93^{e} ± 0.05
T_5	35.12^{d} ± 0.13	40.54^{d} ± 0.18	14.57^{d} ± 0.15	10.90^{c} ± 0.11	16.96^{e} ± 0.05	56.23^{d} ± 0.11	19.76^{e} ± 0.04	5.91^{d} ± 0.03	8.24^{e} ± 0.07	14.93^{d} ± 0.03	11.81^{e} ± 0.03	15.22^{e} ± 0.13
T_6	50.19^{b} ± 0.29	54.48 ± 0.17^{a}	21.60^{b} ± 0.23	14.49^{b} ± 0.16	26.47^{b} ± 0.03	75.47^{a} ± 0.09	35.37^{a} ± 0.09	8.93^{a} ± 0.03	14.13^{a} ± 0.05	22.53^{a} ± 0.07	21.01^{a} ± 0.03	23.80^{a} ± 0.09
T_7	38.50^{d} ± 0.28	43.37^{c} ± 0.08	15.00^{c} ± 0.04	9.97^{d} ± 0.13	19.20^{d} ± 0.02	60.09^{c} ± 0.11	19.98^{e} ± 0.02	5.79^{d} ± 0.05	8.68^{e} ± 0.05	14.23^{d} ± 0.10	12.67^{d} ± 0.04	16.11^{e} ± 0.04
T_8	34.10^{e} ± 0.02	43.86^{c} ± 0.15	13.73^{d} ± 0.38	8.69^{e} ± 0.12	15.98^{e} ± 0.03	53.42^{d} ± 0.04	18.40^{e} ± 0.03	5.94^{d} ± 0.02	7.34^{f} ± 0.08	12.92^{e} ± 0.04	11.01^{e} ± 0.03	15.00^{e} ± 0.02
T_9	47.17^{c} ± 0.03	52.82^{b} ± 0.14	19.34^{b} ± 0.17	12.12^{c} ± 0.13	25.34^{b} ± 0.02	67.84^{b} ± 0.12	28.76^{c} ± 0.74	8.15^{b} ± 0.07	11.91^{c} ± 0.04	18.89^{c} ± 0.09	17.66^{c} ± 0.04	22.08^{b} ± 0.02
T_{10}	39.33^{d} ± 0.08	44.51^{c} ± 0.09	15.83^{c} ± 0.13	9.54^{d} ± 0.09	19.74^{d} ± 0.05	62.68^{c} ± 0.10	22.10^{d} ± 0.09	5.40^{e} ± 0.08	9.18^{d} ± 0.09	15.01^{d} ± 0.07	13.33^{d} ± 0.04	17.88^{d} ± 0.05
CD (5%)	0.65	0.50	0.63	0.51	0.70	0.55	0.71	0.52	0.72	0.53	0.72	0.50

T_1: Farmer's practice, T_2: 100% RDF, T_3: 50% RDF, T_4: 30% RDF, T_5: PSN compost, T_6: 50% RDF + PSN compost, T_7: 30% RDF + PSN compost, T_8: Azolla compost, T_9: 50% RDF + Azolla compost, T_{10}: 30% RDF + Azolla compost
The small letters superscripts are used to show the significant difference in mean values at 5% level

were in conformity with the results of Paramesh *et al.* (2014).

Potassium uptake

Significantly higher Potassium uptake by maize and mustard grain and straw was recorded. Maize plants under the treatment T_2 (100% RDF) recorded maximum K-uptake while comparable potassium uptake by maize and mustard plants were recorded under the treatments with integrated application of PSN and *Azolla* compost in different proportions of inorganic fertilizer (Table 3). Increased potassium uptake by the crop due to addition of inorganic fertilizer might be because of enhanced availability of potassium in soil. Similar results were obtained by Ghosh *et al.* (2017). Balanced use of various plant nutrient sources results in proper absorption, translocation and assimilation of nutrients, ultimately increasing the dry matter accumulation and nutrient contents of crops and thus showing more uptakes of elemental nutrients. The same was evidenced in the present investigation also. The balanced use of enriched compost and azolla compost along with inorganic fertilizer provided adequate amount of nutrients along with potassium to be taken up by plants and thereby influencing its uptake. The results were in close conformity with Meena *et al.* (2021).

Soil fertility parameters

Physical properties

Analysis of soil samples collected after the harvest of second crop in sequence indicated improvement in soil physical properties due to compost application compared to initial soil and inorganic fertilizer treatments. Significant decrease in bulk density (BD), particle density (PD) and increase in water holding capacity (WHC) was recorded, with minimum BD (1.32 g cm^{-3}) in T_6 followed by T_7 (1.33 g cm^{-3}) and T_9 (1.33 g cm^{-3}) treatments in which integrated application of PSN compost and *Azolla* compost was done with different doses of inorganic fertilizer (Table 4). Decrease in BD of soil in compost treatment may be due to supplementation of organic matter through compost compared to control or initial soil where external addition of organic

Table 4: Effect of integrated application of compost on soil fertility parameters

Treatment	Soil fertility parameters										
	BD (gcc^{-1})	PD (gcc^{-1})	WHC (%)	pH	OC (%)	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	SMBC (µg/g soil)	Dehydrogenase (µg TPF g^{-1} h^{-1})	Phosphatase (µg PNP g^{-1} h^{-1})
T_1	1.36^{e} ± 0.01	2.68^{c} ± 0.02	39.12^{e} ± 0.17	5.39^{d} ± 0.01	0.73^{e} ± 0.03	206.23^{f} ± 1.50	17.36^{e} ± 1.20	138.50^{e} ± .90	210.46^{f} ± 1.62	2.43^{g} ± 0.25	300.69^{g} ± 0.61
T_2	1.35^{d} ± 0.01	2.68^{c} ± 0.02	39.56^{d} ± 0.36	5.41^{c} ± 0.01	0.85^{b} ± 0.03	276.42^{b} ± 2.60	22.00^{b} ± 0.02	156.20^{a} ± 2.10	221.11^{e} ± 0.94	4.34^{e} ± 0.04	312.45^{f} ± 1.28
T_3	1.36^{e} ± 0.01	2.68^{c} ± 0.02	39.11^{e} ± 0.17	5.39^{d} ± 0.01	0.79^{d} ± 0.04	267.12^{c} ± 2.60	18.90^{d} ± 1.20	149.00^{b} ± 0.02	238.80^{d} ± 1.62	4.17^{f} ± 0.11	309.36^{f} ± 0.86
T_4	1.36^{e} ± 0.01	2.68^{c} ± 0.02	39.11^{e} ± 0.17	5.39^{d} ± 0.01	0.78^{d} ± 0.02	244.65^{e} ± 1.20	18.00^{d} ± 0.03	141.11^{e} ± 0.90	233.80^{d} ± 0.91	3.14^{f} ± 0.10	309.11^{f} ± 0.56
T_5	1.34^{c} ± 0.01	2.67^{d} ± 0.01	41.13^{b} ± 0.18	5.41^{c} ± 0.02	0.79^{d} ± 0.04	260.19^{d} ± 1.30	19.64^{c} ± 0.90	144.00^{c} ± 0.04	280.78^{b} ± 1.36	5.38^{c} ± 0.07	386.71^{c} ± 1.13
T_6	1.32^{a} ± 0.01	2.68^{c} ± 0.02	42.52^{a} ± 0.48	5.46^{a} ± 0.01	0.87^{a} ± 0.03	281.34^{a} ± 1.40	25.98^{a} ± 0.80	155.81^{a} ± 0.90	299.97^{a} ± 1.40	5.92^{a} ± 0.06	400.01^{a} ± 0.02
T_7	1.33^{b} ± 0.01	2.61^{a} ± 0.02	39.74^{d} ± 0.30	5.42^{b} ± 0.02	0.79^{d} ± 0.04	277.86^{b} ± 1.70	19.96^{c} ± 0.07	143.00^{d} ± 0.05	270.64^{c} ± 1.77	4.92^{d} ± 0.04	373.33^{d} ± 1.92
T_8	1.34^{c} ± 0.02	2.68^{c} ± 0.02	39.60^{d} ± 0.34	5.39^{d} ± 0.01	0.78^{d} ± 0.02	257.88^{d} ± 2.50	18.25^{d} ± 0.90	144.00^{c} ± 0.04	273.01^{c} ± 0.82	5.00^{d} ± 0.01	380.05^{d} ± 1.32
T_9	1.33^{b} ± 0.01	2.66^{b} ± 0.02	43.06^{a} ± 0.12	5.46^{a} ± 0.02	0.84^{b} ± 0.03	279.46^{a} ± 2.10	21.05^{b} ± 0.14	149.36^{b} ± 0.28	290.82^{a} ± 0.88	5.73^{b} ± 0.04	388.55^{b} ± 1.35
T_{10}	1.34^{c} ± 0.02	2.67^{b} ± 0.02	40.48^{c} ± 0.25	5.42^{b} ± 0.02	0.81^{c} ± 0.02	279.15^{a} ± 1.00	22.50^{b} ± 0.40	143.29^{c} ± 0.27	269.63^{c} ± 0.49	4.90^{d} ± 0.06	371.35^{e} ± 1.41
CD (5%)	0.02	0.02	0.50	0.02	0.04	2.50	1.00	1.50	5.0	0.15	3.0
Initial soil test value	1.36	2.68	39.12	5.39	0.77	202.00	20.50	140.45	208.89	1.39	300.45

T_1: Farmer's practice, T_2: 100% RDF, T_3: 50% RDF, T_4: 30% RDF, T_5: PSN compost, T_6: 50% RDF + PSN compost, T_7: 30% RDF + PSN compost, T_8: Azolla compost, T_9: 50% RDF + Azolla compost, T_{10}: 30% RDF + Azolla compost

The small letters superscripts are used to show the significant difference in mean values at 5% level matter in soil was not there. Similar results were reported by Kannan *et al.* (2005). Organic matter like vermicompost and enriched compost enhanced soil physical properties at the time of crop establishment and early growth. Incorporation of vermicompost and enriched compost before sowing had greater beneficial impact, especially on physical properties of soil such as bulk density etc. (Shukla and Tyagi, 2009). Increased addition of organic matter through compost can be held responsible for increase in porosity and subsequent increase in water holding capacity. Kannan *et al.* (2005) also reported increase in soil porosity and water holding capacity due to application of vermicompost and other composts. Improvement in water holding capacity of soil due to addition of compost as compared to control was also reported by Dsouza *et al.* (2018).

Chemical properties

Improvement in soil chemical properties was recorded due to application of different composts. Significant increase in pH of soil was recorded in treatment T_6 and T_9 in which PSN compost and *Azolla* compost was integrated with 50% of recommended dose of inorganic fertilizer (Table 4). Integrated application of compost and inorganic fertilizer significantly enhanced organic carbon content in soil up to 0.14% and 0.11% in treatment T_6 and treatment T_9 respectively over farmer's practice. Treatment T_6 (50% RDF+PSN compost) recorded significantly higher available nitrogen, available phosphorus content in soil followed by treatment T_9 (50% RDF+ *Azolla* compost). However, treatment T_2 with 100% recommended dose of fertilizer recorded maximum content of available potassium in soil. Availability of secondary nutrients like sulphur, calcium and magnesium was also recorded maximum in the treatments where compost especially PSN compost was applied in combination with inorganic fertilizer (Table 4).

The increase in pH due to application of various composts may be because of increase in cation exchange capacity induced by compost that might have increased the concentration of basic nutrients in soil. Moreover, near neutral compost materials used in the experiment might have helped in increased soil pH in treatment with PSN and *Azolla* compost. The results of present findings are in line with Nagar *et al.* (2016) and Meena *et al.* (2021) who have also reported increased pH of soil with the application of phospho enriched compost. Significant increase in pH of soil in the treatments receiving azolla incorporation compared to the sole application of urea was reported by Singh (2020). The high organic carbon in compost treatments either alone or in combination may be due to high organic matter addition through composts. Compost application might have added stable organic matter that have decomposed slowly, enriching the soil with organic carbon through microbial activity and promoting soil aggregation, which protects carbon from further decomposition. The findings of present investigation are in conformity with findings of Oo *et al.* (2015). High available nitrogen content in soil treated with compost, especially in the treatment T_6 and T_9 with integrated application of PSN and *Azolla* compost with inorganic fertilizer probably due to high organic matter and organic carbon supplied by compost as well as root biomass. High available nitrogen in compost treated soil can also be attributed to favorable environment for effective mineralization facilitated by more microorganism population. Moreover, enrichment of PSN compost with urea and high nitrogen content in *Azolla* compost might also have contributed to more available nitrogen in those treatments. Meena *et al.* (2021) have also reported similar results. Billah *et al.* (2020) reported increase in nitrate nitrogen content of soil treated with rock phosphate enriched compost. High available phosphorus in enriched compost added soils may be because of the compost material that has been fortified with rock phosphate. The slow-release phosphorus from rock phosphate enriched compost might have made the native as well as bound phosphorus available in soil for plant uptake. The increased phosphorus availability may also be due to formation of organic chelates with higher stability, which have lower fixation and adsorption possibility in soil. The findings of present investigation are in conformity with Biswas (2011), Billah *et al.* (2020). The high available potassium in RDF treatment may be attributed to effect of fertilizer muriate of potash (MOP) application. Higher available potassium in enriched compost treatment may be due to release of labile potassium from the compost source owing to favorable microclimate. The significant increase in potassium content may also be attributed to efficient mineralization of potassium rich compost by microorganisms. Similar findings were reported by Marzouk *et al.* (2024). The maximum available sulphur in soils with enriched compost (T_6) treatment may be the result of sulphur enrichment in the compost. The high sulphur content in treatment T_6 may also be attributed to high organic matter content and available nitrogen in the treatment. High content of calcium and magnesium due to application of PSN compost may be attributed to role of organic matter and microbial activity. Increased calcium concentration in the treatment may be attributed to increase in CEC augmented by compost application. These results are in agreement with Dsouza *et al.* (2018) and Marzouk *et al.* (2024).

Biological properties

Compost application exhibited enhancement in biological properties of soil. Superior biological properties in terms of higher soil microbial biomass carbon, dehydrogenase and phosphatase enzyme activity were recorded in treatment T_5, T_6, T_7, T_8, T_9 and T_{10} with sole or integrated application of PSN and *Azolla* compost (Table 4). Increased amount of microbial biomass carbon in the compost treatments may be due to the higher amount of substrate materials or organic matter available for microbial consumption and thus increase in their population. Makova *et al.* (2019) also reported high soil microbial biomass carbon due to application of compost and vermicompost. The soil microbial biomass carbon increased with increased fertility levels (Gogoi *et al.*, 2010). Dehydrogenase activity is dependent on addition of number and amount of nutrients. The high amount of substrate material in the form of organic matter in the compost treatments may be the cause of more population of oxidative bacteria that have released the dehydrogenase enzyme in the soil. The result of the present investigation was in conformity with result of Mallikarjun and Maity (2018). Significant increase in soil microbial biomass carbon, dehydrogenase and acid phosphate activity application of soil amendments was reported by Kumawat *et al.* (2025).

Results of the present investigation revealed the benefit of compost application on crop productivity and soil fertility. However, the effect was more pronounced in case of the second crop in the sequence indicating the gradual build-up of residual soil fertility due to continuous application of compost. The results also revealed that integrated application of PSN enriched compost and azolla compost with inorganic fertilizer can provide enough nutrient to arable crops, through better mineralization augmenting microbial activity while storing a substantial amount of nutrient in soil. Hence, integrated application of quality composts along with reduced amount of inorganic fertilizer can be advocated as sustainable soil management practice under Nagaland condition.

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