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Effect of Organic Manures on Soybean [*Glycine max* (L.) Merrill] Performance and Soil Properties in Northeast of India, Nagaland

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ABSTRACT

Background: In 2022, a study was conducted at Nagaland University, Medziphema, to examine the impact of various organic nutrient sources on soybean growth, yield and soil properties during the *kharif* season.

Methods: The experiment utilized a completely randomized design with nine treatments, including a control group and aimed to evaluate the performance of the MACS 1460 soybean variety. The experiment included treatments such as farmyard manure (FYM) at different rates, vermicompost, poultry manure and pig manure, applied at varying quantities.

Result: Application of poultry manure at 3 t ha^{-1} demonstrated superior performance in terms of plant growth, yield and soil nutrient content, making it the optimal nutrient management practice for enhancing soybean productivity and soil properties in this specific context. Additionally, poultry manure at this rate significantly improved protein and oil content in the soybean.

Key words: Organic manures, Poultry manure, Soil properties, Soybean, Yield attributes.

INTRODUCTION

Soybean, also known as the “Golden Bean” of the 20th century (Khadar, 2019) owing to its tremendous nutritional value is a significant legume crop in India. It is an outstanding crop in India, as within a short period of time there has been an unprecedented growth in soybean area which was just 0.03 m ha in 1970 (Agarwal *et al.,* 2013) and has reached to 11.34 million hectares in 2019-20 (Soybean Outlook, 2022). In North Eastern India, soybean is cultivated on diverse landscape such as slopes, *jhum* land, terraces and plains. In Nagaland, it is cultivated in almost all districts either as a mono-crop or intercropped along with maize, ragi, pigeon pea, as well as other pulse crops (Kichu and Singh, 2013). Locally, soybean is widely consumed by the majority of Nagas as a pulse crop and as a fermented product called as “Akhone” or “Axone”. Regardless of its popularity in Naga dishes, there is no large-scale cultivation and commercial production of soybean in Nagaland. The constraints of soybean cultivation in Nagaland are climatic conditions like erratic behavior of monsoon affecting planting, poor adoption of technology, casual approach of farmers towards soybean cultivation and poor management of soil and nutrient management. Chemical fertilizers are crucial for improving crop output; however frequent use of these fertilizers reduces the fertility and productivity of the soil. In recent years, there is a growing interest in using organic manures as a source of nutrients for crop production in order to optimize the use of natural fertilizers and promote soil productivity and ecological stability, reducing the use of chemical fertilizers. Various organic manure sources including poultry manure, pig manure, vermicompost and FYM, promote the soil’s structure, aeration and water-holding capacity. Organic manures particularly vermicompost and FYM are readily accessible in the market. The advantages of using organic manures are it improves the soil biology, increases nutrient solubility, modifies the soil pH, which helps the plants to absorb macro and micronutrients (Alabadan *et al*., 2009). Unlike synthetic fertilizers, which can contribute to water pollution and have negative impacts on the aquatic ecosystems, organic manures are less likely to cause these issues. They are generally safer for the environment and do not have harmful effects on human health. Hence, the study was undertaken to evaluate the effect of organic manures on soybean performance and soil properties.

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MATERIALS AND METHODS

A pot experiment was conducted at the Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences, Medziphema, Nagaland University during *kharif* season, 2022. The soil observed at the experimental site exhibited favourable drainage characteristics and possessed a sandy loam texture. The initial fertility status of the soil was found to be acidic (pH 5.62), low in available N (220.26 kg ha^{-1}), medium in available P (18.44 kg ha^{-1}) and available K (126.80 kg ha^{-1}),

high in organic carbon (0.92%). The experiment consisted of nine treatments T_1 (Control), T_2 (FYM @ 1.5 t ha^{-1}), T_3 (FYM @ 3 t ha^{-1}), T_4 (vermicompost @ 1.5 t ha^{-1}), T_5 (vermicompost @ 3 t ha^{-1}), T_6 (poultry manure @ 1.5 t ha^{-1}), T_7 (poultry manure @ 3 t ha^{-1}), T_8 (pig manure @ 1.5 t ha^{-1}) and T_9 (pig manure @ 3 t ha^{-1}). Treatments were tested in CRD with three replications. Organic manures were applied to each pot according to the pre-planned doses made specifically for each pot. Organic manures were incorporated into the pots, except the control pot one month before sowing for proper decomposition of organic manures. Intercultural operations and plant protection measures were performed in accordance with the requirements. The observations were recorded from randomly selected plants from each pot on different growth, yield and yield attributes. The soil samples from each pot were collected after crop harvest. The samples were air-dried in shade, ground using a wooden pestle and mortar and passed through a 2 mm sieve and stored in polythene bags and analyzed for various soil parameters using standard methods. The recorded observations were then statistically analysed by ANOVA.

RESULTS AND DISCUSSION

Growth attributes

Application of organic manures had significant effect on plant height, number of leaves plant^{-1}, number of nodules plant^{-1}, nodule fresh weight and dry weight, which was represented in Table 1. Amongst the nine treatments, the treatment of poultry manure @ 3 t ha^{-1} resulted in the tallest plant height (65.93 cm) and maximum number of leaves per plant (16.21) at 60 DAS. This could be attributed to the presence of additional nutrients in poultry manure as opposed to other treatments. This result was consistent with the findings of Azuka *et al*. (2022). Analogous results were reported by Rovizelhou and Singh (2021). At flowering maximum number of nodules, nodule fresh weight and dry weight was found in the FYM @ 3 t ha^{-1} which measured 52.91, 0.92 g and 0.24 g respectively. Incorporation of FYM @ 3 t ha^{-1} recorded highest number of nodules, nodule fresh and dry weight due to the addition of more organic matter and better soil health supplied through FYM over other organic manures. Similar studies were recorded by Lakshman *et al*. (2015).

Yield attributes and yield

Table 2 represents the effects of different treatments on the number of pod plant^{-1}, filled pods plant^{-1}, seeds pod^{-1}, seed yield and stover yield. The data presented clearly showed significant variations among the treatments in terms of pod plant^{-1}, filled pods plant^{-1}, seed yield and stover yield. However, among all the treatments poultry manure @ 3 t ha^{-1} demonstrated the highest number of pods plant^{-1} (50.03), filled pods plant^{-1} (46.28) and seeds pod^{-1} (2.82), seed yield (57.68 g pot^{-1}) and stover yield (71.77 g pot^{-1}). The control pot exhibited the lowest number of pods plant^{-1}

Table 1: Effect of organic sources of nutrients on plant growth attributes.

Treatments	Plant height		No. of leaves plant^{-1}		No. of nodules plant^{-1}	Nodule fresh wt. plant^{-1} (g)	Nodule dry wt. plant^{-1} (g)
	30 DAS	60 DAS	30 DAS	60 DAS			
T_1- Control	19.74	41.9	3.95	16.21	32.08	0.57	0.12
T_2- FYM@1.5 t ha^{-1}	23.28	45.28	4.5	20.18	49.12	0.85	0.2
T_3- FYM@ 3 t ha^{-1}	25.84	54.63	5.43	35.62	52.91	0.92	0.24
T_4- Vermicompost @1.5 t ha^{-1}	25.13	52.31	5.33	28.67	41.96	0.74	0.18
T_5- Vermicompost @3 t ha^{-1}	31.38	59.57	7.58	37.23	50.02	0.87	0.21
T_6- Poultry manure @1.5t ha^{-1}	27.87	54.85	6.34	32.34	38.14	0.65	0.14
T_7- Poultry manure @ 3 t ha^{-1}	33.21	65.93	8.61	39.5	41.07	0.71	0.18
T_8- Pig manure @ 1.5 t ha^{-1}	22.06	44.03	4.83	20.17	39.48	0.68	0.15
T_9- Pig manure @ 3 t ha^{-1}	24.25	51.99	5.22	33.17	42.28	0.73	0.18
SEm±	1.1	2.25	0.41	1.41	1.36	0.108	0.012
CD (P = 0.05)	3.28	6.71	1.23	4.21	4.04	0.01	0.037

(36.41), filled pods plant^{-1} (35.13), seeds pod^{-1} (2.22), seed yield (40.26 g pot^{-1}) and stover yield (53.06 g pot^{-1}). Similar results were reported by Soysal. (2021). The treatment poultry manure @ 3 t ha^{-1} outperformed the other treatments due to the fact that the availability of higher nutrients to plants through poultry manure compared to other treatments. Analogous results were given by Tagore *et al*. (2010); Kaur and Verma, (2016); Joshi *et al*. (2016).

Quality attributes

Data represented in Table 3 depicts the influence of different treatments on protein content and oil content. The results revealed significant variations among the treatments in terms of seed protein and oil content. Maximum protein content was observed in the treatment poultry manure @ 3 t ha^{-1} with 38.51% and Minimum protein content was recorded under control pot with 34.83%. Elevated protein content under the treatment poultry manure @ 3 t ha^{-1} is possibly a result of greater nitrogen supply from poultry manure and the fact that nitrogen is a crucial component of amino acids, which serve as the fundamental building blocks of proteins (Bommesha *et al.,* 2012). Maximum oil content was observed in the treatment poultry manure @ 3 t ha^{-1} with 17.87% and minimum oil content was measured under control pot with 15.85%. The treatment with poultry manure applied @ 3 t ha^{-1} exhibited the highest oil content. This could be credited to the provision of well-balanced nutrition and ample organic nutrients, which likely facilitated the conversion of primary fatty acid metabolites into end products of fatty acids, ultimately leading to an increase in oil content within the seeds (Singh and Rai, 2004). Analogous results were given by Rovizelhou and Singh (2021).

Soil properties

Soil physicochemical properties

Table 4 presents the results of an experiment evaluating the effects of different treatments on soil physicochemical properties *viz*., bulk density, particle density, porosity, soil pH and CEC of the soil after harvest. From the scrutiny of the data maximum bulk density and particle density were observed under the treatment FYM @ 3 t ha^{-1} with 1.32 g cm^{-3} and 2.21 g cm^{-3} respectively. Minimum bulk density, particle density and maximum porosity was observed under the treatment Vermicompost @ 1.5 t ha^{-1}. The analysis of the data shows maximum soil pH was observed in the treatment vermicompost @ 3 t ha^{-1} with 5.84. Similar results were given by Shiny *et al*. (2024). Minimum soil pH was recorded under treatment FYM @ 1.5 t ha^{-1} with 5.66. In terms of CEC, maximum soil CEC was observed in the treatment vermicompost @ 3 t ha^{-1} with 12.84 cmol(p+) kg^{-1} and minimum soil CEC was measured under control with 10.89 cmol(p+) kg^{-1}. The results indicated that none of the treatments had a significant effect on these parameters. However, it is important to note that non-significant effects are expected in the short term, as soil physicochemical properties tend to remain relatively stable over a short period of time. It is well-documented and scientifically established that the addition of organic manures can improve soil physicochemical properties. However, significant changes in these properties typically require long-term application of organic manure. In this study, all treatments received organic sources, which may explain the lack of significant effects on soil physicochemical properties. These findings align with the findings reported by Anonymous (2013).

Soil fertility parameters

The experimental findings analyzing the effect of various treatments on soil fertility parameters *viz*., available N, P, K and organic carbon after harvest are shown in Table 5. From scrutiny of the data, it is observed that different organic manures significantly influenced the available N and K in soil after harvest. Poultry manure @ 3 t ha^{-1} exhibited the highest available N, P and organic carbon content after harvest with 225.18 kg ha^{-1}, 20.82 kg ha^{-1} and 1.20% respectively. Similar findings were reported by Azuka *et al*. (2022). Maximum available K after harvest was recorded under the treatment vermicompost @ 3 t ha^{-1} with 134.51 kg ha^{-1}. Similar results were reported by Shiny *et al*. (2024). Minimum available N, P, K and organic carbon was recorded under the control pot with 195.75 kg ha^{-1}, 17.08 kg ha^{-1}, 120.16 kg ha^{-1} and 0.94% respectively. Comparing the different treatments, it was observed that poultry manure and vermicompost generally resulted in higher nutrient availability compared to farmyard manure and pig manure. This could be attributed to the nutrient-rich composition of poultry manure and vermicompost, which likely contributed to the release and availability of nitrogen, phosphorus and potassium in the soil. Comparable results were given by Bhat and Pathak (2018).

Soil acidity parameters

Table 6 presents the results of different treatments on acidity parameters such as exchangeable acidity, exchangeable Al^{+3}, exchangeable H^{+} and total potential acidity in the soil after harvest. The data shows that there were no significant differences in exchangeable acidity,

Table 2: Effect of organic sources of nutrients on yield attributes and yield.

Treatments	Pods plant^{-1}	Filled pods plant^{-1}	Seeds pod^{-1}	Seed yield (g pot^{-1})	Stover yield (g pot^{-1})
T_1- Control	36.41	35.13	2.22	40.26	53.06
T_2- FYM@1.5 t ha^{-1}	42.04	38.87	2.40	42.44	56.42
T_3- FYM@ 3 t ha^{-1}	44.05	40.98	2.49	49.48	64.19
T_4- Vermicompost @1.5 t ha^{-1}	44.39	41.88	2.40	50.96	65.21
SEm±	1.05	1.13	0.16	2.16	2.12
CD (*P* = 0.05)	3.14	3.38	NS	6.42	6.32

exchangeable Al^{+3}, exchangeable H^+ and total potential acidity among the various treatments. Minimum exchangeable acidity, exchangeable Al^{+3}, exchangeable H^+ and total potential acidity in the soil after harvest was exhibited under the treatment vermicompost @ 3 t ha^{-1} with 2.09 cmol(p+) kg^{-1}, 1.19 cmol(p+) kg^{-1},0.90 cmol(p+) kg^{-1}, 11.68 cmol(p+) kg^{-1} respectively. It is evident from the data that the incorporation of vermicompost primarily led to a reduction in soil exchangeable acidity, exchangeable aluminium (Al^{+3}), exchangeable hydrogen (H^+) and total potential acidity after harvest. Analogous results were given by Zhang *et al*. (2019), who stated that inclusion of vermicompost as an organic amendment can enhance soil fertility, improve nutrient availability and promote favourable soil conditions, which collectively contribute to a reduction in soil exchangeable acidity, exchangeable Al^{+3}, exchangeable H^+ and total potential acidity. From the data, it is evident that there is a slight decrease in the acidity parameters such as exchangeable acidity, exchangeable

Table 3: Effect of organic sources of nutrients on quality attributes.

Treatments	Protein content (%)	Oil content (%)
T_1- Control	34.83	15.85
T_2- FYM@1.5 t ha^{-1}	37.39	16.66
T_3-FYM@ 3 t ha^{-1}	37.51	17.36
T_4- Vermicompost @1.5 t ha^{-1}	37.46	17.18

Table 4: Effect of organic sources of nutrient on physicochemical properties of soil.

Treatments	Bulk density(g cm^{-3})	Particle density (g cm^{-3})	Porosity (%)	Soil pH	CEC {cmol(p+) kg^{-1}}
T_1- Control	1.31	2.15	39.04	5.68	10.89
T_2- FYM@1.5 t ha^{-1}	1.27	2.16	40.21	5.66	11.93
T_3- FYM@ 3 t ha^{-1}	1.32	2.21	39.57	5.74	11.81
T_4- Vermicompost @ 1.5 t ha^{-1}	1.26	2.17	41.52	5.76	12.22
T_8- Pig manure @ 1.5 t ha^{-1}	1.27	2.14	40.86	5.68	11.37
T_9- Pig manure @ 3 t ha^{-1}	1.30	2.15	39.92	5.73	11.62
SEm±	0.10	0.10	3.89	0.0237	0.47
CD (*P* = 0.05)	NS	NS	NS	NS	NS

Table 5: Effect of organic sources of nutrients on soil fertility parameters after harvest.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Organic carbon (%)
T_1- Control	195.75	17.08	120.16	0.94
T_2- FYM@1.5 t ha^{-1}	206.68	17.85	124.97	1.07
T_3- FYM@ 3 t ha^{-1}	214.18	18.24	128.39	1.09
T_4- Vermicompost @1.5 t ha^{-1}	210.98	19.68	130.76	1.04
T_5- Vermicompost @3 t ha^{-1}	222.37	20.33	134.51	1.15
T_6- Poultry manure @1.5 t ha^{-1}	210.19	19.94	128.45	0.99
T_7- Poultry manure @ 3 t ha^{-1}	225.18	20.82	130.47	1.2
T_8- Pig manure @ 1.5 t ha^{-1}	206.32	18,42	123.54	1.07
T_9- Pig manure @ 3 t ha^{-1}	212.05	19.37	127.64	1.15
SEm±	4.96	1.21	2.41	0.0603
CD (*P*= 0.05)	14.75	NS	7.18	NS

Table 6: Effect of organic sources of nutrients on soil acidity parameters {cmol(p+) kg^{-1}}.

Treatments	Exchangeable acidity {cmol (p+) kg^{-1}}	Exchangeable Al^{+3} {cmol (p+) kg^{-1}}	Exchangeable H^+ {cmol (p+) kg^{-1}}	Total potential acidity {cmol (p+) kg^{-1}}
T_1-Control	2.35	1.26	1.09	11.87
T_2-FYM@1.5 t ha^{-1}	2.28	1.21	1.07	11.79
T_3-FYM@ 3 t ha^{-1}	2.32	1.23	1.08	11.83
T_4-Vermicompost @1.5 t ha^{-1}	2.18	1.2	0.98	11.7
T_5-Vermicompost @ 3 t ha^{-1}	2.09	1.19	0.9	11.68
T_6-Poultry manure @ 1.5 t ha^{-1}	2.22	1.21	1.01	11.77
T_7-Poultry manure @ 3 t ha^{-1}	2.27	1.22	1.06	11.8
T_8-Pig manure @ 1.5 t ha^{-1}	2.33	1.24	1.09	11.83
T_9-Pig manure @ 3 t ha^{-1}	2.34	1.25	1.1	11.86
SEm±	0.05	0.014	0.044	0.047
CD (*P*= 0.05)	NS	NS	NS	NS

Al^{+3}, exchangeable H^+ and total potential acidity in the soil after harvest due to the fact that organic manures contain alkaline compounds and organic acids that can buffer soil pH and reduce exchangeable acidity and total potential acidity. They also act as liming agents, raising the soil pH and decreasing the presence of exchangeable Al^{+3} and H^+ ions (Zhang *et al*., 2019). Similarly, Singh and Agarwal (2019) reported that when organic manures decompose, they release organic acids that can chelate or bind with Al^{+3} and H^+ ions, forming stable complexes and reducing their availability in the soil solution. But there is no significant difference among the treatments. The lack of significant differences between treatments suggests that the selected organic amendments, such as farmyard manure, vermicompost, poultry manure and pig manure, did not significantly influence soil acidity levels in the short term.

CONCLUSION

The results of the current study revealed that out of the nine organic treatments for nutrient management in soybean, the application of poultry manure @ 3 t ha^{-1} showed superior performance compared to the other organic schedules. This treatment exhibited significant improvements in terms of plant growth, yield, yield attributes and quality attributes, while maintaining the nutrient balance in the soil.

Conflict of interest

All authors declared that there is no conflict of interest.

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