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Soil bio-chemical properties of groundnut rhizosphere and crop performance under Panchagavya and Jeevamrutha

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ABSTRACT

A field experiment was conducted at Research Farm of CPGS-AS, CAU, Umiam, Meghalaya to study the changes in soil bio-chemical properties of groundnut rhizosphere and crop performance under Panchagavya and Jeevamrutha. There are ten treatments, replicated thrice in randomised block design (RBD). The experimental soil has pH 5.09 and organic carbon 1.03 per cent. The available N, P and K were 250.12, 14.22 and 180.6 kg ha^{-1}, respectively. The results indicated that plant height and dry matter accumulation is highest in T_{10} (RDF) over T_1 (control) to the tune of 50 and 76.8 percent at harvest. Further, it was also observed that plant height, plant dry matter production and yield obtained in T_9 was statistically at par with T_6, and following the same trend, all these parameters in T_9 were statistically significant with T_4, T_2, T_3 and T_7. The effect of treatments on the attainment of various development stages in groundnut is non-significant. The N, P and K uptake is also higher in T_{10} following order $T1_0$>T_9>T_6>T_8>T_5>T_3>T_7>T_2>T_4>T_1. The soil pH, SOC, available N, P and K was highest in T_{10} which is significant with other treatments. Further, T_9 is at par with T_6 but significant with T_2, T_3, T_4 and T_7. Lastly, number of nodules per plant and SMBC is highest in T_9 which is at par with T_6 and T_8. However, it is significant with T_1, T_2, T_3, T_4, T_5 and T_{10} representing more biological activities in Panchagavya and Jeevamrutha treatments as compared to control and RDF treatments. It may be concluded from the present study that the soil application of Panchagavya 5% + Jeevamrutha @ 1000 l ha-^{1} (T_9) not only resulted in optimum crop growth, yield attributes, and pod yield compared to control (T_1) as well as significant increase in soil biological properties compared to 100% RDF. However, in contrast, the application of 100% recommended dose of fertilizers appears necessary for *Kharif* groundnut for realizing higher growth, and productivity returns.

Keywords: Panchagavya, Jeevamrutha, NEH, soil biochemical

INTRODUCTION

The success of industrial agriculture and the green revolution in recent decades has often masked significant externalities, especially sustainability of natural resources such as deterioration of soil health, depletion of groundwater, depletion of bio diversity, degradation of ecology and environment, poor nutrition and less farm income due to high input cost, etc. (Sanjay-Swami and Patgiri, 2024). Organic and natural farming are among the broad spectrum of production systems that are supportive to the environment. These farming systems are non-chemical farming systems. Restoring soil health by reverting to non-chemical farming has assumed great importance to attain sustainability in production (Veeranna *et al.,* 2023).

Panchagavya is a mixture of milk, dung, ghee, and curd from cows. Cow dung contains microorganisms, organic matter, undigested fibre, and a variety of nutrients (Nene, 1999) and cow urine contains a lot of urea, minerals, and hormones (Reddy, 1998). Cow milk contains casein, a type of

spreader and adhesive that is a valuable source of microorganisms (Nene, 1999). Cow ghee contains vitamins, minerals, fat, and other nutrients, and curd is a rich source of microbes (Nene, 1999; Yadav and Lourduraj, 2006). Growth hormones are present in coconut water, which increases biomass and crop production (Mamaril and Lopez, 1997). Panchagavya contains naturally occurring, beneficial, and effective microorganisms (EMOs), in addition to helpful Acetobacter and Azospirillum. Panchagavya contained the majority of lactic acid bacteria, yeast, actinomycetes photosynthetic bacteria, some fungi, and useful and efficient organisms like Acetobacter, Azospirillum, and phosphor bacterium. Particularly the soil quality, plant growth, and yield are benefited by these organisms (Selvaraj *et al.,* 2003). Panchagavya, an organic substance, has the potential to significantly support growth and supply immunity in the plant system (Patel *et al.*, 2018). The biochemical composition of Panchagavya indicated that it contains almost all of the essential nutrients for plant growth, including micronutrients, growth hormones, and major nutrients like N, P, and K. Selvaraj *et al*. (2003). It can be applied to the soil along with irrigation water, as a foliar spray, as a treatment for seeds or seedlings, etc. The recommended Panchagavya concentration for foliar spray is 3%. Boraiah *et al*. (2017). The micro- and macronutrients required for crop growth are present in the liquid organic fertilizer described as Jeevamrutha. It is a great source of biomass and natural carbon. It is made with flour, jaggery, dung, and cow urine. The majority of the beneficial microbes found in Jeevamrutha made from cow dung are bacteria, fungi, yeast, and actinomyces (Swain and Ray, 2009). The high amino acid content of cow urine increases the nitrogen content of organic preparations and presents plant pathogen resistance. Jaggery contains potassium, an essential nutrient for plants that helps them resist drought. The high amino acid content of pulse flour, which is also a good source of dietary protein with a lesser fat content from chickpeas, enhances the beneficial microorganism (Boye *et al.,* 2010). Forest soil is a bioinoculant that lasts a long time in organic preparations and is rich in NPK, nitrogen fixer, phosphorus solubilizing bacteria, and other beneficial microorganisms (Papen *et al*. 2002; Dobhal *et al*., 2024). Jeevamrutha improves soil fertility by nutrient-enriching it. Soil application of Jeevamrutha creates favourable conditions for the availability of nutrients by lowering pH in alkaline soil and raising pH in acidic soil, with nutrient availability being maximized at pH 6.5 to 7.89 (Kulkarni, 2019).

Groundnut (*Arachis hypogea* L.), edible oilseeds are a significant contributor to both the Indian and global economies. Groundnut is cultivated over an area of 6.09 mha and production of 10.21 mt with average productivity of 1676 kg ha^{-1}. India ranks first in acreage (58.108 Mha) and second in production (74.015 Mt) in the world. However, growing groundnuts is not traditional in the North Eastern Hill (NEH) region. Farmers are starting to admire the crop's multiple advantages, including edible kernels, vegetable oil, dual-purpose oilcake for organic manure and animal feed, and the capacity to restore soil fertility through biological nitrogen fixation. Groundnut is the second crop grown in Meghalaya after rice, both in the uplands in the West Garo Hills and Ri Bhoi districts. Fallow rice, maize, and riverbeds are typically regarded as important ecosystems for groundnut production in the NEH region (Das *et al*., 2017). In the NEH region, groundnuts have been recognized as the field crop with the highest potential for organic production due to the crop's excellent yield potential, ability to grow successfully in low-quality soil with little care, and lack of pest and disease problems. In Meghalaya, groundnut productivity is significantly below the national average. One of the main issues with this low productivity is soil acidity and the poor and improper nutrient management techniques used by the farmers (Chirwa *et al*. 2017; Chejara *et al*., 2021; Malik *et al*., 2022; Bhardwaj *et al*., 2023). 95 percent of the NER's soils have an acidic nature, and 65 percent of those have a pH below 5.5 (Sharma and Singh, 2002). Inceptisols (45%) and Entisols (28%) are dominant in the soils of Meghalaya, which also have low cation exchange capacity, medium to strongly acidic soils, Al-toxicity, and P deficiency. The production of the crop can be improved by proper management of nutrient uses alone because the surface and subsurface soils of hilly regions are highly leached, exhibiting poor base saturation and low CEC. Keeping the above facts in view, the present study was conducted to study the soil bio-chemical properties of groundnut rhizosphere and crop performance under Panchagavya and Jeevamrutha in acidic soil.

MATERIALS AND METHODS

Experiment site and location

A field trial was carried out at Research Farm of College of Post Graduate Studies in Agricultural Sciences (CAU-Imphal) Umiam during *Kharif* 2022 to study the effect of Panchagavya and Jeevamrutha on growth, yield attributes, yield returns of groundnut and its residual soil fertility status after the harvest of the crop. The experiment site was situated at an altitude of 950 m above mean sea level, with an agro-climatic zone of mixed subtropical hills and falls in the AES-III zone, at 91°18 to 92°18' E longitude and 25°40 to 26°20' N latitude (Choudhury *et al.,* 2013). Pre-monsoon (March to May), monsoon (June to September), and post-monsoon (October to February) months make up Umiam's three distinct seasons. This area experiences temperature ranges of 10 to 30°C and receives 2410 mm of precipitation annually (Ray *et al.,* 2012). The soil of the experimental site was sandy clay loam in texture, strongly acidic in reaction (4.98), medium in organic carbon (0.98%), low in available nitrogen (207.32 kg ha^{-1}), available phosphorous (13.99 kg ha^{-1}), available potassium (200 kg ha^{-1}).

Experiment details

The treatment combination consists of T_1-Control, T_2-Jeevamrutha @ 500 l ha^{-1}, T_3-Jeevamrutha @ 1000 l ha^{-1}, T_4-Panchagavya @ 2.5% soil application, T_5-Panchagavya @ 2.5% soil application + Jeevamrutha @ 500 l ha^{-1}, T_6-Panchagavya @ 2.5% soil application + Jeevamrutha @ 1000 l ha^{-1}, T_7- Panchagavya @ 5% soil application, T_8- Panchagavya @ 5% soil application + Jeevamrutha @ 500 l ha^{-1}, T_9- Panchagavya @ 5% soil application + Jeevamrutha @ 1000 l ha^{-1} and T_{10}- RDF. The experiment was laid out in randomized block design with ten treatments which were replicated thrice.

Preparation of Panchagavya

Panchagavya stock solution was prepared with the help of the components given in Table 1. 2 litres of cow urine and 10 litres of water were added to the mixture, which then remained for 15 days after thoroughly mixing it with 7 kg of cow dung and 1 kg of cow ghee. Then, to hasten the fermentation, 2 litres of cow's milk, 2 litres of curd, 2 litres of tender coconut water, 250 g of black jaggary, and 12 ripe bananas were added. A big mouthed pot with all the ingredients was filled, then it was kept in the shade. After 14 days, the mixture was filtered after being mixed twice daily for about 20 minutes each in the morning and evening. Three percent spray solution was made by combining 30 ml of Panchagavya with 1000 ml of water before being applied to the field. It was applied at 25 and 45 days after sowing.

Table 1. Ingredients of Panchagavya

Ingredients	Quantity
Cow dung	7 kg
Cow urine	3 l
Cow milk	2 l
Cow curd	2 l
Cow ghee	1 kg
Black jaggery	250 g
Ripened banana	12 (no.)
Tender coconut water	3 l
Water	10 l

Preparation of Jeevamrutha

For preparing Jeevamrutha, the ingredients used are given in Table 2. A plastic drum of 200 l capacity was taken and filled with 90 l water. Fresh cow dung (5 kg) was mixed with 10 l water in a bucket and this slurry was added to drum followed by stirring with long stick. Then cow urine (5 l) was poured solely with continuous stirring. Black jaggery was pounded to powder and added to drum. Horse gram flour was added slowly to mixture with stirring to avoid formation of flour clods. One handful fertile soil was added to above mixture and stirred until mixture becomes homogenous and incubated for 5-6 days. It was stirred twice a day morning and evening during its incubation period and the drum was covered with plastic lid. After 6-8 days, Jeevamrutha was applied to soil depending on the treatment @ 500 l ha^{-1} 25 and 45 days after sowing.

Table 2. Ingredients of Jeevamrutha

Ingredients	Quantity
Fresh cow dung	5 kg
Fresh cow urine	5 l
Black jaggery	1 kg
Pulse flour (Horse gram)	1 kg
Fertile soil (Native)	One handful
Water	100 l

RESULTS AND DISCUSSION

Growth and yield attributes

Application of 100 per cent recommended dose of fertilizers (20-40-60 kg N, P_2O_5 and K_2O ha^{-1}) significantly improved all the growth parameters of groundnut *viz.,* plant height, LAI and dry matter production at all the stages of crop growth due to adequate supply of NPK and the major plant nutrients (Zalate and Padmani, 2009). Among the organic liquid, Panchagavya 5% + Jeevamrutha @ 1000 l ha-^{1} (T_9) recorded higher growth parameters of groundnut *viz.,* plant height (Figure 1), LAI and dry matter production (Figure 2) at all the stages of crop growth due to presence of organic manures in slow conversion of organic forms of plant nutrients (all essential nutrients) into available forms and improvement in soil physico-chemical conditions and biological soil properties which might have contributed for improvement in crop growth and development (Kumar *et al.,* 2012). Panchagavya spray is known to produce bioactive substances secreted by beneficial microorganisms like Pseudomonas, Azatobacter and phosphobacteria. These growth promoting secretions might have contributed to improved growth parameters of groundnut (Xu *et al.*, 2000).

Application of 100 per cent RDF improved the yield attributes i.e., number of pods plant^{-1}, hundred pod weight, hundred kernel weight and shelling per cent due to favourable effect of readily available nutrients with 100 per cent RDF (T_{10}) is evident with higher dry matter accumulation and effective translocation of photosynthates to the sink (Figure 3). Among the liquid organic formulation, Panchagavya 5% + Jeevamrutha @ 1000 l, Panchagavya 5% + Jeevamrutha @ 1000 l ha-^{1} (T_9) recorded improved yield attributes i.e. number of pods plant^{-1}, hundred pod weight, hundred kernel weight and shelling per cent due to application of

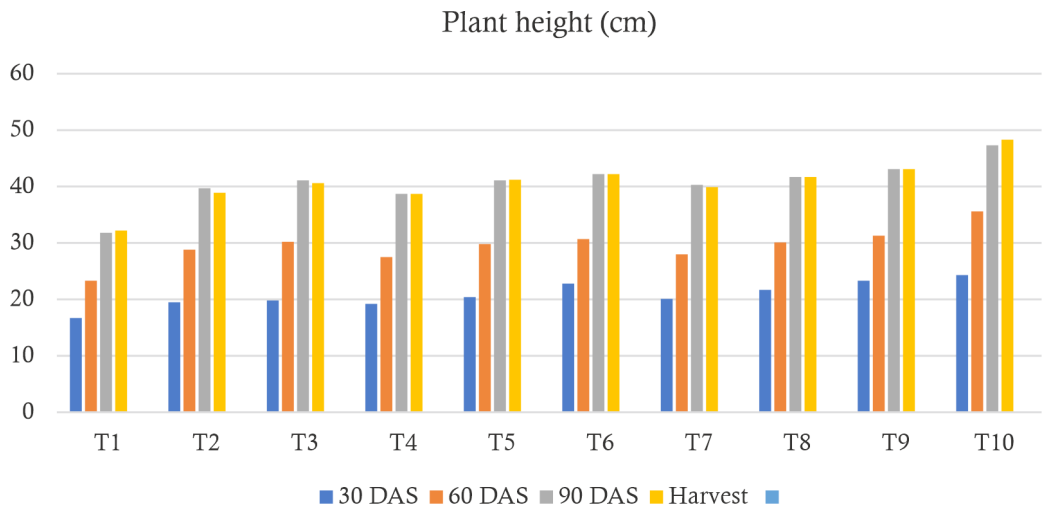

Fig. 1. Effect of Panchagavya and Jeevamrutha on plant height (cm) of groundnut

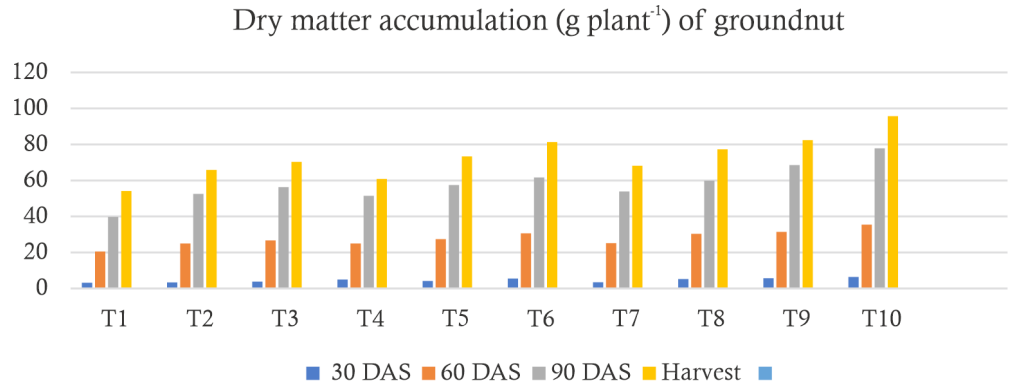

Fig. 2. Effect of Panchagavya and Jeevamrutha on dry matter accumulation (g plant-^{1}) of groundnut

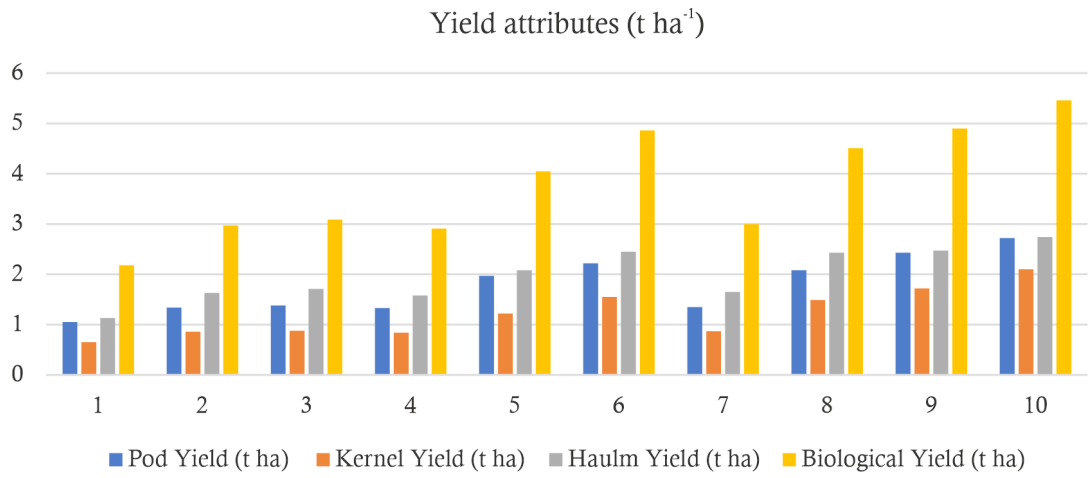

Fig. 3. Effect of Panchagavya and Jeevamrutha on yield attributes in groundnut

organic manures which besides supplying N, P, K, secondary and micro nutrients, also improved the soil condition, which enhanced the root proliferation and source to sink relationship (Choudhary *et al.,* 2014). Panchagavya included coconut water which contain kinetin and hence increased the cytokinin content in leaf, which in turn increased the chlorophyll content and photosynthetic activity and reflected through the inflated stature of all the yield attributes (Mavarkar *et al.*, 2016).

Pod yield and kernel yield significantly improved with the application of 100% recommended dose of fertilizers (20-40-60 kg N, P_2O_5 and K_2O ha^{-1}) over the control due to the reason that fertilizers can supply the required quantity of nutrients instantly in a balanced proportion coinciding with the crop requirement (Thomas and Thenua *et al.*, 2010). Among the liquid organic formulation, Panchagavya 5% + Jeevamrutha @ 1000 l, Panchagavya 5% + Jeevamrutha @ 1000 l ha^{-1} (T_9) recorded higher pod yield due combined application of organic manures which might have improved the soil environment which encouraged better root spread resulting in better absorption of nutrients from lower layers which led to the higher pod yield. Application of Jeevamrutha might have increased the activity of microbes there by solubilisation and uptake of nutrients was enhanced (Manjunatha *et al.*, 2009). The easy transfer of nutrients to plant through foliar spray of Panchagavya, which contains several nutrients *viz.,* macronutrients like nitrogen, phosphorus, potassium and micronutrients required for the growth and development of plants, various amino acids, vitamins and growth regulators like auxins, gibberellins might have influenced the necessary growth and development in plants which lead to higher pod yield (Somasundaram *et al.*, 2007).

Post-harvest soil bio-chemical properties

Under various treatments, a non-significant difference in pH and EC was observed. However, control treatment and the use of 100% RDF indicated the lowest pH and highest values, respectively (Figure 4). The EC of the soil was found maximum and minimum in control treatment and 100% RDF respectively (Figure 4). After crop harvest, a combination of different treatments caused significant variations in SOC. The treatment that had the highest SOC was 100% RDF (T_{10}), which was obviously superior to the other treatments. The soil application of Panchagavya 5% + Jeevamrutha @ 1000 l ha^{-1} (T_9) among the organic sources tested, was comparable to the T_6 and T_8 treatments but significantly higher compared to residual SOC observed in the other treatments (Figure 4). However, in the treatments (T_1) receiving no nutrient inputs, the minimum residual SOC was determined. The highest post-harvest soil nitrogen, phosphorus, and potassium levels were observed with 100% RDF (T_{10}). Among the organic liquid formulation, soil application of Panchagavya 5% + Jeevamrutha @ 1000 l ha^{-1} (T_9), left the maximum amount of residual soil available N, P and K (20.64 kg ha^{-1}) which being at par with T_6 and T_8 but significantly more over the residual soil available N, P and K observed in remaining treatments (Figure 5). The highest post-harvest soil nutrient status may have been achieved by supplying NPK through 100% RDF (T_{10}) Panchagavya 5% + Jeevamrutha @ 1000 l ha^{-1} (T_9) recorded more nitrogen, phosphorus, and potassium

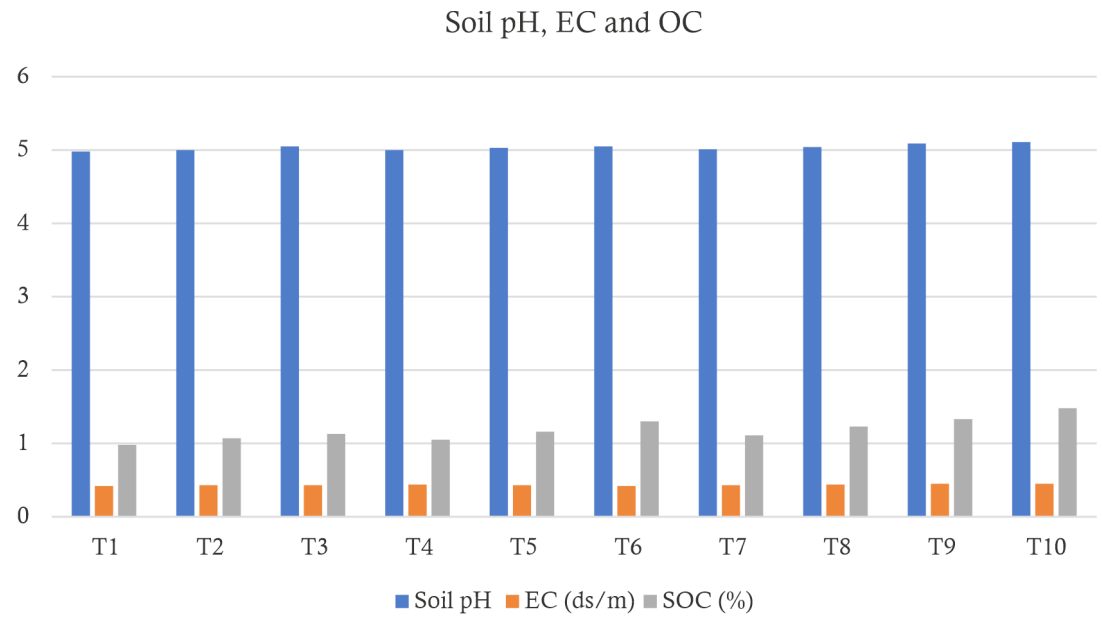

Fig. 4. Effect of Panchagavya and Jeevamrutha on Soil pH, EC and OC in groundnut after crop harvest

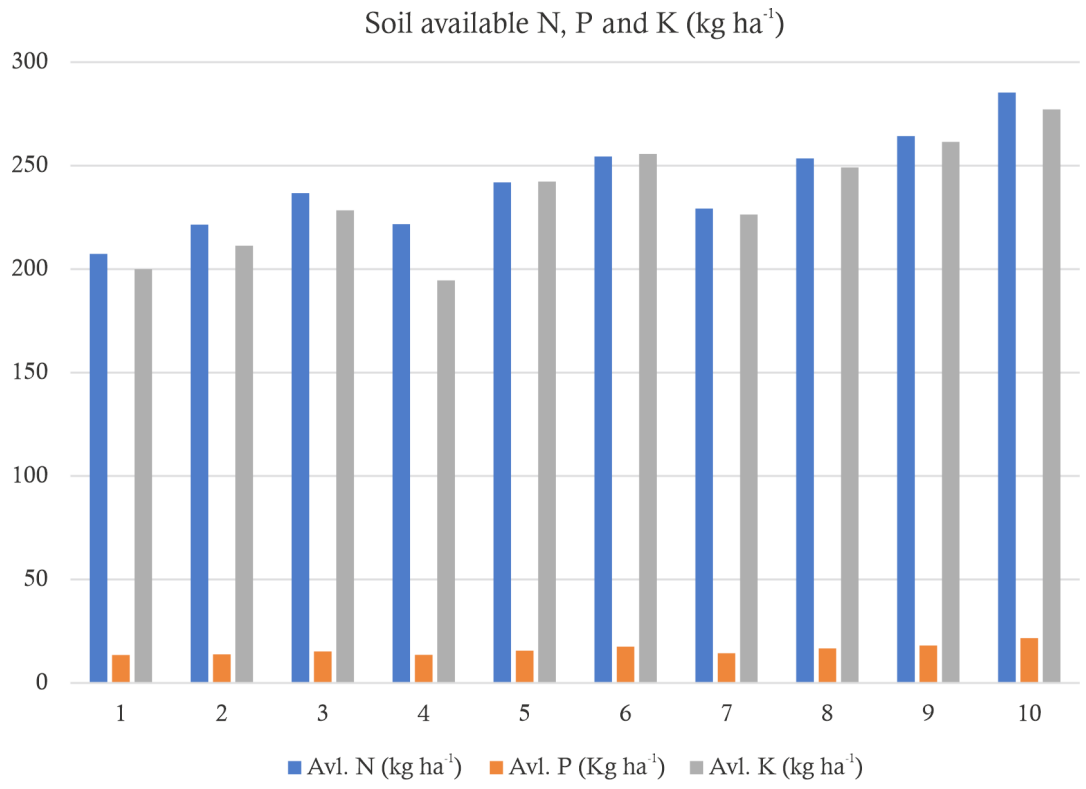

Fig. 5. Effect of Panchagavya and Jeevamrutha on soil available N, P, and K (kg ha^{-1}) in groundnut after crop harvest

available to the soil among the various organic sources tested for the study, however it was comparable to 100% RDF (T_2). The availability of nutrients to the crop may have been increased by organic sources, which might have resulted in a lower status in the soil after harvest compared to the control plot. The soil available nutrients N, P, and K were significantly more readily available in T_9, which could have been led to by an increase in the number of bacteria, fungi, actinomycetes, P-solubilizers, and N fixers as a result of the soil's increased microflora population. These findings

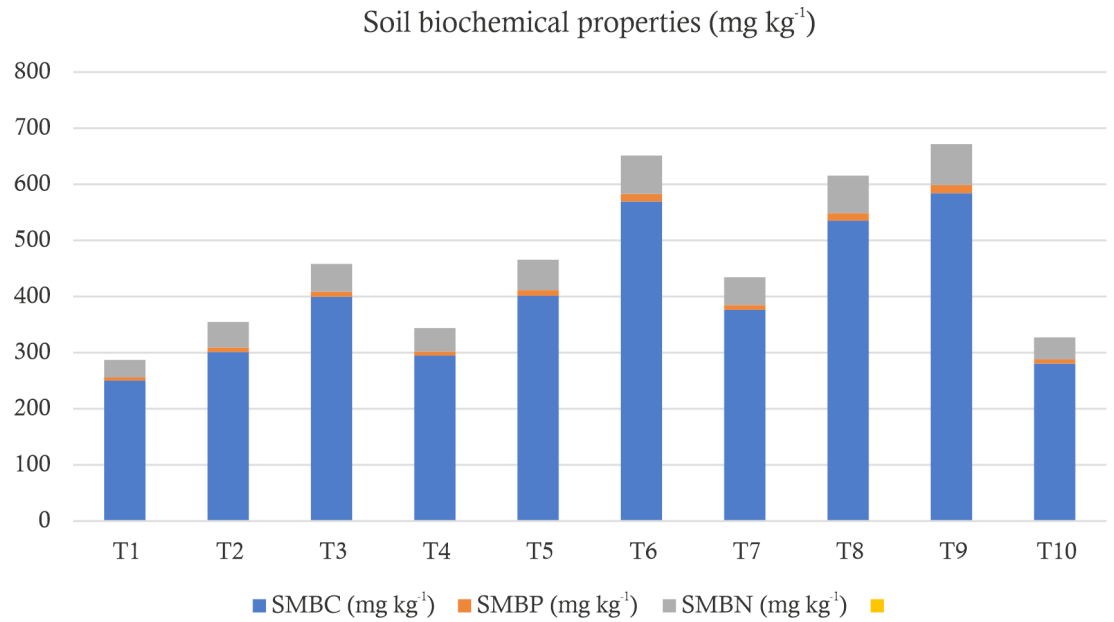

Fig. 6. Effect of Panchagavya and Jeevamrutha on soil biochemical properties mg (mg kg^{-1}) in groundnut rhizosphere after crop harvest

agreed with the results of Latha and Sharanappa (2014). According to Subha *et al.* (2018) and Chandra *et al*. (2020), use of Panchagavya and Jeevamrutha formulations in organic farming helps the farmers to get higher yield and returns besides improvement in soil physico-chemical properties. This may be a result of the presence of beneficial microorganisms in Panchagavya and the improvement in nutrient availability attributed to their establishment in the soil. The absence of NPK from all sources combined with the crop's depletion of native soil nutrients may have led to the lowest levels of nitrogen, phosphorus, and potassium under control. The findings and the earlier results are similar to the findings of Siddaram (2019) and Reddy *et al.* (2021).

The soil biological parameters SMBC, SMBN, and SMBP were found to be significantly higher in plots treated with soil application of Panchagavya 5% + Jeevamrutha @ 1000 l ha^{-1} (T_9), compared to 100% RDF(T_{10}) (Figure 6). In the control plot, SMBN, SMBC, and SMBP were all significantly lower compared to all treated plot. The soil organic carbon content may have increased as a result of the cumulative effects of several sources of organic liquid formulation, acting as a carbon and energy source for microbes and establishing their rapid colonization of the soil (Palekar, 2006). In comparison to other organic liquid formulations, the recommended package of practice treatment for different stages of the crop indicated lower bacterial, fungal, and actinomycetes populations (Bhardwaj *et al.*, 2022). Hence, more number of beneficial microorganisms are found in organic liquid manure formulations. It did not result in significant changes in the soil microbial biomass, which limited the plant's capacity to grow and function as a carbon substrate. The findings of Palekar (2006), Vasanthakumar (2006), and Shreenivas *et al*. (2011) that liquid manures contain micronutrients in addition to several different microflora, particularly nitrogen fixers and phosphate solubilizers, are in agreement with these findings. Similar findings were reported by Swaminathan (2005), who found that organic liquid manures contained naturally occurring beneficial microorganisms, primarily bacteria, yeast, actinomycetes, photosynthetic bacteria, and some fungi. According to Devakumar *et al.* (2014), using small amount of soil to prepare Jeevamrutha acts as a source of the initial inoculum of bacteria, fungi, actinomycetes, N-fixers, and P-solubilizers. These findings are consistent with the findings reported by Devakumar *et al*. (2014), Kumbar *et al.* (2016), Subha *et al*. (2018) and Gowthamchand, *et al*. (2020) Bhargsavi *et al*. (2022) in French bean.

CONCLUSION

On the basis of the results obtained, it may be concluded that the soil application of Panchagavya

5% + Jeevamrutha @ 1000 l ha-^{1} (T_9) not only resulted in optimum crop growth, yield attributes, and pod yield compared to control (T_1) as well a significant increase in soil rhizospheric biological properties compared to 100% RDF. In contrast, for *Kharif* groundnut, 100% of the recommended dose of fertilizers (20-40-60 kg N, P_2O_5, and K_2O ha^{-1}) appears to be beneficial in order to obtain higher productivity as well as nutrient uptake.

AUTHOR CONTRIBUTIONS

Each author contributed equally.

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CONFLICT OF INTEREST

There is no conflict of interest.

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