International Journal of Plant & Soil Science

34(22): 1399-1406, 2022; Article no.IJPSS.90325
ISSN: 2320-7035

Impact on Soil Health under Organic Nutrient Management in Transplanted Finger Millet (*Eleusine coracana* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i2231512

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/90325

Original Research Article

Received 05 June 2022
Accepted 11 August 2022
Published 07 September 2022

ABSTRACT

Background: Finger millet being highly nutritious and easy to digest is one of the important crops grown in Tamil Nadu, Karnataka, and Andhra Pradesh. Organic farming is gaining importance among the farmers with increasing yield, improving the quality of grains, and maintaining soil quality. Since the land availability is decreasing with increasing population. Finger millet has great scope under organic cultivation which could result in increased soil condition.

Methodology: A field trial was performed at Agricultural College and Research Institute, Killikulam, Tuticorin, TNAU, Tamil Nadu from 2019 to 2020 during the rabi season to evaluate the performance of various organic sources concerning the soil properties changes. The study was conducted with an RBD design. Treatments include solid manures and liquid organics combination and their performance was evaluated. Finger millet - Co (Ra) 15 was used as a test variety. Soil health represents the soil properties generally including pH, EC, organic carbon content, N, P, and K levels, and also the soil microbial population.

Results and Discussion: From the study, it was found that the application of 100 percent of nitrogen through poultry with foliar application of panchagavya at 30 and 45 DAT gave better yield and also enriched the soil fertility status.

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Conclusion: 100% N through Poultry manure and 3% panchagavya foliar spray at 30 & 45 DAT in transplanted finger millet gave increased soil health with higher soil properties. Thus, Organic farming proved to be an eco-friendly management option in finger millet for maintaining good soil health.

Keywords: Finger millet; organic agriculture; panchagavya; poultry manure; quality grains; soil health.

1. INTRODUCTION

After sorghum and pearl millet, finger millet [*Eleusine coracana* (L.) Gaertn.] is India's third most significant millet. Finger millet is a climate-resilient crop with a wide range of adaptation to unfavorable weather conditions and minimal input requirements, making it an excellent subsistence food crop. Organic farming is a comprehensive production management method that maintains and increases the health of the agro-ecosystem, including biodiversity, biological cycles, and soil biological activity [1]. In light of the rising need for safe, healthy, and nutritious food, the current global scenario strongly emphasizes the necessity to embrace environmentally friendly agriculture techniques. The usage of farmyard manure (FYM), poultry manure, vermicompost, green manure, oil cakes, bio-fertilizers, and other organic finger millet inputs was heavily emphasized [2]. The scarcity of high-quality, low-cost organic manures is preventing the widespread implementation of organic nutrient management for increasing soil properties. As a result, it is necessary to investigate the various locally accessible on-farm nutrition sources. Liquid organic manures containing a range of beneficial microorganisms may trigger biological processes in the soil to restore fertility, as well as function as plant growth stimulants to improve yield and quality [3]. Furthermore, in this time of climate change, a millet-based organic farming system may provide healthy food and farming stability in India. As a result, based on scientific facts, local conditions, and economic feasibility, it is critical to building a powerful, feasible, and suitable organic nutrition management package for finger millet which would ultimately increase soil health. Data are scarce on the productivity of finger millet when grown with various organic additions. As a result, this study will examine the impacts of various organic supplements on finger millet with their effects on soil attributes.

2. MATERIALS AND METHODS

An experiment was done in the experiment field of Agricultural College and Research Institute, Killikulam, Tamil Nadu Agricultural University, Tuticorin, Tamil Nadu, India (AC&RI, KKM, TNAU) ($8^o46'$ N, $77^o42'$ E, 40m altitude) to evaluate the impact of different organic sources on the production and quality of finger millet (*Eleusine coracana*) and also its influence on the soil properties. The experiment site was situated in a semi-arid tropical region with 70 to 80 percent of relative humidity. The corresponding mean maximum and minimum temperatures are 34.2^oC and 22.5^oC. There was no crop before the sowing of the finger millet and no chemical inputs were used before sowing for the past 3 years. Soil samples were collected before the trial from 0-15 cm depth and these samples were used for analyzing the Physico-chemical and biological properties of the soil. These samples were allowed to air dry for 3 days. It was cleaned and sieved through a 2 mm sieve. The pH and Electrical Conductivity (EC), organic carbon, N, P, and K status of the soil samples were analyzed by using standard analytical methods [4]. The soil microbial population of the soil sample was estimated by the serial dilution plate method [5].

The study includes ten different treatment combination which includes 100% Recommended Dose of Fertilizer (RDF) (T_1), 100% N through farmyard manure (FYM) (T_2), 100% N through FYM + 3% Jeevamrutham foliar spray at 30 & 45 DAT (T_3), 100% N through FYM + 3% Beejamrutham foliar spray at 30 & 45 DAT (T_4), 100% N through FYM + 3% Panchagavya foliar spray at 30 & 45 DAT (T_5), 100% N through Poultry manure (T_6), 100% N through Poultry manure + 3% Jeevamrutham foliar spray at 30 & 45 DAT (T_7), 100% N through Poultry manure + 3% Beejamrutham foliar spray at 30 & 45 DAT (T_8), 100% N through Poultry manure + 3% Panchagavya foliar spray at 30 & 45 DAT (T_9) and Absolute control (T_{10}). These treatment combinations were used in Randomized Block Design (RBD). The study was conducted during the *rabi* season of 2019. The test variety was Co (Ra) 15. The solid organic manures were incorporated based on an equal nitrogen basis to supply 60 kg of recommended N ha^{-1}. The organic spray including panchagavya, jeevamrutham, and beejamrutham was prepared by following the method proposed by Devakumar, Shubha [6], and Shubha, Devakumar [7]. Analysis of variance (ANOVA) for randomized block design (RBD) was used for the comparison of treatment differences among different yield, quality, and soil parameters using AGRES statistical software version 3.01 [8]. The data were statistically analyzed and standard error and critical differences among treatments were determined at the 0.05 level of probability [9].

3. RESULTS AND DISCUSSION

3.1 Post-harvest soil pH, EC, and organic C

The post-harvest soil pH did not show any significant difference across the various organic supplement treatments (Table 1). The pH of the soil was slightly raised from its initial level. The pH of the soil did not significantly vary across organic treatments, ranging from 7.1 to 7.5. The post-harvest soil electrical conductivity varied from 0.21 to 0.27 (dS/m) The organic carbon content of the post-harvest soil was non-significant upon organic treatments. Organic carbon concentrations varied from 4.2 to 5.3 g kg^{-1}.

The chemical parameters of post-harvest soil, such as pH, EC, and organic carbon, were unaffected by different solid and liquid organic treatments (Fig. 1). The addition of organic matter resulted in a mild change in soil pH, soil EC, and organic carbon content. This could be the cause of increased microbial activity and nutrient availability compared to control. Jagadeesha, Srinivasulu [10], and Yogananda, Devkumar [11] all validated these findings.

3.2 Post-harvest soil available N, P_2O_5, and K_2O

3.2.1 Soil available nitrogen: Because of diverse solid and liquid organic supplement combinations, the available nitrogen status of the soil varied dramatically after harvest (Table 1). The treatment of 100 percent N through poultry manure + 3 percent panchagavya foliar spray resulted in significantly enhanced accessible soil N at 30 and 45 DAT (256 kg ha^{-1}) (T_9). This was followed by 100% N through poultry manure + 3% jeevamrutham foliar spray at 30 & 45 DAT (T_7), which was comparable to the application of 100% N through poultry manure + 3% beejamrutham foliar spray at 30 & 45 DAT (T_8), which registered available nitrogen of 246 and 242 kg ha^{-1}, respectively. Similarly, at 30 and 45 DAT (233 kg ha^{-1}), 100 percent N was applied by FYM + 3 percent Panchagavya foliar spray (T_5). In total control, however, a reduced available nitrogen status of 172 kg ha^{-1} was found (T_{10}) (Fig. 2).

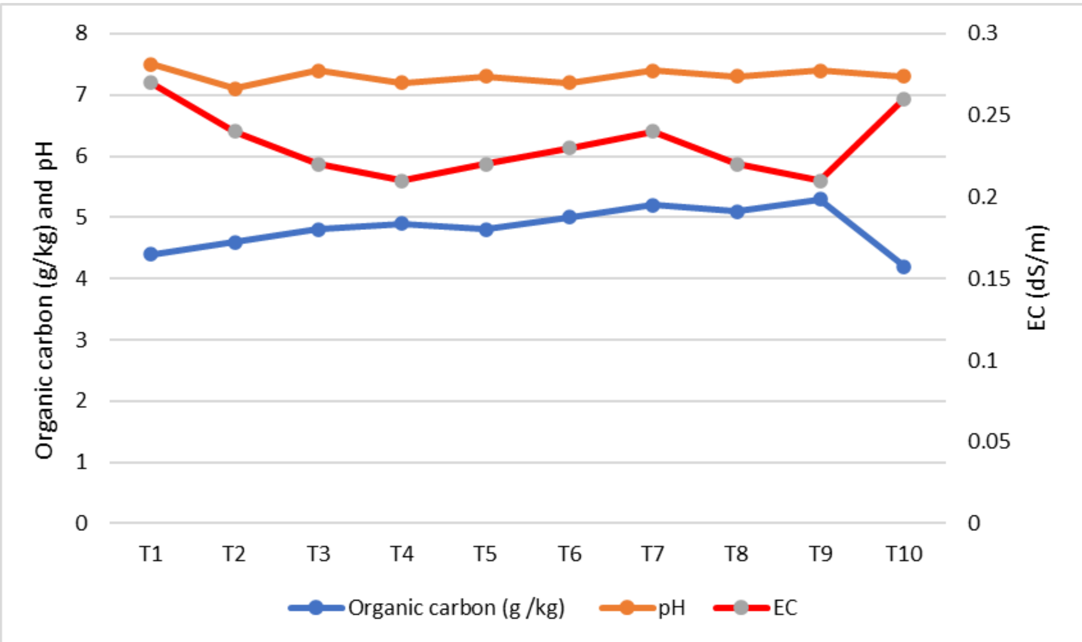

Fig. 1. Effect of organic sources on pH, EC, and organic C content in the soil

This might be attributed to increased plant N absorption. Some nitrogen retained in the soil may have contributed to greater N retention as NH_3 ions in the soil. The C: N ratio may also have contributed to greater soil accessible N, which reflects the soil's ability to retain and recycle nutrients. Organic manure application builds up the desired quantity of N in the soil with a low C: N ratio, resulting in improved N mineralization. The stronger the microbial activity, the easier it is to convert organically bound nitrogen to inorganic nitrogen. These findings are consistent with those of Kaur, Goyal [12], Mairan and Dhawan [13], and Yogananda, Devkumar [11].

3.2.2 Soil available phosphorus: The maximum post-harvest soil accessible phosphorus was considerably recorded with the addition of 100 percent N via poultry manure in addition to 3 percent panchagavya foliar spray at 30 & 45 DAT (29.1 kg ha^{-1}) (T_9) (Table 1). Following that, significantly higher available soil P was recorded with 100% N through poultry manure + 3% jeevamrutham foliar spray at 30 & 45 DAT (26.2 kg ha^{-1}) (T_7), followed by 100% N through poultry manure + 3% beejamrutham foliar spray at 30 & 45 DAT (25.7 kg ha^{-1}) (T_8). These two were on the same level. The absolute control (T_{10}), on the other hand, had the lowest soil available P of 10.2 kg ha^{-1} (Fig. 2). The most likely cause is the mineralization of organic phosphates and the production of organic acids from microbial decomposition of organic manures, which solubilizes native soil phosphates and organic amines, resulting in a halt in P fixation in soil. Jain, Sharma [14] and Roy, Ali [15] found similar results.

3.2.3 Soil available potassium: The post-harvest soil accessible potassium of transplanted finger millet varied dramatically owing to diverse combinations of solid and liquid organic additives. Among the treatments tested, application of 100 percent N through poultry manure + 3 percent panchagavya foliar spray at 30 & 45 DAT (265 kg ha^{-1}) (T_9) resulted in the greatest soil accessible status of potassium (Table 1). This was followed by treatments of 100 percent N through poultry manure + 3 percent jeevamrutham foliar spray at 30 and 45 DAT (257 kg ha^{-1}) (T_7) and 100 percent N through poultry manure + 3 percent beejamrutham foliar spray at 30 and 45 DAT (252 kg ha^{-1}) (T_8). These treatments were on par with one another. The absolute control (T_{10}) resulted in a lower soil available potassium status of 190 kg ha^{-1} (Fig. 2). This might be due to the integration of organic materials, which reduced potassium fixing and ultimately released potassium. Furthermore, the crop demand for K was partially supplied by the released K compounds from decomposition, and also the applied and released K resulted in an increase in accessible K in the soil. These findings are supported by Santhosh, Sridhar [16] and Prashanth, Krishnamurthy [17].

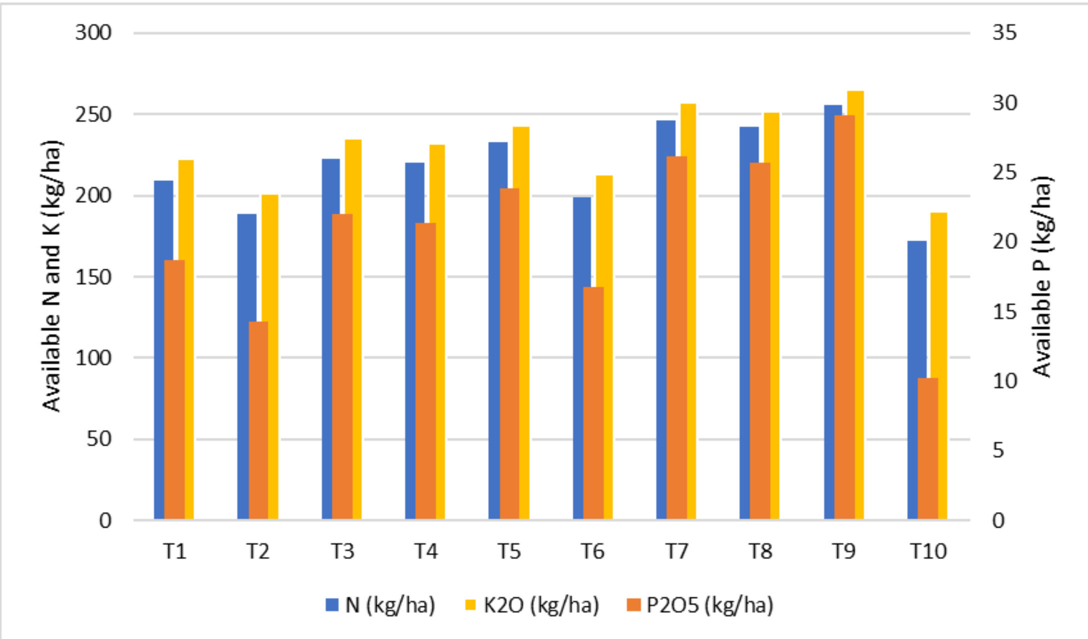

Fig. 2. Available N, P, and K (Kg/ha) as affected by different organic treatments in finger millet

Table 1. Effect of solid and liquid organic supplements on soil health after harvest of transplanted finger millet

T. No.	Organic carbon ($g\ kg^{-1}$)	pH	EC ($dS\ m^{-1}$)	N ($Kg\ ha^{-1}$)	P_2O_5 ($Kg\ ha^{-1}$)	K_2O ($Kg\ ha^{-1}$)	Bacteria (No. x 10^6 cfu[a] g^{-1})	Fungi (No. x 10^4 cfu g^{-1})	Actinomycetes (No. x 10^3 cfu g^{-1})
T_1	4.4	7.5	0.27	209	18.7	223	15.2	6.7	9.4
T_2	4.6	7.1	0.24	189	14.3	201	18.5	8.5	11.2
T_3	4.8	7.4	0.22	223	22.0	235	22.1	13.2	13.5
T_4	4.9	7.2	0.21	220	21.4	232	21.6	12.2	13.2
T_5	4.8	7.3	0.22	233	23.9	243	24.3	15.4	14.7
T_6	5.0	7.2	0.23	199	16.8	213	20.7	10.1	12.1
T_7	5.2	7.4	0.24	246	26.2	257	27.1	18.2	16.2
T_8	5.1	7.3	0.22	242	25.7	252	26.8	17.5	15.7
T_9	5.3	7.4	0.21	256	29.1	265	29.1	19.8	17.3
T_{10}	4.2	7.3	0.26	172	10.2	190	12.4	5.3	7.8
SEd	0.2	0.16	0.01	3.5	0.5	2.9	0.9	0.5	0.4
CD (P=0.05)	NS[b]	NS	NS	7.2	1.4	6.3	1.9	1.2	0.9

[a] cfu- colony-forming units; [b] NS- Not significant

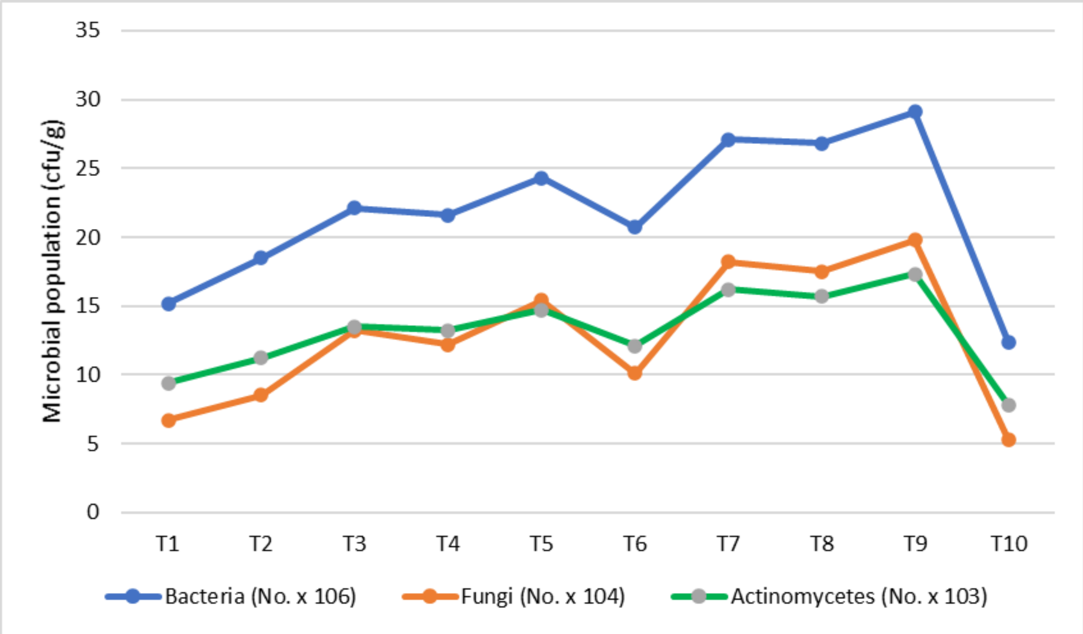

Fig. 3. Post-harvest soil microbial population as influenced by different organic sources

3.3 Post-harvest Soil Microbial Population

Various solid and liquid organic supplements significantly influenced the post-harvest soil microbial population of bacteria, fungi, and actinomycetes (Table 1). Application of 100% N through poultry manure + 3% panchagavya foliar spray at 30 & 45 DAT (T_9) recorded a significantly maximum microbial population in the soil with 29.1 x 10^6 cfu g^{-1}, 19.8 x 10^4 cfu g^{-1}, and 17.3 x 10^3 cfu g^{-1} of bacteria, fungi and actinomycetes population respectively (Fig. 3). This was followed by the treatments of 100% N through poultry manure + 3% jeevamrutham foliar spray at 30 & 45 DAT (T_7) and 100% N through poultry manure + 3% beejamrutham foliar spray at 30 & 45 DAT (T_8). The minimum microbial population was recorded in absolute control (T_{10}).

Organic matter is necessary for the flourishing of soil microorganisms. Incorporated organic manure has a significant impact on microbial activity, which in turn has a direct impact on the breakdown and mineralization of organic manures resulting in higher humus content [18]. The inclusion of organic manures in the soil enhanced the production of root exudates in the rhizosphere region which contains organic acids, sugars, amino acids, etc. These root exudates have aided in the proliferation of microbes in the rhizosphere. These findings were in line with those of Jagathjothi, Ramamoorthy [19], and Kaur, Goyal [12]. In addition, the microbial load in poultry manure and panchagavya is larger [14]. In addition, the presence of native beneficial microorganisms and growth-promoting chemicals in liquid organics acts as an inoculum, encouraging fungus proliferation in the soil environment [6]. The presence of naturally occurring and beneficial microorganisms in panchagavya aided in the accumulation of microbes in the soil environment. These findings matched those of Thakare and Wake [20] and Patel, Patel [21].

4. CONCLUSION

Since, there is a growing concern over food security, food nutrition, climate change, growing population, and land reduction among the different communities, there is a need to develop alternative agriculture like organic farming which has proven to be a promising solution in the recent days. In this context, the present study has proved that the application of a recommended dose of N through poultry manure along with the foliar application of 3 percent panchagavya on 30 and 45 days after transplanting has improved the soil fertility status regarding available nutrients and microbial population. This facilitates greater microbial activity leading to improved mineralization and nutrient release pattern resulting in the timely synchronization of nutrient demand. This provided a better knowledge about the use of different organic manures and their combinations with a liquid organic spray which serves as an alternative to the conventional method of cultivation thus minimizing the usage of chemical fertilizers. Also, we can conclude that repeated cultivation of crops under organic methods will improve the soil fertility in terms of organic C, available micro and macronutrients, microbial activity, etc. and there is a possibility of achieving equivalent yield over the conventional method cementing the base for meeting the sustainable and eco-friendly development goals shortly.

ACKNOWLEDGEMENTS

The author thanks all the faculty members of Agricultural College and Research Institute, Killikulam, Tamil Nadu Agricultural University, India for facilitating my research work and timely guidance throughout my entire research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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