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# Effect of enriched poultry manure compost and liquid organic foliar nutrition on productivity, nutrient uptake, soil fertility, and microbial population in irrigated finger millet

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**Abstract**

A field experiment was conducted at Puliyanthoppu village in Krishnagiri District, Tamil Nadu during December 2019 – April 2020 to study the effect of enriched poultry manure compost and liquid organic foliar nutrition on productivity, nutrient uptake, soil fertility, and microbial population in irrigated finger millet. The experiment was laid out in split-plot design with three replications. The results of the field experiment showed that, among the enriched compost, the application of enriched poultry manure compost applied @ 750 kg $ha^{-1}$ significantly recorded higher ear heads $m^{-2}$, grain and straw yields, higher nutrient uptake, soil fertility, and microbial population. The aforesaid parameters were least under plots received with enriched FYM compost @ 750 kg $ha^{-1}$. In respect of liquid organic manures, foliar application of seaweed extract @ 0.3% on 20, 40, and 60 DAT significantly recorded higher ear heads $m^{-2}$, grain and straw yields, and higher nutrient uptake, whereas soil fertility and microbial population were not significantly influenced by liquid organic manure application. The lowest values were registered in water spray.

**Key words :** Grain yield, nutrient uptake, microbial population, poultry manure, seaweed.

Since millets have such a remarkable nutritional profile and are naturally climatically resilient, they have become known as "super cereals." With their ability to ensure food and nutritional stability, they have great potential to combat hunger and malnutrition. Finger millet (*Eleusine coracana* (L.) Gaertn.), is usually referred to as "Nutritious millet" because the grain is nutritionally superior to several cereals (rice, corn and sorghum) providing proteins, minerals, iron, calcium and vitamins in abundance. When consumed as

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food, it provides a sustaining diet, especially for people doing diligence. Finger millet grains are called "famine reserves" because they store well for an extended period of time. According to reports, there is a yield disparity of over 40% between the lowest and highest performing finger millet crops[12]. One of the main causes of this low productivity has been attributed to improper and unbalanced nutrition.

Recently, finger millet production in Tamil Nadu has been facing a crisis marked by diminishing cultivated areas and profitability, low prices for finger millet, inconsistent production, and stagnant yields, rising input and labour costs, a shift of labour from agriculture to non-agricultural sectors, and increasing water scarcity. These challenges pose a significant threat to the ongoing cultivation of finger millet. Therefore, it is imperative to embrace new technologies to bolster finger millet production in the region, addressing the rising demands of the expanding population in the future.

In India, the use of inorganic fertilizer plays a pivotal role in boosting finger millet productivity. Nonetheless, the escalating costs of chemical fertilizers, growing environmental consciousness, and the energy crisis have led to a rising interest in exploring alternative sources of plant nutrients. Unrestricted use of inorganic fertilizers in recent times has sparked significant apprehensions regarding potential long-term adverse impacts on soil health, soil structure, and environmental pollution. Chemical fertilizers prove ineffective in supporting productivity in continuous and intensive cropping. Conversely, incorporating organic materials improves soil physical properties, enhances soil fertility, and increases crop yields[13].

Hence, there is a need to formulate a comprehensive input package for finger millet cultivation that integrates both organic and inorganic fertilizers. It has been established that the combination of synthetic fertilizers and organic manure contributes to the augmentation of the soil's microflora, fauna, and overall biological attributes, effectively arresting the continuous deterioration of soil health. The application of composted organic waste products serves to enhance soil properties and concurrently decelerate the process of mineralization[7]. In addition, foliar feeding is a method where a nutrient solution is sprayed onto the plant's leaves, facilitating the absorption of nutrients directly through the foliage. Foliar application of liquid organic manures (Humic acid, Panchagavya, Vermiwash and Seaweed extract) are known to influence a wide array of physiological parameters like alteration of plant architecture, assimilate partitioning, promotion of photosynthesis, uptake of nutrients (mineral ions), enhancing nitrogen metabolism, promotion of flowering, uniform grain formation, increased mobilization of assimilates to defined sinks and enhanced grain yield. Compared to the other important cereal crops, information on INM strategies utilizing enriched compost and liquid organic manures are scarce in finger millet. Given this background, the present investigation was undertaken to identify the response of finger millet to various combinations of enriched organic compost and supplemented with liquid organic nutrition, in terms of yield, nutrient uptake, post-harvest soil nutrient status, and microbial population in irrigated finger millet.

The experiment was carried out at the farmer's field at Puliyanthoppu village, Krishnagiri District, Tamil Nadu during

December 2019-April 2020 (Marghazipattam). The experimental site was situated at 11°12 to 12°49'N latitude and 77°27 to 78°38'E longitude and at an altitude of 492 m above MSL. The maximum and minimum temperature during the cropping period (Dec- April) ranges from 27.62 to 34.24°C and 17.1 to 22.28° C, respectively. The mean of morning and evening relative humidity were 62 and 75 percent. The mean rainfall during cropping season is 4 mm. The soil of field site has a clay loam soil texture with a pH of 7.1, EC of 0.35 $dSm^{-1}$ and low in available nitrogen, medium in available phosphorus, and high in available potassium. The cultivar used for the study was CO 15. The experiment with different treatments was tested in the field in a split plot design with three replication.

The treatment details of the field experiment as fallows, with three main plot treatments *viz*., $M_1$- Enriched FYM @ 750 kg $ha^{-1}$, $M_2$- Enriched Pressmud compost @ 750 kg $ha^{-1}$, $M_3$- Enriched Poultry manure compost @ 750 kg $ha^{-1}$ and five sub plot treatments *viz.,* $S_1$- Control (Water spray), $S_2$- Foliar spray of humic acid @ 0.3%, $S_3$-Foliar spray of panchagavya @ 3%, $S_4$- Foliar spray of vermiwash @ 5%, $S_5$-Foliar spray of seaweed extract @ 0.3% (All the foliar sprays were given at 20,40 and 60 DAT). The recommended fertilizer schedule (RDF) of ragi *viz.,* 60:30:30 kg of NPK $ha^{-1}$ was applied in all plots. Enriched FYM compost was prepared under heap method with following procedure, 750 kg of FYM on a dry-weight basis was thoroughly blended with single superphosphate (187.5 kg $ha^{-1}$), *Azospirillum* (10 kg) and *Phosphobacteria (*10 kg). It was maintained in a shaded condition with 60% moisture. After two months, the enriched FYM compost was applied to the respective plots as per the treatment schedule before transplanting. The same procedure adopted for preparation of enriched compost from poultry manure and pressmud. As per treatment schedule, liquid organic manures *viz.,* panchagavya, humic acid, vermiwash and seaweed extract were sprayed by using hand operated knapsack sprayer in the evening hours on 20, 40 and 60 days after transplanting with spray volume 500 l $ha^{-1}$. Harvesting of ear heads was done in each plot separately after observing the maturity symptoms of 50 per cent ear heads turning brown from the net plot area and excluding the border rows. The grains were then cleaned and dried, and their dry weight was obtained at a 14 per cent moisture level. The straw yield was also recorded. The data on each characters were evaluated throughout the investigation was statistically analysed as suggested by Panse and Sukhatme[10]. To make the statistical inferences, the critical differences were calculated at a 0.05 probability level.

*Soil analysis :*

Post-harvest soil samples from each plot were taken, crushed, dried in the shade, and sieved through a 2.0 mm sieve for assessment. The analytical process used to analyse soil is provided in Table-1.

*Plant analysis (nutrient uptake by crop):*

Plant samples that were gathered for estimating the dry matter were dried in a hot air oven at 80°C and crushed into a fine powder

Table-1. Methods employed for soil and plant analysis

| Particulars | Method | Reference |
|---|---|---|
| **A. Soil analysis** | | |
| Available nitrogen | Alkaline permanganate method | Subbiah and Asija (1956) |
| Available phosphorus | Using 0.5 M $NaHCO_3$ of pH 8.5 | Olsen *et al*. (1954) |
| Available potassium | Flame photometric method using neutral normal ammonium acetate extract | Stanford and English (1949) |
| **B. Plant analysis** | | |
| Nitrogen | Micro Kjeldahl's method | Humphries (1956) |
| Phosphorus | Colorimetry-Triple acid digestion | Jackson (1973) |
| Potassium | Flame photometry-Triple acid digestion | Stanford and English (1949) |

in a Willey mill. The chemical analysis of this powder was used to ascertain the intake of nitrogen, phosphorus, and potassium. Based on their respective element concentrations (NPK), crop nutrient uptake were estimated and expressed as kg $ha^{-1}$.The method utilized in plant analysis is specifically described in Table-1.

*Microbial analysis :*

The different types of micro organisms were enumerated using different media favouring the growth of bacteria, fungi and actinomycetes. The standard of serial dilution plating technique was adopted for the estimation of microbial population and are furnished in Table-2.

Table-2. Microbial analysis

| Particulars | Method | Reference |
|---|---|---|
| Total bacteria | Serial dilution method using nutrient agar medium | Williams and Cross (1971) |
| Total fungi | Serial dilution method using potato dextrose agar medium | Aziz and Zainol (2018) |
| Total actinomycetes | Serial dilution method using casein starch agar medium | Williams and Davies (1965) |

*Ear* heads $m^{-2}$, grain and straw yields (Table 3) :

Among the enriched compost, $M_3$ (enriched poultry manure compost @ 750 kg $ha^{-1}$) recorded highest values of number of earhead of 95.81 $m^{-2}$, grain and straw yields of 3504 and 6597 kg $ha^{-1}$, respectively. This could be as a result of composted poultry manure will increases the nutrients availability, microbial activity, and enhance uptake of vital plant nutrients, caused the increases the cell division, cell elongation, chlorophyll formation, Table-3. Effect enriched organic compost and foliar nutrition on yield attribute and grain yield and nutrient uptake in finger millet (kg $ha^{-1}$)

| Treat ments | Yield attributes and Yields | | | Nutrient uptake(kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Number of ear heads $m^{-2}$ | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | N | $P_2O_5$ | $K_2O$ |
| **MAIN PLOTS** | | | | | | |
| **$M_1$** | 72.41 | 2689 | 5467 | 74.73 | 14.51 | 59.69 |
| **$M_2$** | 82.61 | 3098 | 6058 | 78.23 | 17.94 | 62.45 |
| **$M_3$** | 95.81 | 3504 | 6597 | 83.49 | 21.91 | 66.51 |
| **S.Ed.** | 1.09 | 73 | 74 | 0.92 | 0.25 | 0.73 |
| **C.D(P=0.05)** | 3.12 | 158 | 212 | 2.63 | 0.72 | 2.10 |
| **SUB PLOTS** | | | | | | |
| **$S_1$** | 64.73 | 2389 | 4968 | 72.28 | 11.91 | 57.57 |
| **$S_2$** | 87.85 | 3316 | 6347 | 80.52 | 19.78 | 64.20 |
| **$S_3$** | 84.40 | 3090 | 6079 | 78.83 | 18.42 | 62.93 |
| **$S_4$** | 84.95 | 3139 | 6134 | 79.11 | 18.60 | 63.14 |
| **$S_5$** | 96.27 | 3567 | 6675 | 83.33 | 21.88 | 66.58 |
| **S.Ed.** | 0.76 | 37 | 56 | 0.71 | 0.17 | 0.56 |
| **C.D(P=0.05)** | 1.59 | 83 | 119 | 1.47 | 0.35 | 1.17 |

**Main plot treatments**: $M_1$- Enriched FYM @ 750 kg $ha^{-1}$,$M_2$- Enriched pressmud compost @ 750 kg $ha^{-1}$, $M_3$- Enriched Poultry manure compost @ 750 kg $ha^{-1}$
**Sub plot treatments**: $S_1$- Control (Water spray), $S_2$- Foliar spray of humic acid @ 0.3%, $S_3$-Foliar spray of panchagavya @ 3%, $S_4$- Foliar spray of vermiwash @ 5%, $S_5$-Foliar spray of seaweed extract (All the foliar sprays were given at 20,40 and 60 DAT).

nitrogen metabolism and auxin contents in the plants which ultimately increased the LAI values. Higher LAI coupled with good source of nutrients and plant growth hormone in balanced form helps to enhanced the photosynthetic rate, which in turn increased the translocation of photosynthates from source to sink which reflected on higher yield attributing characters such higher ear heads and more filled grains resulting in maximum grain and straw yields were recorded in this treatments[18]. The least number of earheads of 72.41 $m^{-2}$, grain and straw yields of 2689 and 5467 kg $ha^{-1}$, respectively were recorded in $M_1$ (enriched FYM compost @ 750 kg $ha^{-1}$).

Among foliar nutrition treatments, higher number of earhead of 96.27 $m^{-2}$ higher grain and straw yield of 3567 and 6675 kg $ha^{-1}$, respectively were obtained with the foliar spraying of seaweed extract @ 0.3% on 20, 40 and 60 DAT ($S_5$). These could be attributed to the influence of seaweed extract; it contains more auxins and cytokinins, which serve a crucial role in the translocation and distribution of photo-assimilates for grain filling in ragi. They contribute to improvements in sink activity, heightened seed-setting percentage, post-flowering photosynthesis, and the allocation of assimilates to the sink, resulting in an elevated ear heads count per square meter as well as increased grain and straw yields[3]. The lowest number of earhead $m^{-2}$, grain and straw yields were registered under water spray ($S_1$).

The interaction between organic sources and foliar spray of nutrients were significant. The substantial increase in yield attribute, and grain and straw yields were brought about by the nitrogen-rich seaweed extract and composted poultry manure, which was directly impacted on yields and its attributes[11]. The lowest number of earhead $m^{-2}$ grain and straw yields of were found in $M_1S_1$ (enriched FYM @ 750 kg $ha^{-1}$ along with water spray).

*Uptake of nutrients by crop* (Table 3) *:*

Among the enriched organic compost, plots treated with enhanced poultry manure compost @ 750 kg $ha^{-1}$ ($M_3$) had the highest uptake of nitrogen, phosphorus and potassium (83.49, 21.91 and 66.51 kg $ha^{-1}$, respectively). This might be due to consistent and sustained availability of nutrients in compost derived from poultry manure compost that are easily absorbed by plants and that match the pattern of uptake of various physiological growth phases of crop, leading to higher uptake of nitrogen, phosphorus and potassium under composted poultry manure-treated plots. These findings aligned with those of Abhitej Singh Shekhawat *et al.*[1]. The plots that received with enriched FYM compost at 750 kg $ha^{-1}$ ($M_1$) had the lowest nitrogen, phosphorus and potassium uptake of 74.73, 14.51 and 59.69 kg $ha^{-1}$, respectively.

Regarding foliar nutrition's, seaweed extract @ 0.3% on 20, 40 and 60 DAT ($S_5$) registered higher nitrogen, phosphorus and potassium uptake of 83.33, 21.88 and 66.58 kg $ha^{-1}$, respectively. These were primarily due to three times applications of seaweed extract containing auxin, cytokinins and major nutrients. This practice resulted in a well-balanced nutrient supply, stimulated the proliferation of the root system, and enhanced the absorption of water and nutrients from deeper soil layers. As a result, there was a direct impact on the increased uptake of NPK nutrients[8]. This treatment was followed by $S_2$ (humic acid @ 0.3% at 20, 40 and 60 DAT). The least nitrogen, phosphorus and potassium uptake of 72.28, 11.91 and 57.57 kg $ha^{-1}$, respectively were noticed in $S_1$ plots (water spray).

Significant effect was found between enriched compost and foliar nutrition. Application of enriched poultry manure compost @ 750 kg $ha^{-1}$ ($M_3S_5$) along with foliar spray of seaweed extract @ 0.3% on 20, 40 and 60 DAT registered the higher nitrogen, phosphorus and potassium uptake. The integration of organic manure with foliar nutrition has elevated the concentration of easily accessible plant nutrients during crucial growth phases of the crop. This has facilitated effective nutrient absorption, translocation, and assimilation, leading to enhanced accumulation of dry matter and nutrient content in the plant. Consequently, this has resulted in an increased uptake of vital nutrients[14]. The least uptake of nitrogen, phosphorus and potassium were recorded under $M_1S_1$ (enriched FYM compost @ 750 kg $ha^{-1}$ along with water spray).

*Soil fertility* (Table 4) *:*

Soil is a living entity and crop cultivation must either conserve liveliness or rejuvenate to normalcy from the present predicament of soil health deterioration due to intensive crop cultivation.

In respect of available N, $P_2O_5$ and $K_2O$ in post-harvest soil, among the enriched organic compost, application of enriched poultry manure compost @ 750 kg $ha^{-1}$ ($M_3$) registered higher values of available N,

Table-4. Effect enriched organic compost and foliar nutrition on post-harvest soil available NPK (kg $ha^{-1}$) and microbial population at end of the experimentation

| Treat ment | Microbial population | | | Post-harvest soilavailable NPK(kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Bacteris $10^{-6}$ | Fungi $10^{-4}$ | Actinomy cetes $10^{-5}$ | N | $P_2O_5$ | $K_2O$ |
| **MAIN PLOTS** | | | | | | |
| **$M_1$** | 38.73 | 11.39 | 4.39 | 218.49 | 22.21 | 278.98 |
| **$M_2$** | 42.22 | 12.46 | 5.33 | 221.26 | 23.40 | 285.58 |
| **$M_3$** | 46.36 | 14.05 | 6.76 | 224.55 | 25.29 | 282.37 |
| **S.Ed.** | 1.89 | 0.69 | 0.65 | 1.57 | 0.68 | 1.47 |
| **C.D(P=0.05)** | 3.82 | 1.46 | 1.38 | 3.12 | 1.46 | 3.08 |
| **SUB PLOTS** | | | | | | |
| **$S_1$** | 41.92 | 12.48 | 5.41 | 223.40 | 24.61 | 284.50 |
| **$S_2$** | 42.35 | 12.60 | 5.47 | 220.97 | 23.25 | 281.83 |
| **$S_3$** | 42.64 | 12.69 | 5.53 | 222.48 | 24.43 | 285.52 |
| **$S_4$** | 42.81 | 12.74 | 5.55 | 221.55 | 23.83 | 282.39 |
| **$S_5$** | 42.46 | 12.64 | 5.50 | 218.76 | 22.06 | 279.31 |
| **S.Ed.** | 1.92 | 0.83 | 0.79 | 1.85 | 1.26 | 2.24 |
| **C.D(P=0.05)** | NS | NS | NS | NS | NS | NS |

**Main plot treatments**: $M_1$- Enriched FYM @ 750 kg $ha^{-1}$, $M_2$- Enriched pressmud compost @ 750 kg $ha^{-1}$, $M_3$- Enriched Poultry manure compost @ 750 kg $ha^{-1}$
**Sub plot treatments**: $S_1$- Control (Water spray), $S_2$- Foliar spray of humic acid @ 0.3%, $S_3$-Foliar spray of panchagavya @ 3%, $S_4$- Foliar spray of vermiwash @ 5%, $S_5$-Foliar spray of seaweed extract (All the foliar sprays were given at 20,40 and 60 DAT).

$P_2O_5$ and $K_2O$ of 224.55, 25.29 and 282.37 kg $ha^{-1}$, respectively in post-harvest soil under finger millet. It may be attributed to the positive impact of composted poultry manure in mineralizing both native and its own nutrient content by stimulating microbial as well as chemical activities that increased the soil's available nutrient pool. In fact, not all the nutrients are absorbed by the plant, the remaining nutrients present in the soil which improves the soil fertility[6]. The least post-harvest soil available N, $P_2O_5$ and $K_2O$ of 218.49, 22.21 and 278.98 kg $ha^{-1}$, respectively were recorded in $M_1$ (enriched FYM compost @ 750 kg $ha^{-1}$). The availability of N, $P_2O_5$ and $K_2O$ in the soil after harvest is not significantly impacted by the foliar application of different treatments. However, post-harvest soil status showed that the numerically higher values obtained under water spray (control) it might be due to the lesser uptake of nutrients by the crop. In comparison to the control, foliar spray of seaweed extract registered lower values of post-harvest available NPK. This may be attributed to the enhanced root proliferation, greater root length, and increased root volume observed in the ragi crop under this treatment. These factors contributed to a higher uptake of nitrogen, phosphorus, and potassium (NPK), which directly reflected on least soil available NPK registered under this treatment[17]. The interaction effect were found to be non-significant.

*Microbial population* (Table 4) *:*

Among the enriched organic compost, plots received with enriched poultry manure compost @ 750 kg $ha^{-1}$ ($M_3$) registered the higher microbial population of bacteria (46.36), fungi (14.05) and actinomycetes (6.76). Poultry manure compost along with inorganic source of nutrients applied to ragi crop which helps in increasing the humus content in the soil and also involved in supplying food and energy to the microbes. These might be the reasons for rapid multiplication of microbial population in respective plots[4]. In respect of foliar spray and interaction effect was found to be non-significant.

Based on the results of the field experiment, it may be concluded that the application of enriched poultry manure compost at 750 kg $ha^{-1}$ along with foliar applications of seaweed extract at 0.3% on 20, 40, and 60 DAT led to maximum yield attributes, grain yield, and straw yield of irrigated finger millet. Therefore, the above combination may be productive for farmers, along with maintaining soil health.

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