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Enhancing sweet basil (*Ocimum basilicum*) production and quality with fermented organic manure

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Abstract
Studies were conducted during kharif season of 2019 at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar to study the influence of fermented liquid manures (Jeevamrit and Kunapajala), Farmyard manure (FYM) and inorganic fertilizers on fresh herbage yield, essential oil content and total oil yield of sweet basil (Ocimum basilicum) and their effect on soil health. Eight treatments with three replications were adopted in a randomized block design to investigate the effect of fermented liquid manures (500 L ha^{-1}, 1000 L ha^{-1} and 500 L+FYM @ 7.5 t ha^{-1} ha^{-1}), recommended dose of NPK (120:60:40 kg ha^{-1}), and recommended FYM (15 t ha^{-1}) on fresh herbage and oil yield of sweet basil. Results revealed that RDF (N120:P60:K40) gave significantly higher fresh herbage yield (271.86 q ha-1) and oil yield (143.33 kg ha^{-1}) and was statistically at par with Jeevamrit @ 500 L ha^{-1}+FYM @ 7.5 t ha^{-1} (256.07 q ha^{-1} and 138.54 kg ha^{-1} respectively). Organic liquid manures (Jeevamrit and Kunapajala) are rich bio-formulation which contains consortia of beneficial microbes. The highest total microbial population (34.01×104 CFU/g) was obtained with Jeevamrit @ 500 L ha^{-1}+FYM @ 7.5 t ha^{-1} which was followed by FYM @ 15 t ha^{-1} (30.07×104 CFU/g) in soil after harvest. The essential oil content was non significantly affected due to various treatments however Jeevamrit @ 500 L ha^{-1}+FYM @ 7.5 t ha^{-1} recorded numerically higher oil content. Jeevamrit combined with FYM (7.5 t ha^{-1}) was superior to FYM (15 t ha^{-1}) alone with respect to fresh herbage and oil yield.

Keywords: Fermented organic liquid manure, hydro distillation, mulching, sweet basil

Introduction

Indian Basil (*Ocimum basilicum* L.) is one of the most important essential oil producing medicinal and aromatic plants, is grown in India from the ancient time for its medicinal, fragrance and industrial properties. The economic parts of the plant include leaves and seeds. The medicinal properties of basil results from the presence of phenolic compounds, methyl-cinnamate, linalool, methyl chavicol, and camphor etc., in its essential oil which have antibacterial, anti-fungal and antioxidant activities (Nour *et al*., 2009; Sekar *et al*., 2009) [18, 22]. Basil has substantial need of nutrients and fertilizers. It responds extremely well to nitrogenous fertilizers. As the dose of nitrogen increases, yield of sweet basil increases (Daneshian *et al*. 2009; Biesiada & Ku 2010) [4, 3], but Injudicious use of chemical fertilizers in agriculture has not only deteriorated soil environment but also added numerous adverse effects on human health, agro biodiversity and environment. Besides they are expensive inputs also increase the cost of cultivation. It is thus necessary to activate and conserve the population of various species of microorganism and revive the biomass of earthworm through innovation in natural or traditional methods like use of desi cow dung, cow urine and organic matter. Taking into consideration of the poisonous effect of continuous use of chemical fertilizers on the soil structure, organic cultivation could be considered as a convenient replacement of inorganic fertilizer based farming for improving soil organic matter and microbial population (Shahram & Ordookhani 2011) [23]. The use of locally available organic manures give better physical, chemical and microbial environment and in this manner enhance crop yield per unit of applied nutrients. Besides this, for medicinal and aromatic plants (MAPs), the real importance is given to the quality rather than quantity, so that organic mode of cultivation is considered as a suitable method that enhances the performance of these crops. However, complete replacement of inorganic fertilizers by the organic manures requires huge quantities which may not be possible due to scarcity of such materials. In this endeavor, Fermented organic liquid manures play a vital role in agriculture leading to green food Production, which is healthier, safer and cost effective.

Nutritional spray on plants can decrease the delay between consumption and absorption of elements by the plants, which is very important for the fast growth of the plant. Hiltbrunner *et al*. (2005) [9] stated that organic liquid manure increases the yield in organically grown wheat. All the nutrients present in the soil don't remain in available form for the plants. They first need to be converted into the available form by the action of microorganisms normally present in the soil. For the liquid bio fertilizers, a better option is described in ancient Indian literature with more scientific and clinical formulation under the generic name "Kunapajala" given by Surapala (Sadhale, 1996) [26] in 'Vrikshayurveda' literature. These promote biological activities in the soil as well as make the nutrients available to crops. Jeevamrit is also a rich bio-formulation which contains consortia of beneficial microbes (Pathak *et al*., 2013; Kanali, 2016) [21].

2. Material and Methods

Field experiments were conducted on the experimental field at Medicinal Plants Research and Development Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during the *kharif* season of 2019. The experimental station is located in *tarai* belt, 30 kms southward to the foothills of Shivalik range of Himalayas at 79^O, 29′ E longitude and at an altitude of 243.83 meter above mean sea level. The eight treatments of experiment contain T_1 (RDF (N_{120}:P_{60}:K_{40}) kg ha^{-1}), T_2 (FYM 15 t ha^{-1}), T_3 (Kunapajala @ 500 L ha^{-1}), T_4 (Kunapajala @ 1000 L ha^{-1}), T_5 (Kunapajala @ 500 L ha^{-1} +FYM @ 7.5 t ha^{-1}), T_6 (Jeevamrit @ 500 L ha^{-1}), T_7 (Jeevamrit @ 1000 L ha^{-1}) and T_8 (Jeevamrit @ 500 L ha^{-1} + FYM @ 7.5 t ha^{-1}). Treatments were replicated thrice in a randomized complete blocks design. Physical and chemical properties of experimental soil are presented in table 1. The mineral nutrients were applied in the form of straight fertilizers like urea (120 kg N ha^{-1}), NPK grade II (60 kg P_2O_5 ha^{-1}) and muriate of potash (40 kg K_2O ha^{-1}). Half dose of nitrogen and full dose of phosphate and potash were applied as basal dose and the remaining N was applied at 30 days after planting in T_1 treatment. Jeevamrit was prepared as per the method developed by Palekar (2006) [19] who is a strong promoter of natural farming and Kunapajala was prepared by the method developed by Nene and Choudhary (2012) [17] and treatment was given to plants for six times (one pre + five post) at the interval of 15 days by soil application method through water. After 20 days of transplanting, mulching (*acchadana*) was done to cover soil in T_3, T_4, T_6 and T_7 as an important component of natural farming described by Palekar (2006) [19]. Linseed crop residue is used as a mulch material. Each experimental plot size was 5 m long and 3.2 m wide with spacing of 50 cm between the rows and 40 cm between the plants. There was a space of 0.5 meter between the plots and 1.2 meter between replications. Sweet basil variety CIM-Saumya (CIMAP) was sown in two nursery beds (6.0×1.0×0.1 m^3). Fresh herbage weight from each plot was converted to per hectare and it was expressed in quintal (q). In order to determine the essential oil content (%), a sample of 200 g fresh herb of basil from the each plot were sampled and mixed with 500 ml distilled water and then were subjected to hydrodistillation for 3 hour by using a Clevenger-type apparatus (Clevenger, 1928) [6]. Data were analysed under RBD with three replications by the help of OPSTAT statistical programme developed by HISAR (Sheoran *et al.,* 1998) [24]. The analysis of variance was calculated and the Critical difference (CD) values were used to compare treatment means at 5 percent.

Table 1: Physico-chemical properties of the soil of experimental plot (0-15 cm).

Soil texture	Sandy clay loam
Bulk density (g cc^{-1})	1.59
Soil pH	6.3
EC (dSm^{-1})	0.17
Organic carbon (%)	0.68
Available nitrogen (kg ha^{-1})	186.60
Available phosphorus (kg ha^{-1})	18.90
Available potassium (kg ha^{-1})	201.23

3. Results and Discussion

Fresh herbage yield

Fresh herbage yield of sweet basil differed significantly due to application of different doses of Jeevamrit and kunapajala along with and without FYM, FYM alone and inorganic fertilizer in the field experiment. As per the data depicted table 2 that the application of T_1 (NPK: 120:60:40 kg ha^{-1}) recorded significantly the highest fresh herbage yield (271.86 q ha^{-1}). It was closely followed by T_8 Jeevamrit @ 500 L + FYM @ 7.5 t ha^{-1} (256.07 q ha^{-1}) followed by T_5 Kunapajala @ 500 L + FYM @ 7.5 t ha^{-1} (244.03 q ha^{-1}) and these were found statistically *at par* to T_1 (271.86 q ha^{-1}). The lowest fresh herbage yield per hectare was obtained in T_2 applied with FYM (15 t ha^{-1}) alone (199.57 q ha^{-1}). These might be due to nutrients given through chemical fertilizers are assumed to be more readily available that reflect its uptake by plants leading to enhance the growth and fresh herbage yield (Merestala, 1996) [15]. its uptake by plants leading to enhance the growth and fresh herbage yield (Merestala, 1996) [15]. On the other hand, combined application of fermented liquid manures jeevamrit or kunapajala along with FYM increases the decomposition process of FYM and regulates the supply of nutrients to the plants because availability of organic matter helped to increase the microbial population in soil after application of jeevamrit and kunapajala (product of microbial consortia) which in turn increased the yield. Mishra *et al.* (2007) [16] recorded higher grain and straw yield in rice, when kunapajala was applied at every tenth and fifteenth day interval at the rate of 500 ml per pot. Similar findings were also reported by Siddappa (2015) [25] in field bean, where application of jeevamrit @ 1500 L ha^{-1} recorded significantly higher grain yield and straw yield. Sutar *et al.* (2019) [27] recorded similar results in cowpea with application of jeevamrit @ 1000 L ha^{-1}. Similarly, Chauhan (2019) [5] recorded higher fresh biomass yield in bramhi at different doses of jeevamrit combined with FYM.

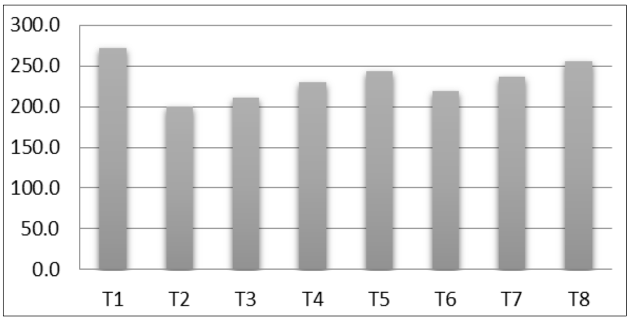

Fig 1: Fresh herbage yield as influenced by treatments.

Essential oil content

Essential oil content plays an important role in the selection of adequate combination of fertilizers in basil cultivation. The mean oil content in herb was 0.58%. The essential oil content in basil not influenced significantly due to application of jeevamrit, kunapajala, kunapajala+FYM, jeevamrit+FYM, FYM alone and inorganic fertilizer (table 2). However, numerically T_8 i.e. application of jeevamrit @ 500 L ha^{-1} + FYM @ 7.5 q ha^{-1} reported higher essential oil content (0.60%) followed by T_5 i.e. kunapajala 500 L ha^{-1} + FYM 7.5 q ha^{-1} (0.59%), whereas the lowest essential oil content was recorded in kunapajala @ 500 l/ha (0.55%). Soil nutrients enhanced with application of organic manure, which had positive effect on the growth parameters, herbage and oil yield (Khalid *et al.* 2006) [13]. In soybean crop, similar results were recorded by Buwasaheb (2009) [4], where application of FYM + vermicompost (50% each) + Jeevamrit 2 times (30 and 45 DAS) showed numerically higher oil and protein content in soybean grain. This is assumed to be due to increased availability of different macro and micronutrients with the application of farmyard manure combined with fermented liquid manures and their higher uptake because of increased microbial activity. Similar findings were reported by Jain *et al.* (1995) [11] and Honale (1996) [10].

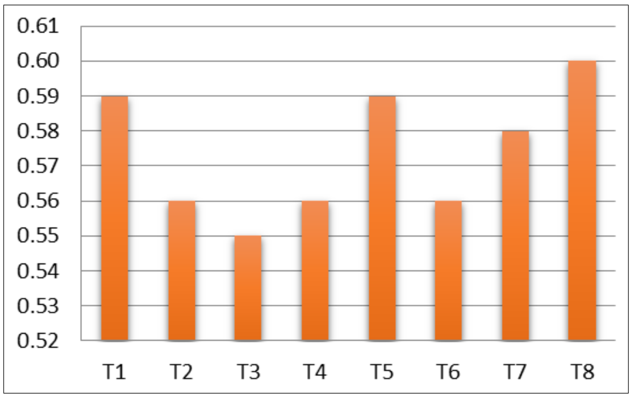

Fig 2: Oil content (%) as influenced by treatments.

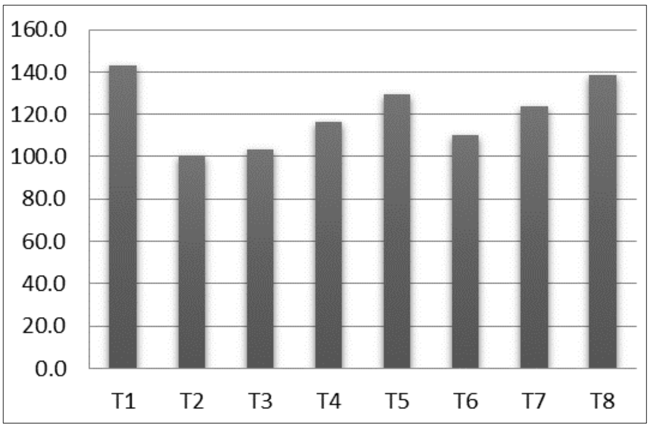

Fig 3: Oil yield (kg ha-1) as influenced by treatment.

Oil yield

Oil production is the most constitutive parameter in sweet basil farming. The results of different levels of fermented liquid organic manures, their combinations with FYM, inorganic fertilizer, FYM alone recorded during the field experiment on total oil yield showed a significant increase in total oil production (Table 2). In the present study, with application of NPK (120:60:40 kg ha^{-1}) recorded maximum oil yield (143.33 kg ha^{-1}). It behaved statistically similar to the application of 500 L jeevamrit + 7.5 ton per ha FYM (138.54 kg ha^{-1}) and also found similar to 500 L kunapajala + 7.5 ton per ha FYM (129.47 kg ha^{-1}), which might be due to soil drenching of jeevamrit and kunapajala resulted in quick mineralization of native and applied nutrients through FYM due to build-up of microflora, as the microbial formulation i.e. jeevamrit and kunapajala when soil drenched at regular intervals, resulted in increased availability and uptake of nitrogen content and consequentially increased the enzymatic reactions (Kaur, 2019) [12]. The lowest oil yield per hectare was recorded in T_2 applied with FYM (15 t ha^{-1}) alone. Similar results were reported by Al-mansour *et al.* (2018) [1] in basil, where lowest oil yield was recorded with application of FYM (10 t/ha) alone and highest in NPK (160:80:80 kg ha^{-1}) + FYM (10 t ha^{-1}).

Soil Microbial Count

The population of bacteria, fungi and actinomycetes in the soil noted before (T_0) and after the harvest of crop has been showed in table 3.

i. Bacterial population

Different treatments had a significant effect on the population of bacteria after harvest of the crop in the soil. Significantly highest bacterial population was recorded in T_8 with application of jeevamrit @ 500 l/ha + FYM @ 7.5 t/ha (20.01×10^4 CFU/g soil) was *at par* with T_2 (17.70×10^4 CFU/g), T_5 (16.83×10^4 CFU/g) and T_7 (14.93×10^4 CFU/g). These treatments were significantly superior to the T_1 and rest of the treatments.

ii. Fungi population

Fungi population (table 3) in the soil after harvest of basil was recorded significantly highest in T_8 with application of jeevamrit @ 500 l/ha + FYM @ 7.5 t/ha (5.00×10^4 CFU/g). It was statistically equal to FYM 15 t/ha (4.67×10^4 CFU/g). Significantly lower fungal population was recorded in T_1 with application of recommended dose of NPK (1.47×10^4 CFU/g).

iii. Actinomycetes population

Treatments had remarkable effect on actinomycetes population in soil the after harvest of basil (table 3). Significantly higher population was noted with application of jeevamrit @ 500 l/ha + FYM @ 7.5 t/ha (9.00×10^4 CFU/g). Significantly lower actinomycetes population was recorded in T_1 with application of recommended dose of NPK (1.70×10^4 CFU/g).

iv. Total microbial population

Total microbial population in soil after harvest of basil recorded significantly superior in T_8 (34.01×10^4CFU/g) which was superior to all other treatments. It was statistically *at par* with T_2 (30.07×10^4 CFU/g) followed by T_5 (25.83×10^4 CFU/g). Treatment T_1 comprising of NPK (120:60:40 kg ha^{-1}) had the lowest total microbial count (11.21×10^4 CFU/g) which was 67.03% lower than T_8.

The results are in accordance with the study of Siddappa (2015) [25] in filed bean, where higher population of bacteria, fungi and actinomycetes was recorded with jeevamrit @ 1500 L ha^{-1} followed by jeevamrita @ 1000 L ha^{-1}. Similar results were also reported by Chauhan (2019) [5] in bramhi, where she reported 64.42% less microbial count in RDF as compared to Jeevamrit @ 5000 l/ha + FYM @ 2.5 t/ha. The results are also matched with the findings of Kaur (2019) [12], where he reported significantly higher population of bacteria (32.69×10^6 CFU/g), fungi (24.86×10^3 CFU/g) and actinomycetes (6.02×10^2 CFU/g) in plot treated with jeevamrit @ 20 percent at two weeks interval among all treatments.

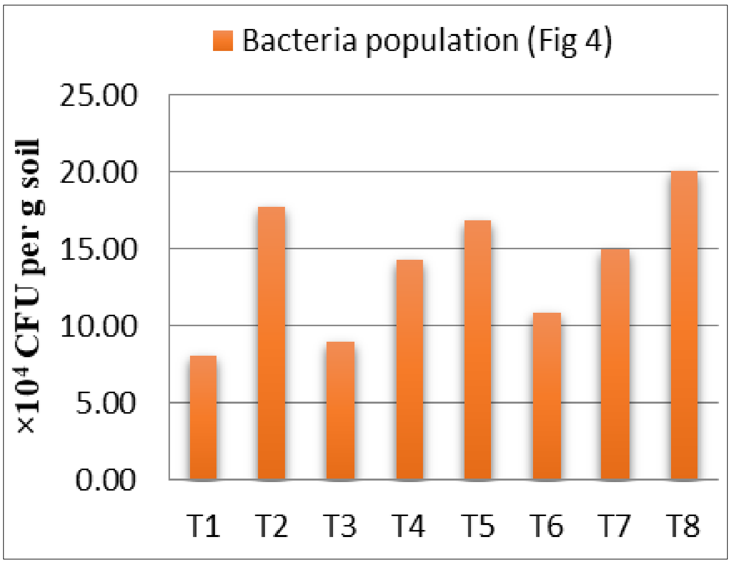

Fig 4: Bacterial count as influenced by treatments.

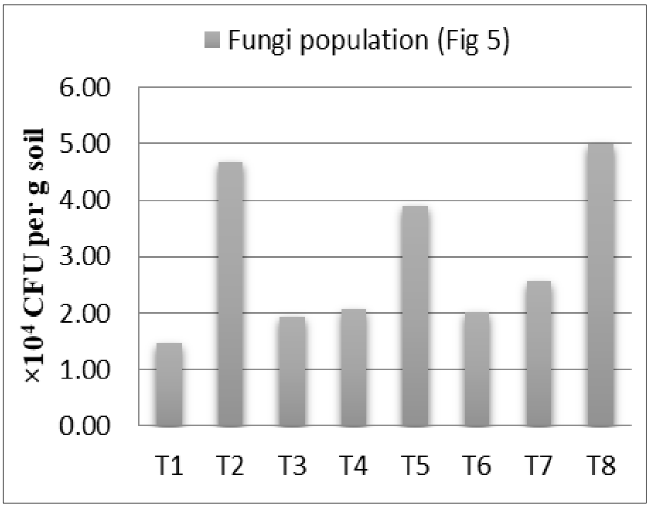

Fig 5: Fungal count as influenced by treatments.

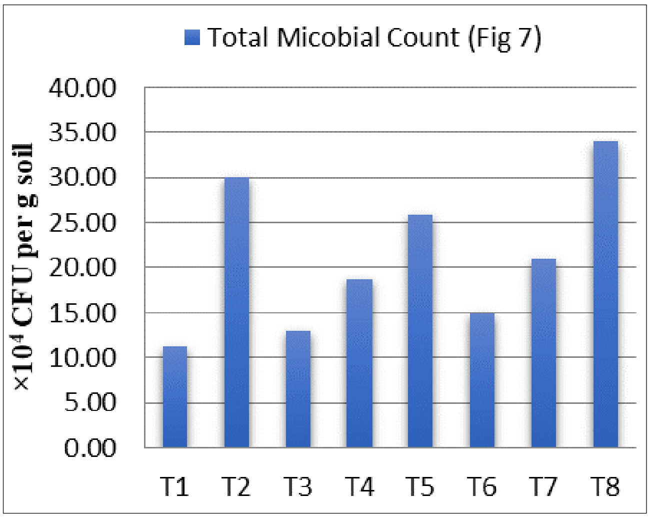

Fig 7: Total microbial count as influenced by treatments.

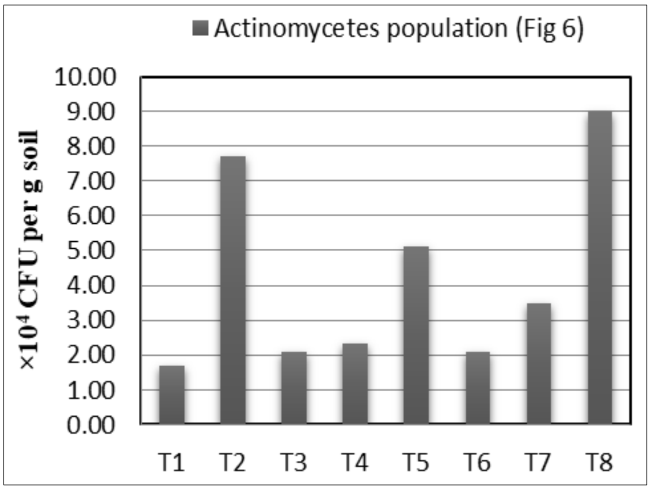

Fig 6: Actinomycetes count as influenced by treatments.

Microbial population increased after harvest in all the treatments with advancement in growth stages of crop as compare to initial microbial population (T_0). It might be possible that increased total root biomass with the passage of time, might be instrumental to supporting higher bacteria, fungi and actinomycetes population. Similar results have been described in a study on wheat, in which total bacteria, fungi and actinomycetes were evaluated (Meena *et al*., 2014) [14]. As compare to RDF, Higher total microbial count in soil treated with fermented liquid manures might be because of fermented liquid manures contain enormous amount of microbes that multiplies in the soil when applied with organics and act as a tonic to sustain and enhance the microbial activity in the soil (Palekar, 2006) [19]. Similar findings were revealed by Swaminathan (2005) [28] who reported that presence of beneficial microorganism occurring naturally predominantly bacteria, fungi, yeast, actinomycetes and certain photosynthetic bacteria were found in organic liquid manures. Devakumar *et al.* (2014) [8] revealed that use of handful of virgin soil for jeevamrit preparation performed as a source of initial inoculums of fungi, bacteria and actinomycetes, P- solubilizers and N- fixers. Consequently, more number of beneficial microorganisms was observed in organic liquid manure formulation. These findings are also resembled with the study of Papen *et al.* (2002) [20].

Supplementary data

Table 2: Fresh herbage yield (q ha^{-1}), Essential oil content (%) and total oil yield (kg ha^{-1}) of sweet basil as influenced by the treatments.

Legends	Treatments	Fresh herbage yield (q ha^{-1})	Oil content in herb (%)	Total oil yield (kg ha^{-1})
T_1	Recommended dose of fertilizers (N_{120}:P_{60}:K_{40}) kg ha^{-1}	271.86	0.59	143.33
T_2	FYM @ 15 t ha^{-1}	199.57	0.56	100.73
T_3	Kunapajala @ 500 L ha^{-1}	211.00	0.55	103.38
T_4	Kunapajala @ 1000 L ha^{-1}	229.33	0.56	116.27
T_5	Kunapajala @ 500 L ha^{-1} + FYM @ 7.5 t ha^{-1}	244.03	0.59	129.47
T_6	Jeevamrit @ 500 L ha^{-1}	218.78	0.56	109.98
T_7	Jeevamrit @ 1000 L ha^{-1}	236.20	0.58	123.89
T_8	Jeevamrit @ 500 L ha^{-1} + FYM @ 7.5 t ha^{-1}	256.07	0.60	138.54
	Mean	233.35	0.58	120.91
	CD at 5%	34.18	NS	16.34
	CV %	8.67	2.33	8.01

1. FYM = Farmyard manure.
2. NS = non-significant.

Table 3: Bacteria, Fungi, Actinomycetes and Total microbial population (×104 CFU/g soil) in soil (0-15 cm) after harvest of sweet basil as influenced by the treatments.

Legends	Treatments	Bacteria $\times10^4$ CFU/g	Fungi $\times10^4$ CFU/g	Actinomycetes $\times10^4$ CFU/g	Total Count $\times10^4$ CFU/g
T_0	Initial microbial population	5.16	0.83	0.72	6.71
T_1	RDF (N_{120}:P_{60}:K_{40}) kg ha^{-1}	8.04	1.47	1.70	11.21
T_2	FYM @ 15 t ha^{-1}	17.70	4.67	7.70	30.07
T_3	Kunapajala @ 500 L ha^{-1}	8.93	1.93	2.10	12.97
T_4	Kunapajala @ 1000 L ha^{-1}	14.30	2.07	2.33	18.70
T_5	Kunapajala @ 500 L ha^{-1} + FYM @ 7.5 t ha^{-1}	16.83	3.90	5.10	25.83
T_6	Jeevamrit @ 500 L ha^{-1}	10.87	2.00	2.10	14.97
T_7	Jeevamrit @ 1000 L ha^{-1}	14.93	2.57	3.47	20.97
T_8	Jeevamrit @ 500 L ha^{-1} + FYM @ 7.5 t ha^{-1}	20.01	5.00	9.00	34.01
	Mean	13.95	2.95	4.19	21.09
	CD at 5%	5.16	0.70	1.11	5.46
	CV %	21.90%	13.99%	15.68%	15.34%

Conclusion

The outcomes of the present investigation concluded that a better approach for sustainability of the system and nutrient management in sweet basil is use of fermented organic liquid manures (natural source) as compared to chemical fertilizer (inorganic source) or Farm yard manure (organic source) alone. Thus, based on the above findings and to maintain the balance between crop production and soil health it can be concluded that Jeevamrit @ 500 L per ha combined with half of the recommended dose of Farm yard manure (7.5 t/ha) is sufficient to supply nutrients to crops, increases fresh herbage and oil yield, and maintain soil health in long run. Keeping in view the poisonous effects of chemical fertilizers, the use of these ecofriendly fermented organic liquid manures provide alternate production technologies to organic farmers and new vision to scientific community for further refinement and validation of age-old farming practices in present scenario to produce safe food, sustain soil health and to save the environment.

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