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Evaluation of Liquid Biofertilizers on Growth and Yield of Finger Millet (*Eleusine coracana* L.)

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ABSTRACT

Biofertilizers are best complementary source for chemical fertilizers and are formed by the combination of different beneficial plant growth promoting microbes (PGPM). Liquid bio fertilizer consortium (LBFC) is more potential compared to carrier based biofertilizers because it has a longer shelf life. In the present study PGPM consortia of LMC is applied to finger millet by different modes namely, seed treatment, seedling root dip, soil application and combination of all the three to enhance its growth and yield. The treatment T_4 (100 % NPK + Seed + Soil + Seedling root dip with LBFC) reported higher plant height, number of tillers per plant, number of leaves per plant and dry matter accumulation were superior when compared to other treatments. Higher yields obtained by PGPM, treatment demonstrate that it is effective in stimulating plant vegetative growth and enhancing crop productivity. The yield in T_4 treatment recorded higher harvest index, grain and straw yield with 0.337, 4080 kg ha^{-1} and 7810 kg ha^{-1}, respectively, when compared to the control (0.329, 1757 kg ha^{-1} and 3710 kg ha^{-1}). Based on the analysis of microbial, plant and yield data, is evident that 100 per cent NPK with application of liquid biofertilizers consortia directly to the soil @ 625 ml in 500 kg of FYM / hectare can be recommended for finger millet crop in eastern dry zone (Zone-V).

Keywords : Plant growth promoting Microorganisms, Finger milled, Seedling root dip, Soil application, Seed treatment

In recent years, chemical fertilizers are being used at an exponential rate to increase crop production. This has lead to land degradation and reduced crop productivity over the years. To overcome these problems biofertilizers are used as alternate source of nutrients. Biofertilizers are the beneficial live microorganisms that aid in plant growth and promotion by increasing the availability of nutrients, production of siderophores and by decreasing pathogenic microorganisms. Biofertilizers are applied in carrier based as well as in liquid form, important microorganisms used as biofertilizers are *Rhizobium, Azospirillum, Azotobacter*, phosphate solubilizing bacteria, potassium solubilizing bacteria and Mycorrhizae (Tamilkodi and Victoria, 2018).

Biofertilizers produced in India are largely carrier based, this formulation has shelf life of only six months (Ansari *et al.,* 2015). They are susceptible to UV rays and high temperatures (>30°C). Colony count of carrier-based biofertilizers gradually decreases over the time from 10^8 CFU/mL initially to 10^6 CFU/mL at the end of four months and after six months, colony count will be minimum. These maybe the reason for not getting enough response from farmers and research alike (Verma *et al.*, 2018).

On the other hand, Liquid Microbial Consortium (LMC) is more potential than carrier based biofertilizers because it has a longer shelf life of upto two years (Brahmaprakash and Sahu, 2012), dosage required is one tenth of carrier based biofertilizers, require less storage space, application is effortless can easily be practiced by farmers and can withstand high temperature (upto 45°C). The increased shelf life can maintain high colony count upto 10^9 CFU/mL for 12-24 months. They can be applied using knapsack sprayers, power sprayers, can be given during drip irrigation as fertigation and mixed along with organic manure in basal application. Liquid biofertilizers can reduce the chemical fertilizer usage upto 30 per cent (Hegde, 2008).

Presently, Finger millet (*Eleusine coracana* L. Gaertn.) known as ragi or madua which is third most important cereal millet is mainly grown by the use of chemical fertilizers. In Karnataka it is grown in 5.55 lakh hectares with production of 6.76 lakh tonnes having productivity of 1.22 tonnes ha^{-1} (Agricultural Statistics at a Glance, 2019).

Considering the above points, current study was designed to exploit the use of liquid biofertilizers to reduce the use of chemical fertilizers, while improving ragi yield through different modes of application (seed treatment, soil application and seedling root dip method).

Material and Methods

The experiment was conducted during summer of 2020-21 at Zonal Agriculture Research Station, University of Agricultural Sciences, GKVK, Bangalore. The site is located in Agro Climatic Zone V (Eastern Dry Zone) of Karnataka. The initial soil sample was analyzed for its physio-chemical and biological properties by adopting standard procedures and are presented in Table 1.

Experimental Details

The experiment was carried out to study the effect of liquid biofertilizers on growth and yield of finger millet (GPU 66) grown on sandy loam soil. The experiment was laid out in randomized block design with 14 treatments replicated thrice with gross plot area of 3.0 × 4.5 m, net plot area of 2.6 × 3.3 m and spacing of 30 cm × 10 cm.

Table 1

Physico-chemical and biological properties of soil

Parameter	Values	Methods employed
Physical properties		
Coarse sand (%)	33.4	International pipette method (Piper, 1966)
Fine sand (%)	30.6	
Silt (%)	6.9	
Clay (%)	29.1	
Textural class	Sandy loar	
Biological properties		
Bacteria (No. X 10^6 cfu g^{-1} soil)	9.	Dilution plate count technique *(Vlassak et al., 1992)*
Fungi (No. X 10^4 cfu g^{-1} soil)	8.	
Actinomycetes (No. X 10^3 cfu g^{-1} soil)	3.	

Nursery beds of dimension 3m × 1m × 0.1m were prepared. Two beds were used to raise the finger millet without seed treatment and one was used with biofertilizer treated seeds. Beds were covered with FYM and irrigated twice a day. In one bed, seeds treated with liquid biofertilizer consortium (LBFC) at the rate of 6 ml kg^{-1} was sown; in other two beds, seeds were sown without seed treatment for transplanting (Lavanya *et al*., 2018).

At the time of transplanting (21 days after sowing) 50 per cent of the recommended dose of nitrogen, full dose of phosphorous and potassium were applied as basal dose in the form of urea, Di-ammonium Phosphate (DAP) and muriate of potash (MOP) according to the treatments. The remaining 50 per cent of the recommended dose of nitrogen was applied in two equal splits in the form of urea during crop growth (*i.e*., 30 and 60 days after transplanting). Farm yard manure at the rate of 10 t ha^{-1} was used for each treatment except absolute control. The crop was harvested at maturity at 113 days after transplanting, as the ear heads turned to brownish colour coupled

with straw turned to yellowish colour in more than 50 per cent plants.

Procurement and Preparation of Biofertilizers

Plant Growth Promoting Microorganisms (PGPM) used in the study (*Azospirillum lipoferum* - associative nitrogen fixer, *Bacillus megaterium* - phosphate solubilizer and *Frateuria aurantia* – Potassium solubilizer) were obtained from biofertilizer unit in Department of Agricultural Microbiology, GKVK, Bengaluru-560 065. A loop full of *Azospirillum lipoferum*, *Bacillus megaterium* and *Frateuria aurantia* pure culture were transferred aseptically into 250 ml conical flasks containing 100 ml of the Döbereiner's broth, Pikovskaya's broth and GYCaA (Glucose Yeast Calcium Extract Agar) broth, respectively and incubated for 2 days at 37°C. These cultures were used as mother cultures for further work and maintained at 4°C in refrigerator. For mass multiplication triple inoculants for the development of liquid biofertilizer consortium were prepared with combinations of *Azospirillum lipoferum* + *Bacillus megaterium* + *Frateuria aurantia*. Each inoculant grown in respective media were mixed in equal proportion (1:1:1). Before mass multiplication compatibility bioassay was conducted.

Application of LBFC (Liquid Biofertilizer Consortium)

Liquid biofertilizers can be applied to crop by seed treatment, seedling root dip and soil application with FYM or compost.

Seed Treatment

For 1 kg of the finger millet seeds, 6 ml of liquid biofertilizer consortium (LBFC) was mixed with equivalent quantity 10 per cent jaggery solution and coated the mixture uniformly on the seed and exposed for drying in shade for 10 minutes before sowing (Khandare *et al.,* 2020).

Seedling Root Dip

500 ml of liquid biofertilizer was mixed with 25 litres of water for one heactare of seedlings and the root portion of the seedlings was dipped for 20 minutes just before transplanting (Poorniammal *et al.,* 2020).

Soil Application

Liquid biofertilizers consortium of 625 ml ha^{-1} was used for soil application. The liquid consortium was diluted with 25 liters of water and then mixed with 500 kg of powdered farm yard manure then incubated overnight. This incubated FYM was applied to field directly in the furrows at the time of transplantation at the rate of one kg of treated FYM per treatment (Trimurtulu and Rao, 2014).

Combined Application

For the treatments with combined method application by seed treatment, seedling root dip and soil application; seedlings from seed treated beds were taken, then dipped in seedling root dip slurry and transplanted in furrows pre applied with FYM treated with liquid biofertilizer consortium.

Observations

Grain yield and straw yield from the net plot area was expressed in kg ha^{-1}. Soil sample for microbial analysis were collected from 0 to 15 cm depth before transplanting of the crop, at 30 DAT and 60 DAT. Viable population of bacteria, fungi and actinomycetes were analyzed by the standard serial dilution plate count method (Vlassak *et al*., 1992) using media *viz*., nutrient agar for bacteria, Martin's Rose Bengal Agar for fungi, Kuster's Agar for actinomycetes. Harvest index was calculated by dividing economic yield by total biological yield (Donald, 1962).

$$\text{Harvest index (HI)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})}$$

Statistical Analysis

The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The significance of comparison was tested. The significant difference values were computed for 5 per cent probability of

error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means.

Results and Discussion

Effect of Liquid Biofertilizers on Plant Growth Parameters at Different Intervals of Crop Growth in Finger Millet

Liquid biofertilizers application significantly influenced the plant height of finger millet at different intervals of crop period and it is presented in Table 2. At 30 DAT, 60 DAT, 90 DAT and at harvest, treatment T_4 (100 % NPK + Seed + Soil + Seedling root dip with LBFC) recorded significantly higher growth parameters than all the other treatments *viz*., plant height (33.9 cm, 79.4 cm, 100.2 cm and 102.2 cm, respectively) and number of leaves (25.2, 24.5, 22.3 and 23.3, respectively) but found on par with T_2 (100 % NPK + Soil application of LBFC), T_3 (100% NPK + Seedling root dip with LBFC) and T_8 (85 % NPK + Seed + Soil + Seedling root dip with LBFC) (Table 3).

Lowest plant height was observed in the treatment T_{14} (Absolute control) at the four growth stages. This indicates that there is no shortage of nutrients to allow the plant to reach its full potential because the combined application of inorganics, organics and microorganisms improved soil properties, increased nutrient availability through mineralization, induced the production of growth-promoting substances which could have caused cell elongation and expansion, resulting in increased growth rate. These findings agree with Kumar & Gautam (2004); Sunitha *et al*. (2004); Narolia *et al*. (2009) and (Rathore *et al*., 2008 & Abhik *et al*., 2020).

Total number of tillers in a plant at various stages of the crop varied significantly by the application of liquid biofertilizers (Table 4). At 30 DAT highest number of tillers were observed in the treatment T_4 (100 % NPK + Seed + Soil + Seedling root dip with LBFC) (3.5) but was on par with T_2 (100 % NPK + soil application of LBFC), T_3 (100 % NPK + Seedling root dip with LBFC) and T_8 (85 % NPK + seed + soil + seedling root dip with LBFC) with 3.4, 3.0 and 3.1, respectively.

Table 2

Effect of liquid biofertilizer on plant height at different intervals of crop growth in finger millet

Treatments	Treatment Details	Plant height (cm)			
		30 DAT	60 DAT	90 DAT	At Harvest
T_1	100% NPK+ Seed Treatment with LBFC	30.07 bcd	71.2 bcde	91.9 bcd	92.1 bcd
T_2	100% NPK + Soil application of LBFC	32.9 ab	78.6 ab	98.2 ab	101.2 a
T_3	100% NPK + Seedling root dip with LBFC	31.6 abc	76.4 abc	97.5 ab	99.5 ab
T_4	100% NPK + Seed + Soil + Seedling root dip with LBFC	33.9 a	79.4 a	100.2 a	102.2 a
T_5	85% NPK + Seed treatment with LBFC	26.5 efg	63.0 fgh	80.9 defg	83.1 defg
T_6	85% NPK + Soil application of LBFC	29.4 cde	70.4 cdef	88.7 bcd	90.8 bcd
T_7	85% NPK + Seedling root dip with LBFC	28.0 def	68.2 defg	87.1 cdef	89.1 cdef
T_8	85% NPK + Seed + Soil + Seedling root dip with LBFC	31.3 abc	74.3 abcd	96.4 abc	98.4 abc
T_9	70% NPK + Seed treatment with LBFC	23.1 gh	55.1 hi	70.9 gh	73.1 gh
T_{10}	70% NPK + Soil application of LBFC	25.9 fg	62.3 gh	78.4 efg	80.5 efg
T_{11}	70% NPK + Seedling root dip with LBFC	24.8 fg	60.7 gh	77.6 fg	79.6 fg
T_{12}	70% NPK + Seed + Soil + Seedling root dip with LBFC	26.8 def	66.3 efg	86.7 cdef	88.2 def
T_{13}	NPK	27.5 def	67.3 defg	88.0 bcde	89.9 bcde
T_{14}	Absolute control	19.6 h	47.5 i	61.2 h	63.3 h
CD@5%		3.49	7.9	10.0	10.1

TABLE 3

Effect of liquid biofertilizers on number of leaves at different intervals of crop growth in finger millet

Treatments	Treatment Details	Number of leaves			
		30 DAT	60 DAT	90 DAT	At Harvest
T_1	100% NPK+ Seed Treatment with LBFC	21.6 bcd	30.6 bcd	34.2 bcd	27.2 bcd
T_2	100% NPK + Soil application of LBFC	24.5 ab	33.1 ab	38.3 ab	31.6 ab
T_3	100% NPK + Seedling root dip with LBFC	22.3 abc	32.2 ab	37.8 ab	30.4 ab
T_4	100% NPK + Seed + Soil + Seedling root dip with LBFC	25.2 a	35.3 a	39.3 a	31.9 a
T_5	85% NPK + Seed treatment with LBFC	19.1 def	26.5 efg	29.4 efg	24.2 efg
T_6	85% NPK + Soil application of LBFC	21.3 cd	29.8 bcde	33.5 bcde	26.2 bcde
T_7	85% NPK + Seedling root dip with LBFC	19.9 cd	27.8 cdef	32.6 cdef	25.7 bcdef
T_8	85% NPK + Seed + Soil + Seedling root dip with LBFC	23.3 abc	31.6 abc	36.2 abc	29.2 abc
T_9	70% NPK + Seed treatment with LBFC	15.9 f	22.3 g	24.4 gh	19.6 gh
T_{10}	70% NPK + Soil application of LBFC	19.0 def	25.3 fg	28.3 fg	22.6 fg
T_{11}	70% NPK + Seedling root dip with LBFC	16.6 ef	23.7 fg	27.8 fg	21.3 fg
T_{12}	70% NPK + Seed + Soil + Seedling root dip with LBFC	19.7 cde	27.3 def	31.1 def	24.5 def
T_{13}	NPK	19.9 cd	27.6 cdef	31.9 cdef	25.2 cdef
T_{14}	Absolute control	12.3 g	16.6 h	19.3 h	15.0 h
CD@5%		3.151	4.25	5.05	4.65

Mean values followed by the same superscript in each column do not differ significantly at P=0.05 level by DMRT

TABLE 4

Effect of liquid biofertilizers on number of tillers at different intervals of crop growth in finger millet

Treatments	Treatment Details	Number of tillers plant^{-1}			
		30 DAT	60 DAT	90 DAT	At Harvest
T_1	100% NPK+ Seed Treatment with LBFC	2.8 b	3.3 bcd	4.4 bc	4.8 bcd
T_2	100% NPK + Soil application of LBFC	3.4 a	4.1 ab	5.3 ab	5.9 ab
T_3	100% NPK + Seedling root dip with LBFC	3.0 ab	4.0 abc	5.0 ab	5.3 abc
T_4	100% NPK + Seed + Soil + Seedling root dip with LBFC	3.5 a	4.3 a	5.6 a	6.0 a
T_5	85% NPK + Seed treatment with LBFC	1.9 c	2.4 ef	3.3 de	3.6 efg
T_6	85% NPK + Soil application of LBFC	2.7 b	3.2 cde	4.3 bc	4.8 bcde
T_7	85% NPK + Seedling root dip with LBFC	2.2 c	3.2 cde	4.0 bcd	4.0 cdef
T_8	85% NPK + Seed + Soil + Seedling root dip with LBFC	3.1 ab	3.6 abcd	4.5 abc	4.9 abcd
T_9	70% NPK + Seed treatment with LBFC	1.1 e	1.6 fg	2.4 ef	2.4 gh
T_{10}	70% NPK + Soil application of LBFC	1.7 cd	2.6 e	3.3 de	3.6 fg
T_{11}	70% NPK + Seedling root dip with LBFC	1.4 de	2.6 e	3.0 de	2.9 fgh
T_{12}	70% NPK + Seed + Soil + Seedling root dip with LBFC	2.0 c	2.8 de	3.6 cd	3.8 def
T_{13}	NPK	2.1 c	3.0 de	3.8 cd	3.9 def
T_{14}	Absolute control	1.0 e	1.5 g	1.6 f	2.0 h
CD@5%		0.5	0.8	1.05	1.2

Mean values followed by the same superscript in each column do not differ significantly at P=0.05 level by DMRT

The lowest number of tillers were observed in the treatment T_{14} (Absolute control) (1.0). Similar results were obtained at all the other growth stages. The application of 100 per cent NPK + combined application of liquid biofertilizers through seed, soil and seedling dip resulted in the highest number of tillers plant^{-1}. This could be because the combined application of inorganic P fertilizer with PSB and KSB that increased the availability of P and other nutrients in the soil, as well as promoted root growth and yield attributing characters. The current results are consistent with those of Divya *et al.* (2017) and Sreenivasamurthy & Harinikumar (2020).

Total dry matter accumulation in a crop is a key indicator in determining the efficiency of uptake of crop dry matter in different parts of the plant *viz.,* crop length, leaf area, tillers, photosynthate formation. Higher dry matter accumulation might be attributed to improve photosynthetic efficiency as a result of increasing chlorophyll content at increased nitrogen levels (Kumar *et al*., 2003). There were significant differences among treatments at different stages of the crop (Table 5). Higher yields are dependent on dry matter accumulation, indicating that different bio-synthetic processes are involved during the development processes of the plant. At 30 DAT, highest dry matter accumulation was recorded in the treatment T_4 (100 % NPK + Seed + Soil + Seedling root dip with LBFC) (8.6 g plant^{-1}) which was superior to all the treatments. The lowest dry matter was observed in the treatment T_{14} (Absolute control) (3.9 g plant^{-1}). Similar results were obtained at remaining growth stages till harvest.

Effect of Liquid Biofertilizers on Yield of Finger Millet

The yield in the finger millet upon treating with liquid biofertilizers is presented in Table 6. Data on the grain yield of finger millet (kg ha^{-1}) as influenced by the application of liquid biofertilizers in transplanted finger millet revealed that the highest grain and straw yield was registered with treatment T_4 (100% NPK + Seed

TABLE 5

Effect of liquid biofertilizer on dry matter accumulation at different intervals of crop growth in finger millet

Treatments	Treatment Details	Dry matter accumulation (g plant^{-1})			
		30 DAT	60 DAT	90 DAT	At Harvest
T_1	100% NPK+ Seed Treatment with LBFC	6.9 bcd	24.3 bc	27.2 bc	32.8 bcd
T_2	100% NPK + Soil application of LBFC	8.0 a	26.6 ab	31.6 ab	38.6 ab
T_3	100% NPK + Seedling root dip with LBFC	7.1 bc	26.0 ab	30.0 ab	37.3 ab
T_4	100% NPK + Seed + Soil + Seedling root dip with LBFC	8.6 a	27.8 a	32.4 a	39.5 a
T_5	85% NPK + Seed treatment with LBFC	6.2 def	20.9 def	22.2 def	26.7 efg
T_6	85% NPK + Soil application of LBFC	6.8 bcd	22.8 bcd	26.5 bcd	32.1 bcde
T_7	85% NPK + Seedling root dip with LBFC	6.4 bcde	22.4 cde	24.8 cde	30.7 cdef
T_8	85% NPK + Seed + Soil + Seedling root dip with LBFC	7.0 bc	24.9 abc	28.1 abc	37.0 abc
T_9	70% NPK + Seed treatment with LBFC	5.4 f	17.5 f	17.2 fg	20.3 g
T_{10}	70% NPK + Soil application of LBFC	6.4 cde	19.3 ef	21.1 ef	25.4 fg
T_{11}	70% NPK + Seedling root dip with LBFC	5.7 ef	19.1 ef	19.8 ef	24.4 fg
T_{12}	70% NPK + Seed + Soil + Seedling root dip with LBFC	6.3 cde	21.8 cde	24.1 cde	30.4 def
T_{13}	NPK	6.4 cde	22.1 cde	24.5 cde	30.6 cdef
T_{14}	Absolute control	3.9 g	10.6 g	12.9 g	13.8 h
CD@5%		0.8	3.501	5.151	6.521

Mean values followed by the same superscript in each column do not differ significantly at P=0.05 level by DMRT

+ Soil + Seedling root dip with LBFC) (4080 kg ha^{-1} and 7810 kg ha^{-1}). Lowest grain yield was obtained in the treatment T_{14} (Absolute control) (1757 kg ha^{-1} and 3710 kg ha^{-1}).

The harvest index is a measure of productive efficiency that indicates how well a crop uses its physiological inheritance. It is one of the most consistent physiological characteristics for grain yield (Pallavi *et al*., 2016). Harvest index of the experiment did not vary significantly by the application of liquid biofertilizers. Values of the harvest index varied from 0.329 to 0.337, highest value was obtained with the treatment T4 (100 % NPK + Seed + Soil + Seedling root dip with LBFC) (0.337) and lowest was obtained with treatment T_{14} (Absolute control) (0.329).

Application of 100 per cent NPK with combined application of liquid biofertilizer consortium in seed, soil and seedling dip methods resulted in better growth performance and yield. As a result, this treatment had grain and straw yields and outperformed the other treatments by increasing grain and highest straw yield by 25 and 24 per cent above RDF respectively. The improvements in yield due to liquid biofertilizer treatment may be ascribed to the availability of critical nutrients in soil throughout the growth period by attaining synchronization between nutrient release and crop demand during the crop growth phase. These findings support the conclusions of Godhawale and Dahiwale (2007). Increased grain production might be attributed to an increase in yield components for improved glucose partitioning from leaf to reproductive regions, as well as an increase in the efficiency of applied nutrients in the soil (Chesti *et al*., 2013). Variations in straw yield are mostly due to differences in dry matter accumulation by various plant sections.

Effect of Liquid Biofertilizers on Bacterial, Fungal and Actinomycetes Population in Finger Millet

Bacterial, fungal and actinomycetes population in soil differed significantly with application of liquid

TABLE 6

Effect of liquid biofertilizers on yield of finger millet

Treatments	Treatment Details	Yield parameters		
		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
T_1	100% NPK+ Seed Treatment with LBFC	3625 ^{bcd}	7032 ^{bcd}	0.334
T_2	100% NPK + Soil application of LBFC	4025 ^{ab}	7718 ^{a}	0.336
T_3	100% NPK + Seedling root dip with LBFC	3938 ^{abc}	7560 ^{ab}	0.335
T_4	100% NPK + Seed + Soil + Seedling root dip with LBFC	4080 ^{a}	7810 ^{a}	0.337
T_5	85% NPK + Seed treatment with LBFC	3178 ^{defg}	6260 ^{cdefg}	0.332
T_6	85% NPK + Soil application of LBFC	3590 ^{bcd}	7016 ^{bcd}	0.333
T_7	85% NPK + Seedling root dip with LBFC	3498 ^{bcde}	6885 ^{bcd}	0.333
T_8	85% NPK + Seed + Soil + Seedling root dip with LBFC	3684 ^{abc}	7038 ^{abc}	0.335
T_9	70% NPK + Seed treatment with LBFC	2735 ^{fg}	5458 ^{g}	0.332
T_{10}	70% NPK + Soil application of LBFC	3148 ^{def}	6191 ^{defg}	0.332
T_{11}	70% NPK + Seedling root dip with LBFC	3085 ^{ef}	6035 ^{fg}	0.331
T_{12}	70% NPK + Seed + Soil + Seedling root dip with LBFC	3200 ^{bcde}	6208 ^{efg}	0.332
T_{13}	NPK	3245 ^{bcde}	6294 ^{cdefg}	0.333
T_{14}	Absolute control	1757 ^{g}	3710 ^{h}	0.329
CD@5%		450	855	NS

Mean values followed by the same superscript in each column do not differ significantly at P=0.05 level by DMRT

biofertilizers. Details of the microbial population are furnished in the Fig. 1 and Table 7. At 30 DAT, the treatment T_4 (100% NPK + seed + soil + seedling root dip with LBFC) was significantly higher than other treatments (27.6×10^6 cfu g^{-1}) but was on par with T_2 (100% NPK + soil application of LBFC), T_3 (100% NPK + seedling root dip with LBFC) and T_8 (85% NPK + seed + soil + seedling root dip with LBFC) with 26.6×10^6 cfu g^{-1}, 25.3×10^6 cfu g^{-1} and 25.6×10^6 cfu g^{-1}, respectively. The lowest bacterial population of 18.7×10^6 cfu g^{-1} was observed in the treatment T_{14} (Absolute control). The same trend was observed at 50 per cent flowering (60 DAT). The fungal population at 30 DAT, the treatment T_4 (100% NPK + Seed + Soil + Seedling root dip with LBFC) was significantly higher than every treatment (25.6×10^4 cfu g^{-1}) and 36.3×10^4 cfu g^{-1} at 50 per cent flowering (60 DAT). However the lowest fungal population was observed in T_{14} (Absolute control) 17.3×10^4 cfu g^{-1}. Actinomycetes population at 30 DAT showed similar trend of bacteria and fungi, the treatment T_4 (100% NPK + Seed + Soil + Seedling root dip with LBFC) was significantly higher than all other treatment (8.6×10^3cfu g^{-1}). At 50 per cent flowering (60 DAT), the treatment T_4 (100% NPK + Seed + Soil + Seedling root dip with LBFC) was significantly higher than other treatment (36.3×10^3 cfu g^{-1}) and it was on par with T_2 (100% NPK + Soil application of LBFC), T_3 (100% NPK + Seedling root dip with LBFC) and T_8 (85% NPK + seed + soil + Seedling root dip with LBFC) having 34.3×10^3 cfu g^{-1}, 33.6×10^3 cfu g^{-1} and 33.3×10^3 cfu g^{-1} actinomycetes population, respectively. The lowest actinomycetes population was observed in T_{14} (22.6×10^3 cfu g^{-1}).

Highest microbial population of bacteria was found in the treatment T_4 (100% NPK + Seed + Soil + Seedling root dip with LBFC) at 30 DAT and 50 per cent

TABLE 7

Effect of Liquid biofertilizers on Bacterial, fungal and actinomycetes population in finger millet

Treatments	Bacterial Population cfu $g^{-1} \times 10^6$			Fungal Population cfu $g^{-1} \times 10^4$			Actinomycetes cfu $g^{-1} \times 10^3$		
	Before transplantation	30 DAT	50% flowering	Before transplantation	30 DAT	50% flowering	Before transplantation	30 DAT	50% flowering
T_1	9.3	24.6 bcde	40.6 bcd	8.6	22.6 bcd	32.3 bcd	3.5	7.3 bcd	12.6 bcd
T_2	10.3	26.6 ab	43.6 ab	7.6	24.6 ab	34.3 ab	4.3	8.3 ab	13.6 ab
T_3	10.6	25.3 abcd	42.6 abc	7.3	23.3 abc	33.6 abc	4.6	7.6 abc	13.3 abc
T_4	9.0	27.6 a	45.6 a	9.3	25.6 a	36.3 a	3.6	8.6 a	14.6 a
T_5	8.6	21.9 fghi	35.6 efg	9.6	20.1 efg	29.0 efg	3.0	6.0 ef	11.0 efg
T_6	10.3	24.0 cdef	38.6 cde	8.6	22.1 cde	30.6 bcde	3.1	6.3 de	11.6 de
T_7	9.6	22.6 efgh	37.6 def	8.6	20.6 def	30.0 cdefg	4.0	6.3 de	11.3 def
T_8	8.6	25.6 abc	42.3 abc	7.6	23.6 abc	33.3 abc	4.2	8.0 ab	13.6 ab
T_9	8.8	19.3 ij	30.6 h	8.3	17.6 gh	25.3 hi	5.0	4.6 gh	9.3 h
T_{10}	9.3	21.3 ghi	33.6 fgh	9.6	19.3 fgh	27.0 fgh	4.3	6.0 ef	10.0 fgh
T_{11}	9.6	20.02 hij	32.6 gh	9.3	17.6 gh	26.3 gh	2.6	5.0 fg	9.6 gh
T_{12}	10.6	22.9 defg	32.3 gh	10.3	20.6 def	29.6 defg	3.6	6.6 cde	12.0 cde
T_{13}	10.3	23.3 cdefg	38.6 cde	8.3	21.3 cdef	30.3 cdef	4.6	6.3 de	11.6 def
T_{14}	8.6	18.7 j	25.3 i	8.6	17.3 h	22.6 i	3.3	3.6 h	6.6 i
CD@5%	2.51 **	2.757	4.5	3.1 **	2.5	3.6	2.5 **	1.2	1.6

Mean values followed by the same superscript in each column do not differ significantly at P=0.05 level by DMRT
** = Non significant @ 5% level of significance

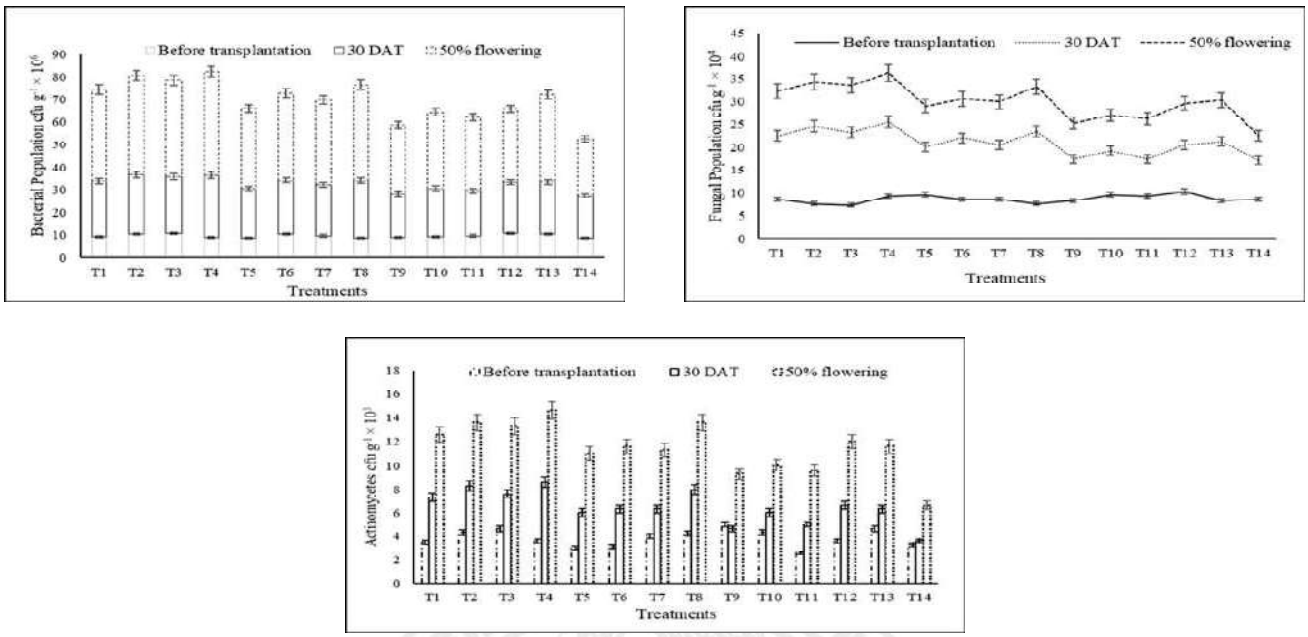

Fig. 1: Effect of Liquid biofertilizers on Bacterial, fungal and actinomycetes population in finger millet

flowering, this maybe attributable to the application of bacterial liquid biofertilizers which contained beneficial microorganisms. They use the organic material near its vicinity and proliferates at maximum extent. Increased fungi and actinomycetes population may be due to the increased plant growth and release of root exudate into the soil which serves as carbon and nitrogen source for the growth and proliferation of fungi and actinomycetes cells. Since root exudation is positively correlated with root growth, actively growing root systems secrete more exudates that mediate positive interactions such as symbiotic associations with beneficial microbes like mycorrhizae, rhizobia and plant growth-promoting rhizobacteria (PGPR), thereby increasing fungal count (Badri and Vivanco, 2009 and Garcia & Kao-Kniffin, 2018). The high number of cells in the rhizosphere, its multiplication and subsistence of cells is due to availability of carbon and energy sources. Obtained results are in line with the findings of (Patra *et al*., 2021; Mondal *et al.,* 2018; Raveendra Reddy, 2019 and Brar *et al*., 2017) who found out that usage of biofertilizers will significantly improve the soil health.

Based on the analysis of microbial, soil, plant and yield data we can conclude that treatment T_4 (100% NPK + seed + soil + seedling root dip with LBFC) was best treatment and followed by T_2 (100% NPK + soil application of LBFC), which is statistically on par with T_4, hence the T_2, where 100 per cent NPK with application of liquid biofertilizers consortia directly to the soil @ 625 ml in 500kg of FYM/hectare can be recommended for finger millet crop in eastern dry zone (Zone-V).

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