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Influence of renowned traditional liquid organic manure in conjunction with bacterial consortia on growth and yield of foxtail millet

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ABSTRACT

The objective of this study is to see how the most well-known nutrient components of natural farming among Indian farmers, *Beejamrutha* and *Jeevamrutha*, interact with bacterial consortia (combination of beneficial soil bacteria) and chemical fertilisers to affect foxtail millet growth and yield (*Setaria italica* L.). A field study was conducted at College of Agriculture, Rajendranagar, PJTSAU, Hyderabad during the *kharif* of 2019. Application of liquid manures (*Beejamrutha* and *Jeevamrutha*) in conjunction with 100% Recommended Dose of Fertiliser and bacterial consortia resulted higher plant height (130.33 cm), number of tillers m^{-2} (107), dry matter production (3760.1 kg ha^{-1}), panicles m^{-2} (85), number of filled grains per panicle (953), grain (2093 kg ha^{-1}) and straw yield (2933 kg ha^{-1}) over all other treatments. When compared to their separate applications, *Beejamrutha* and *Jeevamrutha* application in combination with bacterial consortia were found to be superior in no. of $tillers^{-2}$, dry matter accumulation, no. of panicles m^{-2}, no. of filled grains $panicle^{-1}$, grain yield, and straw yield. When traditional liquid organic manures (*Beejamrutha* and *Jeevamrutha*) are combined with bacterial consortia and synthetic fertilisers, foxtail millet showed improved growth and yield.

***Key words**: Bacterial consortia, Beejamrutha, Biofertilisers, Foxtail millet, Jeevamrutha*

Introduction

Millets are important crops in arid and semi-arid regions of India, where they are largely grown by resource-poor farmers. They can be cultivated on poor soil with less water, fertiliser, pesticides, and they can survive greater temperatures as well as rainfall fluctuations. They are noted for their drought resistance, making them ideal for contingency crop planning and reducing the risk of climate change (Kole *et al*., 2015). *Setaria italica* L., widely referred as foxtail millet, is one of the oldest cultivated millets. Consumers prefer it now days because of the balanced nutrients it contains, and it is becoming more premium as a result of the increased awareness of the health benefits of consuming it.

Climate change, pollution, soil fertility imbalances, and health problems caused by chemicals in our food have sparked interest in returning to traditional organic agricultural methods. Different organic farming products prepared by farmers all over the world, such as *Jeevamrutha*, *Beejamrutha*, *panchagavya*, compost tea, and biodynamic formulations, are related to Kunapajala (filthy fluid)/ *kunapambu* (fermented filth), which is of Indian origin (Nene *et al*., 2018) and is the world's oldest fermented liquid organic manure prepared by Surapala in *Vrikshayurveda* (Sadhale *et al*., 1996). Cow is known in India as 'Kamadhenu,' which means 'provider of wealth.' Cow milk, curd, and ghee are abundant in nutrients and have a high market value, whereas cowdung and urine are strong in microbial activity and can turn soil alive when applied to it. *Jeevamrutha*, on the other hand, is a traditional fermented liquid manure made from desi cow dung and urine. This is abundant in beneficial microbes that partake in nutrient supply interactions and produce a range of growth-promoting hormones, vitamins, and other compounds (Sreenivasa *et al*., 2010). Padmashree Subhash Palekar popularised this through Zero Budget Natural Farming, which gained traction among farmers who choose natural farming (Vinay *et al*., 2020). Desi cow dung, urine, *Beejamrutha*, and *Jeevamrutha* can help to combat the negative impacts of chemical agriculture (Palekar, 2006).

Biofertiliser is another low-cost, environmentally acceptable, yet significant source of plant nutrients for long-term agricultural production. It contains microbies that are essential for vital processes that promote agro-ecosystem stability. Bacterial consortia is a collection of biofertilizers that are compatible with each other. They provide nutrients by natural processes such as nitrogen fixation, phosphorus solubilization, potassium and zinc release, and plant growth stimulation through the creation of growth-promoting chemicals (Jayamma *et al*., 2013).

Farmers who expect high yields do not rely solely on traditional liquid manures; instead, they use chemical fertilisers. To keep this traditional technology of using manures from becoming obsolete, one must recognise its value in terms of yield increase when combined with other nutrient sources. As a result, it can be included as one of the promising components of integrated nutrient management, allowing for the advancement of the technology. In field circumstances, there are very few evidences to support its use in conjunction with biofertilisers and chemical fertilisers. In light of these facts, a special effort was made to determine the impact of these nutrient sources on growth and production of foxtail millet.

Materials and Methods

During the *kharif* of 2019, a field experiment was planned and carried out at College of Agriculture, Rajendranagar, PJTSAU, Hyderabad. The soil texture at the experimental site was sandy loam, with a pH of 6.42, low available Nitrogen (172 kg ha^{-1}), medium Phosphorus (22 kg ha^{-1}), high potassium (398 kg ha^{-1}), sufficient Zinc (0.65 ppm), and with low bacterial population (18 x 105 cfu g^{-1} soil). The gross and net plots were each 4.8 m × 3.9 m and 4.2 m x 3.3 m in size. With three replications and eight treatments, the experiment was set up in Randomized Block Design *viz*., T_1: Control, T_2: 100% RDF, T_3: 50% RDF, T_4: Bacterial consortia, T_5: Liquid organic manures (*Beejamrutha* and *Jeevamrutha*), T_6: T_4 + T_5, T_7: T_6 +100% RDF, T_8:T_6 + 50% RDF

SiA 3085 cultivar was chosen and line sown at a rate of 5 kg ha^{-1}. Full dose of phosphorus and half dose of nitrogen is applied as basal. The other half of nitrogen is applied at 30 DAS. Bacterial consortia, a mix of biofertilizers like *Azotobacter*, PSB, KRB and ZnSB, was customised and obtained from the Department of Microbiology and Bioenergy, PJTSAU, Rajendranagar and was mixed with FYM in equal proportions and applied @ 2.5 kg/250 kg FYM ha^{-1}to the soil before sowing.

Beejamrutha was prepared by soaking 12.5 kilos cowdung in 50 litres of water, blending it with 12.5 litres of cow urine, 250 grams of ant hill soil, and 125 grams of lime, and then treating the seeds before sowing @ 50 L ha^{-1}, as per Vinay*et al*., 2020. *Jeevamrutha* was prepared by fermenting 25 kilos of cow dung, 25 litres of cow urine, 5 kilos of pulse flour, 5 kilos of jaggery, and 250 grams of ant hill soil for 72 hours and then applying it every two weeks @ 500 L ha^{-1}. The microbial population of these two liquid manures was found to be very high at the time of application, with *Beejamrutha* having 20 x 10^6 colony forming units (cfu) ml^{-1} and *Jeevamrutha* having 13 x 10^6cfu ml^{-1}.

The data generated on growth and yield parameters were statistically analysed using the analysis of variance procedure given by Gomez and Gomez (1984) for a simple randomised block design (RBD).

Results and Discussion

Growth Parameters

Perusal of the data indicates that application of

Beejamrutha and *Jeevamrutha* + bacterial consortia + 100% RDF (T_7) was statistically at par with 100% RDF alone and both the treatments were higher compared to the rest of the treatments in case of plant height (Table 1). Similar result was found at 50% level (T_8). Plant height in the treatments with consortia (T_4) or liquid manures (T_5) alone or their combination (T_6) was not statistically different. The superiority of T_7 and T_2 is attributed to improved meristematic activity, cellular division coupled with increase in the size of cells and other structural elements. Thus sufficient nutrient availability might have contributed to taller plants. However, the conjunctive use of bacterial consortia + *Beejamrutha* and *Jeevamrutha* with 100% RDF (T_7) produced significantly higher dry matter accumulation over no conjunctive use (T_2) (Table 1). The application of bioagents together (T_6) was superior to their individual application. The complementary effect of the combination of bacterial consortia + *Beejamrutha* and *Jeevamrutha* can be explained through positive interaction of *Beejamrutha* and *Jeevamrutha* on the bacterial growth. Increased availability and enhanced uptake of nutrients due to conjunction of nutrient sources lead to increased photosynthesis due to which there is an improved photosynthates production, translocation from source to sink and accumulation. Same results were found with tiller production also (Table 1) except that the application of 50% RDF + bioagents (T_3) was significantly superior over 50% RDF alone. Least was found with control (T_1) among all the treatments in all the growth parameters.

These results are in line with that of Ravi *et al*., (2012) who also reported higher growth parameters like plant height, leaf area and dry matter accumulation when *Jeevamrutha* was applied along with biofertilisers and chemical fertilisers in quality protein maize which might be due to higher amount of available major and micro nutrients in organics besides, liquid manure (*Jeevamrutha*) with rich population of microbes which helped in degradation and mobilization of the nutrients. Similarly, higher growth parameters were observed by Upendranaik *et al*., 2018 with application of *Jeevamrutha* along with composts in foxtail millet which was attributed to the presence of growth regulators and slow supply of nutrients to different growth stages of the crop.

Yield attributes

The data recorded on the panicles m^{-2} is presented in Table 2. It i4ndicates that highest number of panicles were recorded in T_7 where 100% RDF was integrated with bacterial consortia + *Beejamrutha* and *jeevamrutha* and it was superior to the rest of the treatments including 100% RDF alone (T_2). The above agents also enhanced the panicle production significantly when applied along with 50% RDF (T_8). Similar to dry matter production, conjunctive use of bacterial consortia + *Beejamrutha* and *Jeevamrutha* (T_6) recorded significantly higher number of panicles per square meter over their individual application (T_4 or T_5). The conjunctive use of synthetic and organic nutrient sources lead to steady supply and improved uptake of nutrients by the plants. The

Table 1. Growth, yield parameters and yield of foxtail millet as influenced by liquid manures inconjunction with bacterial consortia and synthetic fertilisers

Treatment	Plant height (cm)	No. of tillers (m^{-2})	Dry matter production (kg ha^{-1})	No. of panicles m^{-2}	No. of grains $panicle^{-1}$	No. of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	85.98	47.00	1862	41.7	586	531	2.35	709	1400
T_2	122.45	97.33	3361	78.0	894	861	3.23	1760	2800
T_3	106.43	78.67	2836	63.0	750	724	2.95	1342	2256
T_4	96.24	55.00	2123	48.0	660	621	2.57	916	1714
T_5	97.15	56.33	2210	47.0	644	629	2.60	933	1692
T_6	100.33	68.67	2568	55.0	678	634	2.64	1117	2003
T_7	130.33	107.00	3760	85.0	970	953	3.43	2093	2933
T_8	114.87	88.33	3002	70.3	820	801	3.02	1570	2526
SEm±	4.52	2.93	104.9	2.0	28.74	28.4	0.13	56.37	89.8
CD (p=0.05)	13.69	8.89	317.9	6.1	87.17	86.2	0.40	170.95	272.5

repeated application of *Jeevamrutha* act as tonic to the soil and produced variety of growth promoting hormones, vitamins etc. This might have influenced production of more effective tillers leading to higher number of panicles m^{-2}.

The number of grains per panicle (Table 2) was also significantly influenced by the treatments. Highest numbers of grains were recorded with T_7 superior to all the treatments except T_2. Both the above treatments were at par with each other indicating that the effect due to integration of bioagents with chemical fertilizers was not statistically significant even though it was enhanced by 8.5 % compared to 100 % RDF alone. Combined application of bacterial consortia + *Beejamrutha* and *Jeevamrutha* (T_6) enhanced the grain number per panicle over control (T_1) but not their individual application (T_4 or T_5). However, 50% RDF + bioagents (T_8) was at par with 100% RDF alone (T_2) with respect to grain count of foxtail millet.

The filled grains per panicle was also significantly influenced by the nutrient management treatment (Table 2). Among all the treatments, highest number of grains was filled when the soil was added with bacterial consortia + *Beejamrutha* and *Jeevamrutha* along with 100% RDF (T_7). In contrary to the observation in total number of grains per panicle, the above treatment was superior to 100% RDF alone (T_2). The percentage of filling was 98.2% in T_7 compared to 96.3% in T_2. Alone application of these bioagents *i.e*, bacterial consortia (T_4) or *Beejamrutha* and *Jeevamrutha* (T_5) or their combination (T_6) was superior to control and three treatments were at par. Steady supply and uptake of nutrients leads to better growth performance thereby enhanced production of photosynthates, their transfer and accumulation in the sinks. Due to this reason the chaffy grains were less resulting in higher number of filled grains per panicle.

The test weight of foxtail millet crop was also differed significantly due to the effect of various treatments (Table 2). Highest test weight was recorded in T_7 which was at par with T_2 but superior to the rest of the treatments. Lowest test weight of grains was found with the control (T_1) but it was comparable with the bioagents excluding inorganic fertilisers (T_4 or T_5 or T_6). Further 100% RDF (T_2) was at par with 50% RDF (T_3) and its combination with bioagents (T_8).

Soil application of *Jeevamrutha* along with biofertilisers lead to improved number of fingers ear^{-1}, ear length and number of productive tillers m^{-2} in finger millet (Nigade *et al*., 2014). Whereas highest panicle length was observed in rice with application of *Jeevamrutha* along with microbial consortia, FYM, RDF and compost as observed by Basha, 2015.

Yield

The grain yield of foxtail millet as influenced by the treatment combination was presented in Table 3. According to the findings, the highest yield was obtained in the 100 % RDF + bacterial consortia + liquid manures (T_7) treatment, which was significantly superior to all other treatments. Similarly, T_8 (50% RDF + bacterial consortium + liquid manures) outperformed T_8 (50% RDF alone) (T_3). The usage of bacterial consortium in combination with liquid manures (T_6) was superior to using any of them separately (T_4 or T_5), which were comparable with each other. However, all of the treatments, which included chemical fertilisers, biofertilizers, and liquid manures, increased yield over the control. Plants are able to obtain nutrients steadily during the critical stages of growth due to improved soil properties with the combined use of bacterial consortia, liquid manures, and chemical fertilisers, leading to improved growth parameters such as tillers m^{-2} and dry matter production, as well as yield parameters such as number of panicles m^{-2} and number of filled grains per panicle, which may have contributed to higher grain yield compared to other treatments.

Table 3 shows the information collected on straw yield. When looking at the data, it is clear that T_7, which combined 100 percent RDF with bacterial consortia + liquid manures, produced much greater yields, although it was on par with 100 percent RDF alone (T_2). Similarly, in terms of straw yield, the 50 percent RDF combination (T_8) was equal to 50 percent RDF alone (T_3). Similar to grain yield, straw yield was significantly greater in the treatment consisting of conjunctive use of bacterial consortia + liquid manures (T_6) than in the treatments consisting of their solitary application (T_4 or T_5), which were comparable but superior to control (T_1). The combination of nutrient sources improves the plant's performance by enhancing physiological processes such as absorption, translocation, and accumulation, resulting in higher dry matter production and thus contributing to the yield.

Application of FYM and *Jeevamrutha* together improved grain and stalk yield of sunflower crop (Manjunatha *et al*., 2009). Application of RDF, FYM, microbial consortium (*Azospirillum* + PSB) and soil application of *Jeevamrut*@ 500 l ha^{-1} at 30, 60 and 90 DAS resulted in highest grain yield in finger millet (Basha, 2015).

Conclusions

Application of *Beejamrutha* and *Jeevamrutha* along with bacterial consortia and 100% RDF resulted in improved growth parameters over all other treatments. Conjunctive use of *Beejamrutha* and *Jeevamrutha* along with bacterial consortia has shown significant impact on growth parameters over their individual application (T_4 or T_5). Important yield parameters such as panicles m^{-2} and no. of filled grains were found to be highest with the same over all other treatments. Whereas conjunctive use of bacterial consortia and *Beejamrutha*, *Jeevamrutha* not shown significant influence over individual application except for panicle production which is the most important yield attributing character. Highest grain and straw yield was also observed with combined use of chemical fertilisers and bioagents. However it was on par with 100% RDF in case of straw yield. Whereas, conjunction of bioagents shown significant influence on yield of foxtail millet over their individual application. Beneficial upshot was observed under field conditions with traditional liquid manurewhen used along with biofertilisers as well as synthetic fertilisers indicating it's vital role in crop growth, development and suitability in integrated nutrient management practices.

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