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Achieving Yield Sustainability in Small Millets Through Liquid Microbial Consortia-An Eco-friendly Approach

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ABSTRACT

Background: Actually, the millets are grown organically/no manures are applied even under low fertile soils resulted in poor millet production levels and leading to higher price of millets. Hence, there is need for low cost and eco-friendly technologies for getting higher productivity and sustaining the soil health.

Methods: The field experiment was conducted to investigate the benefits of liquid microbial consortia and their mode of application on small millets (Proso, Little and Barnyard millet, respectively) at Zonal Agricultural Research Station, V. C. Farm, Mandya from *kharif*, 2020 to *kharif* 2022. The experimental design followed was randomized complete block design with three replications using the recommended dose of fertilizers (RDF) at various levels (100%, 85% and 70% RDF, respectively) with different mode of application of liquid microbial consortia as seed treatment, soil application and combination of both.

Result: The highest grain and straw yield was realized with treatment receiving 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farmyard manure (FYM) and applied in furrows during sowing as compared to 100% RDF alone. This might be due to the better growth and yield parameters. The nutrient uptake by grain and straw and microbial population and available soil nutrients at harvest and B:C ratio also followed the similar trend as in case of grain and straw yield.

Key words: Barnyard millet, Liquid microbial consortia, Little millet, Proso millet, Uptake.

INTRODUCTION

In India, millets are grown since from ancient period in dry-land condition. Millets are also called as nutri-cereals as they are rich in protein, fibre and minerals. After the green revolution, more importance was given to high yielding rice and wheat varieties resulted in drastic decrease in area and production of the millets. This has paved a way for intensive farming/chemical farming to meet the food requirement of growing population. This has made the India to achieve self-sufficiency in food grain production. The usage of heavy fertilizers and other chemicals over a period of time has led to deterioration of soil health. Under this situation it has become a challenging task to meet out the quality food requirement of growing population. At present situation farmers need an eco-friendly and low cost technologies in enhancing the productivity and to restore the soil health (Veerendra *et al.,* 2022). This dreadful situation has made the scientists as well as the policy makers to volte face towards bio-inputs rather than chemical fertilizer alone. Long term soil fertility can be sustained only through enhancing the organic carbon and biological activity in the soil (Ananda *et al.,* 2017 and Vinay *et al.,* 2020). Under rainfed conditions of India, small millets are grown organically as the farmers are not applying any chemical fertilizers. Hence, low productivity and higher cost of millets. Hence, combine usage of chemical fertilizers as well as bio-inputs helps in getting higher productivity and restoring the soil health (Basha, 2015). Soil health is positively influenced by micro flora present in soil. The microbes present in the liquid microbial consortia helps in enhancing the plant growth and yield by different mechanisms such as synthesis of phytohor-mones, solubilisation of nutrients, biological nitrogen fixation, suppression of pathogens and enhancing the root growth (Manjunath *et al.,* 2020 and Divyashree *et al.,* 2018). In this context, the present investigation was undertaken to study the effect of liquid microbial consortia and their mode of application and fertilizer levels on growth, yield, nutrient uptake, microbial activity and economics of small millets *viz.*, little millet, proso millet and barnyard millet.

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MATERIALS AND METHODS

The small millets *viz.*, little millet (LM), Proso millet (PM) and Barnyard millet (BM) were taken for the study. The field experiments were conducted during the *kharif* -2020, 2021 and 2022 respectively at Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka. The farm is located in the Southern Dry Zone of Karnataka and is geographically situated at 12º 45' and 13º 57' North latitude and 760 45' and 780 24' East longitude at an altitude of 695 meter above mean sea level. The soil was red sandy loam with neutral pH. The available nitrogen, phosphorus and potassium were medium in soil, whereas the organic carbon was Low in range. Initially the beneficial microbial count per g of soil was analyzed *viz.*, Bacteria (7.20, 7.03 and 6.36 $\times 10^6$ CFU respectively in LM, PM and BM); Fungi (4.82, 4.16 and 3.16 $\times 10^3$ CFU respectively in LM, PM and BM); Actinomycetes (6.42, 5.51 and 4.34 $\times 10^4$ CFU respectively in LM, PM and BM). The experiment was laid out in a randomized block design having 3 replications. There were 11 treatments, *viz.* T_1: 100% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed) followed by soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_2: 100% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed); T_3: 100% RDF + Soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_4: 85% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed) followed by soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_5: 85% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed); T_6: 85% RDF + Soil application of liquid microbial consortia Soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_7: 70% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed) followed by soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_8: 70% RDF + Seed treatment with liquid microbial consortia (5 ml/kg seed); T_9: 70% RDF + Soil application of liquid microbial consortia (6.25 l/ha) mixed with 500 kg of FYM and applied in furrows during sowing; T_{10}: Recommended dose of fertilizer (LM:20:20:20 NPK kg/ha; PM and BM: 20:20:00 NPK kg/ha, respectively); T_{11}: Absolute control. The microbial consortium includes functional group *viz.*, N fixers (Azospirillum, Azotobacter, Rhizobium and Acetobacter), P solubilizers (Bacillus, Pseudomonas and Aspergillus) and K solubizers.

Line sowing was done in a row spacing of 30 cm apart to a depth of 2.5 cm. An equal quantity of farm yard manure (7.5 t ha^{-1}) was applied to each plot three weeks prior to sowing except absolute control. Nitrogen was given in splits (50 % at sowing and remaining 50 % at 30 days after sowing as top dress). However the phosphorus and potassium were given completely at the time of sowing. Further the weeds were controlled manually. From individual plot randomly five plants were selected for recording observation. The periodical observations on growth and yield contributing characters of millets, economics of all the treatments were recorded as per the procedure defined by Divyashree *et al.* (2018). The grain and straw yields were recorded during physiological maturity. The dried plant samples collected at harvest were oven-dried and grounded into fine powder and further it was used for analysis of nutrient content. Nitrogen, phosphorus, potassium content of the samples were estimated by microkjeldhal's method, vanadomolybdo phosphoric yellow colour method, flame photometer methods were followed to analyse the nitrogen, phosphorus, potassium content of the samples and further the uptake per hectare was worked out. The microbial population (bacteria, fungi and actinomycetes) in the soil before sowing of crop and at harvest was determined by standard dilution plate count method (Soil extract media for bacteria, Martin's Rose Bengal agar media for fugus and Kuster's agar media for actinomycetes).

The experimental data collected on various growth, yield and other aspects were subjected to Fisher's method of analysis of variance (ANOVA) as per methods outlined by Gomez and Gomez (1984). Critical difference (CD) was calculated wherever the 'F' test was found significant. The data are presented with the level of significance at 5 per cent [Gomez and Gomez, 1984]. The response of millets to liquid microbial consortia and their mode of application were similar in all the three years of study. Therefore, only pooled data of 3 years was discussed.

RESULTS AND DISCUSSION

Effect on crop growth and yield parameters

Application of 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing has recorded significantly higher plant height and dry matter production per plant as compared to 100% RDF alone (Fig 1). However, it was statistically on par with 100% RDF + Soil application of liquid microbial consortia @ 6.25 litres/ha mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing (Fig 1). This was mainly attributed to augmented microbial activity in the rhizosphere resulted in enhanced N fixation, production of phytohormones such as auxins (IAA), cytokinins and gibberellins, solubilisation of bound form of soil minerals and enhanced availability of nutrients in the soil for plant growth and development by the liquid microbial consortia lead to improved seedling germination, vigour, emergence and biomatter accumulation (Upadhaya *et al.,* 2022 and Bablu Yaduwanshi *et al.,* 2021).

The yield parameters *viz.*, number of productive tillers per hill, panicle length, weight of panicle, number of seeds per panicle and1000 grain weight were significantly higher with application of 100% RDF + Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing as compared to 100% RDF alone (Fig 1). However, it was statistically on par with 100% RDF + Soil application of liquid microbial consortia @ 6.25 litres/ha mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing. This was mainly due to better growth parameters (Upadhaya *et al.,* 2022 and Latake *et al.,* 2009).

Effect on yield

The grain and straw yields were significantly affected due to use of liquid microbial consortia and its mode of application. Highest grain and stover yield was recorded with application of 100% RDF + Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing (Fig 2A). However it was statistically on par with 100% RDF + Soil application of liquid microbial consortia @ 6.25 litres/ha mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing (Fig 2A), whereas the lowest grain and straw yield was recorded with absolute control plot. The use of liquid microbial consortia has led to higher availability of nitrogen, phosphorus and potassium that promoted growth and development and ultimately resulted in higher yields (Upadhaya *et al.,* 2022 and Bablu Yaduwanshi *et al.,* 2021).

Economics

Application of application of 100 % RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/

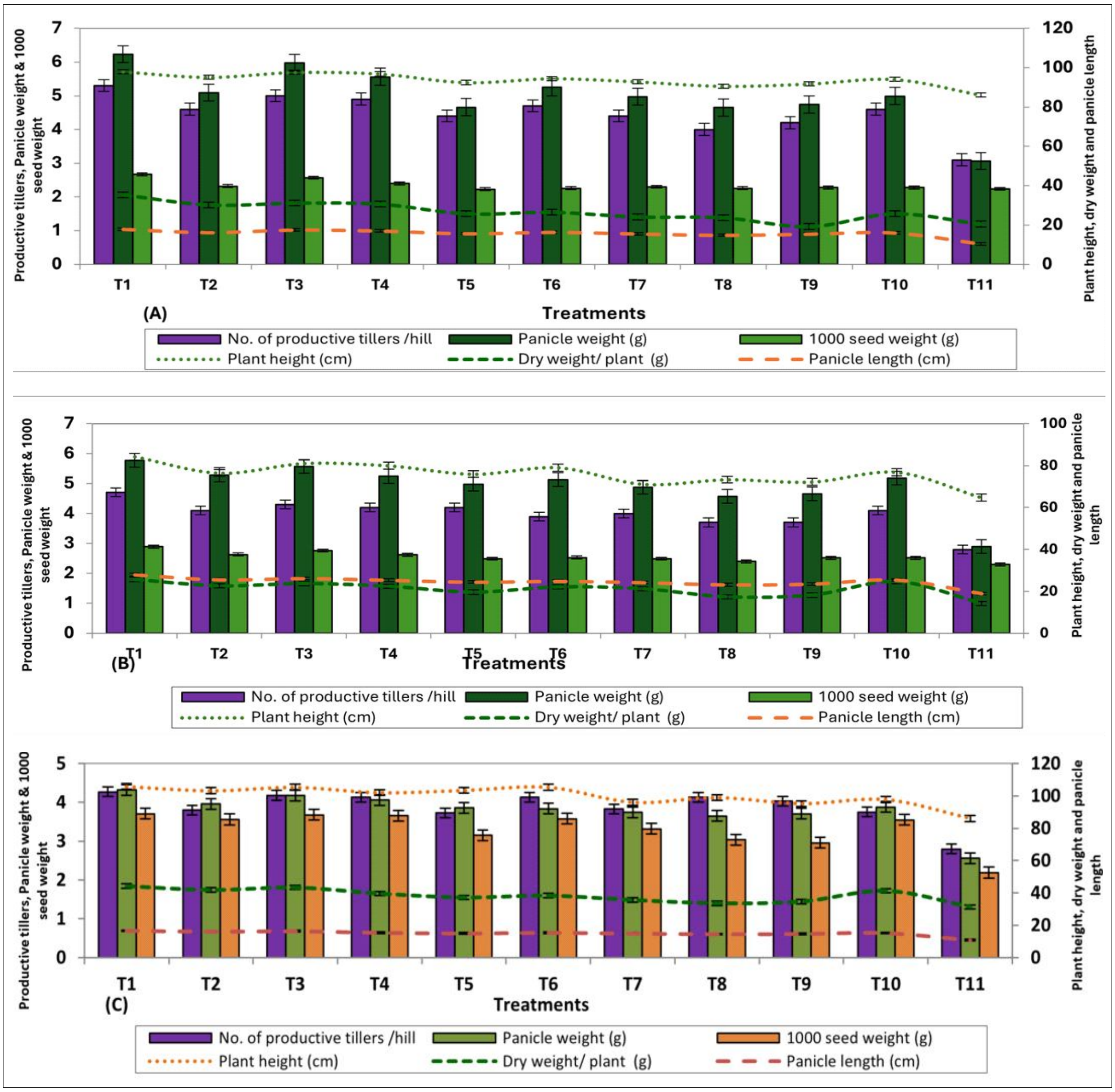

Fig 1: Growth and yield parameters of small millets (A. Little millet ; B Proso millet; C. Barnyard millet) at harvest as influenced by fertilizer levels, liquid microbial consortia and its method of application.

ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing had the highest cost of cultivation followed by 100% RDF + soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing. It was mainly due to higher labour and input cost like cost of liquid microbial consortia and FYM (Fig 2B). The maximum net returns and higher benefit: cost ratios were also achieved with 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing followed by 100% RDF+soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing (Fig 2B). This was mainly attributed to higher grain and straw yields as reported by Upadhaya *et al.* (2022); Rani *et al.* (2019) and Veerendra *et al.* (2022).

Nutrient uptake by small millets

Application of 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing resulted in significantly higher N, P and K uptake by grain and straw. However, it was on par with 100% RDF+soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing (Fig 2A). This was mainly attributed to higher grain and straw yield (Bablu Yaduwanshi *et al.* 2021 and Veerendra *et al.,* 2022). The combined application of FYM and liquid microbial consortium may have enhanced the N fixation, phytohormones production, synthesis of phytosiderophores, also enhanced the phosphate solubilisation and K availability by the production of organic acids resulting in better development and proliferation of roots and thereby uptake of nutrients by small millets.

Microbial population

The bacterial, fungus and actinomycetes count in the form of colony forming units (CFU) was taken at harvest stage apart from the initial stage (Fig 2C). The highest microbial count (bacteria, fungus and actinomycetes) was observed

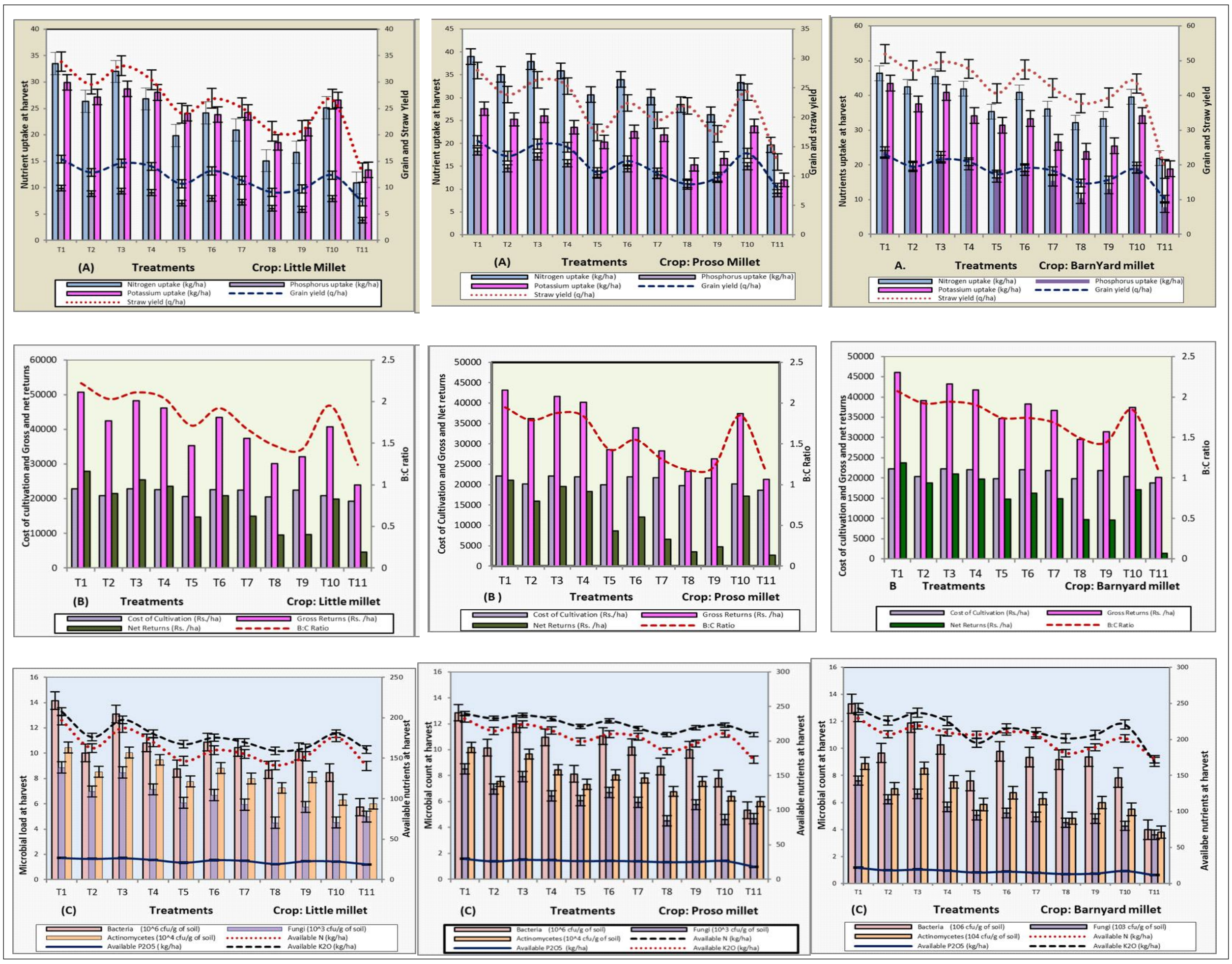

Fig 2: (A) Grain and straw yield and Nutrient uptake at harvest (B) Economics (C) microbial count and available nutrient status in soil at harvest in small millets as influenced by fertilizer levels, liquid microbial consortia and its method of application.

with application of 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing at harvest as compared to application of 100% Recommended dose of fertilizers alone. This has shown a complementary effect between the chemical fertilizers and microbial consortia in improving the microbial status of the soil. The enhanced growth of bacterial, fungal and actinomycetes count is mainly attributed to increased colonization of the microorganisms owing to the increased root growth and their exudates which might have supported the growth of microorganisms (Sahib *et al.,* 2020, Upadhaya *et al.,* 2022 and Bablu Yaduwanshi *et al.,* 2021and Mohammad *et al.,* 2011).

Nutrients availability

The availability of nitrogen, phosphorus and potassium was highest with the application of 100% RDF+Seed treatment with liquid microbial consortia (5 ml kg^{-1} seed) followed by soil application of liquid microbial consortia (6.25 litres/ha) mixed with 500 kg farm yard manure (FYM) and applied in furrows during sowing as compared to application of 100% Recommended dose of fertilizers alone (Fig 2C). The combined application of FYM and microbial consortium may have enhanced the N fixation, phytohormones production, synthesis of phytosediros-phores, also enhanced the phosphate solubilisation and K availability by the production of organic acids resulted in higher availability of nutrients in the soil at harvest (Upadhaya *et al.,* 2022 and Bablu Yaduwanshi *et al.,* 2021and Mohammad *et al.,* 2011).

CONCLUSION

Thus, it may be concluded that inoculation of small millet seeds *viz.* little millet, proso millet and barnyard millet with microbial consortia followed by soil application of microbial consortia with farm yard manure at the time of sowing in lines has resulted in getting higher grain yield, nutrient uptake and further it has also enhanced the availability of nutrients and microbial activity at harvest.

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Authors' Contribution

Dr. Sunil C. M. and Dr. Sukanya, T.S.: The experiments were formulated and conducted. Dr. Asha N. N.: Carried out the Microbial analysis. Dr. Bhagyalakshmi: Soil nutrient analysis and Nutrient uptake by crops was conducted. Dr. Raveendra H.R.: Helped in statistical analysis.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Ananda, M.R., Sharanappa and Murthy, K.N. (2017). Response of finger millet under organic nutrient management in ground nut- finger millet cropping system. International Journal of Pure and Applied Bioscience. 5(5): 200-206.

Bablu Yaduwanshi, Sahu R.K., Mitra, N.G., Dwivedi, B.S. (2021). Impact of microbial consortia on microbial population and available nutrients in soil under soybean crop. Journal of Indian Society Science. 69(2): 187-194.

Basha, J.S. (2015). Plants geometry, irrigation and organic nutrient management practices for aerobic rice in northern transitional Zone of Karnataka. Ph.D *Thesis*, University of Agricultural Sciences, Dharwad, Karnataka, India.

Divyashree, U., Dinesh Kumar, M., Sridhara, S., Basavaraj Naik, T. (2018). Effect of different levels of fertilizers on growth and yield of little millet (*Panicum sumatrense* Roth ex Roem and Schult). International Journal of Farm Sciences. 8(2): 104-108.

Gomez, K.A. and Gomez, A.A. Data that violate some assumptions of the analysis of variance. (In:) Statistical Procedures for Agricultural Research, edn 2, pp. 294-315.

Gomez, K.A. and Gomez, A.A. (Eds), John Wiley and Sons, Inc., 605, Third Avenue, New York.

Latake, S.B., Shinde, D.B., Bhosale, D.M. (2009). Effect of inoculation of beneficial microorganisms on growth and yield of pearl millet. Indian Journal of Agricultural Research. 43(1): 61-64.

Manjunath, M., Yadav, S.K., Desai, S., Maheswari, M. (2020). Perspectives of plant associated microorganisms in drought management of crops. International Journal of Current Microbiology and Applied Sciences. 9(11): 991-1006.

Mohammad, R.A., Daryush, M., Amir, H.S.R., Saeed, M. (2011). Uptake of micronutrients by wheat (*Triticum aestivum* L.) in a sustainable agro-ecosystem. Middle-East Journal of Scientific Research. 7(4): 444-51.

Rani, K.S., Satish, P., Rani, C.S., Sudhakar, C. (2019). Effect of liquid biofertilizers on growth and yield of rabi sorghum (*Sorghum bicolor* L.). Chemistry Science Review and Letters. 8(32): 190-194.

Sahib, M.R., Pervaiz, Z.H., Williams, M.A., Saleem, M., DeBolt, S. (2020). Rhizobacterial species richness improves sorghum growth and soil nutrient synergism in a nutrient poor greenhouse soil. Scientific Report. 10: 15454.

Upadhaya, B., Kaushal, K., Kumar, R. (2022). Foxtail millet (*Setaria italica*) growth, yield and economics as affected by liquid bio-fertilizers and their mode of application. The Pharma Innovative Journal. 11(2): 2225-2230.

Veerendra, M., Padmaja, B., Malla Reddy, M., Triveni S. (2022). Yield, nutrient uptake, quality and economics of foxtail millet cultivation as influenced by integrated nutrient management with bacterial consortia and liquid manures. International Journal of Current Microbiology and Applied Sciences. 10(03): 1703-1711.

Vinay, G., Padmaja, B., Reddy, M.M., Jayasree, G. and Triveni, S. (2020). Effect of natural, organic and inorganic farming methods on microorganisms and enzymes activity of maize rhizosphere. International Research Journal of Pure and Applied Chemistry. 21(6): 11-16.