Environment and Ecology 41 (1A) : 302—307, January-March 2023
ISSN 0970-0420

Response of Barnyard Millet (*Echinochloa esculenta* L.) to Liquid Biofertilizer Consortium and its Methods of Application

Sowmyalatha B. S., Shubhashree K. S., Sahana S. R.

Received 22 September 2022, Accepted 15 November 2022, Published on 6 February 2023

ABSTRACT

A field study was conducted during *kharif* 2020 and *kharif* 2021 at Zonal Agriculture Research Station (ZARS), V.C. farm, Mandya, UAS (B) to study the response of barnyard millet (*Echinochloa esculenta* L.) to liquid biofertilizer consortium and its methods of application. Among various treatment combination tested, application of 100% RDF + seed treatment with liquid biofertilizer (4-5 ml/kg seed) followed by soil application of liquid biofertilizer (2.5-3 liter, mix with 200 kg FYM and apply in furrows at sowing or one acre) resulted in higher growth parameters and yield during both the tested. However, the treatment was found on par with 100% RDF + soil application of liquid biofertilizer (2.5-3 liter, mix with 200 kg FYM and apply in furrows at sowing or one acre). Among two years tested, grain yield was found significantly higher during *kharif* 2020 (1831 kg/ha) and recorded 11.01 % increase in grain yield over *kharif* 2021, respectively. Similarly, among various treatments, application of 100 % RDF + seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer resulted in higher grain and straw yield (2214 and 5097 kg/ha) respectively followed by application of 100 % RDF with soil application of liquid biofertilizer (2078 and 4918 kg/ha). Increase in grain and straw yields of these treatments was 11.28 and 11.71%, respectively against 100% RDF + soil application of liquid biofertilizer. The trend that was noticed in grain and straw yield was also noticed in various growth attributes viz., plant height (cm) and number of tillers plant^{-1}. However, B:C ratio was found higher in 100% RDF + seed treatment + soil application with liquid biofertilizer (2.99).

Keywords Barnyard millet, Liquid biofertilizer, Seed treatment, Soil application, Yield.

Dr Sowmyalatha B. S.*
Assistant Professor & Junior Agronomist (Additional charge), AICRP on Small Millets, ZARS, V.C. Farm, Mandya 571405, UAS (B), India

Dr Shubhashree K.S.
Assistant Professor, Department of Agronomy, College of Agriculture, Chinthamani, UAS (B), India

Sahana S. R.
Junior Research Fellow, AICRP on Rice, ZARS, V.C. Farm, Mandya, UAS (B), India

Email : sowmyalatha.vinu@gmail.com
*Corresponding author

INTRODUCTION

Small millets are a traditional crop, and they are best suited for agriculturally poor soils. Finger millet, Kodo millet, Little millet, Foxtail millet and Barnyard millet are the most common small millets in India.

Barnyard millet (*Echinochloa* species) is an ancient millet crop grown in warm and temperate regions of the world and widely cultivated in Asia, particularly India, China, Japan, and Korea. It is the fourth most produced minor millet, providing food security to many poor people across the world. Globally, India is the biggest producer of barnyard millet, both in terms of area (0.146 m ha^{-1}) and production (0.147 m t) with average productivity of 1034 kg ha^{-1} during the last 3 years (IIMR 2018). Barnyard millet is primarily cultivated for human consumption, though it is also used as a livestock feed. Among many cultivated and wild species of barnyard millet, two of the most popular species are *Echinochloa frumentacea* (Indian barnyard millet) and *Echinochloa esculenta* (Japanese barnyard millet) (Sood *et al.* 2015). Barnyard millet is considered as low input requiring crop for traditional farming community. However, under conditions of low input it suffers from low yields which implies that barnyard millet has good response to the applied nutrients. The majority of soils in semi-arid tropics, where barnyard millet is cultivated are lacking in macro and micronutrients mostly due to continuous cropping, reduced recycling of crop residues and small rates of organic matter application which can edge yield potential (Rao *et al.* 2012 and Sneha *et al.*2017). Hence to improve productivity, integrated nutrient management is vital practice. Even though all nutrients are present in soil, most of the times these nutrients are not available to crops as they are subjected to losses by various processes like the nitrogenous fertilizers are exposed to leaching, denitrification and volatilization losses whereas, phosphatic and potassium fertilizers undergo the process of fixation and immobilization in soil. This resulted in the need to search an additional source of plant nutrients to increase nutrient use efficiency. In context of cost and eco-friendly impact of chemical fertilizers, excessive reliance on the only chemical fertilizer is not a viable strategy.

In this situation biofertilizer in integration with organic and inorganic sources would be the better option for farmers to increase productivity per unit area. Though biofertilizers cannot replace chemical fertilizers fully but certainly are capable of reducing their input to a considerable extent and provides larger prospect for sustainable crop production. Bio fertilizer is a biological product which contains living microorganisms which, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients increasing root biomass or root area and increasing nutrient uptake capacity of plant Vessey 2003.

The advantage of liquid biofertilizers higher projection life (12-24 months), no effect of higher temperature, lesser contamination, no loss of functional properties due to storage at high temperature up to 45ºC, ability to hold high population of more than 109 cells / ml, easy usage by the farming community, high export potential and requirement of doses are ten times lower than carrier based biofertilizers (Verma *et al.* 2011). Therefore, liquid biofertilizers are alleged to be the best substitute for the carrier based biofertilizers in the current agriculture research community perceiving the improved crop yields and soil strength (Pindi and Satyanarayana 2012). It is worth mentioning that nutrient management through organic sources plays a major role in maintaining soil health as it improves the status of soil organic matter, beneficial microbes and enzymes besides improving soil physical and chemical properties (Raviraja *et al.* 2020).

Biofertilizers when not applied properly its effectiveness will be minimized hence to enhance the biofertilizer use efficiency proper application methods must be followed. Most of the researches were already done on carrier based biofertilizer but only few studies were carried out on use of liquid biofertilizer consortium and methods of application in barnyard millet. Hence, the present study was conducted to study the response of barnyard millet (*Echinochloa esculenta* L.) to liquid biofertilizer consortium and its methods of application.

MATERIALS AND METHODS

A field experiment on response of barnyard millet (*Echinochloa esculenta* L.) to liquid biofertilizer consortium and its methods of application was studied during *kharif* season 2020 and 2021 under ICAR- All India Coordinated Research Project on Small Millets (AICRPSM) at Zonal Agriculture Research Station (ZARS), V.C. Farm, Mandya, Karnataka. The soil type was red sandy loam, having neutral pH (7.22), electrical conductivity (0.375 dSm^{-1}) medium in available soil nitrogen (357.50 kg ha^{-1}), high available soil phosphorus (31.5 kg ha^{-1}) and high available soil potassium (336 kg ha^{-1}). RCBD design was adopted in the experiment with three replications. The experiment comprised of 11 treatments with 100 %, 85 % and 70 % RDF with two methods of application of liquid biofertilizers consortium viz., seed treatment (4-5 ml / kg seed), soil application (625 ml of liquid biofertilizer mixed with 500 kg of FYM incubated overnight and applied at the time of sowing in the furrows) and combination of all these methods. Further, one treatment kept as recommended dose of fertilizer as per the package developed by UAS, Bangalore and another treatment as absolute control, which did not received any external source of nutrient application.

Treatment details

T_1: 100% RDF + soil treatment with liquid biofertilizer (4-5 ml/kg seed) followed by soil application of liquid biofertilizer (2.5-3 liter, mix with 200 kg FYM and apply in furrows at sowing or one acre)

T_2: 100% RDF+seed treatment with liquid biofertilizer

T_3: 100% RDF+ soil application of liquid biofertilizer

T_4: 85% RDF + soil treatment with liquid biofertilizer (4-5 ml/kg seed) followed by soil application of liquid biofertilizer (2.5-3 liter, mix with 200 kg FYM and apply in furrows at sowing or one acre)

T_5: 85% RDF + seed treatment with liquid biofertilizer

T_6: 85% RDF + soil application of liquid biofertilizer

T_7: 70% RDF + soil treatment with liquid biofertilizer (4-5 ml/kg seed) followed by soil application of liquid biofertilizer (2.5-3 liter, mix with 200 kg FYM and apply in furrows at sowing or one acre)

T_8: 70% RDF + seed treatment with liquid biofertilizer

T_9: 70% RDF + soil application of liquid biofertilizer

T_{10}: Recommended dose of fertilizers

T_{11}: Absolute control.

Barnyard millet variety VL-172 was sown at the spacing of 30 cm ×10 cm. Liquid biofertilizer consortium was procured from the biofertilizer scheme, Department of Microbiology, College of Agriculture, GKVK, Bengaluru. Liquid biofertilizer consortium contains *Azospirillum lipoferum* (Nitrogen fixer), *Bacillus megaterium* (Phosphorus solubilizing bacteria) and *Frateuria aurantia* (Potassium solubilizing bacteria). The recommended quantity of chemical N, P_2O_5 and K_2O were provided through different sources like urea, di-ammonium phosphate and muriate of potash, respectively as per the treatment protocol. FYM was applied at the rate of 7.5 t ha^{-1} to each treatment except absolute control before sowing. Other cultural operations were followed as per the recommendation of the crop. Observations on growth and yield were recorded and economics was computed. All experimental data was analyzed statistically and presented at five per cent level of significance for making comparison between treatments as per the procedure laid down by Gomez and Gomez (1984).

Table 1. Growth attributes and yield of barnyard millet as influenced by liquid bio-fertilizers and their mode of application (Polled data).

Treatment details	Plant height (cm)	No. of tillers $plant^{-1}$	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Year (Y)				
Y_1	92.55	3.34	1831	3961
Y_2	97.71	3.72	1662	4326
SEm ±	1.14	0.05	44.85	105.35
CD@ P=0.05	3.26	0.14	128.02	300.68
Treatments (T)				
T_1	102.73	3.97	2214	5097
T_2	97.93	3.53	1957	4643
T_3	100.97	3.87	2078	4918
T_4	98.40	3.77	2041	4698
T_5	96.37	3.37	1656	3929
T_6	98.53	3.67	1884	4607
T_7	93.23	3.45	1795	4094
T_8	92.87	3.43	1373	3608
T_9	91.53	3.45	1460	3757
T_{10}	95.13	3.60	1846	4270
T_{11}	78.73	2.73	910	1957
SEm ±	2.68	0.11	105.19	247.08
CD @ P=0.05	7.64	0.32	300.22	705.15
Interaction (YxT)				
SEm ±	3.78	0.16	148.77	349.42
CD@ P=0.05	NS	NS	NS	NS

Table 2. Economics of barnyard millet as influenced by liquid bio-fertilizers and their mode of application.

Treatment details	Gross returns (Rs/ha)	Net returns (Rs /ha)	B:C ratio
Year (Y)			
Y_1	54932	33324	2.53
Y_2	50727	29937	2.43
SEm ±	1200.27	1200.27	0.06
CD @ P=0.05	3425.56	NS	NS
Treatments (T)			
T_1	66511	44246	2.99
T_2	59197	38556	2.87
T_3	62785	40528	2.82
T_4	61311	39310	2.79
T_5	50115	29739	2.46
T_6	57477	35484	2.61
T_7	54456	32608	2.49
T_8	41928	21705	2.07
T_9	44466	22626	2.04
T_{10}	56161	35529	2.72
T_{11}	26716	7607	1.40
SEm ±	2814.87	2814.87	0.13
CD @ P=0.05	8033.64	8033.64	0.38
Interaction (Y×T)			
SEm ±	3980.83	3980.83	0.19
CD @ P=0.05	NS	NS	NS

RESULTS AND DISCUSSION

Effect of liquid bio-fertilizer and its means of application significantly influenced the growth attributes, yield and economics of barnyard millet and are depicted in Tables 1- 2.

Plant height (cm) and number of tillers per plant

Among two years tested, higher plant height and number of tillers per plant was recorded during *kharif* 2021 (97.71 cm and 3.72, respectively) as compared to *kharif* 2020 (92.55 cm and 3.34, respectively). This might be due to increased uptake of nitrogen and phosphorus by the plants, which was made available through nitrogen fixation and phosphate solubilization by the microorganisms. Nitrogen enhanced the vegetative growth of the plant thus, leading to significant increase in plant height (Anmol Pagare *et al.* 2022).

Among various treatments, application of 100% RDF + seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer resulted in higher plant height and tillers per plant (102.73 cm and 3.97) respectively followed by application of 100% RDF with soil application of liquid biofertilizer (100.97 cm and 3.87) as compared to other treatments. This might be due to higher rate of fertilizer application along with application of biofertilizer through soil and seed treatment leads to increase the nutrient availability to the plant resulted in increase in number of tillers compare to lower fertility levels and non-application of biofertilizers, these results are also corroborated with Upadhaya *et al.* (2022) and Latake *et al.* (2009).

Increase in growth parameters might be owing to microbes in consortium that converts unavailable form of nutrients into the easily available form by secreating several acids and application of this liquid biofertilizer consortium containing all these organisms *Azospirillum lipoferum* (Nitrogen fixer), Bacillus megaterium (Phosphorus solubilizing bacteria) and *Frateuria aurantia* (Potassium solubilizing bacteria) through combined methods of application resulted in proper attachment and distribution of microbes and encourages the formation of new cell, cell division, cell elongation and root development. In addition to this, higher level of nutrients through RDF resulted in vigorous growth of root system which ultimately helps in better absorption and utilization of nutrients from soil solution which is reflected in term of better overall plant growth (Deepti *et al.* 2022).

Grain yield (kg/ha)

Among two years tested, grain yield was found significantly higher during *kharif* 2020 (1831 kg/ha) and recorded 11.01 % increase in grain yield over *kharif* 2021, respectively. Similarly, among various treatments, application of 100% RDF + seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer resulted in higher grain and straw yield (2214 and 5097 kg/ha) respectively followed by application of 100% RDF with soil application of liquid biofertilizer (2078 and 4918 kg/ha). Increase in grain and straw yields of these treatments was 11.28 and 11.71%, respectively against 100% RDF + soil application of liquid biofertilizer. Lavanya *et al.*

(2018) reported that application of liquid biofertilizer consortium along with RDF resulted in higher growth and yield of finger millet.

Economics (Rs/ha)

Among pooled data, higher gross returns (Rs 54932 ha^{-1}), net returns (Rs. 33324 ha^{-1}), and B:C ratio (2.53) was observed during *kharif* 2020 compared to *kharif* 2021 (Rs. 50727 ha^{-1}, Rs 29937 ha^{-1} and 2.43). Among various treatments tested, Application of 100% RDF along with seed treatment and soil application of liquid bio fertilizers recorded significantly higher gross returns (Rs 66511 ha^{-1}), net returns (Rs 44246 ha^{-1}), and B:C ratio (2.99) of Barnyard millet and found on par with the application of 100 % RDF along with soil application of liquid biofertilizer (Rs 62785 ha^{-1}, Rs 40528 $ha^{-1}$and 2.82) as compared to other treatments. Maximum net return and B:C ratio with liquid biofertilizer consortium through soil along with 100 % RDF was due to higher yield with reduced cost of cultivation (Deepti *et al.* 2022).

The higher gross return, net return and B:C ratio was found due to the fact that this fertility levels along with mode of biofertilizer application provided better nutritional environment resulted in higher productivity of grain as well as straw resulted in better return. Similar result was reported by Upadhaya *et al.* 2022, Choudhary and Gautam 2007, Latake *et al.* 2009, Singh *et al.* 2017, Ashwani and Rajesh 2019 and Rani *et al.* 2022.

CONCLUSION

From the results of the experiment, it could be concluded that the good response of barnyard millet to liquid biofertilizer was established among different methods of application but response was found much better with soil application of liquid biofertilizer as compared to seed treatment. Hence from economical point of view, 100% RDF coupled with the soil application of liquid biofertilizer has enhanced grain and straw yield to an extent of 11.28 and 11.71% respectively over 100% RDF and the treatment emerged as the most feasible practice for sustained yield. Hence, there is possibility of reducing chemical fertilizer usage to sustain good soil health and to reduce cost over chemical fertilizer.

ACKNOWLEDGMENT

Authors greatly acknowledge to the AICRP on Small millets, Bangalore and IIMR, Hyderabad for providing all necessary facilities to carry out research work.

REFERENCES

Anmol Pagare AK, Thakur PK, Salam T, Chandrakar, Singh DP (2022) Response of liquid bio-fertilizers on growth, yield attributing characters and economics of little millet (*Panicum sumatrense* Roth) under Marhan (Upland) situations. *The Pharma Inno J* 11(8): 1445-1449.

Ashwani S, Rajesh S (2019) Effect of seed bed and integrated nitrogen management on growth and yield of sorghum (*Sorghum bicolor* L.). *Int J Curr Mic Appl Sci* 6 (12):401-407.

Choudhary RS, Gautam RC (2007) Effect of nutrient management practices on growth and yield of pearl millet (*Pennisetum glaucum*). *Ind J Agron* 52(1):64-66.

Deepti CH, Sukanya TS, Latha HS, Umashankar N, Anand MR, Mamatha B (2022) Response of finger millet (*Eleusine coracana* L.) to liquid biofertilizer consortium and its methods of application. *Mysore J Agric Sci* 56(1): 65-71.

Gomez KA, Gomez AA (1984) Statistical procedures for agricultural research. A Willey- *Int Sci Pub John Willey* & Sons, New York.

IIMR (2018) *Ann Rep.*

Latake SB, Shinde DB, Bhosale DM (2009) Effect of inoculation of beneficial microorganisms on growth and yield of pearl millet. *Ind J Agril Res* 43 (1) : 61-64.

Lavanya K, Krishna Reddy G, Pratap Kumar Reddy A, Reddy PVMR, Lavanya Kumari P (2018) Yield and nutrient uptake of finger millet as influenced by organics and liquid biofertilizer consortium. *J Res ANGRAU* 46 (3): 41 - 44.

Pindi PK, Satyanarayan SBV (2012) Liquid microbial consortium - A potential tool for sustainable soil health. *J Biofertil Biol. Pestici* 3: 4.

Rani KS, Satish P, Rani CS, Sudhakar C (2022) Effect of liquid biofertilizers on growth and yield of rabi sorghum (*Sorghum bicolor* L.). *Chem Sci Rev Lett* 8(32):190-194.

Rao BKR, Krishnappa K, Srinivasarao C, Wani SP, Sahrawat KL,Pardhasaradhi G (2012) Alleviation of multinutrient deficiency for productivity enhancement of rainfed soybean and finger millet in the semi-arid region of India. *Comm Soi Sci Pl Anal* 43: 1427 - 1435.

Sneha S, Nair Pramod, Kumar Sahu, Brahmaprakash GP (2017) Microbial inoculants for agriculture under changing climate. *Mysore J Agric Sci* 51(1): 27 - 44.

Sood S, Khulbe R, Kumar RA, Agrawal PK, Upadhyaya H (2015) Barnyard millet global core collection evaluation in the sub mountain Himalayan region of India using multivariate analysis. *Crop J* 3: 517–525.

Verma M, Sharma S, Prasad R (2011) Liquid biofertilizers advantages over carrier based biofertilizers for crop production. *Int Soc Environ Bot* 17: 2.

Singh D, Raghuvanshi K, Chaurasiya A, Dutta SK (2022) Biofertilizers: Non chemical source for enhancing the performance of pearl millet crop (*Pennisetum glaucum* L.). *Bull Environ Pharma Life Sci* pp 38-42.

Raviraja, Balanagoudar SR, Bhat SN, Ravi MV, Yadahalli GS (2020) Effect of inm on yield, quality and economics in foxtail millet *(Setaria italica* L.) in black soil. *Int J Curr Microbiol Appl Sci* 9(3):2109- 2116.

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 Inno J* 11(2):2225-2230.

Vessey JK (2003) Plant growth promoting rhizobacteria as biofertilizers. *Pl Soil* 255: 571-586.