Response of Finger Millet (*Eleusine coracana* L.) to Liquid Biofertilizer Consortium and its Methods of Application

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Abstract

A field study was conducted during summer 2021 at Zonal Agriculture Research Station (ZARS), University of Agricultural Sciences, Bangalore to examine the response of finger millet (*Eleusine coracana* L.) to liquid biofertilizer consortium and its methods of application. Treatment which received 100 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium resulted in higher growth, yield parameters, grain and straw yields. However, the treatment was found on par with 100 per cent RDF + soil application, 100 per cent RDF + seedling rootdip and 85 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium. The grain yield with 100 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium and 100 per cent RDF + soil application was found significantly higher by 25.73 and 24.03 per cent, respectively over 100 per cent RDF. Similarly, respective increase in straw yield of these treatments were 24.08 and 22.62 per cent, respectively against 100 per cent RDF. The trend that was noticed in grain and straw yield was also noticed in various yield attributes *viz*., number of productive tillers plant^{-1}, number of fingers earhead^{-1}, ear head weight and grain weight earhead^{-1}. It was found that there is a possibility of reducing fertilizer up to 30 per cent, since the result obtained at 100 per cent RDF was on par with 70 per cent RDF + liquid fertilizer applied either through soil application or seedling root dip or combination of seed treatment, soil application and seedling root dip. However, from economical point of view for higher net returns, 100 per cent RDF + soil application was found feasible than 100 per cent RDF + combined methods of application (seed treatment, soil application and seedling rootdip).

Keywords : Finger millet, Liquid biofertilizer consortium, Methods, Application

Finger millet (*Eleusine coracana* L. Gaertn.) is a major food crop of the semi-arid tropics of Asia and Africa and is an indispensable component of dryland farming systems (Kerr, 2014). One of the striking features of finger millet is its resilience and ability to adjust to different agro-climates in terms of soil, rainfall and weather parameter and this ability is reflected in having highest productivity among millets. Wider adaptation, easy cultivation and drought tolerance of this crop is a major component of dry farming system. It is grown in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Maharashtra and Uttaranchal over an area of 11.38 lakh ha with a production of 18.21 lakh tons and a productivity of 1,601 kg ha^{-1}. Karnataka is one of the largest producer of finger millet in India and grown in 7.05 lakh ha with an annual output of 11.88 lakh tons and a productivity of 1,685 kg ha^{-1} (Anonymous, 2018). Finger 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 finger millet has good response to the applied nutrients. The majority of soils in semi-arid tropics, where finger 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. Biofertilizer is a live microbial preparation, when applied to seed, root surfaces or soil colonizes the rhizosphere or core of the plant and enhances the growth by releasing growth promoting substances and by increasing the availability of primary nutrients to host plant.

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 10^9 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). 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 finger millet. Hence, the present study was conducted to study response of finger millet (*Eleusine coracana* L.) to liquid biofertilizer consortium and its methods of application.

Material and Methods

A field experiment entitled 'Response of finger millet (*Eleusine coracana* L.) to liquid biofertilizer consortium and its methods of application' was conducted during summer 2021 at Zonal Agriculture Research Station (ZARS), University of Agricultural. Sciences, GKVK, Bengaluru. The soil type was red sandy loam, having acidic pH, low organic carbon content (0.32%), low obtainable nitrogen (226 kg ha^{-1}), high phosphorus (66 kg ha^{-1}) and medium potassium (200 kg ha^{-1}). RCBD design was adopted in the experiment with three replications. The experiment comprised of 14 treatments and it included three level of substitution with liquid bio fertilizer consortium *i.e.*, 0, 15 and 30 per cent coupled with four methods of application of liquid biofertilizers consortium *viz*., seed treatment (6 ml / kg seed), seedling root dip (500 ml in 25 liters of water, dip the seedlings of one hectare for 20 minutes before transplanting), soil application (625 ml of liquid biofertilizer mixed with 500 kg of FYM incubated overnight and applied at the time of transplantation 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 one more treatment as absolute control. which did not received any external source of nutrient application. Finger millet variety GPU 66 was transplanted 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 *Azopirillum lipoferum* (Nitrogen fixer)*, Bacillus megaterium* (Phosphorous 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 10 t ha^{-1} to each treatment except absolute control before transplantation of seedlings. Other cultural operations were followed as per the recommendation of the crop. Observations on growth as well as yield attributes 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.

RESULTS AND DISCUSSION

Growth Parameters

The growth parameters *viz*., plant height, leaves number, leaf area, number of tillers and overall drymatter production of finger millet were significantly differed due to application of liquid biofertilizer consortium and its methods of application (Table 1).

Growth parameters *i.e*., plant height (102.87 cm), number of leaves (32.13), leaf area (908.57 cm^2 plant^{-1}), number of tillers (4.17) and entire dry matter production (52.12 g plant^{-1}) at harvest were significantly higher with application of 100 per cent RDF + seed treatment + soil application+ seedling root dip with liquid biofertilizer consortium (T_4) but was found at par with treatment T_2 : 100 per cent RDF + soil application, T_3: 100 per cent RDF + seedling root dip and T_8: 85 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium.

In the present experiment, significantly higher growth parameters *i.e.,* plant height, leaf area, number of tillers and total dry matter production with superior treatment (T_4) 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 *Azopirillum lipoferum* (Nitrogen fixer), *Bacillus megaterium* (Phosphorous solubilizing

TABLE 1

Growth parameters of finger millet at harvest as influenced by liquid biofertilizer consortium and its methods of application

Treatment	Plant height (cm)	Number of leaves	Leaf area (cm^2 plant^{-1})	Number of tillers (plant^{-1})	Dry matter production (g)
T_1 : 100 % RDF + Seed treatment	91.6	28.9	828.5	3.67	45.42
T_2 : 100 % RDF + Soil application	99.25	31.63	886.5	4.03	50.78
T_3 : 100 % RDF + Seedling root dip	97.16	30.27	861.5	3.7	49.35
T_4 : 100 % RDF + Seed treatment + Soil application + Seedling root dip	102.87	32.13	908.5	4.17	52.12
T_5 : 85 % RDF + Seed treatment	83.95	24.27	749.5	3.27	40.78
T_6 : 85 % RDF + Soil application	91.02	27.13	824	3.63	46.14
T_7 : 85 % RDF + Seedling root dip	89.51	25.07	797.5	3.47	44.71
T_8 : 85 % RDF + Seed treatment + Soil application + Seedling root dip	95.25	29.13	847.5	3.77	47.48
T_9 : 70 % RDF + Seed treatment	76.38	19.63	670.5	2.83	36.14
T_{10}: 70 % RDF + Soil application	83.75	22.87	744.5	3.2	41.5
T_{11}: 70 % RDF + Seedling root dip	81.86	20.77	716.42	3	40.07
T_{12}: 70 % RDF +Seed treatment + Soil application + Seedling root dip	87.6	24.57	768.5	3.33	42.84
T_{13}: RDF (100: 50: 50 N, P_2O_5, K_2O kg ha^{-1}+ 375 g *azospirillum*)	88.5	25.13	789.15	3.4	43.78
T_{14} : Absolute control	65.08	15	590.9	2.4	29.27
S. Em±	3.79	1.57	27.14	0.16	2.24
CD (P = 0.05)	11.2	4.65	79.25	0.48	6.52

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. Besides nutrient availability, these microbes also play an important role in producing of plant growth promoting substances, regulator of plant pathogen and proliferation of beneficial organisms in the rhizosphere, ultimately results in increased growth of crop. The results are in accord with the findings of Rinku *et al.* (2014) and Sivamurugan *et al.* (2018).

Yield Parameters

The application of 100 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium resulted in significantly higher number of productive tillers plant^{-1} (3.63), number of fingers earhead^{-1} (7.77), finger length (5.83 cm), Ear head weight (6.95 g) and grain weight earhead^{-1} (4.63 g), but it was on par with treatment T_2: 100 per cent RDF + soil application, T_3: 100 per cent RDF + seedling root dip and T_8: 85 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer consortium (Table 2). The yield potential of a crop is expressed by its yield attributes. The reason behind increasing yield attributes might be due micro organisms in consortium *viz*., *Azospirillum*, a nitrogen fixing soil and root bacteria, not only

TABLE 2

Influence of liquid biofertilizer consortium and its methods of application on yield components of finger millet

Treatment	No. of productive tillers (plant^{-1})	No. of fingers (ear head^{-1})	Finger length (cm)	Ear head weight (g)	Grain weight (ear head^{-1})
T1 : 100 % RDF + Seed treatment	3.17	6.57	5.03	6.10	4.30
T2 : 100 % RDF + Soil application	3.50	7.63	5.65	6.79	4.55
T3 : 100 % RDF + Seedling root dip	3.33	7.40	5.45	6.78	4.45
T4 : 100 % RDF + Seed treatment + Soil application + Seedling root dip	3.63	7.77	5.83	6.95	4.63
T5 : 85 % RDF+ Seed treatment	2.87	5.70	4.57	6.08	3.89
T6 : 85 % RDF + Soil application	3.20	6.97	4.90	6.48	4.25
T7 : 85 % RDF + Seedling root dip	3.03	6.63	4.75	6.29	4.14
T8 : 85 % RDF + Seed treatment + Soil application + Seedling root dip	3.27	7.23	5.28	6.65	4.33
T9 : 70 % RDF+ Seed treatment	2.50	5.03	3.88	5.40	3.45
T_{10} : 70 % RDF + Soil application	2.83	5.63	4.3	6.00	3.82
T_{11} : 70 % RDF + Seedling root dip	2.67	5.53	4.15	5.79	3.59
T_{12} : 70 % RDF +Seed treatment + Soil application + Seedling root dip	2.97	6.27	4.58	6.25	4.03
T_{13} : RDF (100: 50: 50 N, P2O5, K2O kg ha-1 + 375 g azospirillum)	3.00	6.47	4.95	6.27	4.10
T_{14} : Absolute control	1.97	4.07	3.09	4.50	2.54
S. Em±	0.15	0.38	0.27	0.28	0.17
CD (P = 0.05)	0.45	1.13	0.78	0.84	0.50

fixes atmospheric nitrogen but also produces growth encouraging substances *i.e.*, indole acetic acid, gibberellins, thiamine and niacin and also it encourages root proliferation and finally improves yield and yield ascribing characters. Similar to *Azospirillum*, *Bacillus megathirium* being a phosphate solubilizing micro-organism helped in increasing the phosphorous availability in rhizosphere. Phosphorous directly affects the energy transformation and grain formation. They are also known to yield amino acids, vitamins and growth promoting substances like gibberlic acid which helped in enhanced crop growth and finally higher yield attributing characters and yield. These results agree with the findings of (Rajesh *et al*., 2013) and Jat and Balyan (2013) who stated that yield attributes and increases with application of Recommended Dose of Fertilizer along with biofertilizer.

Yield and Economics

The data relating to yield of finger millet differed significantly due to liquid biofertilizer consortium and its means of application are depicted in Table 3.

Grain and straw yield of finger millet differed significantly due to different treatments. Hundred per cent RDF + combined methods of application of liquid biofertilizer consortium (seed treatment, soil application and seedling root dip) (T_4) resulted in expressively higher grain and straw yield (4080 kg ha^{-1} and 7810 kg ha^{-1}, respectively), but was on par with treatment T_2: 100 per cent RDF + soil application (4025 and 7718 kg ha^{-1}, respectively), T_3: 100 per cent RDF + seedling root dip (3938 and 7560 kg ha^{-1}, respectively) and T_8: 100 per cent RDF + seed treatment + soil application + seedling root dip with liquid biofertilizer (3648 and 7038 kg ha^{-1},

TABLE 3

Effect of liquid biofertilizer consortium and its methods of application on yield and economics of finger millet

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (Rs.ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B : C ratio
T_1 : 100 % RDF + Seed treatment	3625	7032	112048	37870	74178	2.96
T_2 : 100 % RDF + Soil application	4025	7718	124277	39609	84668	3.14
T_3 : 100 % RDF + Seedling root dip	3938	7560	121604	39084	82520	3.11
T_4 : 100 % RDF + Seed treatment + Soil application + Seedling root dip	4080	7810	125955	41390	84565	3.04
T_5 : 85 % RDF + Seed treatment	3178	6260	98374	37168	61206	2.65
T_6 : 85 % RDF + Soil application	3590	7016	111044	38907	72137	2.85
T_7 : 85 % RDF + Seedling root dip	3498	6885	108272	38382	69890	2.82
T_8 : 85 % RDF + Seed treatment + Soil application + Seedling root dip	3648	7038	112701	40688	72013	2.77
T_9 : 70 % RDF+ Seed treatment	2735	5458	84767	36466	48301	2.32
T_{10} : 70 % RDF + Soil application	3148	6191	97431	38205	59226	2.55
T_{11} : 70 % RDF + Seedling root dip	3085	6035	95433	37680	57753	2.53
T_{12} : 70 % RDF +Seed treatment + Soil application + Seedling root dip	3200	6208	98912	39986	58926	2.47
T_{13} : RDF (100: 50: 50 N, P2O5, K2O kg ha-1+ 375 g azospirillum)	3245	6294	100301	37901	62400	2.65
T_{14} : Absolute control	1757	3710	54761	24990	29771	2.19
S. Em±	155	292	-	-	-	-
CD (P = 0.05)	450	855	-	-	-	-

respectively). The grain yield recorded with 100 per cent RDF + combined methods of application of liquid biofertilizer (seed treatment, soil application and seedling root dip) and 100 per cent RDF + soil application was pointedly higher by 25.73 and 24.03 per cent over RDF, respectively. Whereas, straw yield at T_4 also increased by 24.08 and 22.62 per cent, over T_{13}:100 per cent RDF (3245 kg ha^{-1} & 6294 kg ha^{-1}, respectively). Lavanya *et al.* (2018) reported that application of liquid biofertilizer consortium along with RDF resulted in higher growth and yield of finger millet.

The highest net return of Rs.84668 ha^{-1} was obtained under T_2: 100 per cent RDF + soil application with Benefit Cost Ratio of 3.14, followed by treatment T_4 :100 per cent RDF + combined methods of liquid biofertilizer consortium application (seed treatment, soil application and seedling root dip with liquid biofertilizer) which incurred the net return of Rs.84565 ha^{-1} and benefit cost ratio of 3.04. Even though highest gross return was recorded in T_4, higher labour wages and higher dose of liquid biofertilizer consortium increased the cost of cultivation (Rs.41390 ha^{-1}) and hence lowered the B:C ratio. Maximum net return and B:C ratio with liquid biofertilizer consortium through soil along with 100 per cent RDF was due to higher yield with reduced cost of cultivation.

Available Nutrients in Soil after Harvest

The highest soil available nitrogen, phosphorus and potassium was recorded with the application of 100 per cent RDF + combined methods of application (seed treatment, soil application and seedling root dip) (244.09 kg ha^{-1}, 86.25 kg ha^{-1} and 210.25 kg ha^{-1}, respectively) and is followed by T_2: 100 per cent RDF + soil application (242.05 kg ha^{-1}, 83.15 kg ha^{-1} and 208.95 kg ha^{-1}, respectively). Higher availability of nutrients might be due microbes in

TABLE 4

Nutrient status of soil after harvestas influenced by liquid biofertilizer consortium and its methods of application

Treatment		Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	: 100 % RDF + Seed treatment	236.08	79.25	205.25
T_2	: 100 % RDF + Soil application	242.05	83.15	208.95
T_3	: 100 % RDF + Seedling root dip	241.18	82.08	208.05
T_4	: 100 % RDF + Seed treatment + Soil application + Seedling root dip	244.09	86.25	210.25
T_5	: 85 % RDF+ Seed treatment	227.18	66.25	195.65
T_6	: 85 % RDF + Soil application	233.19	71.56	198.85
T_7	: 85 % RDF + Seedling root dip	232.08	70.85	197.12
T_8	: 85 % RDF + Seed treatment + Soil application + Seedling root dip	236.15	74.15	200.18
T_9	: 70 % RDF+ Seed treatment	219.15	53.25	186.95
T_{10}	: 70 % RDF + Soil application	224.28	59.25	190.85
T_{11}	: 70% RDF + Seedling root dip	223.15	58.02	188.25
T_{12}	: 70% RDF +Seed treatment + Soil application + Seedling root dip	227.56	61.25	193.85
T_{13}	: RDF (100: 50: 50 N, P2O5, K2O kg ha-1+ 375 g azospirillum)	229.58	63.25	195.25
T_{14}	: Absolute control	175.15	46.25	138.25
S. Em±		10.65	3.45	9.71
CD (P = 0.05)		30.96	10.08	28.21

consortia like *Azopirillum lipoferum* (Nitrogen fixer) which fixes atmospheric nitrogen in biological nitrogen fixation process. *Bacillus megaterium* (Phosphorous solubilizing bacteria) which solubilizes native fixed P through release of various organic acids during microbial processes and *Frateuria aurantia* which helped in solubilizing and mobilizing the native or non-exchangeable form of K. Result is in harmony with findings of Pindi & Satyanarayan (2012) and Devakumar *et al.,* 2018.

From the results of the experiment, it could be concluded that the good response of finger millet to liquid biofertilizer consortium was established among different methods of application but response was found much better with treatment which received liquid biofertilizer through seed treatment, soil application and seedling root dip along with 100 per cent RDF and which was on par with 100 per cent RDF + soil application. Hence from economical and particle point of view, 100 per cent RDF coupled with the soil application of liquid biofertilizer consortium has enhanced grain and straw yield to an extent of 24.03 and 22.62 per cent, respectively over 100 per cent RDF and the treatment emerged as the most feasible practice for sustained yield. Since RDF was on par with 70 per cent RDF + seedling root dip with liquid biofertilizer in both grain and straw yield. Hence, there is possibility of reducing 30 per cent fertilizer as compared to RDF to sustain good soil health and to reduce cost over chemical fertilizer.

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