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Response of Finger Millet under Organic Nutrient Management in Groundnut (*Arachis hypogaea* L.) – Finger Millet (*Eleusine coracana* L.) Cropping System

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ABSTRACT

A field experiment was conducted during rabi 2015 and rabi 2016 in farmers' field of Chokkahalli village of Chintamani taluk, Chikkaballapura district coming under eastern dry zone Karnataka to study the effect of bio-digested liquid manures on growth, productivity and quality of finger millet(Eleusine coracana). Application of enriched biodigested liquid organic manure (EBDLM) at 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya (PG) at 3 % produced significantly higher grain yield, straw yield, productive tillers plant^{-1}, finger length and 1000 grain weight (3695 kg ha^{-1}, 5169 kg ha^{-1}, 7.33, 9.28 cm and 3.95 g, respectively), LAI, total dry matter production plant^{-1} and SPAD (2.98, 59.41 g plant^{-1} and 23.7, respectively). Further, higher iron, calcium and protein content of finger millet (4.86, 345.43 mg 100 g^{-1}) was recorded with EBDLM at 50 kg N equivalent ha^{-1} with 3 sprays of PG at 3 per centas compared to other treatments.

Key words: *Finger millet, EBDLM, Jeevamrutha, Cow urine, Panchagavya, Vermiwash*

INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn.] commonly known as ragi, is one of the major staple food crops of Karanataka particularly southern region and also an ideal food for patients suffering from diabetes. It occupies the highest area under cultivation among the small millets. The grains are rich in calcium and iron besides being rich in carbohydrate and protein.In India, it is grown in an area of 13.07 million hectares with the production of 19.29 million tonnes and the productivity is 1641 kg ha^{-1}.The state of Karnataka is the largest producer of finger millet in India. In Karnataka, finger millet is grown in an area of 7.88 lakh ha, with an annual production of 12.72 lakh tonnes and productivity of 1871 kg ha^{-1}. It ranks third in area and production after rice and sorghum accounting for 58 per cent area and 44.9 per cent production in the state[1].

In recent years declining organic carbon (0.20- 0.35 per cent) and deficit in many essential nutrients in soils is a major worry among scientists and policy makers.

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Till now most of the research on organic production of finger millet was mainly concentrated on the use of FYM, compost, green manure, oil cakes *etc*. These manures alone or in combination could not boost the crop yields. To improve the physicochemical and biological properties of the soil and to improve the production potential of finger millet large quantity of organic manure is recommended. But the use of organic manure has been continuously declining in Indian agriculture due to several reasons. Decrease in cattle population in recent years and utilization of agricultural wastes into valuable by-products have made the availability of organic manure in agriculture questionable both in time and quantity. Non-availability of sufficient quantity of farmyard manures drawn the attention of researchers and cultivators to utilize the on-farm wastes, green biomass of *Glyricidia maculata, Pongamia pinnata etc*. and ubiquitous weeds *viz.*, parthenium, euphotorium, lantana, calatropis, *etc.*, for biodigested liquid manure production which can substitute the farmyard manure and compost. There is need to generate efficient organic manurial sources using on-farm available organic substrates in addition to integrated use of vermicompost, panchagavya, jeevamruta, beejambruta, vermiwash, mycorrhizae culture, neem cake/ neem seed extractants in organic farming. Further, there are evidences of enriched biodigested liquid manure use in enhancing the yields of finger millet, groundnut, pigeonpea and soybean[6,8]. Further, Liquid cattle manures could supplement the nitrogen requirements of crops. There is a need to enhance nitrogen, phosphorus and potassium content of biodigested liquid manure by enriching with neem, pongamia, jatropa cake, *etc.* and these enriched sources need to be evaluated for their effect on productivity of groundnut. Further, there is also need to evaluate the beneficial effects of cow urine, panchagavya, vermiwash in conjunction with enriched biodigested liquid manure. Hence the investigation was carried out to study the efficacy of bio-digested liquid manures on the yield potential and quality of finger millet.

MATERIALS AND METHODS

The field experiment was carried out during *rabi* 2015 and *rabi* 2016 in farmers' field of Chokkahalli village of Chintamani taluk, Chikkaballapura district, Karnataka to study the effect of bio-digested liquid manures on growth, productivity and quality of finger millet (*Eleusine coracana*). The soil is red sandy loam in texture with a bulk density of 1.43 g cc^{-1} and water holding capacity 39.31%. The soil p^H was neutral (7.59) and the electrical conductivity was normal (0.12 dSm^{-1}). The organic carbon content was low (0.29 %). The soil was medium in available nitrogen (298.5 kg ha^{-1}), phosphorus (27.3 kg ha^{-1}), potassium (195.8 kg ha^{-1}) and available sulphur (21.56 kg ha^{-1}). During both the years of experimentation, more rainfall was received during the first year (917.6 mm) of cropping season with drought during second year (417.7 mm) except for beginning two months of crop period, as compared to normal rainfall (587.8 mm). Crop was raised under rainfed condition with protective irrigation at 5 cm depth during the dry spell of the cropping period. There were ten treatments comprising of three types of organic liquid manures viz. jeevamrutha, enriched biodigested liquid manures (EBDLM) and cow urine (CU) along with foliar spray of 3% panchagavya (PG) and 3% vermiwash (VW) and recommended fertilizers for groundnut as detailed T_1: Jeevamrutha @ 25 kg N equivalent ha^{-1}, T_2: Jeevamrutha @ 25 kg N equivalent ha^{-1} + VW spray @ 3 %, T_3: Jeevamrutha @ 25 kg N equivalent ha^{-1} + PG spray @ 3 %, T_4: EBDLM @ 25 kg N equivalent ha^{-1}, T_5: EBDLM @ 25 kg N equivalent ha^{-1} + VW spray @ 3 % , T_6:EBDLM @ 25 kg N equivalent ha^{-1} + PG spray @ 3 %, T_7: CU@ 25 kg N equivalent ha^{-1} , T_8: CU@ 25 kg N equivalent ha^{-1} + VW spray @ 3 %, T_9: CU@ 25 kg N equivalent ha^{-1} + PG spray @ 3 % , T_{10}: Rec. FYM 10 t +

25:50:25 kg $N:P_2O_5:K_2O$ ha^{-1}. The treatments were laid out in randomized complete block design with three replications. The gross plot was 3.6 m x 3.2 m. The bio-digested liquid manure was prepared in a 200 litre cement tank by adding 15 kg cow dung, 20 litre cow urine, 30 kg of on-farm green biomass and 100 litre water by frequent stirring. The liquid manure was incubated for 45 days, then it was enriched with 10% Pongamia cake. While, jeevamrutha was prepared by mixing 10 kg local cow dung with 10 litres cow urine, 2 kg local jaggery, 2 kg bengalgram flour and handful of garden soil was added and the volume was made upto 200 litres. The plastic drum was kept in shade covering with wet gunny bag and the mixture was stirred clockwise thrice a day and incubated for 9days and the resultant jeevamrutha was used. Jeevamrutha contained 1.48, 0.28 and 0.32 per cent N, P and K, respectively. While, enriched biodigested liquid manure has 1.29, 0.39, 0.57 per cent N, P and K, respectively. The required quantity of liquid manures on nitrogen equivalent was applied to the soil. Liquid manures were applied in two equal splits at 15 and 45 days after sowing groundnut.

Panchagavya was prepared by using five products of desi cow viz. cow urine, dung, milk, curd and ghee. Vermiwash was prepared by dipping adult earth worms in luke warm water. Three per cent panchagavya and vermiwash solutions were prepared by mixing 30 ml each panchagavya and vermiwash in 1000 ml of water separately. Three spray of 3 % panchagavya and vermiwash was applied at 25, 50 and 75 days after transplanting to finger millet as per treatments. Treatment 1 to 9 were supplied with recommended compost comprising of FYM and vermicompost at 50% each based on N equivalent and treatment T_{10} received FYM+vermicompost at 10 t ha^{-1} two weeks before sowing and recommended dose of fertilizer 50:37.5:40 $N:P_2O_5:K_2O$ kg ha^{-1} for groundnut was incorporated into the soil at the time of sowing. The nutrients were applied in the form of urea, single super phosphate and muriate of potash.

The finger millet cultivar KMR-204 was transplanted during *rabi* of 2015 and 2016. The spacing adopted was 30 x 10 cm for groundnut. Thrips and aphids were controlled by spraying 4 per cent neem seed kernel extract twice during crop growth period of finger millet. The yield of finger millet was recorded at harvest. Further, iron, calcium and protein per cent of finger millet were computed.

RESULTS AND DISCUSSION

In general, the productivity of finger millet was more in the second year (2016) than in first year (2015) but response to different treatments was similar in both the years of experimentation and hence, pooled data is discussed here. Application of enriched biodigested liquid organic manure at 25 kg N equivalent ha^{-1} + 3 sprays of panchagavya (PG) at 3 % produced significantly higher grain yield, straw yield, productive tillers $plant^{-1}$, finger length and 1000 grain weight (3695 kg ha^{-1}, 5169 kg ha^{-1}, 7.33, 9.28 cm and 3.95 g, respectively), LAI, total dry matter production $plant^{-1}$ and SPAD (2.98, 59.41 g $plant^{-1}$ and 23.7, respectively). Further, higher iron, calcium and protein content of finger millet (4.86, 345.43 mg 100 g^{-1}) followed by EBDLM at 25 kg N equivalent ha^{-1} + 3 sprays of VW at 3 % cent (3621 kg ha^{-1}, 5277 kg ha^{-1}, 7.10, 9.05 cm, 3.90g, 2.93, 56.76g and 22.5, respectively) and jeevamrutha at 25 kg N equivalent ha^{-1} + 3 sprays of PG at 3 % cent (3679 kg ha^{-1}, 5200 kg ha^{-1}, 7.03, 8.88 cm, 3.84g 2.93, 56.73g and 21.5, respectively) than all other treatments. Significantly lower grain yield, straw yield, productive tillers $plant^{-1}$, finger length and 1000 grain weight (3532 kg ha^{-1}, 5007 kg ha^{-1}, 6.33, 7.83 cm and 3.29g, respectively) was observed with recommended practice (Table I & II).

The yielding ability of a crop is the reflection of yield attributing characters like more number of productive tillers $plant^{-1}$,

number of fingers earhead^{-1}, earhead length, finger length, grain yield plant^{-1}, 100 grain weight. Enriched biodigested liquid manures supplies secondary and micro nutrients along with N, P and K and growth promoters and micronutrients content of panchagavya[10] which might be the reason to record higher test weight and shelling per cent. These results are in line with Somasundaram[8] in greengram, maize and sunflower, Boomiraj[2] in bhendi and Ravi Kumar[7] in finger millet.

Plant growth is also dependent on the rate of accumulation of dry matter. The dry matter accumulation may reflect on the economic yield in view of the fact that vegetative parts of the plant serve as a source where as grains are the sink. Dry matter production per plant differed significantly due to different nutrient sources. Application of EBDLM @ 50 kg N equivalent ha^{-1} + PG spray @ 3 % recorded significantly higher (59.41 g) total dry matter production plant^{-1}, which could be ascribed to the increase in plant size, as indicated by increase in plant height (Table 4.38), number of tillers plant^{-1}(Table 4.39) and dry matter accumulation in different parts like leaf, stem and ear head, LAI (Table 4.41) and SPAD chlorophyll meter reading (Table 4.46) and their cumulative effect of all these parameters. Humic acid sources (enriched biodigested liquid manure and panchagavya) provided protoplasmic elements *viz*., N, P and K that assisted in physiological functions of plant such as chlorophyll and protein synthesis and thereby increased in dry matter accumulation.

Similar results were obtained by Reddy *et al*.[5,6] who carried out various field trials at Research Institute on Organic Farming at Balajigapade, Chintamani, Naganahalli and shimogga for developing package of practices for organic finger millet production through compost and Biodigester liquid manure. At Chintamani, significantly higher grain yield (2788 kg ha^{-1}) of finger millet was obtained with FYM 10 t ha^{-1} + BDLM equivalent to 60 kg N ha^{-1} than recommended practice (FYM 7.5 t h^{-1} + 50:40:25 kg NPK ha^{-1}) (1388 kg ha^{-1}). Similar yields were also obtained at Balajigapade and Chintamani with the application of 10 t FYM and BDLM equivalent to 60 kg N ha^{-1}. Besides, application of cow urine (5000 l ha^{-1}) at Navile, resulted highest grain yield (2098 kg ha^{-1}) and straw yield (4102 kg ha^{-1}) of finger millet as compared to recommended practice (1897 and 3565, respectively).

Quality parameters *viz.,* iron, calcium and protein content of finger millet (4.86, 345.43 mg 100 g^{-1}) with the application of EBDLM at 25 kg N equivalent ha^{-1} + 3 sprays of PG at 3 % is superior as compared to other treatments (Table III).

The improvement in iron and calcium content of finger millet with panchagavya spray might be ascribed to beneficial effects of panchagavya on crop quality. Protein percentage was not significantly influenced by application of different biodigested liquid manures. But higher protein content and protein yield with the application of EBDLM @ 50 kg N equi. ha^{-1} + PG spray @ 3 % followed by EBDLM @ 50 kg N equivalent ha^{-1} + VW spray @ 3 % and jeevamrutha @ 50 kg N equi. ha^{-1}+ PG spray @ 3 % might be due to increased availability of nutrients particularly nitrogen which is an integral part of protein. These results are in conformity with the findings of Sudheendra Saunshi[9], Ravi Kumar[7], Naveen Kumar[4] and Govindappa[3] in finger millet.

It can be concluded from the study that the application of enriched liquid organic manure or jeevamrtha 15 and 45 days after sowing for finger millet equivalent to 100 per cent recommended dose of nitrogen with foliar spray of panchagavya or vermiwash at 3 per cent on 25, 50 and 75 DAS is the best option for higher productivity of finger millet, besides improving iron, calcium and protein content.

Table 1: Growth parameters in finger millet as influenced by different liquid organic manures

Treatments	LAI @ 60 DAS			TDMA (g plant^{-1}) @ harvest			SPAD @ 60 DAS			No. of productive tillers plant^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	2.65	3.07	2.86	51.79	56.69	54.24	15.4	23.6	19.5	5.80	7.60	6.70
T_2	2.68	3.09	2.89	52.36	57.30	54.83	16.2	24.6	20.4	5.80	7.80	6.80
T_3	2.71	3.14	2.93	54.18	59.28	56.73	17.2	25.8	21.5	6.07	8.00	7.03
T_4	2.69	3.11	2.90	52.28	58.80	55.54	16.7	25.5	21.1	5.97	7.80	6.88
T_5	2.72	3.14	2.93	54.52	58.99	56.76	18.8	26.2	22.5	6.13	8.07	7.10
T_6	2.75	3.20	2.98	57.69	61.13	59.41	19.6	27.9	23.7	6.33	8.33	7.33
T_7	2.55	2.89	2.72	49.39	52.46	50.93	13.8	20.8	17.3	5.20	6.80	6.00
T_8	2.57	2.94	2.76	49.13	53.18	51.16	14.2	21.6	17.9	5.47	7.20	6.33
T_9	2.63	2.98	2.81	50.33	54.02	52.18	15.6	22.3	18.9	5.87	7.20	6.53
T_{10}	2.43	2.83	2.63	45.37	48.33	46.85	15.4	24.2	19.8	5.53	7.13	6.33
S. Em±	0.17	0.21	0.12	0.96	1.35	1.02	1.02	1.42	0.89	0.23	0.31	0.19
C. D. at 5 %	0.50	0.62	0.36	2.84	4.01	3.04	3.04	4.23	2.63	0.68	0.94	0.56

T1: Jeevamrutha @ 25 kg N equivalent ha-^{1}
T2: Jeevamrutha @25 kg N equivalent ha-^{1}+ Vermi wash(VW) spray @ 3 %
T3: Jeevamrutha @ 25 kg N equivalent ha-^{1}+ Panchagavya (PG) spray @ 3 %
T4: Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha-^{1}
T5: EBDLM @ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T6: EBDLM @ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T7: Cow Urine (CU) @ 25 kg N equivalent ha-^{1}
T8: CU@ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T9: CU@ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T10: Rec. POP. 25:50:25 kg NPK ha-^{1}
DAS: Days after sowing
NS: Non significant

Table 2: Yield and yield parameters in finger millet as influenced by different liquid organic manures

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			1000 grain weight (g)			Finger length (cm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	2015	2016	Pooled	2015	2016	Pooled	3.71	3.74	3.73	8.10	8.93	8.52
T_2	3504	3674	3589	5155	5519	5337	3.76	3.79	3.78	8.30	9.10	8.70
T_3	3536	3720	3628	5099	5303	5201	3.81	3.86	3.84	8.40	9.37	8.88
T_4	3589	3769	3679	5079	5320	5200	3.78	3.82	3.80	8.10	9.30	8.70
T_5	3526	3717	3621	5125	5429	5277	3.86	3.93	3.90	8.60	9.50	9.05
T_6	3618	3773	3695	5050	5288	5169	3.92	3.98	3.95	8.97	9.60	9.28
T_7	3697	3878	3787	4946	5305	5125	3.51	3.56	3.54	7.83	8.63	8.23
T_8	3316	3513	3414	4989	5248	5118	3.59	3.64	3.62	7.90	8.70	8.30
T_9	3358	3585	3471	4927	5209	5068	3.68	3.72	3.70	8.23	8.80	8.52
T_{10}	3418	3647	3532	4893	5122	5007	3.23	3.34	3.29	7.47	8.20	7.83
S. Em±	3149	3427	3288	4677	5183	4930	0.05	0.05	0.03	0.32	0.36	0.30
C. D. at 5 %	56.94	58.87	38.81	100.54	104.96	70.50	0.14	0.14	0.10	0.94	1.07	0.90

T1: Jeevamrutha @ 25 kg N equivalent ha-^{1}
T2: Jeevamrutha @25 kg N equivalent ha-^{1}+ Vermi wash(VW) spray @ 3 %
T3: Jeevamrutha @ 25 kg N equivalent ha-^{1}+ Panchagavya (PG) spray @ 3 %
T4: Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha-^{1}
T5: EBDLM @ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T6: EBDLM @ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T7: Cow Urine (CU) @ 25 kg N equivalent ha-^{1}
T8: CU@ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T9: CU@ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T10: Rec. POP. 25:50:25 kg NPK ha-^{1}
DAS: Days after sowing
NS: Non significant

Table 3: Quality parameters in finger millet as influenced by different liquid organic manures

Treatments	Fe (mg 100 g^{-1})			Ca (mg 100 g^{-1})			Protein (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	4.73	4.75	4.74	344.23	344.43	344.33	10.20	10.50	10.35
T_2	4.74	4.76	4.75	344.27	344.50	344.38	10.30	10.60	10.45
T_3	4.78	4.80	4.79	344.50	344.83	344.72	10.50	10.70	10.60
T_4	4.75	4.77	4.76	344.50	344.93	344.68	10.40	10.60	10.50
T_5	4.79	4.81	4.80	344.60	345.07	344.83	10.60	10.80	10.70
T_6	4.88	4.83	4.86	345.37	345.50	345.43	10.80	11.10	10.95
T_7	4.71	4.73	4.72	344.37	344.27	344.32	10.00	10.20	10.10
T_8	4.72	4.74	4.73	344.43	344.33	344.38	10.10	10.30	10.20
T_9	4.77	4.77	4.77	344.73	344.43	344.58	10.20	10.40	10.30
T_{10}	4.69	4.71	4.70	344.20	344.23	344.22	10.13	10.10	10.12
S. Em±	0.05	0.04	0.03	1.38	1.33	0.99	0.11	0.05	0.05
C. D. at 5 %	0.15	0.12	0.10	4.11	3.94	2.95	0.33	0.15	0.16

T1: Jeevamrutha @ 25 kg N equivalent ha-^{1}
T2: Jeevamrutha @25 kg N equivalent ha-^{1}+ Vermi wash(VW) spray @ 3 %
T3: Jeevamrutha @ 25 kg N equivalent ha-^{1}+ Panchagavya (PG) spray @ 3 %
T4: Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha-^{1}
T5: EBDLM @ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T6: EBDLM @ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T7: Cow Urine (CU) @ 25 kg N equivalent ha-^{1}
T8: CU@ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %
T9: CU@ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %
T10: Rec. POP. 25:50:25 kg NPK ha-^{1}
DAS: Days after sowing
NS: Non significant

CONCLUSION

In a long term field trial on finger millet at Bangalore revealed that FYM or NPK fertilizers alone could not produce high yields and not sustainable. Many essential plant nutrients became deficit after two-three decades with them. Low finger millet yields with organic manures could be attributed to that generally 40 per cent of applied nutrients through FYM or compost is available and could not have met the crop nutrient demand. Farming system trial being conducted since 30 years at Rodale Institute, USA, showed that crop yields were sustainable, soil was healthy and production costs of corn, soybean, wheat and oats was reduced under organic farming. Besides organic farming could produce more yields to achieve global food security[1]. The liquid bio-digester manure has been used for finger millet, paddy, maize, redgram, groundnut, soybean, fieldbean and other crops along with the compost. High crop productivity, reduction in production costs and improved soil health were noticed with the use of liquid biodigester manure[5]. Finger millet yields were tremendously increased by the combined application of farmyard manure and bio-digester liquid manure at Balajigapade, Chintamani, Naganahally and Shimogga (Karnataka). Further, enrichment of bio-digester liquid manure using high quantities of dung, cattle urine, some oilcakes *etc*., had increased the yields of finger millet, groundnut and redgram. However, the studies involving enrichment with poultry manure, neem cake and rock phosphate *etc*., are needed to raise the content of nitrogen and phosphorus of bio-digester liquid manure. Besides, their effect on crop production is essential for improving the productivity. Now, the agriculture research is focused on evolving ecologically sound, biologically sustainable and socio economically viable technologies and there is need for a fresh look into research agenda to exploit the organic farming approaches using the local manurial sources for growing finger millet without using chemical fertilizers which minimize environmental pollution and maintain long term productivity of soil by maintaining soil health.

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