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Impact of Organic Nutrient Management on Productivity, Nutrient Uptake and Economics of Finger millet in Groundnut (*Arachis hypogaea* L.) – Finger Millet (*Eleusine coracana* L.) Cropping System

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A B S T R A C T

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 productivity, nutrient uptake and economics of finger millet. Significantly higher grain and straw yield (3787 and 5125 kg ha^{-1}) was recorded with the application of EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya @ 3 %, which was on par with application of EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash @ 3 % (3695 and 5169 kg ha^{-1}). Significantly lower grain yield (3288 and4930 kg ha^{-1}) was recorded with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}) and also significantly higher uptake of nitrogen, phosphorus and potassium (129.93, 12.7 and 82.10 kg ha^{-1}, respectively) was noticed with EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of *panchagavya* @ 3 % as compared to other treatments and it was on par with EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash @ 3 % (125.48,11.87 and 79.4 kg ha^{-1}, respectively). However, significantly lower uptake of nutrients (101.22, 8.70 and 66.55 kg ha^{-1}, respectively) was noticed with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}). Further, Application of EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of *panchagavya* @ 3 % recorded higher gross returns (Rs.1,43,167 ha^{-1}), net returns (Rs.1,13,671 ha^{-1}) and B:C ratio (3.85) followed by EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash @ 3 % (Rs.1,40,332 ha^{-1}, Rs.1,11,146 ha^{-1} and 3.81, respectively). Whereas, POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}) recorded lower gross returns (Rs. 1,24,286 ha^{-1}), net returns (Rs.93,725 ha^{-1}) and B:C ratio (3.06) when compared to all other treatments.

Introduction

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. The physico-chemical and biological properties of the soil determine the production potential of any crop either in dry lands or irrigated conditions. Keeping this in view, large quantity of organic manure is recommended for finger millet. But the use of organic manures 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 *Gliricidia maculata, Pongamia pinnata* etc., and ubiquitous weeds, viz. parthenium, euphotorium, lantana, calatropis, cassia etc., for biodigested liquid manure production which can substitute the farmyard manure and compost. Most of the research on finger millet was mainly concentrated on the use of FYM, compost, green manure, oil cakes etc. There is need to generate efficient organic manurial sources using on-farm available organic substrates in addition to integrated use of vermicompost, *panchaga*vya, *dashagavya*, *jeevamruta*, *beejambruta*, amrutapani, sanjeevak, 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 finge rmillet, groundnut, pigeonpea and soybean (Reddy *et al.*, 2011 and Somasundaram, 2003). 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 crops. Further, there is also need to evaluate the beneficial effects of cow urine, *jeevamruta, panchagavya,* vermiwash in conjunction with enriched biodigested liquid manure (EBDLM). Hence the investigation was carried out to study the efficacy of bio-digested liquid manures on the yield, nutrient uptake, balance and their economics of finger millet is needed in *Alfisols* of southern Karnataka.

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 45 per cent production in the state (Anon., 2013).

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, nutrient uptake and economics 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 pH 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

Grain and straw yield

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 (Table 1). Significantly higher grain and straw yield (3787 and 5125 kg ha^{-1}) was recorded with the application of EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya@ 3 %, which was on par with application of EBDLM @ 50 kg N equivalent

ha^{-1} + 3 sprays of vermiwash@ 3 % (3695 and 5169 kg ha^{-1}). Significantly lower grain yield (3288 and4930 kg ha^{-1}) was recorded with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}).

The yielding ability of a crop is the reflection of yield attributing characters like more number of productive tillers $plant^{-1}$, number of fingers $earhead^{-1}$, ear head 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 (Yadav and Lourduraj, 2006) which might be the reason to record higher test weight and shelling per cent. These results are in line with Somasundaram (2003) in greengram, maize and sunflower, Boomiraj (2003) in bhendi and Ravi Kumar (2009) in finger millet.

Yield 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 whereas 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, number of $tillersplant^{-1}$ and dry matter accumulation in different parts like leaf, stem and ear head, LAI and SPAD chlorophyll meter reading 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 reported by Reddy *et al.*, (2010 and 2011) who carried out various field trials at Research Institute on Organic Farming at Balajigapade, Chintamani, Naganahalli and Shimoga 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).

Nutrient uptake

Data on uptake of nitrogen, phosphorus and potassium by finger millet as influenced by different liquid manures is presented in table 3. Significantly higher uptake of nitrogen, phosphorus and potassium (129.93, 12.7 and 82.10 kg ha^{-1}, respectively) was noticed with EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya@ 3 % as compared to other treatments and it was on par with EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash@ 3 % (125.48,11.87 and 79.4 kg ha^{-1}, respectively). However, significantly lower uptake of nutrients (101.22, 8.70 and 66.55 kg ha^{-1}, respectively) was noticed with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}).

The possible reason for increase in uptake of NPK may be attributed to higher nutrient availability due to enhanced microbial activity leading to mineralization and release of nutrients matching with crop demand.

Table.1 Yield of finger millet as influenced by different liquid organic manures

Treatments	*Grain yield (kg ha^{-1})*			*Straw yield (kg ha^{-1})*		
	2015	*2016*	*Pooled*	*2015*	*2016*	*Pooled*
T_1	*2015*	*2016*	*Pooled*	*2015*	*2016*	*Pooled*
T_2	3504	3674	3589	5155	5519	5337
T_3	3536	3720	3628	5099	5303	5201
T_4	3589	3769	3679	5079	5320	5200
T_5	3526	3717	3621	5125	5429	5277
T_6	3618	3773	3695	5050	5288	5169
T_7	3697	3878	3787	4946	5305	5125
T_8	3316	3513	3414	4989	5248	5118
T_9	3358	3585	3471	4927	5209	5068
T_{10}	3418	3647	3532	4893	5122	5007
S. Em±	3149	3427	3288	4677	5183	4930
C. D. at 5 %	56.94	58.87	38.81	100.54	104.96	70.50

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 Uptake of NPK by finger millet as influenced by different liquid organic manures

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	112.50	114.80	113.65	10.20	11.40	10.80	73.23	74.80	74.02
T_2	118.70	120.67	119.68	10.80	11.70	11.25	74.70	76.40	75.55
T_3	123.60	124.80	124.20	11.50	12.30	11.90	76.70	78.30	77.50
T_4	121.33	124.20	122.77	11.30	12.20	11.75	76.60	80.20	78.40
T_5	124.37	126.60	125.48	11.17	12.57	11.87	77.20	81.60	79.40
T_6	128.47	131.40	129.93	12.20	13.20	12.70	79.40	84.80	82.10
T_7	101.30	102.60	101.95	8.80	9.20	9.00	68.83	68.90	68.87
T_8	103.50	104.60	104.05	9.20	9.80	9.50	69.30	70.87	70.08
T_9	108.40	110.30	109.35	9.87	10.40	10.13	70.60	72.40	71.50
T_{10}	98.50	103.93	101.22	8.10	9.30	8.70	65.80	67.30	66.55
S. Em±	3.88	3.99	2.60	0.82	0.64	0.48	3.32	2.72	2.40
C. D. at 5 %	11.54	11.85	7.73	2.44	1.91	1.42	9.86	8.09	7.12

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 Economics of finger millet as influenced by different liquid organic manures

Treatments	Cost of Cultivation (Rs. ha $^{-1}$)			Gross Returns (Rs. ha^{-1})			Net Returns (Rs.ha^{-1})			B:C ratio		
	2015	*2016*	*Pooled*	*2015*	*2016*	*Pooled*	*2015*	*2016*	*Pooled*	*2015*	*2016*	*Pooled*
T_1	28439	28809	28624	132451	138877	135664	104012	110068	107040	3.66	3.82	3.74
T_2	28786	28974	28880	133660	140767	137214	104874	111793	108334	3.64	3.86	3.75
T_3	29069	29249	29159	135664	142468	139066	106595	113219	109907	3.67	3.87	3.77
T_4	28571	28762	28666	133282	140502	136892	104711	111740	108226	3.66	3.89	3.77
T_5	29092	29281	29186	136760	143904	140332	107668	114623	111146	3.70	3.91	3.81
T_6	29406	29587	29496	139746	146588	143167	110340	117001	113671	3.75	3.95	3.85
T_7	28274	28471	28372	125344	132791	129068	97070	104320	100695	3.43	3.66	3.55
T_8	28752	28979	28865	126932	135513	131222	98180	106534	102357	3.41	3.68	3.55
T_9	29119	29349	29234	129200	137894	133547	100081	108545	104313	3.44	3.70	3.57
T_{10}	30423	30701	30562	119032	129540	124286	88609	98840	93725	2.91	3.22	3.06

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

Combined application of FYM + vermicompost and EBDLM acted as slow release nutrient sources. Nutrient uptake by crop mainly depends on both supply of nutrients and rate of uptake by the crop. Slow and steady release of nutrients from FYM and BDLM enriched with poultry manure or neem cake matched with crop demand. These results corroborate with the findings of Suresh Naik (2011) who found that the application of FYM 12.5 t + BDLME at 150 kg N ha^{-1} had significantly resulted in the highest nitrogen uptake of maize (184.5 kg ha^{-1}). Besides, Manjunath (2010) also reported similar results on maize from Mandya.

Nitrogen uptake was significantly higher (137.9 kg ha^{-1}) by finger millet with the application of FYM 10 t ha^{-1} + BDLM enriched with poultry manure and rock phosphate equivalent to 60 kg N ha^{-1} and FYM 10 t + BDLM enriched with neem cake and rock phosphate equivalent to 60 kg N ha^{-1} as reported by Sudheendra Saunshi (2012).

However, the increase in uptake of nutrients with foliar spray of panchagavya was ascribed to increased biological efficiency of crop plants and creating greater source and sink in the plant system (Boomathi *et al.,* 2005) that might have contributed for greater absorption of the nutrients. There was increase in leaf area index in the treatments which received sprays of 3 per cent panchagavya facilitating increased photosynthetic efficiency of plants leading to increased uptake of nutrients.

Economics

The acceptance of any generated technology by the farmers ultimately depends on the profits realized upon cost incurred in the production. Among the different indicators of monitory efficiency, the net returns have a greater impact on the practical utility and acceptance of technology. Data on the effect of different liquid manures and organic source of nutrients on economic parameters *viz*., cost of cultivation, gross returns, net returns and benefit cost ratio are presented in table 3.

The total cost of cultivation was higher (Rs. 30,562 ha^{-1}) with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}) as compared to other treatments. Whereas, in case of CU @ 50 kg N equivalent ha^{-1} the cost of cultivation was lower (Rs.28,372 ha^{-1}).

Application of EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya @3 % recorded higher gross returns (Rs.1,43,167 ha^{-1}) and net returns (Rs.1,13,671 ha^{-1}) followed by EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash at 3 % (Rs.1,40,332 ha^{-1}) and (Rs.1,11,146 ha^{-1}), respectively.

Whereas, POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}) recorded lower gross returns (Rs. 1,24,286 ha^{-1}) and net returns (Rs.93,725 ha^{-1}) when compared to all other treatments.

The Benefit: Cost ratio was higher with EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of panchagavya@ 3 % (3.85) followed by EBDLM @ 50 kg N equivalent ha^{-1} + 3 sprays of vermiwash@ 3 % (3.81). While, lower Benefit: Cost ratio (3.06) was recorded with POP (50:37.5:40 Kg N: P_2O_5:K_2O ha^{-1}). Reddy *et al.,* (2010) at ARS, Balajigapade obtained higher B C ratio of 1.66 in finger millet with the application of FYM 10 t ha^{-1} + biodigester liquid manure equivalent to 60 kg N ha^{-1}.

Similar results of higher gross returns, net returns and B: C ratio were obtained with the application of EBDLM and panchagavya in finger millet by Govindappa (2003), Sudheendra Saunshi (2012) and Latha and Sharanappa (2014b) in ground nut-onion sequence.

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 and economics besides improving other parameters.

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