Effect of establishment method and organic nutrient management practices on yield and quality of finger millet

Abstract

A field experiment was conducted during the *kharif* seasons in 2020 and 2021 at Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar to study the effect of establishment method and organic nutrient management on yield and quality parameters of finger millet. (Variety Arjuna). The experiment was laid out in a split-plot design and replicated thrice. The treatments comprised of 2 methods of crop establishment *viz.* conventional method of line transplanting (20 cm x 10 cm) and system of finger millet intensification (25 cm X 25 cm) in the main plot with the application of 4 organic nutrient sources *viz.* FYM @ 100% RDN, FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal), FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) and FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (topdressing) allotted to sub plot in finger millet during *Kharif* season. SFMI method of establishment resulted in superior grain yield (2051 kg ha^{-1}), straw yield (2901 kg ha^{-1}), harvest index (41.42%) and quality parameters of finger millet grains *viz.* protein (7.56%), crude fibre (3.6 g 100^{-1}), vitamin E (0.14 mg 100 g^{-1}), Ca (344.1 mg $100g^{-1}$), Mg (164.3 mg 100 g^{-1}), Fe (4.86 mg $100g^{-1}$), Zn (3.71 mg $100g^{-1}$) content than line transplanting. The grain yield (2092 kg ha^{-1}), straw yield (2889 kg ha^{-1}) , harvest index (42.00 %) and quality parameters of finger millet grains *viz.* protein (7.91%), crude fibre (3.9 g $100g^{-1}$), vitamin E (0.16 mg 100 g^{-1}), Ca (346.7 mg $100g^{-1}$), Mg (176.4 mg 100 g^{-1}), Fe (4.94 mg $100g^{-1}$), Zn (3.98 mg $100g^{-1}$) content was higher with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) in finger millet and was statistically similar with the application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). The benefit-cost ratio was higher in SFMI and with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) to finger millet. The interaction of establishment methods with organic nutrient management was significant please add the result of this part.

Keywords: SFMI, organic nutrient, grain yield, quality parameters

Introduction

Millets are sometimes referred to as "Shree-Anna'' because of their importance as healthy food. Millets contain about 10 times more Ca and 2-10 times higher Fe than wheat or rice (Bala et al. 2010) [3]. Finger millet (*Eleusine coracana* L.) is an important small millet ranking third in India in area and production having the highest productivity. Out of the total minor millet produced, finger millet accounts for about 85% of production in India (Sakamma *et al*.2018) [10]. In Odisha, the area, production and productivity are 116.8 th/ha,128.73 th.tonnes and 1102 kg/ha, respectively (5 Decades of Odisha Agriculture Statistics,2020) [1]. It is nutritionally superior with a high nutrient profile of protein (6-8%), fat (1.3%), calcium (70-76%), lysine (2.86%), tryptophan (1.39%), methionine (2.86%), vitamins, minerals and fibre (Aparna and Ansari, 2017) [2]. It is a rich source of calcium, iron, protein, and fiber having high levels of methionine and amino acid. Moreover, presence of the antioxidant properties, low sugar content and phytochemicals make it easily and slowly digestible and is also ideal for patients suffering from diabetes and digestive problems as the grains contain an essential amino acid methionine which has a low glycemicindex and no gluten. Due to its plausible health benefits, it is sometimes referred to as a miracle grain. System of finger millet intensification or SRI-finger millet cultivation is a method of cultivating finger millet by applying cultivation principles adopted in System of rice intensification (SRI) in order to get higher productivity (Somashekhar and Loganandhan, 2020) [10]. SRI principle has been followed in finger millet which mainly emphasizeson utilizing early growth and vigour of seedlings, less competition for light and nutrients,enhancing resource use efficiency (seeds, water, fertilizer and pesticide) and bringing down over-dependence on chemical fertilizers, breaking soil anoxia condition and promoting healthy root growth and increasing soil microbial activity; and thereby enhancing soil organic matter content. Conversion of modern chemically intensive agriculture to a more sustainable form of agriculture like organic farming appears to be an option for maintaining desirable agricultural production in future. Further, growing finger millet organically may insure nutritional food and farming security at the juncture of climate change.

Materials and method

The field experiment was conducted at the Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha with finger millet grown during the *kharif*

season *of* 2020 and 2021. The experimental site is situated between 20°15' N latitude, 85°52' E longitude and at an altitude of 25.9 m above the mean sea-level and about 64 km away of the Bay of Bengal, Odisha. The soil was sandy loam in texture, acidic in reaction (pH 4.64),

low in organic carbon (4.24 g kg), medium in available nitrogen (298.1 kg ha^{-1}), medium in available phosphorus (17.6 kg ha^{-1}) and low in available potassium (95 kg ha^{-1}). Total rainfall amounting to 989.1 mm (44 rainy days) and 1317.9 mm (59 rainy days) was received during *Kharif* season of 2020 and 2021, respectively. The experiment was laid out in a split plot design with three replications. The treatments comprised of 2 methods of plant establishment *viz.* M_1: conventional method of line transplanting (20 cm x 10 cm) and M_2: system of fingermillet intensification (25 cm X 25 cm) in main plot with 4 organic nutrient sources *viz.* N_1: FYM @ 100% RDN(basal), N_2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN(basal), N_3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing), N_4: FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 %RDN (top dressing) allotted to sub plot in finger millet. The recommended dose of nitrogen (RDN) applied to finger millet was 60 kg ha^{-1}. In SFMI, square planting of 12 days old seedling was done @ one seedling $hill^{-1}$ .The organic formulation '*Jibamruta'* was sprayeduniformly to all the treatments at 21 DAT for controlling insect pests and diseases. Weedingoperation was done in SFMI by using a cycle weeder.

The harvested produce from the net plot area was sun-dried plot-wise up to constant weight and then weighed. The grain and straw yields were presented separately in kg ha^{-1}. The harvest index was calculated as the ratio of grain yield to biological yield as per Yoshida *et al*. (1972)[14] and expressed in percentage. Protein content in grain of finger millet was estimated by multiplying the nitrogen content of grain with a factor 6.25. (Tsen and Martin, 1971) [13]. Protein yield was measured by multiplying protein content (%) with grain yield of finger millet and expressed in kg ha^{-1}. Vitamin E Content was estimated after Emmerie-Engel reaction and then estimated spectrophotometrically as described by Rosenberg (1992) [9]. Crude fibre content of the grains was analysed by treated with 0.25N $H2SO_4$ then filtered through muslin cloth and again treated with alkali (0.35N NaOH). The grain samples were digested in diacid mixture. The Ca and Mg content was estimated by EDTA titration method Jakson, (1973) [8].The micronutrient Fe and Zn analysis was conducted by atomic absorption spectrophotometer.

Observations on grain yield, straw yield of finger millet were recorded at harvest and the quality parameters of grains were compiled in appropriate tables. The collected data were analyzed statistically by standard analysis of variance technique for split plot design as suggested by Gomez and Gomez (1984) [7] and significant differences between the treatments were compared with the critical difference at ± 5% probability by a least significant difference.

Result and discussion

The pooled data of two years of the *Kharif* season of 2020 and 2021 for yield and quality parameters of finger millet are presented in Tables 1 to 3.

Effect of establishment methods on yield and quality parameters of finger millet grains

The yield parameters like grain yield (2051 kg ha^{-1}), straw yield (2901 kg ha^{-1}) and harvest index (41.42%) were higher in SFMI than the conventional method of line transplanting. Similarly, the quality parameters of finger millet grains *viz.* protein content (7.56%), protein yield (155.8 kg ha^{-1}), crude fibre (3.6 g 100^{-1}), and vitamin E (0.14 mg 100 g^{-1}) were higher in SFMI than line transplanting. The mineral content of grains *viz*. Ca (344.1 mg $100g^{-1}$), Mg (164.3 mg 100 g^{-1}), Fe (4.86 mg $100g^{-1}$) and Zn (3.71 mg $100g^{-1}$) content were also higher in SFMI than line transplanting. Yield and quality parameters exhibited higher values in SFMI due to better congenial environment provided to augment

photosynthesis and mobilization of photosynthates from source to sink (Somashekhar and Loganandhan., 2020) [8].

Effect of organic nutrient management on yield and quality parameters of finger millet grains

The grain yield (2092 kg ha^{-1}), straw yield(2889 kg ha^{-1}), and harvest index (42.00 %) were higher when FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) was applied to finger millet but was statistically at par with the application of FYM @ 25% RDN(basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). Balanced combination of organic sources is indispensable to supplement nutrients in accordance with the demand of plants for ensuring higher production and productivity without having a deleterious effect on soil health. Application of FYM provided necessary nutrients readily and top dressing of vermicompost ensured continuous availability of nutrients throughout the crop growth stages due to steady transformation, mineralization, solubilisation, decomposition of minerals and nutrients that might help in ensuring superior yield attributing characters, yield and quality of grains. Supply of nitrogen and other nutrients at the right time and quantity enables the plants to assimilate sufficient photosynthetic products and thus increased yield attributes and yield of the crop and also bring an improvement towards physical properties of soil and thereby improving nutrient and water holding capacity (Bhardwaj and Gaur, 1985) [2]. Sharma et al. (2020) [11] also reported that an increase in the yield of rice due to the addition of various organic manures could be attributed to an adequate supply of nutrients, higher uptake and recovery of applied nutrients, which in turn, must have improved synthesis and translocation of metabolites to various reproductive structures of the plant. Similarly, quality parameters *viz.* protein (7.91%), crude fiber (3.9 g $100g^{-1}$) and vitamin E (0.16 mg 100 g^{-1}) were higher when FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) was applied to finger millet but was statistically at par with application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). Mineral content *viz.* Ca (346.7 mg $100g^{-1}$), Mg (176.4 mg 100 g^{-1}), Fe(4.94 mg $100g^{-1}$), Zn (3.98 mg $100g^{-1}$) content of finger millet were also higher when FYM @ 50% RDN (basal) + Vermicompost @ 50 % RDN (top dressing) was applied to finger millet but was statistically at par with application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). Improvement in quality parameters due to combined use of FYM and vermicompost was also reported by Dixit & Gupta. (2000) [6]. The increased uptake of nitrogen to the finger millet due to vermicompost

along with FYM resulted in a higher accumulation of photosynthates which have translocated

to sink due to better development of source-sink channel resulting in improved grain protein and nutrient content of finger millet. Similar findings were reported by Bana and Gautam. (2009) [4].

Interaction

The interactionof establishment methods with organic nutrient management was significant. SFMI with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50%RDN (top dressing) produced higher yield and quality parameters. However, it was at parwith the application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50 % RDN (top dressing). This corroborates the findings of Somashekhar and Loganandhan. (2020) [12].

Table 1. Grain yield, straw yield and harvest index of finger millet as influenced by establishment method and organic nutrient management

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishment method (M) in finger millet									
M1: Line transplanting	1642	1714	1678	2483	2579	2531	39.81	39.93	39.87
M2: SFMI	2007	2095	2051	2844	2958	2901	41.37	41.46	41.42
SEm±	46.60	53.30	35.32	57.1	58.89	41.01	0.46	0.46	0.33
CD(p=0.05)	141.2	161.5	102.3	173.1	178.4	118.8	1.4	1.4	0.9
Nutrient management (N) in finger millet									
N1: FYM @ 100% RDN (basal)	1510	1610	1560	2504	2562	2533	37.62	38.59	38.10
N2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal)	1800	1840	1820	2565	2712	2638.5	41.24	40.42	40.83
N3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	2028	2157	2092	2812	2967	2889.5	41.90	42.10	42.00
N4: FYM @ 25% (basal) + *toria* oilcake @ 25% RDN (basal)+Vermicompost @50%RDN(top dressing)	1961	2011	1986	2773	2833	2803	41.42	41.52	41.47
S.Em(±)	65.90	75.37	49.95	80.73	82.57	57.74	0.20	0.20	0.14
C.D (p=0.05)	199.7	228.4	144.6	244.8	252.2	167.2	0.6	0.6	0.4
M x N									
S.Em (±)	126.10	139.60	93.95	148.30	152.20	106.25	0.78	0.78	0.55
CD (p=0.05)	382.0	422.9	270.6	449.3	461.1	306.0	2.4	2.4	1.6

Table 2. Quality parameters of finger millet as influenced by establishment method and organic nutrient management

Treatment	Protein content (%)			Protein yield (kg ha^{-1})			Crude fibre (g/100 g)			Vitamin E (mg/100 g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishment method (M) in finger millet												
M1: Line transplanting	7.44	7.50	7.47	122.1	128.6	125.3	3.0	3.4	3.2	0.08	0.12	0.1
M2: SFMI	7.56	7.63	7.59	151.8	159.7	155.8	3.5	3.7	3.6	0.12	0.16	0.14
SEm±	0.03	0.03	0.02	5.38	6.03	4.03	0.13	0.06	0.06	0.009	0.009	0.006
C.D (p=0.05)	0.10	0.11	0.06	16.32	18.28	11.7	0.4	0.2	0.19	0.03	0.03	0.01
Nutrient management (N) in finger millet												
N1: FYM @ 100% RDN (basal)	7.06	7.13	7.09	106.6	114.7	110.7	2.9	3.1	3.0	0.06	0.1	0.08
N2: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal)	7.44	7.56	7.50	133.9	139.2	136.5	3.0	3.2	3.1	0.09	0.11	0.10
N3: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	7.88	7.94	7.91	159.7	171.2	165.5	3.8	4.0	3.9	0.14	0.18	0.16
N4: FYM @ 25% (basal + *toria* oilcake @ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing)	7.62	7.63	7.63	149.5	153.3	151.4	3.3	3.9	3.6	0.11	0.17	0.14
S.E.m(±)	0.13	0.10	0.008	5.65	6.10	4.15	0.23	0.19	0.14	0.01	0.02	0.01
C.D (p=0.05)	0.41	0.32	0.23	17.1	18.5	12.04	0.7	0.6	0.43	0.04	0.05	0.03
M x N												
S.Em (±)	0.22	0.23	0.15	12.3	12.8	8.87	0.48	0.36	0.29	0.02	0.02	0.01
CD (p=0.05)	0.7	0.7	0.45	37.2	38.8	25.6	1.4	1.0	0.85	0.06	0.06	0.04

Table 3 Quality parameters of finger millet as influenced by establishment method organic nutrient management

Treatment	Mineral content (mg 100 g^{-1})											
	Ca			Mg			Fe			Zn		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishment method (M) in finger millet												
M1: Line transplanting	311.6	312.6	312.1	144.1	149.2	147.1	4.69	4.76	4.72	3.53	3.55	3.54
M2: SFMI	344.0	344.2	344.1	160.3	168.1	164.3	4.85	4.88	4.86	3.69	3.72	3.71
SEm±	6.20	6.73	4.57	4.15	4.65	3.18	0.03	0.03	0.02	0.03	0.04	0.02
CD (p=0.05)	18.8	20.4	13.2	12.6	14.1	9.23	0.12	0.10	0.06	0.12	0.14	0.07
Nutrient management (N) in finger millet												
N1: FYM @ 100% RDN(basal)	306.7	307.1	306.9	129.2	135.2	132.2	4.65	4.71	4.68	3.31	3.34	3.33
N2: FYM @ 50% RDN(basal) + Vermicompost @ 50% RDN (basal)	323.5	324.5	324.0	144.1	148.3	146.1	4.69	4.75	4.72	3.45	3.47	3.46
N3: FYM @ 50% RDN(basal) + Vermicompost @ 50% RDN (Top dressing)	346.3	347.1	346.7	174.2	178.8	176.4	4.93	4.95	4.94	3.97	3.99	3.98
N4: FYM @ 25% (basal)+Vermicompost @ 50% RDN (top dressing) + *toria* oilcake @ 25% RDN (basal)	334.7	334.9	334.8	161.3	172.3	166.8	4.81	4.87	4.84	3.71	3.74	3.72
S.E.m (±)	6.0	4.7	3.78	4.52	4.05	3.03	0.05	0.05	0.02	0.10	0.11	0.07
CD (p=0.05)	18.3	14.4	10.9	13.7	12.3	8.8	0.18	0.17	0.07	0.31	0.34	0.21
M x N												
S.Em (±)	13.40	12.20	9.01	9.87	9.61	6.88	0.11	0.12	0.08	0.18	0.22	0.14
CD (p=0.05)	40.6	36.9	26.0	29.9	29.1	19.8	0.33	0.36	0.23	0.54	0.66	0.42

Conclusion

The study indicates that SFMI method of crop establishment resulted in superior grain yield, straw yield and harvest index of finger millet over the conventional method of line transplanting. Application of FYM @ 50% RDN as basal + Vermicompost @ 50% RDN as top dressing to finger millet resulted in higher yield in finger millet and this was statistically similar with the application of FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal)+ Vermicompost @ 50% RDN (top dressing) to finger millet.

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