

Effect of Establishment Methods and Organic Nutrient Management Practices on Productivity and Profitability of Finger Millet (*Eleusine coracana* L.) in Lateritic Soils of Odisha, India

Abstract

A field experiment was carried out during *Kharif* seasons in 2020 and 2021 at Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, India, to study the effect of crop establishment method and organic nutrient management on 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 main plot with 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 (top dressing) allotted to sub plot in finger millet during *Kharif* season. SFMI method of establishment resulted in superior yield attributes, grain yield (2051 kg ha⁻¹), straw yield (2901 kg ha⁻¹) and harvest index (41.42%) in finger millet than line transplanting. Yield attributes, grain yield (2092 kg ha⁻¹), straw yield (2889 kg ha⁻¹) and harvest index (42.00%) were higher with the application of FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) in finger millet and was statistically similar with 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.

Keywords: SFMI, organic nutrient, yield attributes, grain yield, economics

Comment [E1]: ...finger millet ('Arjuna' variety).

Comment [E2]:sources viz. farm yard manure (FYM) @ 100% recommended nitrogen dose (RDN), FYM @ 50% RDN (basal)....

Comment [E3]: SFMI method of establishment Please explain the abbreviation. System of finger millet intensification (SFMI)?

Comment [E4]: 2051 or As in English....2,051? ...and so on later.

Introduction

Millets have been accorded a prominent position as super food in the present era. Under the changing scenario of global warming and climate change, cultivation of ecologically suitable hardy millets may be a wise alternative for optimum food and nutritional security. Finger millet (*Eleusine coracana* L.) is an important small millet ranking third in India in area and production having highest productivity. Out of the total minor millets produced, finger millet accounts for about 85% of production in India (Sakamma *et al.* 2018) [12]. In Odisha, the area, production and productivity is 116.8 th.ha, 128.73 th.tonnes and 1102 kg/ha, respectively (5 Decades of Odisha Agriculture Statistics, 2020) [1]. It is a versatile climate resilient crop with wide adaptability to adverse weather conditions, with low input requirements, easy cultivation, free from major pests and diseases and drought tolerance, which have made this crop an automatic choice in dry farming system. It is nutritionally superior with high nutrient profile and is ideal for patients suffering from diabetes and digestive problems as the grains contain the essential amino acid methionine having low glycemic index and no gluten. SRI principle have been followed in finger millet which mainly emphasizes on utilizing early growth and vigour of seedlings, less competition for light and nutrients, enhancing resource use efficiency (seeds, water, fertilizer, and pesticide) and bring 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 the 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, India, with finger millet grown during ~~K~~ 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

Comment [E5]: 1.INTRODUCTION

Comment [E6]: Reference style

References must be listed at the end of the manuscript and numbered in the order that they appear in the text. Every reference referred in the text must also present in the reference list and vice versa. In the text, citations should be indicated by the reference number in brackets [1].

So,production in India [1].

Following I will not do this observation, but, please pay attention and do the necessary changes.

Comment [E7]: In Odisha, the area, production and productivity is 116.8 th.ha, 128.73 th.tonnes and 1102 kg/ha?

Not clear here.

....arefor area- 116.8 t/ha?

.....for production - 128.73 tonnes as total?

Comment [E8]: System of Rice Intensification (SRI) principle.....

Please review the phrase. Too many ...and.....and.

Comment [E9]: Any previous literature as regard as your study?

Some citations are recommended. If there were not done any, please specify. Then, at the end of this section, kindly clear present the current work objectives.

Comment [E10]: 2.MATERIALS AND METHOD

This section will include sub-sections.

Example:

2.1. Experimental site

.....

2.2. Biological material

.....

2.3. Experimentally variants

.....

Etc.

Formatted: Font: 12 pt, Not Italic

Comment [E11]:organic carbon (4.24 g/kg),

.....

...in factorganic carbon (4.24 g kg⁻¹)? or ?

¹), medium available phosphorus (17.6 kg ha⁻¹) and low available potassium (95

Comment [E12]: Please delete the space....

UNDER PEER REVIEW

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 split plot design with three replications. The treatments comprised of 2 methods of plant establishment viz. M₁: conventional method of line transplanting (20 cm x 10 cm) and M₂: system of finger millet intensification (25 cm x 25 cm) in main plot with 4 organic nutrient sources viz. N₁: FYM @ 100% RDN (basal), N₂: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (basal), N₃: FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing), N₄: FYM @ 25% RDN (basal) + *toria* oil cake @ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing) allotted to subplot 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 hill¹. The organic formulation '*Jibamruta*' was sprayed uniformly to all the treatments at 21 DAT for controlling insect pests and diseases. Weeding operation was done in SFMI by using a cycle weeder.

Observations on yield attributes, grain yield and straw yield of finger millet were recorded at harvest. The collected data were analyzed statistically by standard analysis of variance technique for split plot design suggested by Gomez and Gomez (1984)^[4] and significant differences between the treatments were compared with the critical difference at ±5% probability by least significant difference.

Result and discussion

The pooled data of two years of *Kharif* season of 2020 and 2021 for yield attributes, yield and economics of finger millet are presented in Table 1 to 3.

Effect of establishment methods on yield attributes, yield and economics of finger millet

Yield attributing characters i.e. earhead hill⁻¹, finger ear⁻¹, spikelets finger⁻¹, grains spikelet⁻¹, finger length, 1000 grain weight of finger millet were higher in SFMI (7.9, 6.4, 88.6, 5.98, 7.90 cm and 3.37 g, respectively) than line transplanting. Less competition between plants due to wider space allowed the individual plants to develop massive root system and ultimately higher nutrient uptake. Better aeration at wider spacing resulted in healthy plant growth with more tillers (Somashankar and Loganandhan, 2020)^[13]. These results were in conformity with the findings of Prakasha *et al.* (2018)^[8].

Comment [E13]: N1: farm yard manure (FYM) @ 100% recommended dose of nitrogen (RDN)....?

So, please explain the abbreviation at their first apparition in text. Then, you can use only the abbreviations.

Comment [E14]: ...*toria* oil cake.....

Comment [E15]: The recommended dose of nitrogen (RDN) ?

The explanation has been done at its first apparition as I recommended before. Now, you can use only....RDN.

Comment [E16]: In SFMI? The explanation of this abbreviation, please.

Comment [E17]:at 21 DAT The explanation of the abbreviation.....(DAT)

Comment [E18]: So, Subheading 2.....The parameters determined Please clear present all the parameters and the expression units for each.

Then, the last subheading will be: 2.....Statistical analysis

Comment [E19]: 3.RESULTS AND DISCUSSION

Subsections are warmly recommended.

The grain yield, straw yield and harvest index of finger millet were higher (2051 kg ha⁻¹, 2901 kg ha⁻¹ and 41.42%, respectively) in SFMI than line transplanting. Grain yield and straw yield are the final outcome of a crop which generally relies on the development of yield attributes. Increase in growth attributes due to increased uptake of nitrogen and translocation of photosynthates from source to sink increased most of the yield attributing characters in SFMI. Similar findings were also reported by Naidu and Rao (1958)^[5]; Narasimha Rao *et al.* (1963)^[7]; Diva Karan (1967)^[3]; Narasimha Murthy and Hegde (1981)^[6]; PSI (2009)^[10] and Rajesh (2011)^[11] in finger millet. The gross return (Rs. 110721 ha⁻¹ and Rs. 118080 ha⁻¹), net return (Rs. 53121 ha⁻¹ and Rs. 60480 ha⁻¹) and B: C ratio (1.92 and 2.05) was higher in SFMI method of establishment in 2020-21 and 2021-22, respectively.

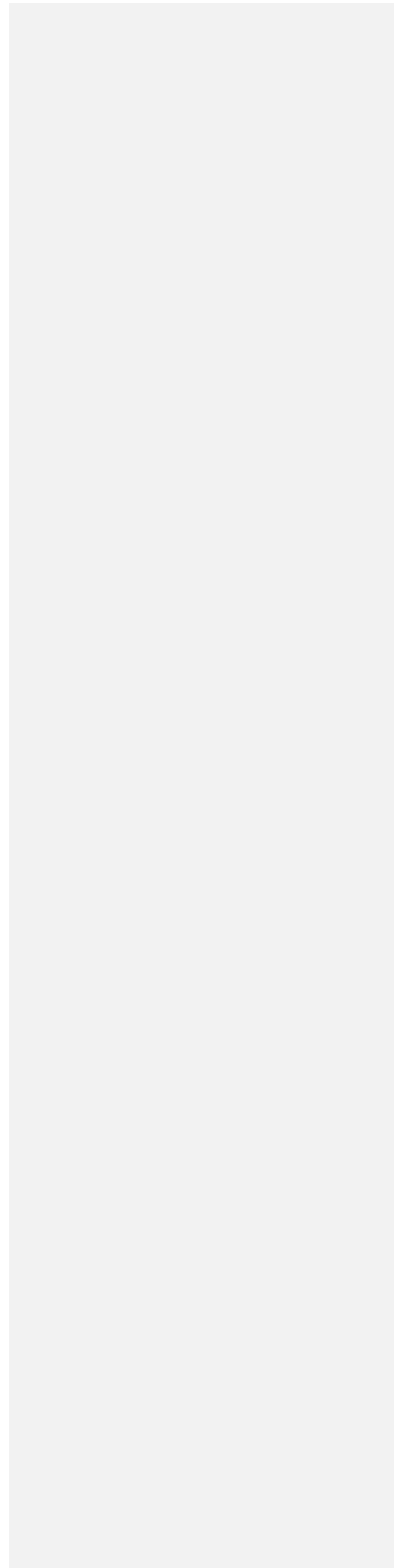
Effect of organic nutrient management on yield attributes, yield and economics of finger millet

Yield attributing characters i.e. earhead hill⁻¹, finger ear⁻¹, spikelets finger⁻¹, grain spikelet⁻¹, finger length, 1000 grain weight of finger millet were higher (6.5, 6.5, 71.5, 5.84, 7.86 and 3.36 g, respectively) 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). The grain yield, straw yield and harvest index (%) of finger millet were also higher (2092 kg ha⁻¹, 2889 kg ha⁻¹ and 42.00%, respectively) 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). The higher yield attributes might be due to higher macro and micronutrient content of vermicompost which enabled continuous and steady release of nutrients. FYM application also increased the nutrient uptake which might have helped in better tillering, ear length, grain filling, number of grains per earhead⁻¹ (Priya and Sathyamoorthi, 2019)^[9]. 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 deleterious effects on soil health. 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 and yield. Supply of nitrogen and other nutrients at right time and quantity enable the plants to assimilate sufficient photosynthetic products and thus increased yield attributes and yield of the crop and

Comment [E20]: ...and benefit : cost (B: C) ratio ...

alsobringanimprovementtowardsphysicalpropertiesofsoil andthereby

UNDER PEER REVIEW



improving nutrient and water holding capacity (Bhardwaj and Gaur, 1985)^[2]. Highest gross return (Rs. 112573 and 121595 ha⁻¹), net return (Rs. 51873 and Rs. 60474 ha⁻¹) and B:Cratio (1.85 and 2.00) were recorded with the treatment receiving FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) during 2020-21 and 2021-22, respectively.

Interaction

It is observed that interaction of SFMI with nutrient management by application of FYM @ 50% RDN (basal) + Vermicompost @ 50% RDN (top dressing) produced maximum numbers of yield attributes and ultimately resulted in higher yield. However, it was at par with application of FYM @ 25% RDN (basal) + toria oil cake @ 25% RDN (basal) + Vermicompost @ 50% RDN (top dressing). Wider spacing with organic nutrient management resulted in less competition between plants for solar radiation, space and increased supply of nutrients and efficient utilization helps in better growth and yield (Somashekhar and Loganathan., 2020)^[13].

Table1. Yieldattributing characters offingermilletasinfluenced byorganicnutrientmanagement practices

Treatment	Yieldattributes																	
	Earheadhill ⁻¹			Fingersear ⁻¹			Spikeletsfinger ⁻¹			Grainspikelet ⁻¹			Fingerlength (cm)?			1000grainweight (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishmentmethod(M)infigermillet																		
M1:Linetransplanting	2.9	3.2	3.1	4.9	5.1	5.0	39.2	41.4	40.2	4.40	4.41	4.41	7.03	7.08	7.06	3.14	3.15	3.15
M2: SFMI	7.8	8.0	7.9	6.4	6.3	6.4	92.6	91.8	88.6	5.90	6.05	5.98	7.96	7.83	7.90	3.37	3.36	3.37
S.E.m(±)	1.4	1.4	1.0	0.27	0.2	0.16	1.18	1.7	1.01	0.40	0.43	0.29	0.23	0.24	0.17	0.06	0.06	0.04
CD(0.05)	4.1	4.3	2.8	1	1.1	0.5	3.6	3.2	2.9	1.2	1.3	0.8	0.7	0.7	0.5	0.2	0.2	0.1
Nutrientmanagement(N)infigermillet																		
N1: FYM@100%RDN(basal)	4.3	4.5	4.4	5.0	5.1	5.1	61.8	62.0	61.9	4.67	4.675	4.67	7.11	6.98	7.05	3.11	3.13	3.12
N2: FYM@50%RDN(basal) + Vermicompost @50%RDN(basal)	4.9	5.0	5.0	5.3	5.4	5.4	62.9	63.5	63.2	4.97	4.94	4.95	7.4	7.32	7.36	3.25	3.24	3.25
N3: FYM@50%RDN(basal) + Vermicompost @ 50% RDN (topdressing)	6.3	6.6	6.5	6.4	6.5	6.5	71.0	71.9	71.5	5.74	5.93	5.84	7.84	7.88	7.86	3.36	3.35	3.36
N4: FYM @ 25% (basal) + toria oilcake@ 25% RDN (basal) +Vermicompost@50% RDN(top dressing)	5.9	6.3	6.1	5.9	5.8	5.9	67.9	69.1	68.5	5.38	5.38	5.38	7.64	7.66	7.65	3.30	3.29	3.29
S.Em(±)	0.46	0.42	0.31	0.39	0.26	0.22	2.24	2.41	1.64	0.24	0.3	0.19	0.13	0.14	0.09	0.03	0.03	0.02
CD(0.05)	1.4	1.3	0.9	0.9	0.8	0.7	6.8	7.3	4.8	0.7	0.9	0.5	0.4	0.4	0.3	0.1	0.1	0.06
M x N																		
S.Em(±)	1.98	1.94	1.38	0.78	0.58	0.48	3.51	4.21	2.72	0.76	0.84	0.56	0.47	0.48	0.33	0.16	0.16	0.11
CD(0.05)	5.9	5.8	4.0	2.36	1.75	1.38	10.7	12.7	7.86	2.3	2.5	1.6	1.42	1.45	0.96	0.48	0.48	0.32

Table2. Grainyield,strawyieldandharvestindexoffingermilletasinfluencedbyestablishmentmethodandorganicnutrientmanagement

Treatment	Grain yield(kgha ⁻¹)			Straw yield(kg ha ⁻¹)			Harvestindex(%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Establishmentmethod(M)infigermillet									
M1:Linetransplanting	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	57.10	58.89	41.01	0.46	0.46	0.33
CD(0.05)	141.2	161.5	102.3	173.1	178.4	118.8	1.4	1.4	0.9
Nutrientmanagement(N)infigermillet									
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(topdressing)	2028	2157	2092	2812	2967	2889.5	41.90	42.10	42.00
N4:FYM@25% (basal)+toriaoilcake@25%RDN (basal)Vermicompost@50%RDN(topdressing)	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
CD(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(0.05)	382.0	422.9	270.6	449.3	461.1	306.0	2.4	2.4	1.6

Comment [E21]: 1642?
or ...as in English....1,642?
.....and so on, later

Table 3. Economic of finger millet as influenced by establishment method and organic nutrient management practices

Treatment	Gross return (Rs. ha ⁻¹)		Net return (Rs. ha ⁻¹)		Benefit: Cost (B-C) ratio	
	2020	2021	2020	2021	2020	2021
Establishment method (M) in finger millet						
M1: Linetransplanting	97158	103051	34433	40326	1.55	1.64
M2: SFMI	110721	118080	53121	60480	1.92	2.05
Nutrient management (N) in finger millet						
N1: FYM@100% RDN(basal)	90088	96954	32138	39004	1.55	1.67
N2: FYM@50% RDN(basal) + Vermicompost@50% RDN(basal)	103175	107917	42475	47217	1.70	1.78
N3: FYM@50% RDN(basal)+ Vermicompost @50% RDN(topdressing)	112573	121594	51873	60474	1.85	2.00
N4: FYM@25% (basal)+ toria oilcake@25% RDN(basal)+ Vermicompost@50% RDN(topdressing)	109947	115796	48047	54316	1.78	1.88

Comment [E22]: 97158?.....or as in English.....97,158?and so on later

Conclusion

The study indicates that SFMI method of crop establishment resulted in superior yield attributes and yield 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 attributing characters and 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. The gross return, net return and B:Cratio was higher in FYM @ 50% RDN as basal + Vermicompost @ 50% RDN as top dressing. So considering the productivity and profitability, farmers can adopt SFMI with the application of FYM @ 50% RDN as basal (6.55 t/ha) + Vermicompost @ 50% RDN as top dressing (1.62 t/ha) in finger millet in lateritic soil of Odisha.

References

1. 5 decades of Odisha Agriculture Statistics, 2020. Directorate of Agriculture and Food Production, Govt. Of Odisha.
2. Bharadwaj KR, Gaur AC. Recycling of organic wastes. ICAR Publication. New Delhi. 1985.
3. Diva Karan K. Studies on age of seedlings in ragi (*Eleusine coracana* L.). Madras Agric. J. 1967; 54(9):4-75.
4. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research (2nd Eds.). Wiley Interscience publication, New York. 1984; 76-83pp.
5. Naidu BA, Rao KS, RKS. Effect of transplantation on ragi plant (*Eleusine coracana* L.). Indian Botanical Society. 1958; 37(1): 194-199.
6. Narasimha Murthy SN, Hegde BR. Tillering in relation to intra-row competition in ragi under rainfed condition. Indian Journal of Agronomy. 1981; 26(3):337-338.
7. Narasimha Rao DV, Damodaram G, Rama Moorthy AK. Preliminary studies on the proper time of sowing and plant population in irrigated ragi in Chittoor district. Andhra Agric. J. 1963; 15(2):208-213.
8. Prakasha G, Kalyan Murthy KN, Prathima AS, Rohini N. Effect of spacing and Nutrients level on Growth Attributes and Yield of Finger Millet

Comment [E23]: References must be listed at the end of the manuscript and numbered in the order that they appear in the text. Every reference referred in the text must also present in the reference list and vice versa. In the text, citations should be indicated by the reference number in brackets [1].

Example:

Reference to a journal:

For Published paper:

1. Hilly M, Adams ML, Nelson SC. A study of digit fusion in the mouse embryo. Clin Exp Allergy. 2002; 32(4):489-98.

cultivated under Guniplanting method in red sandy loam soil of Karnataka, India. 2018.

9. Priya G, Sathyamoorthi K Influence of organic manures on the growth and yield of foxtail millet (*Setaria Italica* L.). Chemical Science Review and Letters. 2019; 8(29):114-117.
10. PSI (People Science Institute). Results of SCI with finger millet and maize in Kharif season . System of Crop Intensification (SCI)-SRI concepts and methods applied to other crops. 2009.
11. Rajesh K. System of Crop Intensification in Finger Millet (*Eleusine coracana* (L.) Gaertn.) under irrigated condition. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore. 2011.
12. Sakamma S, Umesh KB, Girish MR., Ravi SC, Satishkumar M, Veerabhadra Bellundagi. Finger millet (*Eleusine coracana* L. Gaertn.) production system: Status, potential, constraints and implications for improving small farmer's welfare. Journal of Agricultural Science. 2018; 10(1):162-17.
13. Somashekhar, Loganandhan N. SRI-Finger Millet Cultivation a Case study in Tumakuru District, India. International Journal of Current Microbiology and Applied Sciences. 2020; 9(1):2089-2094.

UNDER PEER REVIEW

