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Economic evaluation of finger millet under different crop geometries and nutrient management practices

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Abstract
Field experiment with finger millet was conducted at Agricultural college farm, Bapatla during the *kharif* seasons of 2018 and 2019. The experimental design was split plot with three replications. The trial comprised of three crop geometries with different age of seedlings (30x10 cm with 30 days old seedlings, 30x30 cm with 15 days old seedlings and 45x45 cm with 15 days old seedlings) in main plots and seven nutrient management practices (S_0: absolute control, S_1: FYM @ 10 tonnes ha^{-1} + application of *dravajeevamrutham,* S_2: FYM @ 10 tonnes ha^{-1} + application of *dravajeevamrutham* along with wooden log treatment, S_3: FYM @ 10 tonnes ha^{-1} + 100% RDF, S_4: FYM @ 10 tonnes ha^{-1} + 100% RDF along with wooden log treatment, S_5: FYM @ 10 tonnes ha^{-1} + 125% RDF, S_6: FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment) in subplots. The highest grain and straw yields, gross and net returns and return per rupee investment were observed with closer spacing of 30x10 cm, transplanted with 30 days old seedlings. Among the nutrient management practices tried application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment had superiority in grain and straw yields, gross and net returns and return per rupee investment compared to other nutrient management practices.

Keywords: Yield, gross return, net return, return per rupee investment, crop geometry, nutrient management practice and finger millet

Introduction
Millets are a major food source in arid and semiarid parts of the world and excellent sources of carbohydrates, protein, fatty acids, minerals, vitamins, dietary fiber and polyphenols. Among different millets, finger millet (*Eleusine coracana* L. Gaertn.), is a major staple crop among tribal farming communities in developing countries like India, which is highly productive and can thrive under a variety of harsh environmental conditions. It possess superior nutritional properties and referred to as a nutricereal or as a nutraceutical crop and is seen as a potential solution for addressing malnutrition and hidden hunger worldwide. Despite of the great value associated with this nutri-crop, there has been decline both in area and in production of the crop. Some of the primary reasons are poor crop management practices like use of low quality seeds, higher seed rate, broadcasting method of sowing leading to low plant population, delayed transplanting, lower fertilizer use efficiency etc.
Among the modern agro-management practices, suitable planting method and fertilizer application are imperative for boosting the growth and production of finger millet especially under rainfed condition. An ideal crop geometry is essential for obtaining optimum plant stand in the field as the yield of a crop depends on the final plant density with effective utilization of growth resources. Conjunctive use of chemical fertilizers and organic manures is important to maintain and sustain soil fertility and crop productivity. So, under these circumstances it is imperative to study various crop geometries and nutrient management practices to better understand the resource use efficiencies particularly of economic efficiency.

Materials and Methods
A Field trial was conducted with finger millet variety (VR-847) at Agricultural college farm, Bapatla during the *kharif* seasons of 2018 and 2019. The soil of experimental site was sandy clay loam in texture with slightly alkaline reaction, low organic carbon content, low available nitrogen and medium in available phosphorous and potassium.
The experiment was laid in split plot design having 21 treatments replicated thrice.
The treatments comprised of two factors, *viz.*, crop geometries with different age of seedlings

(M_1: 30x10 cm with 30 days old seedlings, M_2: 30x30 cm with 15 days old seedlings and M_3: 45x45 cm with 15 days old seedlings) and seven nutrient management practices (S_0: absolute control, S_1: FYM @ 10 tonnes ha^{-1}+ application of *dravajeevamrutham*, S_2: FYM @ 10 tonnes ha^{-1} + application of *dravajeevamrutham* along with wooden log treatment, S_3: FYM @ 10 tonnes ha^{-1} + 100% RDF, S_4: FYM @ 10 tonnes ha^{-1} + 100% RDF along with wooden log treatment, S_5: FYM @ 10 tonnes ha^{-1} + 125% RDF, S_6: FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment. Yield of finger millet was calculated based on the yield obtained from each net plot and further converted to kg ha^{-1}. The cost of cultivation for each treatment was worked out. Similarly, gross returns were calculated based on existing rates of finger millet. The net return from each treatment was arrived by deducting the cost of cultivation from the gross return on ha^{-1} basis. Return per rupee investment for all the treatments was worked out on the basis of gross return in terms of rupees and the cost of treatments using the following formula

$$\text{Return per rupee investment} = \frac{\text{Gross return (₹ ha}^{-1})}{\text{Cost of cultivation (₹ ha}^{-1})}$$

Results

Grain and Straw yields

Grain and straw yields were significantly affected by various crop geometries and nutrient management practices and not by their interaction during both years of study. The highest grain and straw yields were recorded with the narrow spacing of 30×10 cm transplanted with 30 days old seedlings (M_1) which was distinctly superior to the wider spacings of 30x30 cm (M_2) and 45x45 cm (M_3) transplanted with 15 days old seedlings.

The current findings are also supported by the study conducted by Borkar *et al*. (2008) [2] who opined that though wider spacing favoured most of the yield attributes compared to closer spacing, it could not compensate the grain yield on a unit area basis exhibiting superiority of closer spacing over wider spacing. Since the number of plants per unit area are higher in closer spacing, compared to wider spacing, this reflected in realizing greater grain yield ha^{-1}. Shinggu and Gani (2012) [12] recorded higher grain yield at 10 and 15 cm spacing and this could be attributed to higher plant population per unit area and reduced competition from weeds due to closer spacing. Though higher number of tillers $hill^{-1}$ were recorded at wider spacing, this could not compensate for more number of plants per unit area. Similar higher straw yields at closer spacing was also reported by (Rajesh, 2011) [9], Kalaraju *et al*. (2011) [6] and Anitha (2015) [1].

With regard to the nutrient management practices, application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment (S_6) recorded the highest grain and straw yields and statistically comparable with 125% of RDF + FYM (S_5). Sustained release of available nutrients during crop growth period was found to increase yield substantially (Raniperumal *et al*. 1991, Goudar, 2014 and Senthilkumar *et al*. 2018) [10, 3, 11].

Economics

The highest gross return, net return and return per rupee investment were recorded in closer spacing of 30x10 cm (M_1), which was significantly superior to the rest of the treatments. Higher grain and straw yields recorded in closer spacing might attributed to higher gross return, net return and return per rupee investment. The current results are in accordance with the earlier findings of Khafi *et al*. (2000) [5] and Hebbal (2017) [4]. Among the nutrient management treatments, combined use of organic and inorganic sources of nutrients progressively improved the gross return, net return and return per rupee investment of finger millet and the highest gross return, net return and return per rupee investment were produced with application of 125% RDF + FYM 10 tonnes ha^{-1} along with wooden log treatment (S_6) which was significantly superior to rest of the treatments and comparable with S_5 and S_4 treatments. This might be attributed to the higher grain and straw yields recorded by the integrated nutrient management, ultimately resulting in higher economics. The application of organics alone and absolute control did not register higher yield which finally resulted in lower economic returns. The present findings are in similarity with the earlier findings by Mathew *et al*. (1994) [7], Patel & Patel (2002) [8] and Hebbal (2017) [4] who reported that the economic returns were increased with conjunctive use of FYM + RDF. Interaction effect of crop geometries and nutrient management treatments was significant with net return and closer spacing of 30x10 cm (M_1) and application of 125% RDF along with FYM @ 10 tonnes ha^{-1} + wooden log treatment (S_6) registered the highest net return and the lowest in wider spacing of 45x45 cm with no fertilizer application (M_3S_0). The highest population per unit area along with the highest fertility level resulted in the highest yield and in turn the highest net return. The present results are in close confirmation with the earlier reports of Hebbal (2017) [4].

Table 1: Yield of finger millet as influenced by crop geometry and nutrient management practices during *kharif,* 2018-19 and 2019-20

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2018-19	2019-20	Pooled data	2018-19	2019-20	Pooled data
Crop geometry						
M_1- 30×10cm with 30 days old seedlings	2668	2773	2721	6538	6722	6630
M_2- 30×30cm with 15 days old seedlings	2258	2363	2310	5757	5896	5827
M_3- 45×45cm with 15 days old seedlings	2079	2172	2126	4350	4504	4427
S.Em±	91.61	48.79	61.18	147.14	200.83	177.42
CD (p = 0.05)	360	192	240	578	789	697
CV(%)	17.98	9.18	11.75	12.15	16.13	14.45
Nutrient management						
S_0-Absolute control	1213	1324	1268	2483	2520	2502
S_1- FYM @ 10 tonnes ha^{-1} + *dravajeevamrutham*	1765	1837	1801	3603	3738	3671
S_2- S_1+ passing wooden log	2051	2102	2076	4884	4944	4914
S_3- FYM @ 10 tonnes ha^{-1} + 100% RDF	2521	2668	2595	6131	6338	6234
S_4- S_3+ passing wooden log	2761	2884	2822	6358	6737	6547
S_5- FYM @ 10 tonnes ha^{-1} + 125% RDF	2955	3046	3000	7652	7770	7711
S_6- S_5+ passing wooden log	3079	3191	3135	7729	7903	7816

S.Em±	136.30	128.22	98.73	325.33	388.27	320.07
CD (p = 0.05)	391	368	283	933	1114	918
CV (%)	17.51	15.79	12.42	17.59	20.41	17.06
Interaction						
M x S	NS	NS	NS	NS	NS	NS
S x M	NS	NS	NS	NS	NS	NS

Table 2: Cost of cultivation (₹ha^{-1}), gross return (₹ha^{-1}), net return (₹ha^{-1}) and return per rupee invested of finger millet as influenced by crop geometry and nutrient management practices during *kharif*, 2018-19 & 2019-20 and in pooled data

Treatments	2018-19				2019-20				Pooled data			
	Cost of cultiva-tion	Gross return	Net return	Return per rupee invested	Cost of cultiva-tion	Gross return	Net return	Return per rupee invested	Cost of cultiva-tion	Gross return	Net return	Return per rupee invested
Crop geometry												
M_1- 30×10 cm with 30 days old seedlings	40952	83840	42888	2.02	42332	94066	51734	2.19	41642	88953	47311	2.11
M_2- 30×30 cm with 15 days old seedlings	38042	71161	33119	1.85	39422	80319	40897	2.02	38732	75740	37008	1.93
M_3- 45×45 cm with 15 days old seedlings	36464	64582	28117	1.75	37844	72919	35075	1.91	37154	68750	31596	1.83
S.Em±	-	2657.67	1309.85	0.03	-	2079.87	1624.33	0.03	-	1784.44	1619.08	0.03
CD (p = 0.05)	-	10435	5143	0.12	-	8167	6378	0.13	-	7007	6357	0.11
CV (%)	-	16.64	17.29	7.48	-	11.56	17.49	7.71	-	10.51	19.20	6.81
Nutrient management												
S_0-Absolute control	26777	37634	10857	1.41	28157	44211	16054	1.57	27467	40922	13455	1.49
S_1- FYM @ 10 tonnes ha^{-1} + *dravajeevamrutham*	39977	54735	14758	1.37	41357	61609	20252	1.49	40667	58172	17505	1.43
S_2- S_1+ passing wooden log	40877	64302	23425	1.57	42257	71147	28890	1.68	41567	67725	26157	1.63
S_3- FYM @ 10 tonnes ha^{-1} + 100% RDF	39547	79176	39629	1.99	40927	90381	49454	2.19	40237	84778	44542	2.09
S_4- S_3+ passing wooden log	40447	86345	45898	2.12	41827	97573	55746	2.32	41137	91959	50822	2.22
S_5- FYM @ 10 tonnes ha^{-1} + 125% RDF	40439	93245	52806	2.30	41819	103703	61884	2.48	41129	98474	57345	2.39
S_6- S_5+ passing wooden log	41339	96922	55583	2.34	42719	108419	65700	2.53	42029	102670	60641	2.44
S.Em±	-	4089.78	2078.88	0.11	-	4459.38	2548.36	0.10	-	3823.52	2295.24	0.08
CD (p = 0.05)	-	11730	5963	0.32	-	12790	7309	0.29	-	10966	6583	0.23
CV (%)	-	16.76	17.97	18.10	-	16.23	17.96	14.82	-	14.74	17.82	12.47
Interaction												
M x S		NS	S	NS		NS	S	NS		NS	S	NS
S x M		NS	S	NS		NS	S	NS		NS	S	NS

Table 2a: Interaction between crop geometry and nutrient management practices on net return (₹ha^{-1}) of finger millet during *kharif*, 2018-19 & 2019-20 and in pooled data

Treatments	Nutrient management practices (2018-19)							Mean	Nutrient management practices (2019-20)							Mean	Nutrient management practices (Pooled data)							Mean
	S_0	S_1	S_2	S_3	S_4	S_5	S_6		S_0	S_1	S_2	S_3	S_4	S_5	S_6		S_0	S_1	S_2	S_3	S_4	S_5	S_6	
M_1	10572	15159	26670	56760	64744	62998	63313	42888	17988	15827	39674	74527	74097	62839	77187	51734	14280	15493	33172	65643	69421	62918	70250	47311
M_2	11689	15303	21642	33628	40261	53392	55916	33119	16880	26401	25951	38123	41883	67578	69464	40897	14285	20852	23796	35875	41072	60485	62690	37008
M_3	10309	13812	21964	28500	32689	42028	47519	28117	13293	18529	21045	35714	51258	55235	50449	35075	11801	16170	21504	32107	41974	48632	48984	31596
Mean	10857	14758	23425	39629	45898	52806	55583		16054	20252	28890	49454	55746	61884	65700		13455	17505	26157	44542	50822	57345	60641	
	S.Em±	CD (p=0.05)	CV (%)						S.Em±	CD (p=0.05)	CV (%)						S.Em±	CD (p=0.05)	CV (%)					
Main Plot	1310	5143	17.29						1624	6378	17.49						1619	6357	19.20					
Sub Plot	2079	5963	17.97						2548	7309	17.96						2295	6583	17.82					
Interaction																								
M x S	3601	10327							4414	12660							3975	11402						
S x M	5471	15963							6717	19608							6142	18010						

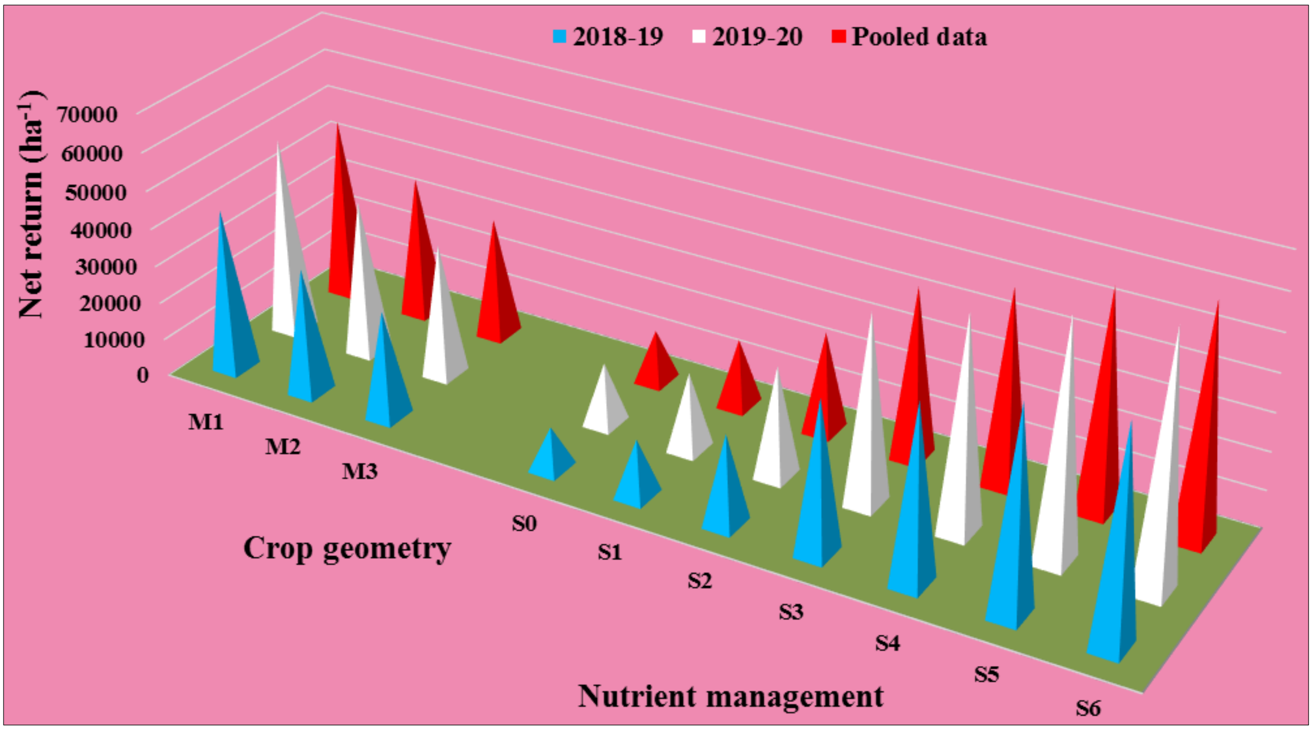

Fig 1: Interaction between crop geometry and nutrient management practices on net return (₹ha^{-1}) of finger millet during *kharif*, 2018-19 & 2019-20 and in pooled data

Conclusion
In conclusion from the study, it was revealed that transplanting of 30 days old seedlings at a spacing of 30x10 cm and application of FYM @ 10 tonnes ha^{-1} + 125% RDF along with wooden log treatment resulted in the higher economics of finger millet.

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