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Evaluation of '*Guni'* method on growth dynamics and yield of rainfed finger millet

P Shashikala, B Padmaja, SA Hussain and KPC Reddy

Abstract
Millets now called as 'nutricereals' have made a comeback to human diet with the recognition of their role in healthy life style. Mostly grown in rainfed ecosystem, proper nutrient supply and suitable planting method is important to raise the yield level of millets. A new method called '*guni*' or '*guli*' method with wider planting and spot application of FYM has been developed in finger millet in line with "System of Crop Intensification". An investigation was carried out during the *kharif* season, 2019-20 at Professor Jayashankar Telangana State Agricultural University, Hyderabad to study the performance of rainfed finger millet in '*guni*' method and crop geometry in a split plot design. The results of the study indicated that the transplanting of 25 days old seedlings of finger millet in '*guni*' method at 30 cm × 30 cm or 45 cm x 45 cm spacing was found to be the best with improved growth parameters like plant height, leaf area index, number of tillers and dry matter production and yield of finger millet over mere transplanting or direct sowing.

Keywords: Finger millet, growth, '*Guni*' method, yield

Introduction
Millets play an important role in rainfed ecosystem which contributes larger per cent of the total cultivated area. Finger millet, a seeded annual commonly known as 'ragi' is one of the important millet crops grown for grain and fodder purpose under varied agro-climatic conditions. In India, finger millet is cultivated over an area of 1.19 million hectares with a production of 1.98 million tonnes giving an average productivity of 1661 kg ha^{-1} (http://www.indiastat.com, 2019) [15].

The productivity of finger millet is low due to poor management practices. The secret of boosting its yield mainly lies with suitable planting method and proper nutrition to the crop. There are various agronomic practices through which yield of finger millet can be increased and among them method of establishment plays an important role to fully exploit all available resources for growth as it provides optimum growing condition (Gavit *et al.*, 2017 and Sandhyarani *et al.*, 2017) [3, 11].

System of crop intensification (SCI) was practiced in rice to increase the yield by planting single young seedling at wider spacing. The main objective of SCI is to produce more from less using fewer seed and less water but manage the relationship between plant and soil so this is called as low input approach (Abraham *et al.*, 2014) [1]. The most practiced method in finger millet is broadcasting and random transplanting. It leads to uneven distribution of plants which causes the competition for moisture and nutrients. Of late, a new method called as '*guni*' or '*guli*' method has been practiced by farmers of Kolar, Bengaluru rural and Haveri districts of Karnataka (Narayan *et al.*, 2018) [8]. '*Guni'* method otherwise called as scooping is square planting technique adopting wider spacing 30-60 cm x 30-60 cm along with spot application of FYM to each hill. It is similar to SRI method of paddy cultivation called as "System of Ragi Intensification" (http://agritech.tnau.ac.in).

In case of rice by following SRI technique (wider spacing) many researchers reported yield increase in the range of 10-42% (Thakur *et al.*, 2010 and Sunilkumar and Amrendrakumar, 2018) [14, 13]. In view of the growing concern over natural resources conservation and surge in the interest of the farmers, a need has arisen to generate the scientific data to validate the '*guni*' method.

Materials and Methods
A field experiment was carried out during *kharif*, 2019 at College Farm, PJTSAU, Rajendranagar, Hyderabad. The experimental soil was sandy clay loam in texture, neutral in

reaction (pH 7.11), low in organic carbon (0.48 per cent) and available nitrogen (121 kg ha^{-1}), medium in available phosphorous (32.2 kg ha^{-1}) and available potassium (219.2 kg ha^{-1}). The experiment was laid out in split plot design replicated thrice. Twelve treatment combinations were taken viz., Main plots: Methods of establishment: 3; M_1: Direct line sowing, M_2: Transplanting of 25 days old seedlings, M_3: Transplanting of 25 days old seedlings in '*Guni*' method; Subplots: Planting geometries: 4; S_1: 30×10 cm, S_2: 30×30 cm, S_3: 45×45 cm and S_4: 60 ×60 cm. Direct line sowing (M_1) was done on 18th July, 2019. On the same day, the raised nursery beds were prepared with a bed size of 2.0 m x 2.0 m. The seeds were line sown evenly on the beds. Powdered FYM was sprinkled to cover the seeds and watering was done at evening hours. In M_2 and M_3 methods, the nursery raised 25 days old seedlings were transplanted @ 2-3 seedlings hill on 12th August, 2019. The row to row and plant to plant spacing were kept 30 cm x 10 cm, 30 cm x 30 cm, 45 cm x 45 cm, 60 cm x 60 cm as per the treatments. One week after direct sowing/transplanting, gap filling was done to maintain the plant population. In *guni* method (M_3), before transplanting, small *guni*s or scoops (0.5x0.5x0.5') were formed manually and filled with well rotten FYM @ 1 kg/*guni*. All the other recommended package of practices was implemented to raise the crop. In order to record the growth observations in each net plot, five representative plants were randomly selected and tagged. All the successive biometric observations were recorded periodically on the selected plants during the crop growth period. For recording leaf area and dry matter production, destructive sampling method was adopted. Experimental data obtained were subjected to statistical analysis adopting Fisher's method of 'analysis of variance' as out lined by Gomez and Gomez (1984) [4].

Results and Discussion

Plant height

Among the establishment methods, significantly higher plant height was obtained with direct line sowing as compared to transplanting of 25 days old seedlings and '*guni'* method at all the intervals of observation (Table 1). The favorable initial establishment and no transplanting shock under direct sowing might have stimulated the increased activity of meristematic cells and cell elongation of internodes resulting in higher growth of the stem, in turn, promoting the plant height. Significantly taller plants were recorded with crop geometry of 30×30 cm and it was at par with 30×10 cm, while the least plant height was obtained with 60×60 cm geometry at 90 days after sowing (DAS) and harvest. Increased plant height under closer spacing might be due to intense competition between the plants for solar radiation and space which led to the increased elongation of internodes accompanied by decreased dry matter production.

Leaf area per hill

The leaf area of finger millet was significantly influenced by different establishment methods at all the crop growth stages except at 30 DAS. At 60 DAS, the leaf area obtained with transplanting of 25 days old seedlings in '*guni'* method was at par with transplanting of 25 days old seedlings (Table 2). At 90 DAS and at harvest, '*guni'* method registered significantly highest leaf area over other methods while the lowest leaf area was recorded with direct line sowing. The leaf area obtained with 60×60 cm geometry was significantly higher at all the stages of crop growth and the lowest leaf area was registered with that of 30×10 cm. Favorable supply of growth resources at wider spacing enabled the plant to develop more number of tillers and higher leaf area owing to better spread and canopy width (Mahajan *et al.*, 2004) [7].

Number of tillers per square meter

At 30 DAS, the significantly highest number of tillers m^{-2} was produced with direct line sowing and it was distinctly superior to transplanting of 25 days old seedlings (M_2) and transplanting of 25 days old seedlings in '*guni'* method (M_3) (Table 3). On the other hand, at 60, 90 DAS and at harvest the reverse trend was noticed wherein tiller number was significantly enhanced in '*guni'* method (M_3) followed by transplanting of 25 days old seedlings (M_2). This might be attributed to the fact that each individual plant got the advantage of liberal supply of nutrients, adequate space and other growth factors. Thus, finger millet plants grown with an adequate supply of FYM make rapid and thrifty growth due to rapid conversion of synthesized carbohydrates into protein and consequent increase in the number and size of growing cells, resulting in increased number of tillers (Singh and Agarwal, 2001) [12].

On the other hand, the highest number of tillers m^{-2} was recorded with closer spacing (30x30 or 30x10 cm) compared to wider spacing (45x45 or 60x60 cm) at all the observation intervals (Fig.1).

Dry matter production

The highest dry matter production was recorded with that of transplanting of 25 days old seedlings in '*guni'* method (M_3) compared to the other treatments while the lowest dry matter production was recorded with direct line sowing at 60, 90 DAS and harvest (Table 4). This might be attributed to the fact that dry matter accumulation in finger millet is associated with the plant height, number of leaves and leaf growth and a combination of number of tillers, weight of the ear head and grain weight (Payero *et al.*, 2008) [9]. At 30 DAS, the significantly highest dry matter was recorded with planting of finger millet crop at 30×10 cm spacing and the lowest dry matter production was recorded with 60×60 cm geometry. At 60 DAS, 90 DAS and at harvest, highest dry matter was recorded when crop was grown at 30×30 cm. The lowest dry matter production was obtained with the crop geometry of 30×10 cm. Higher number of tillers and enhanced leaf area per hill have promoted accumulation of more dry matter with 30×30 cm compared to other crop geometries.

Table 1: Plant height (cm) of finger millet as influenced by different methods of establishment and crop geometry

Treatment	30 DAS				60 DAS				90 DAS				Harvest			
	Establishment method (M)															
Crop geometry (S)	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	33.3	29.9	29.2	30.8	68.3	68.8	67.9	68.3	109.5	103.5	107.0	106.7	110.2	103.7	107.3	107.1
S_2	33.2	29.3	29.0	30.5	72.7	68.1	68.6	69.8	112.1	104.7	107.3	108.0	112.8	105.2	108.0	108.7
S_3	32.4	29.7	29.2	30.4	70.3	69.3	66.6	68.7	108.3	102.5	104.3	105.1	109.5	103.0	105.0	105.8
S_4	32.5	28.8	30.2	30.5	69.5	67.8	66.8	68.0	106.3	100.3	102.3	103.0	106.8	102.0	103.3	104.1

Mean	32.9	29.4	29.4		70.2	68.5	67.5		109.1	102.8	105.3		109.8	103.5	105.9	
For comparison the mean of	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	
Establishment method (M)	0.3		1.3		0.6		NS		0.3		1.3		0.5		2.0	
Crop geometry (S)	0.3		NS		0.6		NS		0.4		1.3		0.4		1.3	
Sub plot (S) at same level of main plot (M)	0.5		NS		1.0		NS		0.7		NS		0.7		NS	
Main plot (M) at same level of sub plot (S)	0.6		NS		1.2		NS		0.8		NS		0.9		NS	

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

Table 2: Leaf area (cm^2 hill^{-1}) of finger millet at different intervals as influenced by methods of establishment and crop geometry

Treatment	**30 DAS**				**60 DAS**				**90 DAS**			
	Establishment method (M)											
Crop geometry (S)	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	349	351	356	352	661	735	761	719	1403	1612	1686	1567
S_2	378	362	409	383	706	922	962	863	1547	1827	2032	1802
S_3	427	406	429	421	988	1220	1250	1153	2121	2071	2658	2283
S_4	425	407	419	417	1058	1234	1270	1187	2216	2272	2667	2385
Mean	395	382	403		853	1028	1061		1822	1945	2261	
For comparison the mean of	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	
Establishment method (M)	4.3		NS		17.9		70.1		37.1		145.5	
Crop geometry (S)	4.3		12.8		15.1		44.9		46.6		138.4	
Sub plot (S) at same level of main plot (M)	7.5		NS		26.2		NS		80.7		NS	
Main plot (M) at same level of sub plot (S)	9.0		NS		33.3		NS		91.3		NS	

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

Table 3: Number of tillers m^{-2} of finger millet at different intervals as influenced by methods of establishment and crop geometry

Treatment	**30 DAS**				**60 DAS**				**90 DAS**			
	Establishment method (M)											
Crop geometry (S)	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	68.7	64.0	66.7	66.4	135.3	170.0	188.0	164.4	157.7	196.0	202.3	185.3
S_2	16.7	9.3	9.7	11.9	58.4	70.4	84.3	71.0	65.0	92.0	106.7	87.9
S_3	9.3	5.3	6.3	7.0	29.3	38.7	46.0	38.0	35.3	46.7	80.3	54.1
S_4	6.0	4.7	5.3	5.3	22.7	23.3	26.7	24.2	26.0	36.0	46.7	36.2
Mean	25.2	20.8	22.0		61.4	75.6	86.3		71.0	92.7	109.0	
For comparison the mean of	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	
Establishment method (M)	0.7		2.9		0.5		2.0		0.5		2.0	
Crop geometry (S)	0.6		1.9		0.5		1.5		0.5		1.6	
Sub plot (S) at same level of main plot (M)	0.7		NS		0.9		2.7		0.9		2.7	
Main plot (M) at same level of sub plot (S)	1.0		NS		1.1		3.0		1.1		3.1	

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

Table 4: Dry matter productions (kg ha^{-1}) of finger millet at different intervals as influenced by methods of establishment and crop geometry

Treatment	**30 DAS**				**60 DAS**				**90 DAS**				**Harvest**			
	Establishment method (M)															
Crop geometry (S)	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	1562	1558	1608	1576	3427	3816	4233	3825	4865	5417	6009	5430	5583	6327	7033	6314
S_2	1261	1251	1246	1253	3706	4281	4700	4250	5266	6078	6757	6034	6063	7036	7789	6963
S_3	1018	1029	1032	1026	3006	4198	5102	4102	4267	5960	7243	5823	5176	6954	8596	6909
S_4	918	916	947	927	2879	4031	5127	4012	4087	5722	7277	5696	4901	6689	8255	6615
Mean	1190	1189	1208		3255	4082	4805		4621	5794	6822		5431	6752	7918	
For comparison the mean of	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	

Establishment method (M)	6	NS	31	122	44	173	103	403
Crop geometry (S)	7	22	56	168	80	238	57	169
Sub plot (S) at same level of main plot (M)	13	NS	98	290	139	412	98	292
Main plot (M) at same level of sub plot (S)	15	NS	104	278	148	394	154	472

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

Table 5: Days to 50% flowering of finger millet as influenced by methods of establishment and crop geometry

Treatment	**Establishment method (M)**			
Crop geometry (S)	**M_1**	**M_2**	**M_3**	**Mean**
S_1	71.0	71.3	70.3	70.9
S_2	70.7	69.7	68.0	69.4
S_3	69.7	67.3	67.0	68.0
S_4	67.0	66.3	66.0	66.4
Mean	69.6	68.7	67.8	
For comparison the mean of	S.Em±		CD (P=0.05)	
Establishment method (M)	0.3		1.3	
Crop geometry (S)	0.4		1.1	
Sub plot (S) at same level of main plot (M)	0.6		NS	
Main plot (M) at same level of sub plot (S)	0.7		NS	

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

Table 6: Grain yield (kg ha^{-1}), Straw yield (kg ha^{-1}) and Harvest Index (%) of finger millet as influenced by methods of establishment and crop geometry

Treatment	**Grain yield (kg ha^{-1})**				**Straw yield (kg ha^{-1})**				**Harvest Index**			
	Establishment method (M)											
Crop geometry (S)	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	1747	2206	2552	2168	3936	4122	4467	4175	0.31	0.35	0.36	0.34
S_2	2028	2670	3093	2597	4057	4363	4667	4362	0.33	0.38	0.40	0.37
S_3	1915	2565	3423	2634	3336	4398	4939	4224	0.37	0.37	0.40	0.38
S_4	1663	2406	3295	2455	3245	4279	4973	4166	0.34	0.36	0.40	0.37
Mean	1838	2462	3091		3644	4290	4762		0.34	0.36	0.39	
For comparison the mean of	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	
Establishment method (M)	39		152		112		438		0.003		0.012	
Crop geometry (S)	58		173		64		NS		0.006		0.019	
Sub plot (S) at same level of main plot (M)	101		300		111		329		0.011		NS	
Main plot (M) at same level of sub plot (S)	110		299		170		518		0.012		NS	

Establishment method
M_1: Direct line sowing
M_2: Transplanting of 25 days old seedlings
M_3: Transplanting of 25 days old seedlings in *Guni* Method (Scooping)

Crop geometry
S_1: 30 cm × 10 cm
S_2: 30 cm × 30 cm
S_3: 45 cm × 45 cm
S_4: 60 cm × 60 cm

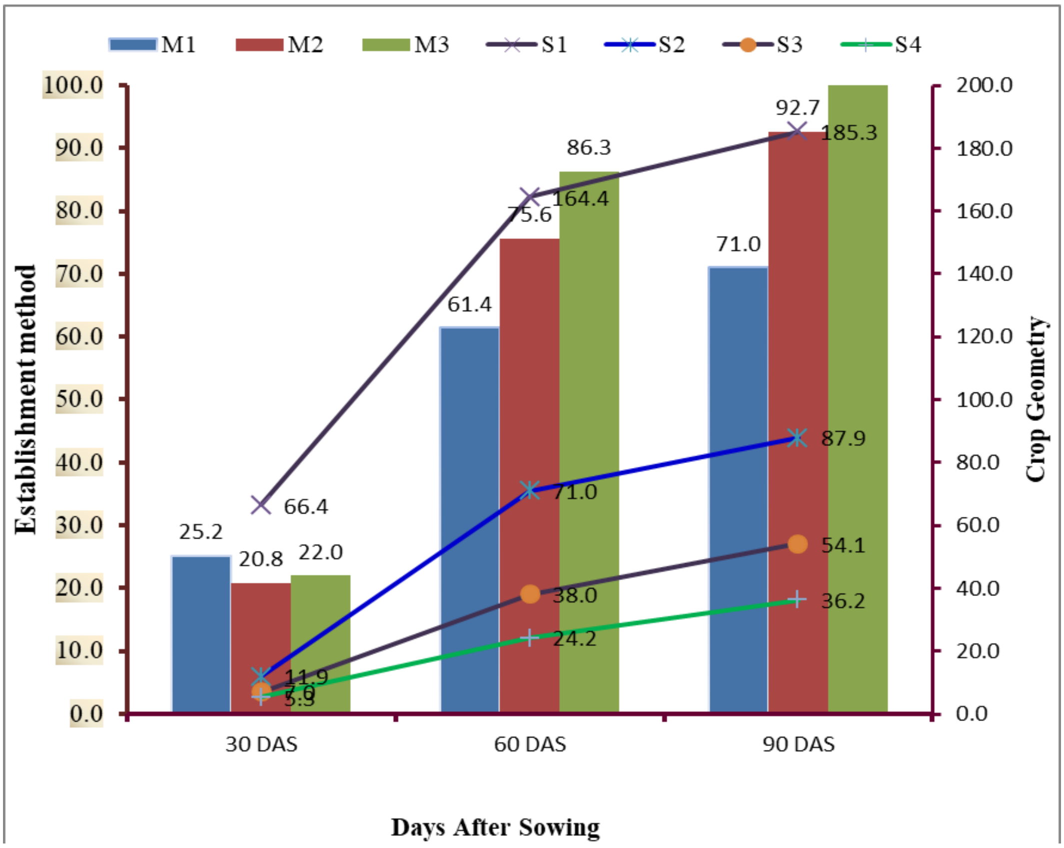

Fig 1: Number of tillers m^{-2} of finger millet at different intervals as influenced by methods of establishment and crop geometry

Number of days to 50% flowering

Finger millet crop grown with direct line sowing took significantly more number of days to reach 50% flowering and it was statistically on par with that of transplanting of 25 days old seedling in comparison with guni method through transplanting. Variation in number of days taken to reach 50% flowering in relation to different method of planting was also reported by Prakasha (2015) [10] and Chandankumar (2018) [2]. Earlier attainment of 50% flowering in finger millet crop was observed when sown with the 60×60 cm crop geometry compared with other crop geometries tested. Transplanting of seedlings advances the tillering process and flowering. This advantage is carried over by the crop and thereby attains early maturity (Linhua *et al*., 2006) [6].

Grain yield

Among the different establishment methods, discernibly highest grain yield of 3091 kg ha^{-1} was evident from the transplanting of 25 days old seedlings of finger millet under '*guni'* method of planting (M_3) compared to transplanting of 25 days old seedling (M_2) and direct line sowing (M_1) method. Further, transplanting of 25 days old seedlings also recorded significantly higher grain yield of 2462 kg ha^{-1} over direct line sowing method. Transplanting in '*guni'* method had an opportunity to get better moisture, nutrient supply and optimum growth condition owing to wider spacing and FYM application resulting in significant improvement in grain yield. Significantly highest grain yield of 2634 kg ha^{-1} was evident when finger millet was planted with 45 cm x 45 cm geometry and found to be at par with that of S_2 (30 cm x 30 cm) geometry. On the other hand, significantly lowest grain yield of 2168 kg ha^{-1} was recorded with 30 cm x 10 cm (S_1) crop geometry. Increased yield at spacing of 45 cm x 45 cm or 30 x 30 cm was mainly due to higher growth parameters. The wider spacing especially in square planting reduced the inter-row competition for resources and higher number of effective tillers and more number of healthy grains per unit area were produced which ultimately resulted to higher yield.

Straw yield

Significantly higher straw yield of 4762 kg ha^{-1} was in '*guni'* method of planting (M_3) compared to transplanting of 25 days old seedling (M_2) while the lowest straw yield was observed under direct line sowing method (3644 kg ha^{-1}). The straw yield of finger millet was not influenced by different crop geometries.

Harvest Index

Finger millet transplanted with 25 days old seedling in *guni* method (M_3) recorded significantly higher harvest index of 0.39 as compared to rest of the treatments. Further, the harvest index recorded with M_2 (transplanting of 25 days old seedling) was statistically superior over M_1 (Direct line sowing). This could be due to the fact that, more number of effective tillers, number of fingers per ear head, ear head weight and grain yield which were superior in case of *guni* method as compared with other methods tested. These results were in conformity with the outcome of Jain (2006) [5]. Among the different geometries, the significantly higher harvest index of 0.38 was evident from the spacing of 45 cm x 45 cm (S_3) however, it was found to be statistically at par with that of 30 x 30 cm (S_2) and 60 x 60cm (S_4) crop geometries. On the other hand, significantly lowest harvest index of 0.34 was recorded with 30 cm x 10 cm (S_1) geometry.

Conclusion

The results of the investigation clearly indicates the superiority of transplanting of 25 days old seedlings in '*guni'* method coupled with 45 cm × 45 cm or 30 cm x 30 cm crop geometry performed better than mere transplanting of 25 days old seedlings and direct line sowing method.

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