RESEARCH ARTICLE

Influence of Seedling Age and Planting Pattern on Yield, Labour Productivity and Economics of Transplanted Finger Millet

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ABSTRACT

The present study was aimed to evaluate the influence of seedling age and planting pattern on grain and straw yield, labour productivity, and economics of transplanted finger millet (*Eleusine coracana* L. Gaertn.) by conducting the field experiment at Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2019 (July to November). The experiment was laid out in split-plot design and each treatment was replicated thrice. It consisted of three seedling ages *viz*., 14, 17, and 20 days (old seedlings) as main plot factor and four planting patterns *viz*., rectangular (30 cm × 10 cm) and square (25 cm × 25 cm) planting with one and two number of seedlings per hill as subplot factor. From the experimental results, yield, labour productivity, and economics of finger millet differed due to seedling age and planting pattern. Transplanting of 20 days old seedlings under rectangular planting (30 cm × 10 cm) with two seedlings per hill recorded higher grain yield, straw yield, labour productivity, gross return, net return, and B:C ratio. Younger seedlings of 14 days old transplanted under rectangular planting (30 cm × 10 cm) with two seedlings per hill recorded a higher cost of cultivation.

Keywords: *Finger millet; Labour productivity; Ecomomics; Seedling age; Planting pattern*

INTRODUCTION

Finger millet is a predominant dryland crop due to its resilience and ability to withstand aberrant weather conditions and is majorly cultivated in the semiarid regions of Africa and Asia. The crop is well adapted to very poor and marginal uplands, where other crops cannot be grown successfully (AICSMIP, 2014). In India, finger millet is the third most crucial millet crop next to sorghum and pearl millet and accounts for nearly 60 percent of the global finger millet production. The area under finger millet cultivation in India was 1.19 million hectares with an average productivity of 1661 kg ha^{-1} during 2017 (Chamoli *et al.,* 2018). Nutritionally, finger millet is comparable with rice in terms of carbohydrate, protein, and fat and has 8 to 10 times more calcium than rice (Chappalwar *et al.,* 2013). With several advantages, finger millet is considered as a crop for the future, which secures food and nutrition for growing populations.

Besides its adaptability and nutritious quality, the crop has the highest productivity among the millets. However, the results of past decades revealed that productivity was in a declining trend due to the cultivation of major food and commercial crops. To utilize its benefits, research should be done to increase productivity without increasing the cultivated area. Among the several crop management strategies, altering the agronomic practices could increase productivity and profitability. Considering the several agronomic practices, transplanting is a prime factor that tends to improve the yield by ensuring optimum crop stand in the main field (Hebbal *et al.,* 2018). Under transplanting, age of seedling, spacing and number of seedlings are the major yield limiting factors and optimization of these factors allows the plants to utilize the maximum resources, leading to increased productivity. Altering the above parameters may not influence the cost of production, but they contribute to higher return through yield enhancement.

Tillering is the critical yield contributing character, which mainly depends on the age of seedlings at the time of transplanting (Pasuquin *et al.,* 2008). Beyond the optimum age of seedlings, the crop cannot attain its full growth and yield potential. Plant density is another essential factor determined by crop spacing and the number of seedlings per hill. They largely influence the interception of solar radiation, photosynthesis rate, water, nutrient uptake, and other physiological phenomena (Imran *et al.,* 2015).

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If plant density exceeds an optimum, competition among plants for above and below ground resources becomes severe (Bayala *et al.,* 2002). Keeping in view the above important points, the present research was conducted to find the optimum age of seedlings, spacing, and number of seedlings per hill to get higher productivity and profitability of finger millet under transplanted conditions.

MATERIAL AND METHODS

During the *Kharif* season of 2019 (July to November), the field experiment was carried out in field No. 37F at Eastern block farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The research farm is located in the Western Agro Climatic Zone of Tamil Nadu at 11°01'N latitude, 76°93' E longitude, and an altitude of 427 m above MSL. The experimental soil was sandy clay loam in texture and was slightly alkaline (pH-7.99) with low soluble salts (EC-1.2 dS m^{-1}). Irrigation water used for the experiment was slightly alkaline (pH-8) with high soluble salts (EC-5.7 dS m^{-1}).

The experiment was laid out in a split-plot design with three replications. The main plot consisted of three seedling ages *viz*., 14 (M_1), 17 (M_2) and 20 (M_3) days old seedlings and subplot consisted of four planting patterns *viz*., rectangular planting (30 cm × 10 cm spacing) with one seedling per hill (S_1), square planting (25 cm × 25 cm spacing) with one seedling per hill (S_2), rectangular planting (30 cm × 10 cm spacing) with two seedlings per hill (S_3) and square planting (25 cm × 25 cm spacing) with two seedlings per hill (S_4).

Healthy seeds of finger millet variety CO 15 were selected for sowing. Seeds were sown in raised nursery beds with a seed rate of 7.5 kg ha^{-1} and covered with vermicompost. For transplanting seedlings of different ages, nursery sowing was carried out on three different days with two days intervals. In main field preparation, FYM @ 12.5 t ha^{-1} was uniformly applied at last ploughing and at the time of transplanting, TNAU MN mixture @12.5 kg ha^{-1} blended with *Azospirillum* and *Phosphobacteria* each @ 2 kg ha^{-1} were applied. The recommended fertilizer rate for finger millet is 60:30:30 kg ha^{-1} of N, P_2O_5 and K_2O. For each treatment plot, a half dose of N, full dose of P_2O_5 and K_2O were applied as basal and the remaining half dose of N was top-dressed at 30 DAT. Seedlings aged 14, 17 and 20 days were separately uprooted from the respective nursery beds and transplanted in the main field. All the treatment factors were carefully considered and incorporated as per the requirement at the time of transplanting. All the management practices followed above were based on CPG, 2019. Grain yield and straw yield were calculated based on the yields obtained from the whole net plot area of the treatment plot.

The labor requirement for different field operations in each treatment was recorded separately and the labor productivity was worked out using the following formula (Pratten, 1976).

$$\text{Labour productivity } (₹ \text{ man day}^{-1}) = \frac{\text{Output } (₹ \text{ ha}^{-1})}{\text{Labour input (Man days ha}^{-1})}$$

The cost of cultivation was worked out as per the input price followed in TNAU. The worked-out cost of ₹ 32,678 ha^{-1} was commonly considered irrespective of different treatments and added with individual treatment costs to get the total cost of cultivation. The sale price of grain yield was calculated based on the MSP given by the Government of India (MAFW, 2019), and income from straw yield was worked out based on current market prices for outputs followed in TNAU.

RESULTS AND DISCUSSION

The results on grain yield, straw yield, labor productivity, and finger millet economics as influenced by seedling age and planting pattern are discussed below. The data on grain and straw yields were analyzed statistically and presented in Table 1 and Figure 1, whereas labour productivity and economics were not analyzed statistically but numerically worked out and presented in Table 2 and Figure 2, respectively.

Table 1. Influence of seedling age and planting pattern on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of finger millet

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	3281	3560	3625	3489	8112	8510	8778	8467
S_2	3202	3338	3491	3344	7510	7841	7981	7777
S_3	3658	3923	3980	3853	8413	8622	8804	8613
S_4	3432	3753	3895	3693	7919	7890	8144	7984
Mean	3393	3644	3748	3595	7989	8216	8427	8210
Factors	M	S	M × S	S × M	M	S	M × S	S × M
SEd	77.0	77.4	139.4	134.1	56.5	73.4	123.8	127.2
CD (P=0.05)	213.8	162.7	NS	NS	156.9	154.3	NS	NS

Main plot: Seedling age

M_1: Transplanting of 14 days old seedlings
M_2: Transplanting of 17 days old seedlings
M_3: Transplanting of 20 days old seedlings

Sub plot: Planting pattern

S_1: Rectangular planting (30 × 10 cm) with one seedling per hill
S_2: Square planting (25 × 25 cm) with one seedling per hill
S_3: Rectangular planting (30 × 10 cm) with two seedlings per hill
S_4: Square planting (25 × 25 cm) with two seedlings per hill

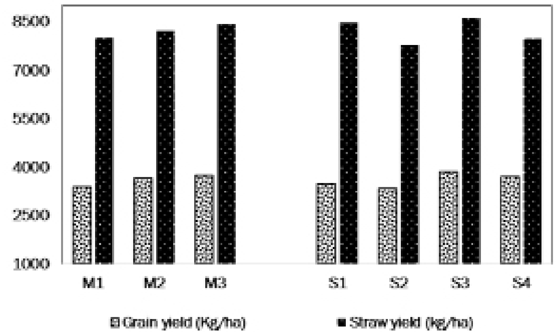

Fig 1. Influence of seedling age and planting pattern on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of finger millet

Grain yield and straw yield as influenced by seedling age and planting pattern

In transplanting, seedling age and planting pattern had a significant impact on grain and straw yields of finger millet, however, the interaction effect was non-significant.

Transplanting 20 days-aged seedlings (M_3) recorded a higher grain yield of 3748 kg ha^{-1}, followed by 17 days old seedlings (M_2). Better root establishment at transplanting in 20 days older seedlings tend to faster establishment and growth, which might increase the yield compared to younger seedlings. Comparatively, a lower grain yield of 3393 kg ha^{-1} was obtained from 14 days (M_1) seedlings. Grain yield decreased with decreasing age of seedlings, as reported by Alam *et al.* (2002), Khatun *et al.* (2002), and Sarker *et al.* (2013). Among different planting patterns, rectangular planting (30 cm × 10 cm) with two seedlings per hill (S_3) recorded a higher grain yield of 3853 kg ha^{-1}, which was comparable with square planting (25 cm × 25 cm) with two seedlings per hill (S_4). More tillers per unit area in rectangular planting favored higher grain yield, whereas increased yield attributes per hill in square planting encouraged the grain yield. Square planting (25 cm × 25 cm) with a single seedling per hill (S_2) observed a lower grain yield of 3344 kg ha^{-1}, which was statistically comparable with rectangular planting (30 cm × 10 cm) with a single seedling per hill (S_1). This was mainly due to the fewer tillers per unit area than other planting patterns. Thakur *et al.* (2010) reported that beyond optimum plant density, wider spacing does not give higher grain yield on an area basis than closer spacing. According to Paul *et al.* (2002) and Faruk *et al.* (2009), two seedlings per hill produced higher grain yield compared to a single seedling per hill. The results agreed with the findings of Rasool *et al.* (2012) and Vijayalaxmi *et al.* (2016).

Table 2. Influence of seedling age and planting pattern on labor productivity (₹ man days^{-1}) of finger millet

Treatments		Labour input (man days)				Total labor input (man days)	Gross return (₹ ha^{-1})	Labor productivity (₹ man days^{-1})
		Transplanting	Gap filling	Weeding	Harvesting			
M_1	S_1	27	3	23	22	75	107,408	1432
	S_2	31	2	20	19	72	104,618	1453
	S_3	26	3	23	25	77	119,434	1551
	S_4	30	2	20	20	72	112,068	1556
M_2	S_1	22	2	23	22	69	116,395	1687
	S_2	29	1	20	19	69	109,068	1581
	S_3	20	2	23	25	70	127,886	1827
	S_4	29	1	20	20	70	122,165	1745
M_3	S_1	22	2	23	22	69	118,577	1719
	S_2	25	1	20	19	65	113,957	1753
	S_3	18	2	23	25	68	129,772	1908
	S_4	27	1	20	20	68	126,765	1864

*Labour charges ₹ 360 man day^{-1} for all the above mentioned operations (one man day - 8 hours)

Main plot: Seedling age

M_1: Transplanting of 14 days old seedlings
M_2: Transplanting of 17 days old seedlings
M_3: Transplanting of 20 days old seedlings

Sub plot: Planting pattern

S_1: Rectangular planting (30 × 10 cm) with one seedling per hill
S_2: Square planting (25 × 25 cm) with one seedling per hill
S_3: Rectangular planting (30 × 10 cm) with two seedlings per hill
S_4: Square planting (25 × 25 cm) with two seedlings per hill

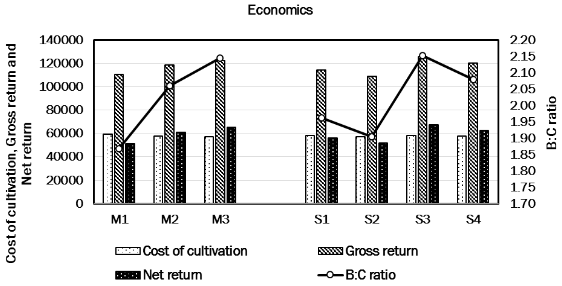

Fig 2. Influence of seedling age and planting pattern on economics of finger millet

A higher straw yield of 8427 kg ha^{-1} was obtained from transplanting of 20 days old seedlings (M_3) followed by 17 days old seedlings (M_2). Seedlings aged 20 days exhibited better growth and development throughout the crop period and resulted in higher straw yield than younger seedlings. The results are in agreement with the findings of El-Khoby and Shahe in (2016). A significantly lower straw yield of 7989 kg ha^{-1} was recorded with 14 days seedlings (M_1). Rectangular planting (30 cm × 10 cm) with two seedlings per hill (S_3) recorded a higher straw yield of 8613 kg ha^{-1}. However, the treatment was statistically comparable with rectangular planting (30 cm × 10 cm) with a single seedling per hill (S_1). Higher plant population in rectangular planting led to higher straw yield than square planting, which showed a lower plant population. The results conform the findings of Hebbal *et al.* (2018) and Korir *et al.* (2018), who reported that closer spacing produced a higher yield of straw than wider spacing. A significantly lower straw yield of 7777 kg ha^{-1} was recorded under square planting (25 cm × 25 cm) with a single seedling per hill (S_2). According to Faruk *et al.* (2009), Bhowmik *et al.* (2012), and Vijayalaxmi *et al.* (2016), single seedling per hill produced lower straw yield than more number of seedlings per hill.

Labour productivity as influenced by seedling age and planting pattern

Labor productivity is a measure to estimate the labor input, which would convert into the output in terms of economics. Seedlings of 20 days old transplanted under rectangular planting (30 cm × 10 cm) with two seedlings per hill (M_3S_3) recorded higher labor productivity (₹ 1908 man day^{-1}). Higher gross return and the added advantage of lower labor requirement indicated the efficient conversion of input (labour) into output (yield), which might be the reason for higher labour productivity in older seedlings with rectangular planting with two seedlings per hill. The findings of Rakotomalala (1997) revealed that SCI in rice required more labours for transplanting than conventional planting. Comparatively, lower labour productivity (₹ 1432 man day^{-1}) was obtained with 14 days old seedlings transplanted under rectangular planting (30 cm × 10 cm) with a single seedling per hill (M_1S_1). Smaller seedling sizes with a higher mortality rate in younger seedlings (14 days old) tend to have higher labor requirements for transplanting and gap filling. At the same time, younger seedlings under rectangular planting with a single seedling per hill produced lesser grain yield (Kewat *et al.,* 2002), reducing labor productivity.

Economics as influenced by seedling age and planting pattern

The higher cost of cultivation (₹ 60,398 ha^{-1}) was recorded with transplanting of younger seedlings of 14 days old under rectangular planting (30 cm × 10 cm) with two seedlings per hill (M_1S_3). Younger seedlings of 14 days old required more labor input for transplanting and gap filling. Seed cost for gap filling was also higher in younger seedlings, increasing the cost. Similarly, rectangular planting with two seedlings per hill required more seed and labour due to higher plant population per unit area than square planting and single seedling per hill. Whereas the lower cultivation cost (₹ 56,078 ha^{-1}) was recorded with the age of 20 days old seedlings transplanted under square planting (25 cm × 25 cm) with a single seedling per hill (M_3S_2). Lengthier seedlings in 20 days old consumed less labour time for transplanting and quicker establishment and plant stand took minimum seed and labor for gap filling. This might have reduced the cost of cultivation in older seedlings. Similar results were recorded by Damodaran *et al.* (2012) and Hebbal *et al.* (2018), who reported that a higher cost of cultivation was recorded under closer spacing. Similarly, transplanting single seedlings per hill recorded a lower cost of cultivation than two seedlings per hill (Devi *et al.,* 2019).

Transplanting of 20 days old seedlings under rectangular planting (30 cm × 10 cm) with two seedlings per hill (M_3S_3) recorded a higher gross return of ₹ 129,772 ha^{-1} compared to other treatments. Seedlings aged 20 days transplanted under rectangular planting with two seedlings per hill attributed better plant establishment and higher population. This might have facilitated increased grain yield and straw yield and resulted in higher gross return. Transplanting of 14 days old seedlings under square planting (25 cm × 25 cm) with a single seedling per hill (M_1S_2) recorded a numerically lower gross return of ₹ 104,618 ha^{-1}. Poor establishment and growth in younger seedlings coupled with lower plant population in square planting with a single seedling per hill might have reduced gross return by lowering the yields. The results are following the finding of Ram *et al.* (2014) and Hebbal *et al.* (2018).

A comparatively higher net return of ₹ 72,614 ha^{-1} was acquired with 20 days old seedlings under rectangular planting (30 cm × 10 cm) with two seedlings per hill (M_3S_3). Higher gross return and the lower cost of cultivation resulted in a higher net return. Similar findings were reported by Ram *et al.* (2014) and Hebbal *et al.* (2018), who found that a spacing of 30×10 cm recorded a higher net return compared to wider spacings. Transplanting of two seedlings per hill recorded a higher net return compared to a single seedling per hill as reported by Damodaran *et al.* (2012). Comparatively lower net return of ₹ 46,020 ha^{-1} was recorded with 14 days old seedlings under square planting (25 cm × 25 cm) with a single seedling per hill (M_1S_2).

The calculated value on benefit-cost ratio was higher (2.27) in transplanting of 20 days old seedlings under rectangular planting (30 cm × 10 cm) with two seedlings per hill (M_3S_3). According to Ram *et al.* (2014) and Hebbal *et al.* (2018), closer spacing of 30 cm ×10 cm recorded a higher B:C ratio. Whereas, younger seedlings of 14 days old transplanted under square planting (25 cm × 25 cm) with a single seedling per hill (M_1S_2) recorded a comparatively lower benefit-cost ratio of 1.79.

CONCLUSION

It is evident from the above results, that transplanting of 20 days old seedlings under rectangular planting (30 cm × 10 cm) with two seedlings per hill was an economically viable option to achieve higher yield and profit in transplanted finger millet under Western Agro Climatic zone of Tamil Nadu.

Ethics statement

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication

All the authors agreed to publish the content.

Competing Interests

The authors declare no conflict of interest in publication of this content

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