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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 2834-2838

www.thepharmajournal.com
Received: 02-09-2021
Accepted: 08-11-2021

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Evaluation of suitable nursery and transplanting techniques on the performance of sesame (*Sesamum indicum* L.)

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Abstract

Sesame is the one of the oldest traditional oilseed crop belonging to Pedaliaceae family and it is considered as "queen of oil seeds". Sesame oil has significant therapeutic qualities, such as lowering cholesterol and preventing cancer. In recent days the production of sesame was declined due to poor crop stand with adoption of improper cultural practices. As a result of these transplanting in sesame has been recognized as one of the potential measure to increase the productivity of crop. Proper nursery for raising seedlings and transplanting techniques was not yet standardized. Therefore, this experiment was conducted during *Rabi* 2019 at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai to study the effect of different nursery types and transplanting techniques on performance of transplanted sesame. The experiment was laid out in split plot design with three replications. The results revealed that leaf area index (3.77 at harvest), dry matter production (3708 kg ha^{-1} at harvest), crop growth rate (1.84 g m^2 day^{-1} at harvest), root length (16.9 cm at 60 Days After Transplanting DAT) and root volume (17.0 cc at 60 DAT) was registered higher in manual transplanting of double seedlings raised under weed mat. The least physiological parameters were recorded under transplanting raised bed single seedling with manual transplanter. Therefore, the manual transplanting of double seedling raised under weed mat is an effective practice to obtain the better crop growth in turn which increase the yield of the transplanted sesame.

Keywords: Transplanted sesame, leaf area index, dry matter production, root length

Introduction

Sesame (*Sesamum indicum* L.) is one among the major oil seed, belonging to the Pedaliaceae family and commonly cultivated in various regions of the globe and it ranks fourth among widely cultivated oil seeds**.** Sesame commonly known as "poor man's substitute for ghee" because of its higher amount of fat, proteins, carbohydrates, fiber and essential minerals present in seed with exhibit both nutritive and pharmaceutical properties. Due to early senescence and the crop's vulnerability to biotic and abiotic factors, sesame has a much lower yield potential than other oil seed crops and it is mainly cultivated by small and marginal farmers under rainfed conditions, mechanisms for reaching out and demonstrating improved technologies under actual farm conditions are required.

The Ministry of Agriculture and Farmers Welfare, Government of India, mentioned that the area under sesame in India declined from 16.67 lakh ha to 15.79 lakh ha in the year 2017-18, while production and productivity raised from 7.4 lakh tonnes and 448 kg ha^{-1} to 7.5 lakh tonnes and 478 kg ha^{-1}. The productivity has progressively increased to around 417 kg ha^{-1}, which is 25% less than the global average output of 554 kg ha^{-1} (FAO, 2017). This scenario requires a reorientation in agriculture in order to achieve a strong development in sesame yield. Production can be done by increasing the size of the farm or by adopting better agro techniques. In general line sowing and broadcasting were commonly used to cultivate the sesame. Thinning and gap filling seems to be most crucial intercultural actions in these approaches. It takes a large labour force to keep the plant population at its peak. Thinning in sesame requires time and also involves high cultivation cost. As a result of these effects, transplanting in sesame has been recognized as a potential measure to reduce labour hours (Sindhuja *et al*., 2019) [15]. Transplanting is one of the agronomic strategies to achieve higher productivity in sesame.

The maximum production potential of any crop is achieved by healthy seeds and seedlings. Raising healthy seedlings under proper nursery is one of the most important components for successful crop production (Pandiyaraj *et al*., 2017) [12]. A nursery is a space where small seedlings are raised or maintained till they are suitable for transplantation. Traditionally, farmers produced the seedlings needed for transplanting without raising proper bed. Some seedlings are still raised in the ground and pulled out when they are matured as bare-root seedlings. When such seedlings are transplanted into the open field, they are susceptible to soil borne pathogens and susceptible to transplanting shock. In some intense cultivating areas, seedling production is increasingly shifting from open field nurseries to covered raised bed or seedling tray production (Bharathi and Ravishankar, 2018) [3]. Development of healthy seedling in suitable nursery results in better establishment of crop which ultimately results in higher productivity. Seedlings raised with portray germinate early with profuse and robust root system as compared to regular nursery beds (Vivek and Duraisamy, 2017) [20]. The protray grown transplant has been expanded to give a consistent availability of good seedlings and enhanced transplanting efficiency (Jeong, 1992) [9].

Among the different agro-techniques, the optimal number of seedlings hill^{-1} is the most essential agronomic practice for increasing crop productivity under both ample and constrained resource situations (Gurjar *et al*., 2018) [7]. Optimum number of seedlings hill^{-1} promotes better crop establishment which induces more growth and yield attributes ultimately results in higher yield (Islam and Salam 2017) [8]. When a single seedling is planted, there is a possibility of missing hills. Instant of using optimum seedlings hill^{-1}, more number of seedlings results in overcrowding and competition results in improper utilization of resources. And therefore it is essential to determine the ideal number of seedlings needed per hill in order to obtain a higher number of yield parameters and crop yield in terms of both quality and quantity (Mishra and Salokhe, 2008) [10]. The appropriate type of nursery and transplanting of optimum number of seedlings hill^{-1} is key to obtaining successful outcomes from the crop and also optimum number of seedlings based on soil status and cultural practices is one of the non-monetary inputs for farmers, especially those with limited resources.

Materials and Methods

The experiment was conducted at Central Farm, Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India in *Rabi* 2019. The experimental site is located 9º 58´ N and 78º 12´ E and 147 m above Mean Sea-Level. The climate of the location is semi arid type. The soil of the experimental field was sandy clay loam and taxonomically known as Typic udic Haplustalf. The soil was slightly high in pH (8.1), normal EC (0.24 ds m^{-1}), low in available N (228 kg ha^{-1}), medium in available P (16.7 kg ha^{-1}) but high in available K (327 kg ha^{-1}).

The different nursery beds are prepared to raise the seedlings as per the treatments.The experiment was laid out in split plot design with three replications, the main plot consist of four different nursery techniques *viz*., raised bed nursery (M_1), raised bed nursery on weed mat (M_2), raised bed nursery on fertilizer gunny (M_3), protray nursery (M_4) and sub plots embedded with transplanting techniques of manual transplanting of single seedlings (S_1),manual transplanting of double seedlings (S_2), transplanting of single seedlings with manual transplanter (S_3), transplanting of double seedlings with manual transplanter (S_4). Sesame variety TMV – 7 released from Oilseed Research Station, Tindivanam was used as a seed material. Twenty days old seedlings are removed from the nursery with the soil intact and transplanted into the main field with the spacing of 30 × 30 cm. Physiological parameters *viz*., Leaf Area Index, Crop Growth Rateg (m^{-2} day^{-1}), Root Length (cm), Root Volume (cc) and Dry Matter Production (kg ha^{-1}) were recorded at various growth stages of transplanted sesame.

The data on various parameters studied during the course of investigation were statistically analyzed by applying the technique of analysis suggested by Gomez *et al*. (2010). Wherever the treatment differences were found significant (“F” test) critical difference was worked out at five percent probability level. The treatment differences that were not significant were denoted as “NS”.

Results and Discussion

Leaf Area Index

The leaf area index increases gradually from the beginning and then falls as the crop matures (Table 1). LAI is also one of the key parameters that improved crop dry matter by higher photosynthetic rate by more number of leaves (Ali *et al*., 2017). Among the different nursery type, raised bed nursery on weed mat (M_2) recorded higher LAI at 60 DAT (3.59) and harvest (3.22) it was on par with seedlings raised on protrays (M_4). Where the lowest leaf area index (3.17 and 2.85) was registered under raised bed seedlings (M_1) at 60 DAT and harvest. The data on different transplanting technique, manual transplanting of double seedling (S_2) registered more leaf area index (3.75 and 3.36 at 60 DAT and harvest) followed by transplanting double seedling with manual transplanter (S_4). Among interaction raised bed seedlings on weed mat with manual transplanting of double seedlings (M_2S_2) recorded higher leaf area index (4.16 at 60 DAT and 3.77 at harvest) was on par with transplanting protray nursery double seedling with manual transplanter (M_4S_4). Transplanting raised bed single seedling with manual transplanter (M_1S_3) recorded lower leaf area index (2.86 at 60 DAT and 2.58 at harvest). This might be due to raised bed seedlings on weed mat recorded improved root development, which might have aided enhanced cell division and cell elongation, lead to an increase in photosynthesis rate (El-Rewainy *et al.*, 2007) [4]. When compared to single seedling, double seedling per hill produced more number of leaves (Nayak *et al.*, 2003) [11]. A higher leaf area helped to intercept sunlight, which aid in assimilate production (Umar *et al*., 2012) [19].

Table 1: Effect of different nursery and transplanting techniques on LAI of sesame

	60 DAT					Harvest				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	3.19	3.47	3.30	3.33	3.32	2.88	3.11	2.97	2.96	2.98
S_2	3.46	4.16	3.57	3.82	3.75	3.10	3.77	3.18	3.41	3.36
S_3	2.86	3.03	2.99	3.09	3.00	2.58	2.69	2.70	2.76	2.69
S_4	3.18	3.69	3.37	3.97	3.55	2.82	3.30	3.01	3.61	3.18

Mean	3.17	3.59	3.31	3.56		2.85	3.22	2.97	3.19	
	M	S	M × S	S × M		M	S	M × S	S × M	
S.Ed	0.10	0.08	0.17	0.15		0.07	0.08	0.16	0.16	
CD (P=0.05)	0.25	0.16	0.37	0.32		0.18	0.17	0.34	0.34	

Crop Growth Rate

At earlier stages the crop growth rate was observed slow as a result of transplanting shock. Different nursery and transplanting strategies have a considerable impact on crop growth rate, which would be a component of dry matter accumulation. Crop growth rates are much lower in the initial days and increased in the latter stages (Table 2). Among the different nurseries, raised bed nursery on weed mat (M_2) recorded higher crop growth rate (3.26, 7.75 and 1.65 at 20-40 DAT, 40-60 DAT and 60 DAT - harvest) and the lowest were recorded in raised bed nursery. When compared to transplanting techniques, manual transplanting of double seedling (S_2) registered maximum crop growth rate (3.45, 8.21and 1.75 at 20-40 DAT, 40-60 DAT and 60 DAT - harvest) when compared to transplanting single seedling with manual transplanter (S_3). The interaction effect between different nursery type and transplanting techniques shows no significant effect. In double seedlings, more number of leaves leads to increased leaf area, which results in higher photosynthetic activity, ultimately enhancing the crop growth rate (Banerjee and Kole 2009) [2]. Similar findings were observed by Thakur *et al.* (2010) [17].

Table 2: Effect of different nursery and transplanting techniques on crop growth rate (g m^2 day^{-1}) of sesame

	20 - 40 DAT					40 - 60 DAT					60 DAT - Harvest				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	2.94	3.24	2.97	3.02	3.04	6.93	7.72	7.06	7.27	7.25	1.41	1.64	1.49	1.64	1.54
S_2	3.18	3.87	3.29	3.44	3.45	7.59	9.11	7.87	8.27	8.21	1.63	1.84	1.70	1.82	1.75
S_3	2.46	2.56	2.48	2.66	2.54	5.79	6.17	5.90	6.35	6.05	1.15	1.40	1.24	1.37	1.29
S_4	2.71	3.35	3.11	3.74	3.23	6.59	8.01	7.42	8.74	7.69	1.54	1.74	1.59	1.68	1.64
Mean	2.82	3.26	2.96	3.21		6.73	7.75	7.06	7.66		1.43	1.65	1.51	1.63	
	M	S	M × S	S × M		M	S	M × S	S × M		M	S	M × S	S × M	
S.Ed	0.02	0.10	0.18	0.20		0.19	0.19	0.39	0.03		0.03	0.04	0.08	0.09	
CD (P=0.05)	0.05	0.21	NS	NS		0.47	0.40	NS	NS		0.08	0.09	NS	NS	

Root characters

Crop root depth and root spread aid in the absorption of soil moisture from nearby regions, resulting in increased crop output. Root hairs play a major role in the absorption of nutrients and moisture from soil.

Transplanting in sesame had a significance influence on root length (Table 3) and root volume (Table 4) at various growth stages of sesame. Raised bed seedlings on weed mat (M_2) recorded maximum root length of (11.3 and 14.4 cm at 40 and 60 DAT) and it was on par with protray seedlings (M_4). Among the transplanting technique, the highest root length(12.0 and 15.1cm at 40 and 60 DAT respectively) was recorded under manual transplanting of double seedling (S_2) and the lowest root length was registered under transplanting single seedling with manual transplanter (S_3). In interaction raised bed seedlings on weed mat with manual transplanting of double seedlings (M_2S_2) recorded higher root length (13.2 and 16.9 cm at 40 and 60 DAT) was on par with transplanting protray nursery double seedling with manual transplanter (M_4S_4). Among the interaction the lowest root length (9.1 and 11.6cm at 40 and 60 DAT) was registered in transplanting raised bed single seedling with manual transplanter (M_1S_3). The same trend of results was obtained in the root volume also.

In double seedlings, the root system has been well formed to support the crop's survival percentage. Higher nitrogen and starch intake may aid in the production of new roots, resulting in increased root volume and length (Sridevi and Chellamuthu, 2012) [16]. The results corroborate with the findings of Prakash *et al.* (2019).

Table 3: Effect of different nursery and transplanting techniques on root length (cm) of sesame

	40 DAT					60 DAT				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	10.1	11.0	10.4	10.5	10.5	12.9	14.0	13.3	13.3	13.4
S_2	10.9	13.2	11.3	12.0	11.8	13.9	16.9	14.3	15.3	15.1
S_3	9.1	9.6	9.5	9.8	9.5	11.6	12.1	12.1	12.4	12.1
S_4	10.0	11.6	10.6	12.6	11.2	12.7	14.8	13.5	16.2	14.3
Mean	10.0	11.3	10.4	11.2		12.8	14.4	13.3	14.3	
	M	S	M × S	S × M		M	S	M × S	S × M	
S.Ed	0.40	0.25	0.59	0.51		0.49	0.36	0.79	0.72	
CD (P=0.05)	0.98	0.52	1.33	1.05		1.19	0.75	1.75	1.49	

Table 4: Effect of different nursery and transplanting techniques on root volume (cc) of sesame

	40 DAT					60 DAT				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	4.5	4.9	4.6	4.7	4.7	7.07	7.64	7.29	7.29	7.32
S_2	4.9	5.9	5.0	5.4	5.3	7.61	9.24	7.83	8.38	8.26
S_3	4.0	4.2	4.2	4.3	4.2	6.35	6.63	6.63	6.79	6.60
S_4	4.4	5.2	4.7	5.6	5.0	6.94	8.10	7.40	8.85	7.82
Mean	4.5	5.0	4.6	5.0		6.99	7.90	7.29	7.83	

	M	S	M × S	S × M		M	S	M × S	S × M	
S.Ed	0.14	0.12	0.24	0.23		0.18	0.18	0.35	0.35	
CD (P=0.05)	0.34	0.24	0.53	0.48		0.44	0.36	0.77	0.72	

Dry Matter Production

There was a gradual enhancement of dry matter production from initial to harvest stage (Table 5). Transplanting double seedling $hill^{-1}$ shows a significant impact on dry matter accumulation than single seedling $hill^{-1}$.With respect to nursery type raised bed seedling on weed mat (M_2) registered more dry matter production (2753 and 3166 kg ha^{-1}) at 60 DAT and harvest. Among transplanting techniques, manual transplanting of double seedling (S_2) produced significantly higher dry matter (2915 and 3352 kg ha^{-1}) at 60 DAT and harvest than rest of the treatments. In interaction manual transplanting of double seedling raised under weed mat (M_2S_2) recorded higher dry matter accumulation (3252 at 60 DAT and 3708 kg ha^{-1} at harvest) on par with transplanting of double seedling raised under protray with manual transplanter.

The least dry matter (2068 and 2356 kg ha^{-1}) at 60 DAT and harvest was recorded under transplanting raised bed single seedling with manual transplanter (M_1S_3). Number of seedlings $hill^{-1}$ which increases the intake and translocation of nutrients during the growth and development stages of crop responsible for higher dry matter accumulation (Sindhuja *et al.*, 2019) [15]. This corroborates with the findings of Thawait *et al.* (2014) [18].

Table 5: Effect of different nursery and transplanting techniques on dry matter production (kg ha^{-1}) of sesame

	60 DAT					Harvest				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	2470	2741	2507	2570	2572	2822	3151	2880	2980	2958
S_2	2693	3252	2790	2924	2915	3101	3708	3217	3384	3352
S_3	2068	2178	2096	2253	2149	2356	2529	2405	2596	2472
S_4	2320	2840	2634	3127	2730	2706	3276	3032	3547	3140
Mean	2388	2753	2507	2719		2746	3166	2883	3127	
	M	S	M × S	S × M		M	S	M × S	S × M	
S.Ed	82.62	73.06	151.13	146.12		85.8	63.9	140.1	127.9	
CD (P=0.05)	202.17	150.80	329.22	301.59		209.9	132.0	309.2	263.9	

Conclusion

According to this study, various nursery types and transplanting techniques significantly influences the physiological parameters of transplanted sesame. Leaf area index, crop growth rate, root length, root volume and dry matter production are highly influenced by manual transplanting of double seedling raised on weed mat. Furthermore, transplanting double seedlings have positive effect over single seedling. Finally, the result of this study concluded that the manual transplanting of double seedling raised under weed mat is an effective agronomic management practices to attain better plant growth improves physiological parameters in turn which increase the yield of the transplanted sesame.

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