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RESEARCH ARTICLE

Optimizing media composition for sesame seedling: A pathway to improved transplant success and yield

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Abstract

Sesame (*Sesamum indicum* L.), often referred to as the "Queen of oilseeds," is one of the world's most traditional oilseed crops. A field experiment was conducted during 2021 and 2022 at V. O. Chidambaranar Agricultural College and Research Institute, Killikulam to investigate the effect of various media compositions on the performance of sesame seedlings grown for transplanting. The experiment followed a randomized block design with five treatments and four replications. Observations including seed germination percentage, shoot length, number of leaves, root length, root volume and vigour index were recorded. In the preliminary experiment, among the media combinations, the results showed that T_4 recorded the highest seed germination percentage (82.30 %), shoot length (18.8 cm), number of leaves (5.2), root length (2.9 cm), root volume (0.15 cc) and vigour index (1786), while the lowest values were recorded in the control (T_5) with no media application. So that red earth, sand and vermicompost (1:1:2) media used for raising different age of seedling transplanted in the main field. Ridge planting of 20 days old sesame seedlings (T_4) for transplanting resulted significantly higher dry matter production of 2888 kg ha^{-1}, crop growth rate of 3.96 g m^{-2} day^{-1}, relative growth rate of 0.016 g g^{-1} day^{-1} from 60 DAT to harvest and a seed yield of 901 kg ha^{-1} compared to all other treatment combinations.

Keywords: crop growth rate; relative growth rate and yield; root length; seed germination; shoot length; vigour index

Introduction

Sesame (*Sesamum indicum* L.), often referred to as the "Queen of oilseeds," is one of the world's most traditional oilseed crops. It thrives primarily in tropical and subtropical regions of Asia, Africa and Latin America. The seeds are mainly used in confectionery and baking, while the oil is utilized in producing vegetable oils, perfumes, soaps and carbon paper (1). Known for its drought tolerance due to genetic and environmental factors, sesame often has reduced yields, which can be enhanced through scientific management practices and intensive agricultural systems (2). Additionally, natural antioxidants like sesamin, sesamol and sesamolin found in sesame are known to help lower cholesterol, manage hypertension and reduce cancer risk (3).

Sesame is typically cultivated using line sowing and broadcasting methods. These methods require significant intercultural operations, with thinning and gap filling being the most crucial for maintaining an optimal plant population. However, thinning in sesame cultivation is labour intensive, time-consuming and costly. Developing a suitable nursery system with enhanced nutrition, appropriate transplanting age and the optimal number of seedlings is essential for achieving a healthy crop stand (4). Similarly, a study highlighted that higher crop productivity can be achieved by ensuring the proper age and number of seedlings (5). Physically, growing media vary in texture, porosity and particle size, influencing their ability to retain water and provide aeration. Chemical properties such as pH, cation exchange capacity and nutrient content determine the media's ability to supply essential minerals to plants**.** Therefore, optimizing the nursery media for sesame cultivation is of utmost importance. Considering this, the present study was undertaken to optimize nursery media for sesame seeds, focusing on seed germination, seedling growth and vigour index.

Materials and Methods

Preliminary experiment

The experiment was carried out in two stages at the V.O.Chidambaranar Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam. The first stage was designed as a randomized block trial with five treatments and four replications using the sesame variety TMV 7 to evaluate the effects of different proportions of media components - red earth, sand and vermicompost on volume basis. The treatment groups were as follows: T_1- red earth: sand: vermicompost (1:1:1), T_2- red earth: sand: vermicompost (2:1:1), T_3- red earth: sand: vermicompost (1:2:1), T_4 - red earth: sand: vermicompost (1:1:2) and T_5 - control (field soil).

Well-decomposed vermicompost used for preparing the nursery media was analyzed and found to contain 1.64 % nitrogen (N), 0.85 % phosphorus (P_2O_5) and 1.30 % potassium (K_2O). Similarly, red earth collected from nearby cultivated fields was incorporated into the nursery media. Sand and red earth was mixed with vermicompost in the required proportions to create a standard nursery medium according to the treatments. Growth parameters were measured 15 days after sowing and the recorded observations included germination percentage, shoot length (cm), number of leaves, root length (cm), root volume (cc) and vigour index. The vigour index of seedlings was calculated using the formula (6):

Vigour index = Germination percentage × (shoot length + root length)

Main field experiment

The experiments were conducted using randomized block design with nine treatments and three replications. Based on the nursery media results, T_4 (red earth: sand: vermicompost at 1:1:2) was selected for raising seedlings from the nursery to the main field.

The treatment details are as follows:

T_1: Line sowing with 30 × 30 cm

T_2: Ridge planting of 12 days old seedling

T_3: Ridge planting of 16 days old seedling

T_4: Ridge planting of 20 days old seedling

T_5: Ridge planting of 24 days old seedling

T_6: Flat planting of 12 days old seedling

T_7: Flat planting of 16 days old seedling

T_8: Flat planting of 20 days old seedling

T_9: Flat planting of 24 days old seedling

The experimental plot had sandy clay loam soil with the following characteristics: pH 7.8, EC 0.24 dS m^{-1}, organic carbon 4.30 g kg^{-1}, low available nitrogen (238 kg ha^{-1}), medium available phosphorus (19 kg ha^{-1}) and high available potassium (290 kg ha^{-1}). During experiments I and II, the recorded weather parameters were as follows:

- Maximum temperature: 35.6 °C and 33.2 °C
- Minimum temperature: 25.2 °C and 20.1 °C
- Relative humidity: 60.4 % and 69.4 %
- Rainfall: 102 mm and 119.6 mm
- Average evaporation: 6.9 mm day^{-1} and 5.1 mm day^{-1}
- Sunshine: 6.9 hrs and 6.4 hrs
- Wind speed: 4.3 km hr^{-1} and 5.1 km hr^{-1}

Statistical analysis

The pooled data of 2021 and 2022 (rabi season) were analyzed statistically according to standard methods (7).

Results and Discussion

Preliminary trial

Germination percentage

The experiment results showed that sesame seed germination begins on the 5th day, producing two cotyledon leaves. Adequate moisture is crucial for germination; however, excess moisture after germination leads to damping off in seedlings. Using media with varying compositions significantly influenced germination rates, shoot and root lengths, leaf numbers and vigour index. The highest germination rate (82.3 %) was observed with a medium composed of red earth, sand and vermicompost in a 1:1:2 ratio (T_4), while the lowest germination rate (60.5 %) was recorded in the control (T_5). These findings align with the results of a previous study (8). The improved germination rates are primarily attributed to vermicompost, as the organic components enhance the medium's physical and chemical properties, increasing porosity and reducing compactness (Table 1).

Shoot length and root length

After germination, the emergence of sesame seedlings was initially very slow. The shoot and root lengths of sesame were significantly influenced by the composition of the growth media. The highest shoot length (18.8 cm) was observed with a media composition of red earth, sand and vermicompost in a 1:1:2 ratio, while the lowest shoot length (11.1 cm) was recorded in the control group without media application (Table 1). Vermicompost has been scientifically proven to be an exceptional plant growth enhancer, with a marked difference in shoot length between plants treated with a higher

Table 1. Effect of different nursery media on seed germination, seedling height, number of leaves, root length, root volume and vigour index of sesame seedlings

Treatment	Germination (%)	Shoot length (cm)	No. of leaves	Root length (cm)	Vigour index	Root volume (cc)
T_1 - 1: 1: 1	72.2	15.5	4.2	2.1	1271	0.15
T_2 - 2: 1: 1	77.4	16.7	4.4	1.9	1440	0.15
T_3 - 1: 2: 1	65.1	13.6	3.9	2.3	1035	0.15
T_4 - 1: 1: 2	82.3	18.8	5.2	2.9	1786	0.15
T_5 - Control	60.5	11.1	3.5	1.7	774	0.12
SE.d	2.1	0.54	0.11	0.07	82	0.002
CD (P = 0.05)	4.2	1. 05	0.26	0.15	163	NS

proportion of vermicompost and those treated with other media. These findings align with the results of previous research (9). Similarly, the maximum root length (2.9 cm) was achieved using the same 1:1:2 media composition, whereas the minimum root length (1.7 cm) was recorded in the control group. This could be attributed to the production of hydrolytic enzymes that release nutrients in the basal media, enhancing nutrient uptake and promoting root development. These results are consistent with the findings of an earlier study (10).

Number of leaves

Sesame leaves grow in pairs and alternate in arrangement. The highest number of leaves (5.2) was observed when the medium was a 1:1:2 mix of red earth, sand and vermicompost. In contrast, the lowest number of leaves (3.5) was recorded in the absence of any medium (Table 1). Vermicompost promotes the production of favourable hormones that drive cell multiplication and division, leading to an increased number of leaves. The addition of organic material to the media will donate macro elements N, P, K which is very good for improving plant growth including the number of leaves (11).

Vigour index and root volume

Low seed vigour has been identified as the primary factor contributing to poor establishment, ultimately leading to reduced yield (12). A significantly higher vigour index (1786) was observed with the application of 1:1:2 ratio of red earth, sand and vermicompost. In contrast, the control treatment recorded the lowest vigour index (774) (Table 1). This improvement can be attributed to the optimal media combination, which provides suitable pH, adequate nutrients and promotes better seedling growth and survival. These results align with the findings of a previous study with a similar trend observed in root volume (13).

Main field experiment

Dry matter production

Ridge planting with 20-days old seedlings (T_4) resulted in higher dry matter production (850, 2096 and 2888 kg ha^{-1}) during 40, 60 DAT and harvest stages respectively (Table 2). This finding aligns with the observations of an earlier study which reported the highest soil moisture and growth attributes when using the ridge and furrow method (14). The increased dry matter production from transplanting 20 days old seedlings can be attributed to significant improvements in morphological traits such as plant height and leaf area index, which in turn enhance dry matter accumulation. This effect is likely due to the timely transplantation of seedlings at the optimal age. The positive impact on various growth attributes is linked to the ideal timing of crop transplantation, which supports early survival by maintaining transpiration balance and meeting the plant's energy needs. Lowest dry matter production (487, 1141 and 1843 kg ha^{-1}) during 40, 60 DAT and harvest stages respectively was noticed under flat planting of 12 days old seedling.

Crop growth rate and relative growth rate

At first, the crop growth was slow due to transplant shock, but it quickly recovered once the roots were well established. The crop growth rate (CGR) and relative growth rate (RGR) were significantly affected by the crop's dry matter production. Both CGR and RGR were lower during the early stages but increased in the later stages (15). Seedlings that were 20 days old (T_4) showed higher CGR (6.23, 3.96 g m^{-2} day^{-1}) and RGR (0.045, 0.016 g $g^{-1}day^{-1}$) during the 40-60 DAT and 60 DAT to harvest stages respectively. Fig. 1, 2 show the effect of different planting methods and age of seedlings on crop growth rate and relative growth rate.

Yield

The results indicated that ridge planting with 20-days old seedlings (T_4) achieved significantly higher seed yield (901 kg ha^{-1}), followed by ridge planting with 16-day-old seedlings (T_3) (836 kg ha^{-1}), while the lowest yield (T_6) (661 kg ha^{-1}) was recorded in flat planting of 12 days old seedling (Table 2). The experiment revealed that 20-days old seedlings had a positive impact on seed yield, producing significantly higher yield per hectare compared to 12, 16 and 24-days old seedlings. This increase in seed yield was linked to a notable improvement in photosynthetic activity observed when sesame was transplanted with 20 days old seedlings, which contributed to higher yield related characteristics. These findings align with the results of previous studies which reported that optimum seedling age and number lead to higher crop productivity (16, 5). Research indicates that transplant shock occurs when extremely young or old seedlings are transplanted, as they take longer to establish in the field (17). Seedlings of older age were more resilient during transplanting, with fewer pest and disease issues, leading to higher stalk yields compared to conventional methods. These results are consistent with the findings of an earlier study (18). It is an effective strategy when conditions are less favourable for direct seeding; therefore, transplanting is commonly used to establish crops (19).

Table 2. Effect of different planting methods and age of seedlings on dry matter production and yield kg $ha^{-1}$of transplanted sesame (Average of two years)

Treatments	Dry matter production (kg ha^{-1})			Seed yield (kg ha^{-1})
	40 DAT	60 DAT	At harvest	
T_1	652	1424	2173	692
T_2	555	1383	2037	664
T_3	798	1944	2658	836
T_4	850	2096	2888	901
T_5	630	1415	2170	753
T_6	487	1141	1843	661
T_7	580	1452	2157	728
T_8	755	1759	2499	799
T_9	690	1536	2288	769
SE.d	23	66	96	31
CD (P = 0.05)	49	134	192	62

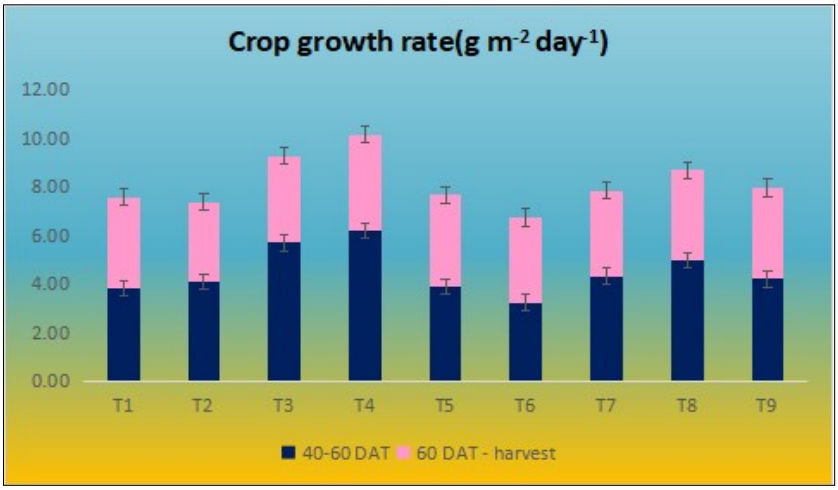

Fig. 1. Effect of different planting methods and age of seedlings on crop growth rate (g m^{-2} day^{-1}).

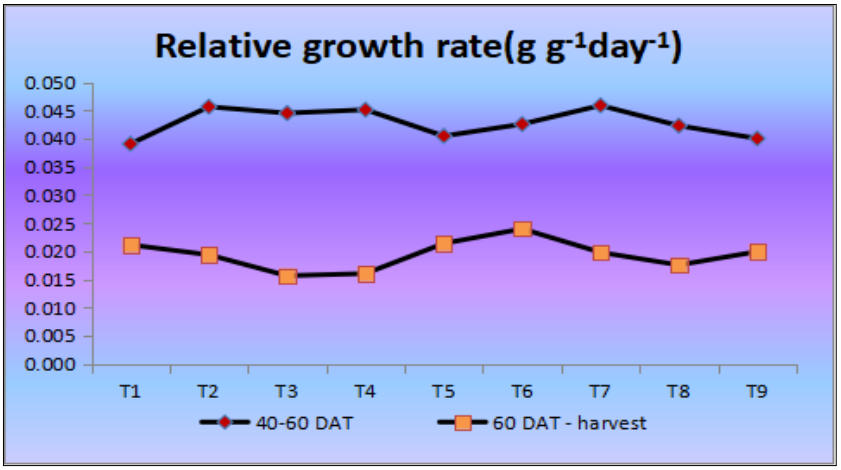

Fig. 2. Effect of different planting methods and age of seedlings on relative growth rate (g $g^{-1}$$day^{-1}$).

Conclusion

The preliminary trial concluded that a nursery media mixture of red earth, sand and vermicompost in a 1:1:2 ratio was the most effective for producing healthy and robust sesame seedlings for transplanting. Additionally, ridge planting of 20 days old seedlings was found to be the best method for achieving higher seed yield. However, in areas where labour is limited, farmers may consider flat planting with seedlings of the optimal age as an alternative to line sowing for better returns.

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Authors' contributions

JB and MA were involved in the research activities, field establishment and writing the research article. MH and MJ reviewed and proofread the manuscript. NV, TS and SKN contributed to the statistical analysis of the data collected during the research, while MM and ST assisted with the analysis and participated in the sequence alignment. All authors read and approved the final manuscript.

Compliance with ethical standards

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