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Performance of Mulberry Saplings as Influenced by Different Proportions of Vermicompost

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ABSTRACT: Vermicompost is rich in nutrients and is a microbiologically active amendment that is obtained from the interaction between microorganisms and earthworms in the breakdown of organic matter. The experiment was conducted to study the performance of mulberry saplings as influenced by the different proportions of vermicompost. Different proportions of vermicompost (10%, 20%, 30% and 40% + red soil and sand) were used as treatments with control (1/3 compost + 1/3 sand + 1/3 red soil) in three varieties of mulberry cuttings (V-1, S-36 and S-13). The results revealed that in all three varieties of mulberry cuttings, treatments with 20 per cent, 30 per cent and 40 per cent vermicompost were statistically on par with each other compared to control with respect to number of leaves per sapling, shoot length, fresh and dry weight of shoots, rooting percentage. The length of the longest root, survival percentage, fresh weight and dry weight of the root were on par in treatments with 30 per cent vermicompost and 40 per cent vermicompost followed by 20 per cent vermicompost. The higher proportion of vermicompost in planting media improved significantly the mulberry plant growth and yield parameters.

Keywords: Vermicompost, mulberry, variety, Cuttings, proportion.

INTRODUCTION

Mulberry a hardy and perennial plant has short proliferation period, fast growth rate and plant adapts itself to varied environmental conditions like tropical, subtropical and temperate regions. Mulberry (*Morus alba* L.) a commercial crop that is food for silkworm (*Bombyx mori* L.). Soil and climatic condition in which mulberry is grown influences the quality of mulberry, which in return decides the quantitative and qualitative feature of cocoon yield. Mulberry being a vegetatively propagated perennial crop; initial establishment is of prime importance. Vegetative propagation of mulberry by stem cuttings raised in the nurseries or by direct planting in the field is commonly practiced.

Nursery is the place where saplings/seedlings are raised under intensive management for transplanting to the main field. This practice ensures economy of planting material and permits intensive management that reduces infestation of pathogens and insect pest attack on seedlings.

In commercial cultivation, mulberry garden is established from stem cuttings. Planting of saplings initially in the mulberry garden has many advantages compared to direct planting of mulberry cuttings. To improve the rooting ability, success per cent and for proper growth and establishment of the plants, the rooting substrate in which it is grown plays a very important role. The type of media used has significant influence on the vegetative growth and root establishment of cuttings. Knowing that good pot media is a reservoir of plant nutrients, has good water holding capacity, and enables gas exchange. It also provides good anchorage for the plants.

Varied growing media commonly used for growing plants are peat moss, sphagnum moss, sawdust, coir pith, cocopeat, poultry manure, farm yard manure (FYM), vermicompost, *etc*. Hartman and Kester (1997) quoted that "there is no ideal rooting medium for cuttings because the requirements depend on the plant species, type of cuttings, season and propagation system"

Abbasi and Ramasamy (1999) quoted that "amongst organic manures vermicompost is becoming popular because it is eco-friendly and favourite soil conditioner. Vermicompost has additional attributes of providing enzymes and hormones which stimulate plant growth"

Vermicompost is rich in nutrient, microbiologically active amendment which is obtained from the interaction between microorganisms and earthworms in the breakdown of organic matter (Domínguez and Edwards, 2004).

MATERIAL AND METHODS

A pot experiment was conducted with reference to the topic "Study on growth parameters of mulberry saplings as influenced by different proportions of vermicompost" during 2021-2022, at the Department of Sericulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru.

The details of the material used and methodologies adopted during the study are discussed below.

A. Experiment details

The present study was undertaken to demonstrate the effect of different proportions of vermicompost on

growth parameters of mulberry cuttings of V-1, S-36 and S-13 mulberry varieties.

B. Material

Filling of polythene bags. Fifteen polythene bags were taken for each replication in the treatments. Two small holes were made at the base of each bag, for proper drainage after which the bags were filled with as per treatments with varied proportions of vermicompost mixed with sand and soil and kept replication-wise for further planting of mulberry cuttings.

Source and preparation of cuttings. The cuttings of selected mulberry varieties *viz*., V-1, S-36, and S-13 were prepared from 8-month-old branches of the existing mulberry garden at the department of sericulture. Cuttings were prepared an hour before planting by giving a straight cut on the distal ends. All the cuttings were showered thoroughly with water to prevent drying of cuttings just before planting in to the bags containing different proportions of vermicompost (10 %, 20 %, 30 % and 40 %).

Treatments	Treatment details
T_1	10 % vermicompost + 90 % soil* for V-1
T_2	20 % vermicompost + 80 % soil* for V-1
T_3	30 % vermicompost + 70 % soil* for V-1
T_4	40 % vermicompost + 60 % soil* for V-1
T_5	Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1
T_6	10 % vermicompost + 90 % soil* for S-36
T_7	20 % vermicompost + 80 % soil* for S-36
T_8	30 % vermicompost + 70 % soil* for S-36
T_9	40 % vermicompost + 60 % soil* for S-36
T_{10}	Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36
T_{11}	10 % vermicompost + 90 % soil* for S-13
T_{12}	20 % vermicompost + 80 % soil* for S-13
T_{13}	30 % vermicompost + 70 % soil* for S-13
T_{14}	40 % vermicompost + 60 % soil* for S-13
T_{15}	Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13

*- Sand + Red soil

Preparation of potting media. The potting media was prepared by mixing combinations of different proportions of vermicompost with the required quantity of soil and filled into polythene bags measuring 14.5 × 5.0 cm.

Vermicompost: Vermicompost was procured from the Gandhi Krishi Vignana Kendra, Zonal Agricultural Research Station (ZARS) vermicompost sale unit.

METHODS

Commencement of experiment	May 2022 – August 2022
No. of treatments	15
No. of replications	3
No. of cuttings per replications	15
Design	CRD (Completely Randomized Design)
Crop	Mulberry
Variety	V-1, S-36 and S-13
Poly bag size	14.5 ×5.0 cm
Location	Department of Sericulture, GKVK, Bengaluru

Planting and after care. Each treatment consists of 15 polythene bags with V-1, S-36 and S-13 mulberry cuttings replicated three times and the mixture of the different proportions of vermicompost and soil was filled in polythene bags of half kilogram leaving one-inch gap at the top. Cuttings were planted in the bags measuring 14.5 × 5.0 cm. One cutting was planted in each polythene bag. After planting of cuttings, a fine spray of water was given with the help of rose water can in such a way that water soaked to the bottom of polythene bags. Later irrigation was given at regular intervals of three to four days.

Weeding. Weeds were completely removed as soon as they appeared in polythene bags. Weeding was done manually and polythene bags were kept clean by uprooting the weeds at regular intervals.

C. Observations recorded

The following shoot and root parameters were recorded on 60th and 90th days after planting (DAP). Each time five cuttings were used for recording observations as destructive samples and economics were calculated.

(i) Shoot parameters

Days taken for the first bud break. After planting of cuttings as per treatments, the experimental site was visited daily and all the mulberry cuttings under experiment were observed critically and the date on which bud break occurred and green portion of bud exposed for the first time. Thereafter the days taken for bud breaking was calculated by taking the duration between date of planting treatments and first bud break.

Number of sprouted cuttings. Days taken to start sprouting was recorded on 5th, 10th and 15th days after planting of cuttings by counting number of buds sprouted in a particular treatment.

Survival percentage. The survival percentage for each treatment was determined by counting the number of survived saplings to the number of cuttings planted, it was recorded at 30 days of planting and values were expressed as percentage (%).

$$\text{Survival percentage}\,(\%) = \frac{\text{Number of survived cuttings}}{\text{Total number of cuttings planted}} \times 100$$

Number of leaves per sapling. The number of leaves for five randomly selected saplings was counted visually at 30 days interval for three months and mean number of leaves was calculated.

Length of shoot (cm). The length (cm) of saplings was measured by using normal scale in centimetres from base to the tip of the seedlings and average length of five saplings was calculated.

Fresh weight of shoot (g). The shoot portion of the sapling was weighed one by one for five saplings by using digital balance in each treatment to calculate the average fresh weight of the shoot, treatment wise.

Dry weight of shoot (g). The shoots of all the saplings were air dried and then placed in an oven at 70°C for 24 hours. Dry shoots were weighted in grams by using an electronic balance.

(ii) Root parameters

Rooting percentage. The rooting percentage for each treatment was determined by counting the number of rooted saplings to the number of cuttings planted, it was

recorded at 60 and 90 DAP. The values were expressed as percentage.

$$\text{Rooting percentage}\,(\%) = \frac{\text{Number of cuttings rooted}}{\text{Total number of cuttings}} \times 100$$

Length of longest root (cm). The length of longest root was measured by using normal scale in centimetres from its base to the tip. Five seedlings were taken in each replication to calculate the average root length.

Fresh weight of root (g). The entire root was removed from the seedling at the point of its origin and dried between the folds of a blotting paper and weighed using digital balance and the average for five seedlings was calculated.

Dry weight of root (g). The roots of all the saplings taken were air dried and then placed in an oven at 70°C for 24 hours for complete drying. These dry roots were weighed in grams by using an electronic balance.

D. Statistical analysis. The data recorded on various parameters were subjected to fisher's method of Analysis of variance (ANOVA) and interpreted according to Gomez and Gomez (1984). The level of significance used in F and t-tests was P=0.05 for CRD. The critical difference (CD) values were computed where F- test was found significant.

RESULTS AND DISCUSSION

A. Effect of different proportions of vermicompost on shoot parameters of mulberry saplings

Days taken for first bud break. Bud opening in mulberry depends on the variety and the place where it is growing. Mulberry bud growth can be classified into a) bud break stage - where the bud growth starts, b) swallow beak stage - where the leaves emerge and c) leaf opening stage – where leaves become horizontal to cutting.

Data presented in Table 1 shows that the days taken for the first bud break in V-1, S-36 and S-13 mulberry cuttings ranged from 3.33 to 4.82 days. There was significant difference in bud break between all the treatments. The earliest bud break (3.33, 3.69 and 3.58 days) was seen in treatments with 40 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 30 per cent vermicompost (3.67, 3.89 and 3.73 days) and 20 per cent vermicompost (4.33, 4.63 and 4.47 days) compared to control (1/3 compost +1/3 sand + 1/3 red soil) (4.58, 4.75 and 4.67 days). Whereas, late bud break (4.62, 4.82 and 4.73 days) was recorded in treatments with 10 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13.

The present results are agreement with the study of Anusha (2020) who observed earliest bud break (3.33 days) in vermicompost + soil (3:1) followed by vermicompost + FYM + soil (1:1:2) (3.67 days).

Tahseen *et al*. (2005) observed that early bud break may be on account of accumulation of endogenous substances promoting growth in the cuttings, usually the initial growth of mulberry depends on reserve nutrients, therefore the amount of stored food material(carbohydrates) affects the bud break. Early bud break in vermicompost and soil rooting substrate could be because of larger pore size, good aeration capacity and better utilization of the nutritional reserves. According to Sujit (2012) vermicompost contains humic acid that stimulates plant growth even when present in smaller quantities.

Table 1: Effect of different proportions of vermicompost on bud break.

Treatments	Days taken for first bud break
T_1 = 10 % vermicompost + 90 % soil* for V-1	4.67
T_2 = 20 % vermicompost + 80 % soil* for V-1	4.33
T_3 = 30 % vermicompost + 70 % soil* for V-1	3.67
T_4 = 40 % vermicompost + 60 % soil* for V-1	3.33
T_5 = Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	4.58
T_6 = 10 % vermicompost + 90 % soil* for S-36	4.82
T_7 = 20 % vermicompost + 80 % soil* for S-36	4.63
T_8 = 30 % vermicompost + 70 % soil* for S-36	3.89
T_9 = 40 % vermicompost + 60 % soil* for S-36	3.69
T_{10} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	4.75
T_{11} = 10 % vermicompost + 90 % soil* for S-13	4.73
T_{12} = 20 % vermicompost + 80 % soil* for S-13	4.47
T_{13} = 30 % vermicompost + 70 % soil* for S-13	3.73
T_{14} = 40 % vermicompost + 60 % soil* for S-13	3.58
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	4.67
F-test	**
SEm±	0.065
CD @ 5%	0.188

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Number of sprouted cuttings. The number of sprouts is an indication of liveliness of the cuttings planted in different rooting media (Ankita, 2012). Data presented in Table 2 regarding number of sprouted cuttings of V-1, S-36 and S-13 varieties of mulberry cuttings differ significantly on 5th, 10th and 15th days after planting (DAP).

On fifth day of planting, the treatments with 40 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13 resulted in highest number of sprouted cuttings (3.67, 3.67 and 4.67) followed by treatments with 30 per cent vermicompost (3.33, 3.67 and 3.67), 20 per cent vermicompost (3.33, 3.00 and 3.33) and 10 per cent vermicompost (2.67, 2.67 and 3.33), while lowest

number of sprouted cuttings (2.33, 2.33 and 2.97) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

On tenth day of planting, the treatments with 40 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13 resulted in highest number of sprouted cuttings (8.67, 7.98 and 8.42) followed by treatments with 30 per cent vermicompost (7.33, 7.67 and 7.34), 20 per cent vermicompost (7.33, 5.52 and 6.67) and 10 per cent vermicompost (6.33, 4.67 and 5.33), while lowest number of sprouted cuttings (4.67, 3.67 and 3.67) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

Table 2: Effect of different proportions of vermicompost on the number of sprouted cuttings.

Treatments	Number of sprouted cuttings		
	5th DAP	10th DAP	15th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	2.67	6.33	10.98
T_2 = 20 % vermicompost + 80 % soil* for V-1	3.33	7.33	11.67
T_3 = 30 % vermicompost + 70 % soil* for V-1	3.33	7.33	12.00
T_4 = 40 % vermicompost + 60 % soil* for V-1	3.67	8.67	12.52
T_5 = Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	2.33	4.67	9.42
T_6 = 10 % vermicompost + 90 % soil* for S-36	2.67	4.67	10.00
T_7 = 20 % vermicompost + 80 % soil* for S-36	3.00	5.52	10.34
T_8 = 30 % vermicompost + 70 % soil* for S-36	3.67	7.67	11.67
T_9 = 40 % vermicompost + 60 % soil* for S-36	3.67	7.98	12.33
T_{10} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	2.33	3.67	8.98
T_{11} = 10 % vermicompost + 90 % soil* for S-13	3.33	5.33	10.67
T_{12} = 20 % vermicompost + 80 % soil* for S-13	3.33	6.67	11.34
T_{13} = 30 % vermicompost + 70 % soil* for S-13	3.67	7.34	11.98
T_{14} = 40 % vermicompost + 60 % soil* for S-13	4.67	8.42	12.34
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	2.97	3.67	9.33
F-test	**	**	**
SEm±	0.069	0.136	0.231
CD @ 5%	0.198	0.394	0.667

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

On fifteenth day after planting, the number of sprouted cuttings was statistically on par in treatments with 30 per cent vermicompost (12.00, 11.67 and 11.98) and 40 per cent vermicompost (12.52, 12.33 and 12.34) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (11.67, 10.34 and 11.34) and 10 per cent vermicompost (10.98, 10.00 and 10.67), while lowest number of sprouted cuttings (9.42, 8.98 and 9.33) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

The results show similarity to the findings of Rashmita (2015) who observed maximum number of sprouted cuttings (15.49) with (vermicompost + soil, 1:1) in pear cuttings. The reason behind this could be high organic matter content along with good moisture retaining capacity, these findings also are in conformity with Panchal *et al*. (2014) who conducted same kind of study in *Manilkara hexandra*. The same kind of study was also conducted by Hernandez *et al*. (2014) with rosemary cuttings.

Number of leaves per sapling. The number of leaves indicate the vigour of the sprouted cuttings (Ankita, 2012). Data regarding the effect of different proportions of vermicompost on number of leaves in V-1, S-36 and S-13 mulberry saplings was recorded periodically as shown in Table 3 and Fig. 1.

At sixty days after planting, the number of leaves per sapling was significantly on par in treatments with 30 per cent vermicompost (11.60, 11.11 and 11.60) and 40 per cent vermicompost (13.00, 11.40 and 12.33)in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (7.10, 10.50 and 9.01) compared to control (1/3 compost + 1/3 sand + 1/3 red soil) (7.18, 7.76 and 6.90) in all three varieties *viz*., V-1, S-36 and S-13, while the minimum number of leaves(6.83) was recordedinT_1 (10 % vermicompost + 90 % soil* for V-1).

At ninety days after planting, the number of leaves per sapling was statistically on par in treatments with 20 per cent vermicompost (14.35, 11.70 and 13.40), 30 per cent vermicompost (14.66, 13.83 and 14.00) and 40 per cent vermicompost treatments (16.53, 14.43 and 14.46) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with10 per cent vermicompost (12.13, 11.30 and 12.10), while the minimum number of leaves per sapling (9.63, 9.18 and 9.51) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

Maximum number of leaves were recorded in treatments with 40 per cent vermicompost (T_4, T_9 and T_{14}) in all three varieties of mulberry *viz*., V-1, S-36 and S-13 were on par with the results of Ghazy *et al*. (2020) who reported that higher proportions of vermicompost improved the mulberry plant growth and yield parameters significantly. In addition, Venugopal *et al*. (2010) stated that vermicompost increased the leaf production.

Enhanced number of leaves with vermicompost as component of rooting substrate seems to be due to its high moisture holding capacity and enhanced levels of humic acid and humates which made possible availability of higher levels of plant nutrients (Thyagi and Kumar 2006).

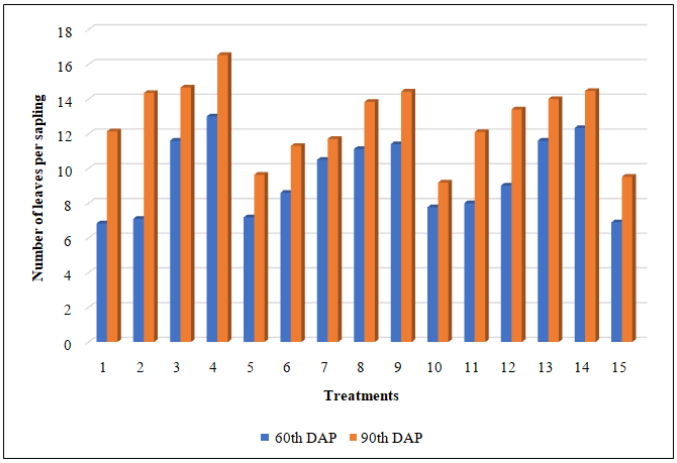

Fig. 1. Effect of different proportions of vermicompost on number of leaves.

Table 3: Effect of different proportions of vermicompost on number of leaves.

Treatments	Number of leaves per sapling	
	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	6.83	12.13
T_2 = 20 % vermicompost + 80 % soil* for V-1	7.10	14.35
T_3 = 30 % vermicompost + 70 % soil* for V-1	11.60	14.66
T_4 = 40 % vermicompost + 60 % soil* for V-1	13.00	16.53
T_5 = Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	7.18	9.63
T_6 = 10 % vermicompost + 90 % soil* for S-36	8.60	11.30
T_7 = 20 % vermicompost + 80 % soil* for S-36	10.50	11.70
T_8 = 30 % vermicompost + 70 % soil* for S-36	11.11	13.83
T_9 = 40 % vermicompost + 60 % soil* for S-36	11.40	14.43
T_{10} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	7.76	9.18
T_{11} = 10 % vermicompost + 90 % soil* for S-13	8.00	12.10
T_{12} =20 % vermicompost + 80 % soil* for S-13	9.01	13.40
T_{13} = 30 % vermicompost + 70 % soil* for S-13	11.60	14.00
T_{14} = 40 % vermicompost + 60 % soil* for S-13	12.33	14.46
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	6.90	9.51
F-test	**	**
SEm±	0.718	1.905
CD @ 5%	2.075	5.504

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Shoot length (cm). On sixty days after planting, there was no significant difference between treatments with 20 per cent vermicompost (17.33, 13.45 and 16.03 cm), 30 per cent vermicompost (21.13, 16.33 and 16.93 cm) and 40 per cent vermicompost (21.88, 18.97 and 19.03 cm) regarding shoot length in all three varieties *viz*., V-1, S-36 and S-13, followed by treatments with 10 per cent vermicompost (17.27, 12.99 and 13.73 cm), while the minimum shoot length (13.27, 12.12 and 12.09 cm) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

On ninety days after planting, there was no significant variations found between treatments with 30 per cent vermicompost (23.80, 22.93 and 22.39 cm) and 40 per cent vermicompost (24.45, 23.28 and 23.88 cm) regarding shoot length in all three varieties *viz*., V-1, S-36 and S-13, followed by treatments with 20 per cent vermicompost (22.27, 18.53 and 21.76 cm) and 10 per cent vermicompost (20.27, 18.35 and 19.14 cm), while the minimum shoot length per sapling (19.67, 17.12 and 19.15) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

The current results agree with the findings of Swati (2019) who reported that maximum shoot length of 3.80 cm with vermicompost 25% + sand 50% + soil 25% in Damask Rose, which could probably be attributed to higher water and nutrient holding capacity of the rooting medium.

The reason for highest shoot height could be because of organically rich material like vermicompost which has altered soil structure, soil productivity, increased microbial population and enhanced bacterial activity of the media (Follet *et al*., 1981).

Table 4: Effect of different proportions of vermicompost on shoot length (cm).

Treatments	Shoot length (cm)	
	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	17.27	20.27
T_2 =20 % vermicompost + 80 % soil* for V-1	17.33	22.27
T_3= 30 % vermicompost + 70 % soil* for V-1	21.13	23.80
T_4= 40 % vermicompost + 60 % soil* for V-1	21.88	24.45
T_5= Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	13.27	19.67
T_6= 10 % vermicompost + 90 % soil* for S-36	12.99	18.35
T_7=20 % vermicompost + 80 % soil* for S-36	13.45	18.53
T_8 = 30 % vermicompost + 70 % soil* for S-36	16.33	22.93
T_9 = 40 % vermicompost + 60 % soil* for S-36	18.97	23.28
T_{10}= Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	12.12	17.12
T_{11}= 10 % vermicompost + 90 % soil* for S-13	13.73	19.14
T_{12}=20 % vermicompost + 80 % soil* for S-13	16.03	21.76
T_{13}= 30 % vermicompost + 70 % soil* for S-13	16.93	22.39
T_{14}= 40 % vermicompost + 60 % soil* for S-13	19.03	23.88
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	12.09	19.15
F-test	**	**
SEm±	1.908	0.443
CD @ 5%	5.510	1.278

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Fresh weight of shoot. The data regarding the fresh weight of the shoot was given in Table 5. On sixty days after planting, the fresh weight of shoot was statistically on par in treatments with 20 per cent vermicompost (3.84, 3.39 and 3.59 g), 30 per cent vermicompost (3.90, 3.41 and 3.63 g) and 40 per cent vermicompost (3.96, 3.73 and 3.74 g) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (3.45, 3.33 and 3.46 g), while the minimum fresh weight of shoot (2.74, 2.43 and 2.73 g) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

On ninety days after planting, the fresh weight of shoot was significantly on par in treatments with 20 per cent vermicompost (7.92, 7.62 and 7.83 g),30 per cent vermicompost (7.97, 7.78 and 7.89 g) and 40 per cent vermicompost (8.23, 7.97 and 8.04 g) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (5.97, 5.73 and 5.82 g), while the minimum fresh weight of shoot (5.72, 5.18 and 5.40 g) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

The present results agree with the study of Anusha (2020) who observed maximum fresh weight of shoot (7.97 g) in vermicompost + soil (3:1) which was on par with vermicompost + FYM + soil (1:1:2) (7.92 g) and vermicompost + soil (1:1) (7.93 g). Similarly, Verma (2018) recorded maximum fresh weight of shoot (1.95 g) in vermicompost + soil + FYM in the ratio 1:1:1.

Table 5: Effect of different proportions of vermicompost on fresh weight and Dry weight of shoot (g).

Treatments	Fresh weight of shoot (g)		Dry weight of shoot (g)	
	60th DAP	90th DAP	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	3.45	5.97	0.62	1.18
T_2 =20 % vermicompost + 80 % soil* for V-1	3.84	7.92	0.66	1.42
T_3= 30 % vermicompost + 70 % soil* for V-1	3.90	7.97	0.68	1.45
T_4= 40 % vermicompost + 60 % soil* for V-1	3.96	8.23	0.69	1.47
T_5= Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	2.74	5.72	0.58	1.17
T_6= 10 % vermicompost + 90 % soil* for S-36	3.33	5.73	0.61	1.13
T_7=20 % vermicompost + 80 % soil* for S-36	3.39	7.62	0.63	1.39
T_8 = 30 % vermicompost + 70 % soil* for S-36	3.41	7.78	0.65	1.40
T_9 = 40 % vermicompost + 60 % soil* for S-36	3.73	7.97	0.66	1.42
T_{10}= Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	2.43	5.18	0.55	1.03
T_{11}= 10 % vermicompost + 90 % soil* for S-13	3.46	5.82	0.62	1.16
T_{12}=20 % vermicompost + 80 % soil* for S-13	3.59	7.83	0.65	1.41
T_{13}= 30 % vermicompost + 70 % soil* for S-13	3.63	7.89	0.67	1.42
T_{14}= 40 % vermicompost + 60 % soil* for S-13	3.74	8.04	0.68	1.46
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	2.73	5.40	0.57	1.14
F-test	**	**	**	**
SEm±	0.147	0.148	0.021	0.027
CD @ 5%	0.426	0.427	0.061	0.079

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Dry weight of shoot (g). On sixty days after planting, the dry weight of shoot was significantly on par in treatments with 20 per cent vermicompost (0.66, 0.63 and 0.65 g), 30 per cent vermicompost (0.68, 0.65 and 0.67 g) and 40 per cent vermicompost treatments (0.69, 0.66 and 0.68 g)in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (0.62, 0.61 and 0.62 g), whereas the least dry weight of shoot of mulberry saplings (0.58, 0.55 and 0.57 g)was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 (Table 5).

On ninety days after planting, the dry weight of shoot was significantly on par in treatments with 20 per cent vermicompost (1.42, 1.39 and 1.41 g), 30 per cent vermicompost (1.45, 1.40 and 1.42 g) and 40 per cent vermicompost treatments (1.47, 1.42 and 1.46 g)in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (1.18, 1.13 and 1.16 g), Whereas the least dry weight of shoot (1.17, 1.03 and 1.14 g) was observed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 (Table 5).

The present results are in agreement with the findings of Swati (2019) who reported highest dry weight of shoot (1.20 g) in vermicompost 25 % + sand 50 % + soil 25 %. Similarly, Anusha (2020) recorded maximum dry weight of shoot (1.42 g) in vermicompost + soil (3:1) which was on par with vermicompost + FYM + soil (1:1:2) (1.41 g) and vermicompost + soil (1:1) (1.41 g).

Survival percentage of saplings. The data regarding survival percentage of mulberry saplings was greatly influenced by different proportions of vermicompost (Table 6, Fig. 2).

Survival percentage was recorded on thirty days after planting, the maximum survival percentage (95.66, 93.11 and 94.55 %) was recorded in treatments with 40 per cent vermicompost which wason par with 30 per cent vermicompost (94.00, 92.01 and 93.66 %) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (93.00, 91.66 and 92.55 %) and 10 per cent vermicompost (91.66, 90.22 and 91.34 %), while the minimum survival percentage of mulberry saplings (90.55, 89.33 and 91.55 %) was obtained in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

Similar results are seen in the findings of Anusha (2020) who recorded maximum survival percentage (96.00 %) obtained in vermicompost + soil (3:1) followed by vermicompost + soil (1:1)(93.33 %).

The results are in conformity with the study of Krishan (2018) who observed highest survival percentage (51.10 per cent) in Phalsa (*Grewia asiatica* L.) cuttings, when planted in 100 per cent vermicompost and same author observed maximum survival percentage of 71.10 per cent in mulberry saplings when grown in 100 per cent vermicompost.

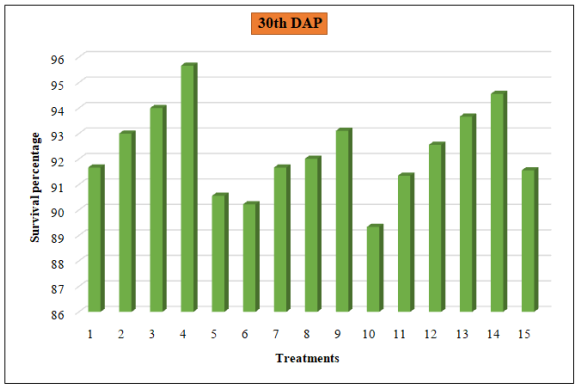

Fig. 2. Effect of different proportions of vermicompost on survival percentage.

Table 6: Effect of different proportions of vermicompost on survival percentage.

Treatments	Survival percentage
	30th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	91.66
T_2 =20 % vermicompost + 80 % soil* for V-1	93.00
T_3= 30 % vermicompost + 70 % soil* for V-1	94.00
T_4= 40 % vermicompost + 60 % soil* for V-1	95.66
T_5= Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	90.55
T_6= 10 % vermicompost + 90 % soil* for S-36	90.22
T_7=20 % vermicompost + 80 % soil* for S-36	91.66
T_8 = 30 % vermicompost + 70 % soil* for S-36	92.01
T_9 = 40 % vermicompost + 60 % soil* for S-36	93.11
T_{10}= Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	89.33
T_{11}= 10 % vermicompost + 90 % soil* for S-13	91.34
T_{12}=20 % vermicompost + 80 % soil* for S-13	92.55
T_{13}= 30 % vermicompost + 70 % soil* for S-13	93.66
T_{14}= 40 % vermicompost + 60 % soil* for S-13	94.55
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	91.55
F-test	**
SEm ±	0.546
CD @ 5%	1.579

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

B. Effect of different proportions of vermicompost on root parameters of mulberry saplings

Rooting percentage. Regarding rooting percentage, there was no significant difference observed between treatments with 20 per cent vermicompost (94.45, 93.11 and 94.33 %), 30 per cent vermicompost (94.58, 94.11 and 94.52 %) and 40 per cent vermicompost (95.60, 94.52 and 94.81 %) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (94.33, 91.78 and 94.11 %), while minimum rooting percentage (77.45, 75.11 and 76.11 %) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 which were recorded on sixty days after planting.

Table 7: Effect of different proportions of vermicompost on rooting percentage.

Treatments	Rooting percentage	
	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	92.73	95.21
T_2 =20 % vermicompost + 80 % soil* for V-1	94.45	95.67
T_3= 30 % vermicompost + 70 % soil* for V-1	94.58	95.81
T_4= 40 % vermicompost + 60 % soil* for V-1	95.60	96.67
T_5 = Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	77.45	85.43
T_6= 10 % vermicompost + 90 % soil* for S-36	91.78	93.52
T_7=20 % vermicompost + 80 % soil* for S-36	93.11	94.81
T_8 = 30 % vermicompost + 70 % soil* for S-36	94.11	95.11
T_9 = 40 % vermicompost + 60 % soil* for S-36	94.52	95.60
T_{10} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	75.11	83.23
T_{11}= 10 % vermicompost + 90 % soil* for S-13	92.04	95.11
T_{12}=20 % vermicompost + 80 % soil* for S-13	94.33	95.33
T_{13}= 30 % vermicompost + 70 % soil* for S-13	94.52	95.52
T_{14}= 40 % vermicompost + 60 % soil* for S-13	94.81	95.77
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	76.11	84.57
F-test	**	**
SEm ±	0.810	1.425
CD @ 5%	2.340	4.115

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Regarding rooting percentage, there was no significant difference between treatments with 20 per cent vermicompost (95.67, 94.81 and 95.33 %), 30 per cent vermicompost (95.81, 95.11 and 95.52 %) and 40 per cent vermicompost (96.67, 95.60 and 95.77 %) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 10 per cent vermicompost (95.51, 93.52 and 95.11 %), while minimum rooting percentage(85.43, 83.23 and 84.57 %) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 which were recorded on ninety days after planting.

Length of longest root (cm). Root length is an indicator of the ability of plants to absorb water from the soil and the capacity to provide the necessary nutrients for the growth and development of saplings (Ankita, 2012).

On sixty days after planting, length of longest root was statistically on par in treatments with 30 per cent vermicompost (6.37, 6.15 and 5.80 cm) and 40 per cent vermicompost (6.65, 6.41 and 6.08 cm) followed by treatments with 20 per cent vermicompost (5.83, 5.75 and 5.64 cm) compared to control (1/3 compost + 1/3 sand + 1/3 red soil) (5.20, 4.37 and 4.40 cm) in all three varieties *viz*., V-1, S-36 and S-13,while shortest root (4.37, 4.31 and 4.33 cm) was observed in treatments with 10 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13.

On ninety days after planting, length of longest root was statistically on par in treatments with 30 per cent vermicompost (11.25, 10.46 and 10.72 cm) and 40 per cent vermicompost (11.65, 10.98 and 11.31 cm) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (10.17, 9.87 and 9.97 cm) and 10 per cent vermicompost (9.81, 9.11 and 9.77 cm),while shortest root (9.50, 8.97 and 9.33 cm) was noticed in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13.

Muscsolo *et al*. (1999) found that soil, FYM, sand, vermicompost (1:1:1:1) recorded the maximum root length (8.50 cm) in carrot (*Daucos carota*). This may be due to vermicompost as part of rooting medium which contain plant growth regulating materials, such as humic acid and plant growth regulating substances like auxins, gibberellins and cytokinins (Tomati *et al*., 1988).

Soil and vermicompost combination gain more EC, has better water and nutrient holding capacity, provides good aeration and contains growth regulating substances as well as beneficial micro- organisms (Moradi *et al*., 2014). All these factors contribute positively towards the root length.

Table 8: Effect of different proportions of vermicompost on length of longest root.

Treatments	Length of longest root (cm)	
	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	4.37	9.81
T_2 =20 % vermicompost + 80 % soil* for V-1	5.83	10.17
T_3= 30 % vermicompost + 70 % soil* for V-1	6.37	11.25
T_4= 40 % vermicompost + 60 % soil* for V-1	6.65	11.65
T_5= Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	5.20	9.50
T_6= 10 % vermicompost + 90 % soil* for S-36	4.31	9.11
T_7=20 % vermicompost + 80 % soil* for S-36	5.75	9.87
T_8 = 30 % vermicompost + 70 % soil* for S-36	6.15	10.46
T_9 = 40 % vermicompost + 60 % soil* for S-36	6.41	10.98
T_{10}= Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	4.37	8.97
T_{11}= 10 % vermicompost + 90 % soil* for S-13	4.33	9.77
T_{12}=20 % vermicompost + 80 % soil* for S-13	5.64	9.97
T_{13}= 30 % vermicompost + 70 % soil* for S-13	5.80	10.72
T_{14}= 40 % vermicompost + 60 % soil* for S-13	6.08	11.31
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	4.40	9.33
F-test	**	**
SEm ±	0.115	0.213
CD @ 5%	0.331	0.615

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

Fresh weight of root (g). At sixty days after planting, fresh weight of root ranged from 0.23 to 0.67 g and the fresh weight of root was observed in treatments with 40 per cent vermicompost (0.67, 0.53 and 0.63 g) was found on par with 30 per cent vermicompost (0.49, 0.42 and 0.45 g)in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (0.45, 0.39 and 0.42 g) compared control (1/3 compost + 1/3 sand + 1/3 red soil) (0.39, 0.30 and 0.34 g), while the treatments with 10 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13 recorded minimum fresh weight of root (0.29, 0.23 and 0.27 g) (Table 9).

At ninety days after planting, fresh weight of root ranged from 1.36 to 1.64 g and there was no significant difference found between treatments with 30 per cent vermicompost (1.55, 1.52 and 1.54) and 40 per cent vermicompost (1.64, 1.63 and 1.63 g) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (1.51, 1.45 and 1.47 g) and 10 per cent vermicompost (1.49, 1.41 and 1.46 g), while minimum fresh weight of root (1.43, 1.36 and 1.41 g) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 (Table 9).

These results are similar to the study of Yadav *et al*. (2012) who observed highest fresh weight of root in acid lime (*Citrus aurantifolia* Swingle) cuttings, in media containing Soil + Sand + Vermicompost + Vermiculite + Coco peat (1:1:1:1). The reason being greater amount of N, P, K present in vermicompost compared to other growth media making it an ideal growth media. Vermicompost having vast surface area results in more microbial activities, provide strong absorbability and beneficial effect of increasing nutrient uptake leading to formation of more roots, higher accumulation of food material as well as longer root length and changes in amino acid metabolism during the regeneration of roots.

Dry weight of the root (g). At sixty days after planting, the dry weight of root was significantly on par in treatments with 40 per cent vermicompost (0.27, 0.23 and 0.25 g) and 30 per cent vermicompost (0.24, 0.19 and 0.21 g) in all three varieties *viz*., V-1, S-36 and S-13 followed by 20 per cent vermicompost (0.17, 0.14 and 0.15 g) compared to control treatments (0.16, 0.13 and 0.15 g), while minimum dry weight of root (0.13, 0.11 and 0.13 g) was recorded in treatments with 10 per cent vermicompost in all three varieties *viz*., V-1, S-36 and S-13 (Table 9).

At ninety days after planting, the dry weight of rootwas significantly on par in treatments with 30 per cent vermicompost (0.68, 0.63, and 0.65 g) and 40 per cent vermicompost (0.71, 0.67 and 0.69 g) in all three varieties *viz*., V-1, S-36 and S-13 followed by treatments with 20 per cent vermicompost (0.59, 0.55 and 0.57 g) and 10 per cent vermicompost (0.57, 0.51 and 0.54 g), while minimum dry weight of root (0.56, 0.50 and 0.53 g) was recorded in control (1/3 compost + 1/3 sand + 1/3 red soil) in all three varieties *viz*., V-1, S-36 and S-13 (Table 9).

The present results agree with the findings of Khot (2017) who reported highest root dry weight with media Soil + Vermicompost (1:1) in Bullock's Heart (*Annona reticulate* L.). This could be due to the application of vermicompost which has resulted in higher number of roots and root fresh weight, which may be the reason for increase in root dry weight.

Table 9: Effect of different proportions of vermicompost on fresh weight and dry weight of root (g).

Treatments	Fresh weight of root (g)		Dry weight of root (g)	
	60th DAP	90th DAP	60th DAP	90th DAP
T_1 = 10 % vermicompost + 90 % soil* for V-1	0.29	1.49	0.13	0.57
T_2 = 20 % vermicompost + 80 % soil* for V-1	0.45	1.51	0.17	0.59
T_3 = 30 % vermicompost + 70 % soil* for V-1	0.49	1.55	0.24	0.68
T_4 = 40 % vermicompost + 60 % soil* for V-1	0.67	1.64	0.27	0.71
T_5 = Control (1/3 compost + 1/3 sand + 1/3 red soil) V-1	0.39	1.43	0.16	0.56
T_6 = 10 % vermicompost + 90 % soil* for S-36	0.23	1.41	0.11	0.51
T_7 = 20 % vermicompost + 80 % soil* for S-36	0.39	1.45	0.14	0.55
T_8 = 30 % vermicompost + 70 % soil* for S-36	0.42	1.52	0.19	0.63
T_9 = 40 % vermicompost + 60 % soil* for S-36	0.53	1.63	0.23	0.67
T_{10}= Control (1/3 compost + 1/3 sand + 1/3 red soil) S-36	0.30	1.36	0.13	0.50
T_{11} = 10 % vermicompost + 90 % soil* for S-13	0.27	1.46	0.13	0.54
T_{12} = 20 % vermicompost + 80 % soil* for S-13	0.42	1.47	0.15	0.57
T_{13} = 30 % vermicompost + 70 % soil* for S-13	0.45	1.54	0.21	0.65
T_{14} = 40 % vermicompost + 60 % soil* for S-13	0.63	1.63	0.25	0.69
T_{15} = Control (1/3 compost + 1/3 sand + 1/3 red soil) S-13	0.34	1.41	0.15	0.53
F-test	**	**	**	**
SEm±	0.066	0.031	0.004	0.012
CD @ 5%	0.189	0.090	0.011	0.036

** Significant at 5%, DAP- days after planting, * Sand + Red soil (Equal proportion)

APPENDIX

Plate 1: General view of the experimental site.

Plate 2: Planting of cuttings in polythene bags.

Plate 3: Sprouted cuttings of mulberry.

Plate 4: General view of plot after 60th DAP in different proportions of vermicompost.

Plate 5: General view of plot after 90th DAP in different proportions of vermicompost.

Plate 6: Mulberry saplings grown in different proportions of vermicompost on 90th DAP.

CONCLUSIONS

The present study has revealed that 20 per cent vermicompost, 30 per cent vermicompost and 40 per cent vermicompost have performed better with respect to shoot and root parameters compared to control (1/3 compost + 1/3 sand + 1/3 red soil).

FUTURE SCOPE

Since the current study has revealed that 20 percent vermicompost as a component of rooting media is good enough in terms of overall performance of mulberry saplings and economics it can be extended to the field in future for economical and vigorous mulberry sapling production

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