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# Physico-Chemical Properties and Plant Growth Characteristics of Tomatoes Grown Using Different Media

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author ES designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ES and HGN managed the analyses of the study. Author NVA managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

Soilless culture is a technique of crop production using no soil. The main reason towards need for soil to soilless culture for horticultural crops is the problem related to proliferation of soil borne pathogen in the soil cultivation. Recent research studies reported that commercial production of greenhouse vegetables with soilless media has paved the way for reduction in economic losses caused by soil-borne pathogens. In this context, the present study was initiated to identify suitable substrate mixes for soilless culture. The experiment was laid out in a randomized block design. There were fifteen different media levels including control, with three replications. Crop Tomato TNAU hybrid CO3 were assessed for the mean performance in respect of growth characters namely shoot length, root length, germination percent and vigour index. The treatment Vermicompost: Coir pith (3:1) was found to have the highest value for growth characters for the crop. With regard to the physical and chemical properties, all combination media showed optimal range for crop growth. Further a cost analysis was made to find the suitable media based on cost aspects comparing

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reduction in vigour index and cost of media with that of best media. Treatment $T_7$ (Vermicompost: coir pith (2:1)) and $T_6$ (Vermicompost: Coir pith (1:3) were found to be the best media considering above factors.

*Keywords: Physio-chemical properties; plant growth characteristics; soilless growing media; cost analysis.*

## 1. INTRODUCTION

Soil-based agriculture is facing some major challenges with the advent of civilization all over the world, such as decrease in per capita land availability, non-availability of work force, incidence of pests and diseases, etc. Apart from this, due to rapid urbanization and industrialization as well as threats from climate change and its related adverse effects, the land cultivation is going to face further challenging threats. Under such circumstances, in the near future it becomes intricate to feed entire population using the production from soil field system. Naturally, soilless culture is gaining its relevance in the present scenario, to cope-up with these challenges. Soilless culture is the modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. Possibly it is the most intensive culture system utilizing all the resources efficiently for maximizing yield of crops and the most intense form of agricultural enterprises for commercial production of vegetables. Several studies suggested that soilless culture is an alternative to traditional field production for high-value vegetable crops. Md. Asaduzzaman et al. [1] reported that the quality of horticultural crops grown through soilless culture improves significantly compared to conventional soil culture. This artificial growing system provides plants with mechanical support, water and mineral nutrient for higher growth and development. Soilless growing media are easier to handle and it may provide better growing environment (in terms of one or more aspects of plant growth) compared to soil culture. Organic substrates includes sawdust, coco peat, vermicompost, peat moss, woodchips, fleece, marc, bark, etc. whereas, inorganic substrate of natural origin are perlite, vermiculite, zeolite, gravel, rock wool, sand, glass wool, pumice, sepiolite, expanded clay, volcanic tuff and synthetically produced substrates are hydrogel, foam mates (polyurethane), oasis (plastic foam), etc. Various raw materials have been used to produce growing media for vegetable production throughout the world. The present research was initiated in this context to analysis the physico-chemical properties of different growing media, to conduct germination studies to find the best media and to assess the economic viability of growing media to establish suitable substratum mixes for soilless cultivation.

## 2. METHODOLOGY

The field experiment was conducted in the farm Imayam Institute of Agriculture and Technology, Thuraiyur. The experimental site lies geographically in between 11° 8’ 29” N latitude and 78° 35’ 40” E longitude and at an altitude of 151 m above mean sea level. The experiment was designed under randomized block design as 15 treatments with three replications as mentioned in Table (1). The loamy soil available was used as control. Physico and chemical properties of media like bulk density, particle density, porosity, pH and EC were analyzed by standard procedure reported by Keen and Rackzowski [2]. The climatic parameters such as temperature and relative humidity are monitored at 8.30 am and 2.30 pm with the digital thermo hygrometer throughout the crop growth period of 09.03.2019 to 08.04.2019.

Hybrid variety of Tomato crop (CO3) 20 days seedlings with three replications were taken for the study and their physiological parameters and growth characteristics were determined as follows.

### 2.1 Root Length

Root length was measured from the collar region to the tip of the primary root and the average expressed in centimeters.

### 2.2 Shoot Length

The length from the collar region to the tip of the shoot was measured as shoot length and the average was expressed in centimeters.

### 2.3 Germination Percentage (GP)

The germination percentage was calculated based on formula:

$$GP = \frac{No.of\ sprouted\ seed}{No.of\ total\ seeds} x\ 100 \quad (1)$$

## 2.5 Vigour Index (VI)

$$VI = GP\ x\ (Root\ length, cm\ +\ Shoot\ length, cm) \quad (2)$$

## 2.6 Statistical Analysis

Statistical analysis (AGRES) was carried out to study the effects of alternate growing systems in plant growth parameters. Least significant differences test (LSD) was used to compare the significant differences among mean of the treatments at 0.05 level of probability.

## 2.7 Cost Analysis

Cost analysis was used to find out the best suitable media which has the lowest % reduction in vigour index along with percentage reduction in total cost.

**Table 1. Media and their combinations for different treatments**

| Treatment | Growing media(v/v) |
|---|---|
| $T_1$ | Coir pith |
| $T_2$ | Sawdust |
| $T_3$ | Vermicompost |
| $T_4$ | Vermicompost : Coir pith (1:1) |
| $T_5$ | Vermicompost : Coir pith (1:2) |
| $T_6$ | Vermicompost : Coir pith (1:3) |
| $T_7$ | Vermicompost : Coir pith (2:1) |
| $T_8$ | Vermicompost : Coir pith (3:1) |
| $T_9$ | Vermicompost : Sawdust (1:1) |
| $T_{10}$ | Vermicompost : Sawdust (1:2) |
| $T_{11}$ | Vermicompost: Sawdust(1:3) |
| $T_{12}$ | Vermicompost : Sawdust (2:1) |
| $T_{13}$ | Vermicompost : Sawdust (3:1) |
| $T_{14}$ | Vermicompost : Coir pith: Sawdust (1:1:1) |
| $T_{15}$ | Control (Clay loam) |

## 3. RESULTS AND DISCUSSION

The study identified a suitable growing media for tomatoes. In this context the physico chemical characteristics of growing media were analyzed and the environmental factors like temperature and relative humidity were recorded. The effects of growing media on plant growth character were observed. The cost analyses were done to determine the best media for crop growth. The observations of the study were analyzed and the results are as follows.

### 3.1 Selection of Suitable Growing Media Based on Physico-chemical Properties, Climatic Parameters, Physiological Parameters

**Bulk density:**

Bulk density of medium is one of the indices for the evaluation of physical conditions of the growing media. Optimum bulk density for optimal plant growth ranges between 0.25 to 0.58 g $cm^{-3}$ and it is high as 1.3 g $cm^{-3}$ [3]. In this study the combination of Vermicompost: Coir pith (3:1) ($T_8$) was observed with bulk density of 0.55 g $cm^{-3}$ was in the recommended range. The highest value of bulk density was observed for loamy soil (1.3 g $cm^{-3}$) and the lowest bulk density was noticed in coir pith (0.28 g $cm^{-3}$) as individual media whereas in combination media, $T_9$ - Vermicompost: Sawdust (1:1) recorded the lowest value (0.35 g $cm^{-3}$).

**Porosity:**

The porosity characteristics of a media are measured in terms of Total Porosity (TP), Air Filled Porosity (AFP) and Water Holding Capacity (WHC). The highest porosity was obtained for coir pith (88%) followed by Vermicompost: Coir pith (3:1) (78%) while loamy soil had low porosity (40%). In general, all combination media almost showed optimal total porosity (65 – 80%), air filled porosity (20 - 30%) and water holding capacity (45- 55%). These results are in conformity with the results reported by Di Lorenzo et al. [4]. Raviv and Lieth [5] reported that most media and mixes have an air filled porosity of 10-30%. The results obtained in this experiment are similar and all media combinations employed as treatments have shown ideal porosity characteristics.

**pH Value variation in treatments:**

The values were all in slightly acidic or neutral range except for the control. The highest pH was observed in treatments $T_3$ - (7.32) and in control (7.57) but in the case of media combination the highest pH was observed in $T_{13}$ (7.05), the lowest value of pH was observed in the case of media $T_1$ - (6.1). The pH is an important factor in the availability and the uptake of nutrients and satisfactory pH of the medium ranged between 5.5 and 6.5 as reported by Waters et al*.,* 1970.

**EC value variation in treatments:**

The EC value of the different media varied between 0.13 to 0.45 dS $m^{-1}$ during the growing period. The maximum EC value of 0.45 dS $m^{-1}$ was recorded for $T_3$ (Vermicompost) and the lowest value for $T_2$ - Sawdust (0.13 dS $m^{-1}$). According to the results of Bunt [6] there was no salinity problem in the substrates. Substrate should have low salinity because it decreases mineral acquisition and salts that enter the soil decrease the capacity of roots to absorb water by decreasing the potential gradient from the soil to the roots. The EC values were below the established limit (0.5 dS $m^{-1}$) for an ideal substrate reported by Abad et al. [7]. The low pH and EC values might have been ideal for crop growth whereas the high values recorded for these parameters might have led to reduced plant growth as already reported by Francesco et al. [8].

### 3.2 Variation of Temperature and Relative Humidity during the Growth Period

The maximum, the minimum temperature and relative humidity were 38.5°C, 26.0°C and 79%, 26% respectively was recorded during the crop growing period. For most of the days, the temperature exceeded 35°C during the recorded time.

Ganesan, [9] reported that the average 24 h temperature is believed to be responsible for the growth rate of the crop the higher the average air temperature, the faster the growth. Higher humidity was observed during morning hours and gradually decreased in the afternoon because of increase in temperature. Growth is positively correlated to relative humidity and normal plant growth occurs at relative humidity of 25 - 80 percent.

### 3.3 Effect of Different Growing Media on Plant Growth Parameters

Significant differences were observed in the mean shoot length, root length, germination percentage and vigour index between treatments. Treatment $T_8$ (Vermicompost : Coir pith- 3:1) and treatment $T_2$ (Sawdust) recorded the highest and lowest root length, shoot length, germination percentage and vigour index as 18 cm, 9.0 cm, 80.11%, 3.18 and 8.1 cm, 3.2 cm, 36.13%, 2.47 respectively, 30 days after sowing (DAS). The variations are graphically illustrated in Figs. (1 to 4).

The significant increase in plant growth in treatment $T_8$ (Vermicompost: Coir pith - 3:1) may be related to the good physical properties of vermicompost and due to high organic matter, macro and micronutrient content present in it. The $T_8$ and $T_2$ treatments were shown in Figs. 5 and 6 which was taken on 30 days after sowing. Similar results were obtained by Umamaheswari, [10] who reported that the vermicompost is the granular aggregate, the stability of which is due to the mucopolysaccharides of microbes and earthworms and it is rich in plant nutrient.

**Table 2. Vigour index, reduction in vigour index (%), total cost of the media (Rs/$m^3$) and increase or decrease in cost (%) compared with best media $T_8$ (Vermicompost : Coir pith - 3:1)**

| Treatments | Vigour index (VI) | % Reduction in VI | Total cost (Rs)/$m^3$ | % Increase or decreases in Total cost |
|---|---|---|---|---|
| $T_1$ | 2.77 | 12.9 | 1400.0 | -68.0 |
| $T_2$ | 2.47 | 22.3 | 1020.0 | -76.7 |
| $T_3$ | 3.02 | 4.8 | 5360.0 | 22.7 |
| $T_4$ | 2.91 | 8.5 | 3380.0 | -22.7 |
| $T_5$ | 2.80 | 11.7 | 2692.8 | -38.4 |
| $T_6$ | 3.04 | 4.3 | 2390.0 | -45.3 |
| $T_7$ | 3.10 | 2.3 | 3999.6 | -8.5 |
| $T_8$ | 3.18 | 0.0 | 4370.0 | 0.0 |
| $T_9$ | 2.96 | 6.9 | 3190.0 | -27.0 |
| $T_{10}$ | 2.86 | 10.1 | 2442.0 | -44.1 |
| $T_{11}$ | 2.98 | 6.3 | 2105.0 | -51.8 |
| $T_{12}$ | 2.84 | 10.7 | 3874.2 | -11.3 |
| $T_{13}$ | 2.73 | 14.0 | 4275.0 | -2.2 |
| $T_{14}$ | 2.77 | 12.9 | 2567.4 | -41.2 |
| $T_{15}$ | 2.63 | 17.2 | | |

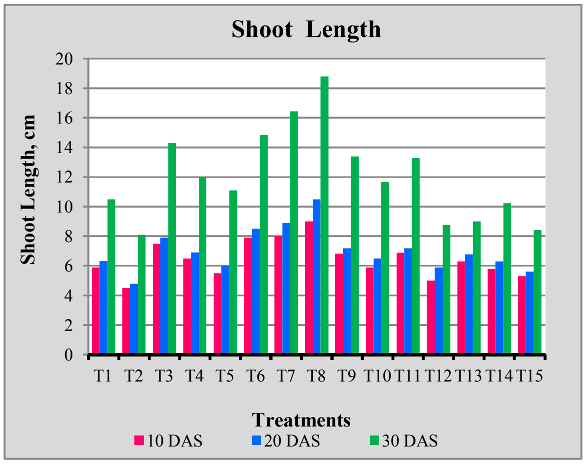


Fig. 1. Effect of different growing media on shoot length (cm)

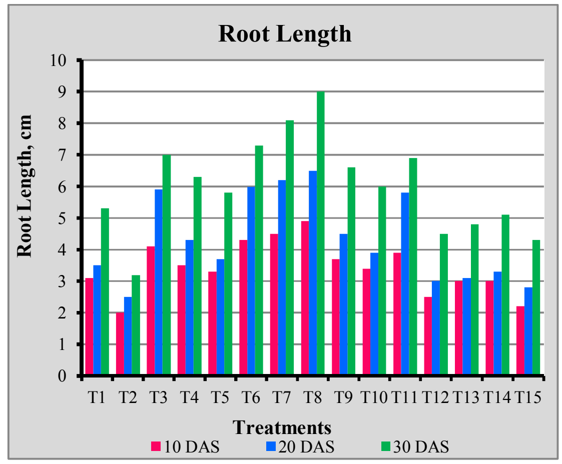


Fig. 2. Effect of different growing media on Root length (cm)

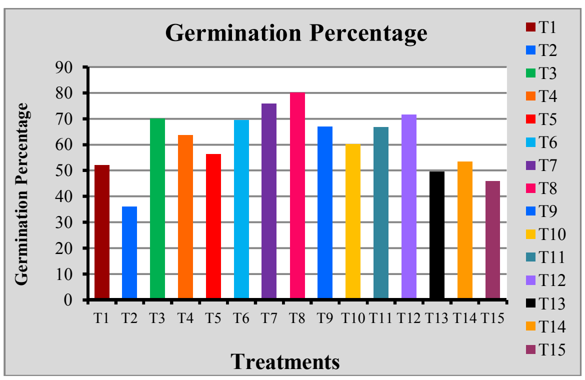


Fig. 3. Effect of different growing media on germination percentage

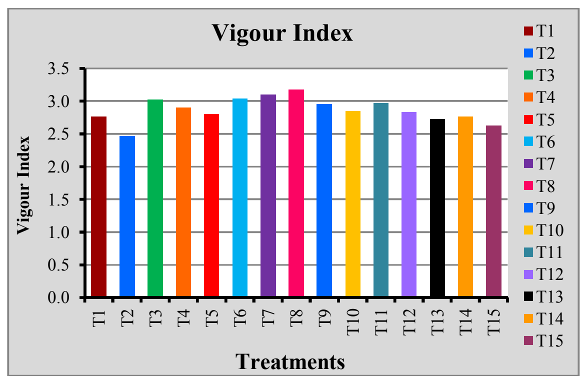


Fig. 4. Effect of different growing media on vigour index

Fig. 5. Treatment $T_8$

Fig. 6. Treatment $T_2$

### 3.4 Cost Analysis of Growing Media

Based on all treatments conducted $T_8$ displayed more positive influence on plant growth but was costly based on economic aspects (Rs. 4370.0). As compared to $T_8$, treatments $T_7$ and $T_6$ shows the lowest reduction in vigour index (2.3% and 4.3%) and the highest reduction in cost (-8.5%

and -45.3%), respectively. Based on the above analysis regarding performance of different media, $T_6$ and $T_7$ may be suggested as suitable and economically viable media (Table 2).

## 4. CONCLUSION

The plant growth was high in treatments where coir pith was present as combination media, probably because it has good physical properties such as high water holding capacity, good aeration and excellent thermal properties and it enhanced root and shoot development throughout crop period. The treatment $T_2$ and treatments in combination with sawdust showed poor performance compared to other media. The results of the present study showed that a growing medium consisting of Vermicompost: Coir pith (3:1) positively affects the plant growth and increases the yield. Based on cost analysis T7 (Vermicompost: Coir pith (2:1)) and T6 (Vermicompost: Coir pith (1:3)) were suggested as suitable and economically viable media because if compared with other media and combinations these media mixtures showed low reduction in vigour index (2 - 4%) and low price (3999.00/$m^3$ and 2390.00/$m^3$). Treatment $T_7$ (Vermicompost: coir pith (2:1)) and $T_6$ (Vermicompost: Coir pith (1:3) were found to be the best media considering above factors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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