Research Article

Effect of Growing Media on Plant Growth of Rough Lemon (*Citrus jambhiri* Lush.) and Poncirus (*Citrus trifoliata*)

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Abstract | The research was conducted at Citrus Research Institute, Sargodha to check the influence of growing media (peat mass, compost, soil, silt, sand, sawdust and leaf manure) in 14 different combinations of growth media to check for plant growth of rough lemon and poncirus rootstocks. Five plants per treatment were growing in black polythene bags filled with the required media using a Completely Randomized Design with three replications. Data of stem length stem diameter, number of leaves, leaf area, and survival percentage was recorded. Chemical analysis of leaf was done by taking samples from treatments were analyzed for determination of N, P, K. Results indicated that stem length, stem diameter, number of leaves, leaf area and survival percentage were significant in different growing media after everyone months of transplantation. Various media i.e. peatmass+soil+sawdust, leafmanure+soil+sawdust, compost+silt+sawdust, leaf manure+silt+saw dust, compost+soil+sand was proved promising growing media than the other treatments. However, T_8 proved superior in rough lemon (*Citrus jambhiri*) than other treatments. Minimum stem length, stem diameter, number of leaves, leaf area and survival percentage was recorded in soil (control) that might be due to low fertility in the medium. Overall results suggested that plant growth was better on leaf manure+silt +straw, peat mass+soil+saw dust, and leaf manure+soil+sawdust as compared to other treatments due to the use of peat and compost.

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1. Introduction

Fruit sector of Pakistan is dominated by citrus both in area and production. Citrus fruit plays a major role in human diet, worldwide. Commercially important citrus species include oranges, mandarin, limes, lemon, and tangerines. Citrus fruits are grown in the tropical and sub-tropical regions in the northern hemisphere of more than 140 countries of the world. Major citrus producing countries of the world are Brazil, China, India, Mexico, USA and Spain. Pakistan is at the 13th position among citrus growing countries of the world and citrus occupies the first rank with respect to area and production among all fruits. Global average production of citrus is 1760.3 thousand tons on an area of 176.5 thousand hectares. Punjab shares 94 and 96 percent in area and production, respectively (Malik *et al*., 2016). Kinnow is the major species that maintains its monopoly in Pakistan among other citrus species with 95% share. It is grown at 200,000 hectares (2.25% of the world) due to suitable climatic and soil conditions. The annual average yield is 2.2 million tones and having an export of 192 thousand tons per year and fetching

7,518 million rupees (GOP, 2019).

Growing media are soilless materials necessary for the growth of plants. These can be non-inert material or organic materials consist of such as (compost, peat, coconut (*Cocos nucifera* L.), tree bark, coir and poultry feathers) and inert material or inorganic materials (perlite, clay mineral wool, and vermiculite). Inert substances do not supply any nutrition to the plants so all nutrition comes from the nutrient solution while these substrates can be used alone or mixture are also being used widely (Grunert *et al*., 2008; Vaughn *et al*., 2011). Growing media not only provide mechanical support to plant but also act as a resrvoir for nutrient and water, and a source of nutrient for plant growth (Richard *et al*., 1986; Agro, 1998; Abad *et al*., 2002). In different parts of the world, growth media like peat moss, vermicompost, sawdust and fine sand are used successfully having key role in improving seed germination and enhanced rates of seedling growth and development (Mhango *et al*., 2008). The potting media is considerably capable to change canopy development pattern and function for e.g. photosynthesis (Richardson *et al*., 2003).

A potting medium must have organic matter required for the physical and chemical needs of the crop to attain its potential growth and development. According to Khan *et al*. (2006) good potting media management is essential for the production of quality fruit tree seedlings, since vigorous growth is needed to face the seasonal hazards encountered on the field. Nasir *et al*. (2011) reported that a growing media containing different mixture of loam, sand and cattle manure at a ratio of 2:1:1 had a significant effect on the growth of sour orange and troyer citrange container-grown seedling. Similarly, maximum growth was observed in *Citrus limonia* Osbeck container-grown nursery plants in mixture of cattle manure, lignite and two commercial products, Agrohumus 51 and 61 (Grassi *et al*., 1999). Optimum water holding capacity, electrical conductivity, pH, better aeration and organic matter of a medium are the dominant factors considered when choicing materials for a potting medium (Khan *et al*., 2006). Poor structural composition of the media arising from the physical status of the potting sources may have resulted in poor aeration, water holding capacity and nutrient utilization. Hazarika and Aheibam (2019) conducted research project on combinations of organic and inorganic fertilizers which showed that 75% N through FYM +25% through inorganic fertilizer+Azotobacter+phosphate solubilizing bacteria+potash solubilizing bacteria revealed highest growth, development, yield and quality of lemon. The objective of current research work was conducted to evaluate influence of different combinations of growing media required for the healthy growth of citrus rootstocks seedlings.

2. Materials and Methods

This trial was done during 2013-14 at Citrus Research Institute (CRI), Sargodha to evaluate the effect of different growing media for rough lemon. For the propose of study seven different growing media i.e. peat mass, compost, soil, silt, sand, saw dust and leaf manure were used. The treatments included T_0= soil (heavy loam having pH 6.5 and 1.5 dSm^{-1} EC level), T_1= soil+silt+sand, T_2= peatmass+silt+sand, T_3= compost+silt+sand, T_4= leaf manure+silt+sand, T_5=soil+silt+saw dust, T_6=peatmass+silt+saw dust, T_7=compost+silt+saw dust, T_8=leaf manure+silt+saw dust, T_9=compost+soil+sand, T_{10}=peat mass+siol+sand, T_{11}=leaf manure+soil+sand, T_{12}=compost+soil+saw dust, T_{13}=peat mass+soil+saw dust and T_{14}=leaf manure+soil+saw dust. Five plants per treatment were grown in black polythene bags filled with the required media in completely randomized design with three replications. Data was recorded on plant parameter like height, stem diameter, leaves per plant, leaf area, survival rate (% age) and tissue analysis for nitrogen, posphorus and potassium using following methodology.

2.1 Methodology for tissue N analysis

To one gram of plant material, added 30 ml of concentrated H_2SO_4 and 10 g digestion mixture (K_2SO_4: $FeSO_4$:$CuSO_4$, 10:1:0.5) and then digest the sample on gas heater using Kjeldahl flask. Cooled and made the volume 250 ml. 10 ml Aliquot was taken from this for distillation of ammonia in to a receiver containing boric acid (4%) and mixed indicator (Bromocresol green and methyl red) and titrated against standard H_2SO_4 (Jackson *et al*., 1973).

2.2 Methodology for tissue P analysis

One gram of plant material was digested in 20 ml concentrated HNO_3 and 10 ml $HCIO_4$ (72%), cooled the digest, transferred to 100 ml. volumetric flask and made the volume with distilled water (Method 54a 1. To 5 ml aliquot taken in 50 ml volumetric flask, added 5 ml each of H_2S0_4 (1+6), ammonium molybdate

(5%) and ammonium vanadate (0.25%), made the volume up to the mark and allowed to stand for 15-30 minutes. Yellow color was developed. Reading was recorded on colorimeter using blue filter (Cotton, 1945).

2.3 Methodology for tissue K analysis

One-gram plant material was digested in 20 ml of concentrated $HN0_3$ and 10 ml of 72% MCIO4. Cooled the digest, transferred in 100 ml volumetric flask and made the volume. Available potassium was determined by Sherwood- 410 Flame Photometer. A series of KCl solutions (2, 4, 6, 8, 10, 12 and 14 ppm K^+) were used to standardize the Sherwood-410 Flame Photometer. Sample readings were recorded and concentrations (ppm) were calculated from regression equation obtained by plotting concentration of standards against their readings from flame photometer (Cotton, 1945).

$$K\ percentage = \frac{ppm\ from\ regression\ equation}{104}$$

2.4 Statistical analysis

Data of the experiment was subjected to statistical analysis in Complete Block Design (CRD). Significance of the differences among the treatments and were determined using LSD Test (Steel *et al.*, 1997).

3. Results and Discussions

3.1 Plant height (cm)

The plant height data were collected each month for six months of shifting of seedlings. The increase in stem length after every one month up to six months of transplanting (Figure 1). The analysis of variance of plant height showed significant results for standardization of potting media for citrus nursery production. T_8 exhibited maximum plant height which was at par with T_{13}, T_9, T_{14} followed by T_{10}, statistically the treatments, T_4, T_5, T_3, T_1 were non-significant. The treatment T_0 showed minimum plant height. Results showed that T_9 exhibited overall best growth throughout the experiment period while T_{11}, T_7, T_6, T_2 initially behaved poorly and improved gradually after 6 months they produced plants with similar in height to T_1 treatment.

Leaf analysis showed that optimum and beneficial concentration of N, P and K were recorded in treatments T_8, T_{13} and T_{14} respectively. Maximum height in T_9 might be due to maximum uptake of these nutrient elements. Adequate levels of these nutrients have been considered vital for best growth of plant. Such results are parallel with previous findings, which proved that the growth rate, plant height, vegetative growth and root fresh weight were increased in media containing sand + peat (1:4) Sand plus river sand mixed with sugarcane waste and mushroom compost by reporting similar results by Ma *et al.* (2000). Results are also supported by Willson and Stoffella (2003) described that plants grown in media amended with compost generally produced slightly taller plants than when grown in soil or silt based media. Riaz *et al.* (2008) recorded highest plant height of zinnia in a potting mixture of silt+leaf manure+coconut compost (1:1:1).

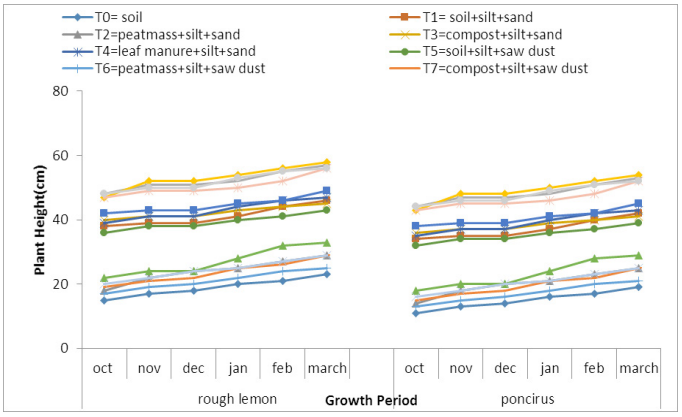

Figure 1: Effect of different potting media on plant height of rough lemon and poncirus during the growth period.

3.2 Stem diameter (mm)

The analysis of variance of stem diameter of each treatment gave highly significant results for standardization of potting media for citrus nursery production in containers. The data on stem diameter taken one-month interval up to six months, after transplanting of seedling was recorded. By studying the means of stem diameter of each treatment it, was depicted that maximum stem diameter was found in T_8 while minimum was in T_0. The treatments T_{13} and T_{14} produced statistically similar results having 4.9 and 4.97 mm stem diameter, respectively. The treatments T_3 and T_6 were at the same level of significance with 1.62 and 1.68 mm stem diameter, respectively. However, the treatments T_0, T_8, T_9, T_{10} and T_{11} were not at par, when statistically examined, all these treatments showed 1.73, 2.03, 1.57, 1.83 and 1.81 mm stem diameter, respectively. The increase in

stem diameter after every one month up to six months of transplanting (Figure 2). It is evident that after one month there was slight difference in, stem diameter among all the treatments whereas after second month T_1 remained superior at the end of experiment.

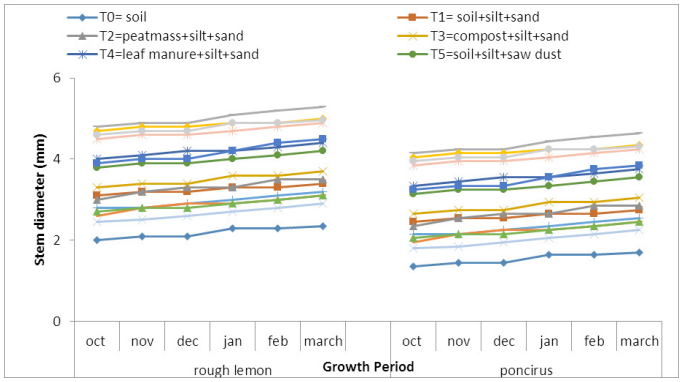

Figure 2: Effect of different potting media on stem diameter of rough lemon and poncirus during the growth period.

A study conducted by Ma *et al.* (2000) showed that media containing peat+sand (1:4) exhibited maximum plant growth and stem diameter of citrus seedlings. However, Anvari *et al.* (1994) observed maximum stem diameter of plants in media containing sand and manure. This media was also best favored for plant growth and development. In our experiment the better results on T_9 treatment media indicated that it fulfills the proper nutrient (N. P and K) as well as belter soil structure (moisture % total porosity) requirements of rough lemon seedling growth.

3.3. Number of leaves

The analysis of variance of number of leaves/ plants of each treatment gave highly significant differences for standardization of potting media for citrus nursery production in containers. The number of leaves / plant after every one month up to six months of transplanting of seedling was recorded. It was revealed that maximum number of leaves/plant was recorded in T_{13}, while minimum number of leaves/plant were found in T_0 and T_2 treatments respectively (Figure 3). The treatments T_5 and T_{10} did not differ significantly from each other as having 11.46 and 11,20 number of leaves per plant. The treatments T_2 and T_8 were also statistically at par having 10.86 and 10.83 number of leaves/plant, respectively. Whereas T_0, T_7 and T_9 showed statistically different results with 10.63, 11.74 and 9.82 number of leaves/plant, respectively. Similar results were obtained from treatments T_3 and T_{11} which were statistically non-significant. Current results are in line with the findings of Bhagat *et al.* (2013) who used organic matter sources (cocopeat and vermicompost) to improve the proportion of Kinnow mandarin resulted in higher seedling height, stem diameter, number of leaves, leaf area and root–shoot ratio compared with control. This might be due to increase water-holding capacity.

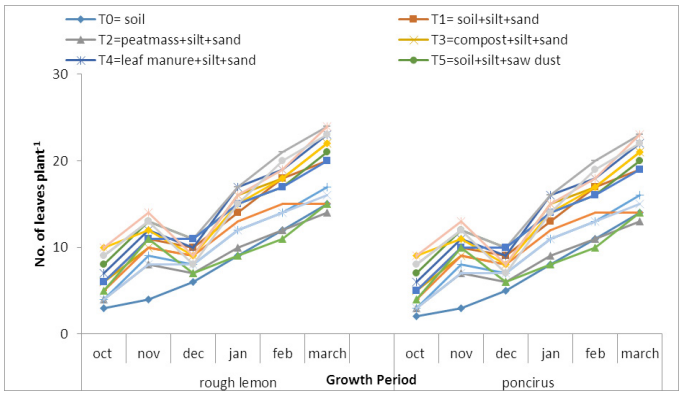

Figure 3: Effect of different potting media on number of leaves per plant of rough lemon and poncirus during the growth period.

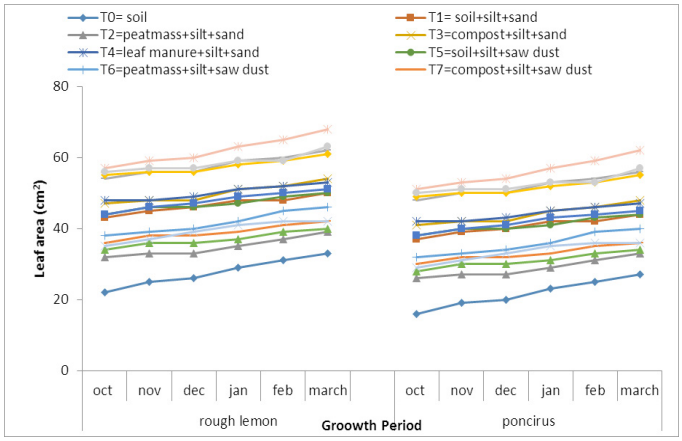

Figure 4: Effect of different potting media on stem thickness of rough lemon and poncirus during the growth peri.

3.4 Leaf area (cm^2)

The means of leaf area were significantly different from one another (Figure 4). The leaf area after every one month up to six months of transplanting of seedling was recorded. The means of leaf area depicted that maximum (10.52, 10.60 and 11.18 cm) for T_1, T_8 and T_{11} respectively while minimum leaf area (5.93 cm^2) was found in T_4. The treatments T_2 and T_{10} produced statistically similar results having 8.79 and 8.75 cm leaf area, respectively. The treatments T_6 and T_7 also showed statistically no differences having 7.04 and 6.96 cm leaf area, respectively. Whereas the treatments T_5 and T_8 had statistically dissimilar results having

9.66 and 7.61 cm^2 leaf area, respectively. Treatments T_0 and T_3 were statistically at par having 6.32 and 6.41 cm^2 leaf area, respectively.

Previously, Grassi *et al.* (1999) and Ma el at. (2000) conducted experiment on different types of media and observed that the media consisting 50% river sand to which different amount of peat and organic compounds were added showed the best results for growth of citrus rootstock seedlings. Leaf area was depended on plant growth and leaf retention on stem.

3.5 Survival percentage (%)

Survival percentage at the end of experiment was recorded which showed that minimum survival percentage (40%) was recorded in the treatment T_0 and maximum (80%) was noted in the treatment T_8. Survival percentage is an important factor for the standardization of potting media. Treatments T_0, T_2, T_4, T_6, T_9, and T_{11} showed high percentage of survival i.e. 38, 30, 56, 48, 46 and 26% respectively. Low percentage of survival i.e. 10, 22, 14 and 12%, respectively, was observed in treatments T_5, T_7, T_8 and T_{10} as compared to other treatments (Figure 5).

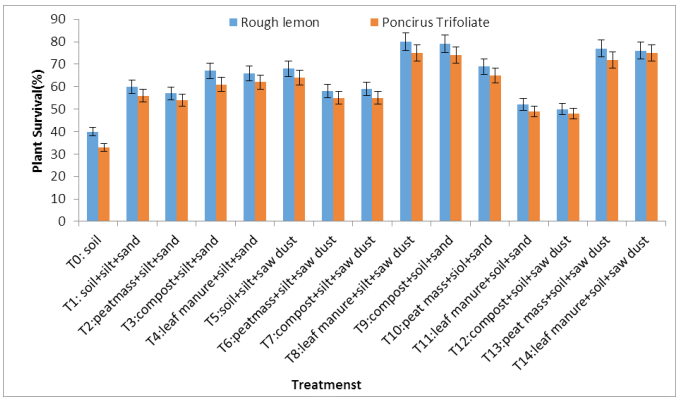

Figure 5: Survival percentage of rough lemon and poncirus as affected by different treatments of soil medium.

Maximum survival and poor plant growth were recorded in treatment T_3 and T_8, where leaf manure+soil+saw dust were applied without combination with peat moss. This might be due to high toxicity present in spent compost mushroom and farmyard manure which might be due to balanced nutrient availability due to organic matter. Mazhabi *et al.* (2011) observed more or less similar results and reported that coco-peat in tulip.

3.6 Nitrogen (%) in leaf tissues

There were non-Significant trends of nitrogen percentage in rough lemon leaves. Results indicated that maximum Nitrogen content (3.36%) was observed in T_8, while minimum (2.44%) was in T_0 leaves. Leaf analysis showed the maximum concentration of N in T_8, T_{11} and T_1 treatments (Figure 6). There was maximum plant height in T_1 and it might be due to maximum uptake of these nutrient elements. Adequate levels of these nutrients have been considered vital for best growth of plant. Range of different levels of nitrogen contents in leaves of plants and affected by different types of potting media for citrus nursery grown in containers. Our results are supported by the observation taken by Wilson and Stoffella (2003). They found that leaf nitrogen concentration was higher in plants grown in 50% compost media than in 100% compost or peat based media.

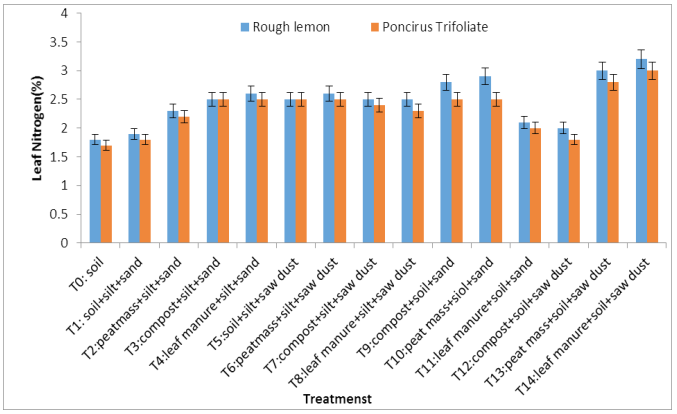

Figure 6: Nitrogen contents in leaves of rough lemon and poncirus as affected by different treatments of soil medium.

3.7 Phosphorus (%) in leaf tissues

A non-significant trend of phosphorus content (%) was recorded in rough lemon leaves. Results indicated that maximum phosphorus content in leaves (0.26%) was observed in T_7, while minimum phosphorus content (0.15%) was recorded in T_0. Leaf analysis showed that optimum concentration of Phosphorus was in all treatments except T_0. Maximum growth measured as height in T_{13} and they could be due to maximum uptake of P. Adequate levels of P has been considered vital for best growth of plant. Different levels of Phosphorus contents in leaves are affected by different types of potting media for citrus nursery grown in containers (Figure 7). These results are supported by the findings of Wilson and Stoffella (2003), who observed that Phosphorus contents was higher when plants were grown in 100% compost as compared to 100% peat based porting medium.

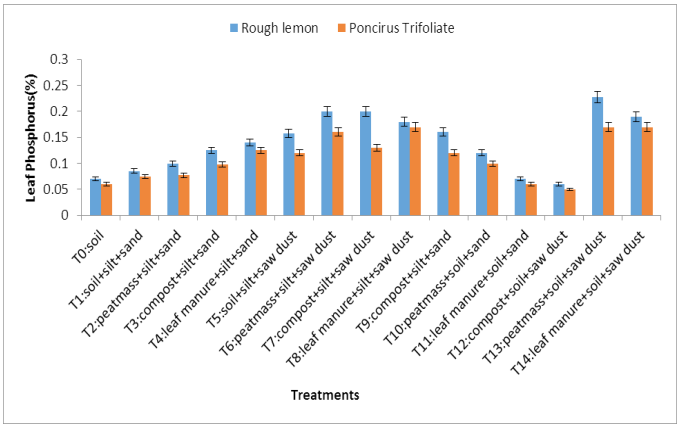

Figure 7: Effect of different potting media on Leaf P of rough lemon and poncirus.

3.8 Potassium (%) in leaf tissues

There were non-significant differences in potassium percentage in leaves of rough lemon. Results indicated that maximum potassium content in leaves (4%) was observed in T_4, while minimum potassium content (1%) was recorded in rest; other treatments (Figure 8). Leaf analysis showed that optimum concentration of K (1%) was recorded in T_0, T_1, T_2, T_5, T_8. Maximum growth measured as height in T_{13} may be due to optimum uptake of K element. Adequate level of potassium has been considered vital for best growth of plant. Range of different levels of Potassium contents in leaves of plants are affected by different I type of potting media for citrus nursery grown in containers (Figure 8). The enhancement of potassium contents must be due to mmore availability of more activity of micro-organisms which are similar with outcomes of Singh *et al.* (2018) who demonstrated that bio-inoculants enhance growth, nutrient uptake, and buddability of citrus plants under protected nursery conditions.

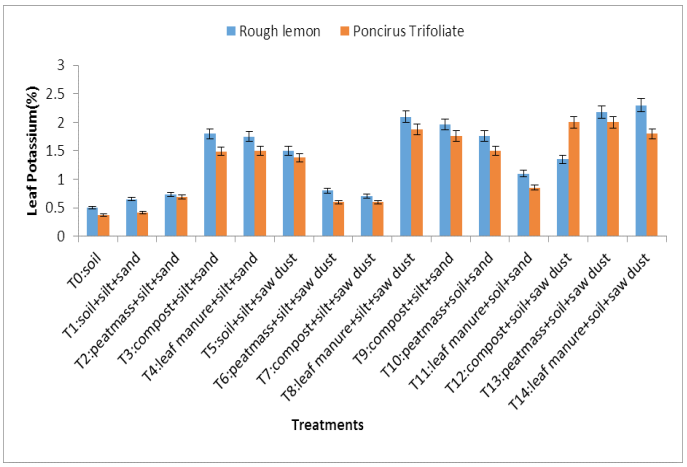

Figure 8: Effect of different potting media on K contents of rough lemon and poncirus.

Conclusions and Recommendations

Nursery production and traditional growing media lead to poor germination along with inadequate growth, and development. Therefore, healthy citrus nursery production for protected cultivation requires an appropriate mixture of growing media for optimum nutrients, water, and anchorage provision. It was concluded from the present study that for better performance of citrus seedlings, the potting media containing leaf manure + silt + straw, peat mass+soil+saw dust, and leaf manure+soil+saw dust was found best as compared to other media.

Novelty Statement

This research would enhance healthy citrus nursery production by utilizing 14 different growing media combinations utilizing the peat mass, compost, soil, silt, sand, sawdust and leaf manure). Such combinations were not used before in Pakistan. Success rate of transplanting of rough lemon and poncirus nursery would be profitable to citrus growers.

Author's Contribution

Malik Abdul Rehman and Hafiz Muhammad Ehsan conducted the research trial. Tehseen Ashraf supervised the experiment, while Zulfiqar Ali Gurmani, Sajjad Khan and Mujahid Ali reviewed and improved the research article.

Conflict of interest

The authors have declared no conflict of interest.

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