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Performance of leafy and fruit vegetables for growth and yield in vertical structure

SS Deekshith, GJ Janavi, J Rajangam and C Muthiah

Abstract
A study was conducted at the Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu in the year 2021-2022 to evaluate performance of leafy vegetables and fruiting vegetable brinjal in vertical farming system. The aim of the study is to produce green leafy vegetables and fruiting vegetable like brinjal in a single vertical farming structure for urban dwellers. Cultivable land is shrinking day by day in urban areas and the population in urban regions is increasing rapidly, according to United Nations estimate the total world population will be doubled by the year 2050 accounting for 80% of the total population in urban areas. With increasing population and decreasing cultivable land in urban areas, production of fresh vegetables will be a serious issue. Vertical farming is a soilless technology of growing plants that serves as an alternative for cultivating fresh vegetables in a limited land area. Green leafy vegetables like Palak, amaranthus, mint and fruiting vegetable like brinjal play important role in the Indian diet. The leafy vegetables grown in vertical structure showed superior vegetative growth in turn yielded high. Among the 3 leafy vegetables grown in vertical structure Palak shown the highest yield/pot (653.50 g/pot) followed by mint (329 g/pot) and amaranthus (269.33 g/pot) and the fruiting vegetable brinjal had an average yield of 535.10 g/plant. The results clearly showed that leafy vegetables performed better rapid regrowth of new shoots w after each harvest especially in Palak and mint, which resulted in the highest leaf biomass.

Keywords: Vertical farming, urban areas, leafy vegetables, nutrient solution

1. Introduction
The population of the entire planet is growing rapidly, and the pace of urbanization is rising as well. By 2050, the population is expected to have doubled, accounting for almost 6.5 billion people, according to United Nations estimates (2015). Given that urban areas produce more than 70% of the world's CO_2 emissions, which lead to pollution and adverse impacts, food security is going to be a top priority in urban regions. Producing fresh fruits and vegetables through conventional farming will be challenging in urban settings, owing to less nutrient rich soil and unusable land as the population of urban areas rises, making the supply of fresh fruits and vegetables a severe problem (Zareba *et al.*, 2021) [9].

Vertical farming is a technique of growing fresh vegetables that incorporates soilless agriculture, and it is getting popular and has huge future potential. Scientists and researchers are investigating this type of agriculture for adopting by urban dwellers. Though the word is not new to the world, very few people are aware of this type of farming, and even fewer have used it to grow fresh food.

People in metropolitan cities in developing nations like India are dependent on adjacent rural areas for fresh veggies, which lead to problems like price swings, quality issues and many more. In this scenario, metropolitan residents should be prepared to grow their own food. However, due to rising land prices and scarcity of agricultural land in urban areas, conventional farming will be challenging. However, rooftop and terrace farming are always good alternatives. Rooftop/ terrace farming is also considered as "zero-acreage farming", as they are characterized by non-use of land. Vertical farming or rooftop farming will serve as a source of cultivation of fresh vegetables in urban areas. Vertical farming otherwise soilless cultivation, where growing media is used instead of soil in order to give support to plants and nutrients will be supplied through nutrient solutions. From a small rooftop to enormous commercial buildings, vertical farming is practiced in a wide range of configurations. Technologies including hydroponics, aeroponics, and aquaponics are used in vertical farming. In order to serve fresh food to the urban dweller's, present study carried out to produce fresh

leafy vegetables like Palak, amaranthus, mint and fruiting vegetable like brinjal in a vertical farming structure.

2. Materials and Methods

The present study was carried out at the Department of Vegetable Science, Horticultural College and Research Institute (HC&RI), TNAU, Periyakulam during 2021-22. The experiment was carried out to standardize a vertical farming structure for the production of leafy vegetables and fruiting vegetables. A vertical farming structure made out of 4 inch PVC pipe was used in this study, fertigation was given through a 40W submersible pump which was regulated by an electronic timer, and 3-inch netpots were used for growing the plants. Coirpith was used as growing media, the compressed cocopeat slabs were soaked overnight, washed thoroughly to remove dirt particles and then it was used for planting. Water used in this study was taken from a reverse osmosis unit, which has a TDS range of 40–50ppm, pH range of 6.5-7.0 and EC range of 0.4-0.5 dSm^{-1}.

Leafy vegetables like palak, amaranthus, mint and fruiting vegetable brinjal were grown in this vertical structure. The study was carried out in completely randomized design and each crop was taken as treatment and four replications were adopted in this study.

2.1 Preparation of Nutrient solution

Two stock nutrient solutions were prepared and used in this study. Nutrient solution A and nutrient solution B were prepared and used as stock solutions. Nutrient solution A contained nitrate, calcium nitrate and potassium nitrate were taken 50g each and dissolved in 1000 ml of distilled water to make stock A. Nutrient solution B contained magnesium sulphate and micronutrient mixture, 50g of magnesium sulphate and micronutrient were taken and dissolved in 1000 ml of distilled water to make stock B. Both the nutrient stock solution were stored separately in room temperature. 1 litre of reverse osmosis water was taken in a beaker and TDS was checked initially. First 50ml nutrient solution A was added and mixed thoroughly and then 50 ml of nutrient solution B was added and both were mixed thoroughly. Then this nutrient solution mixture was added to the fertigation tank slowly (by checking the TDS of the water, nutrient solution) till 300 ppm TDS was achieved in the fertigation tank.

2.2 Raising crop in vertical structure

The coirpith with optimum moisture was taken to fill 3 inch netpots. For sowing of palak and amaranthus seeds coirpith was filled in the netpots then seeds were sown and closed with the coirpith, the seed sown netpots were dipped gently into the water to remove air pockets and to get optimum moisture. Mint nodal cuttings were taken and cuttings were kept in the netpots first and then the cocopeat was filled into the netpots. Seedlings of brinjal were taken and kept in the middle of the netpots then half filled with moist coirpth. All the seed sown and planted netpots were kept in the cells of vertical structure.

2.3 Morphological observations

Observations were recorded such as plant height, fresh weight of shoot, length of roots, dry weight of shoot and yield per plant/pot were recorded and analysed statistically.

3. Results and Discussion

Vegetative growth parameters *viz.* plant height (cm), fresh weight of shoot (g), length of roots (cm), dry weight of shoot (g) and yield (g) were recorded, furnished in Table 1 to 3 and Figure 1 to 3.

3.1 Plant height

Plant height of Palak, amaranthus and mint grown in vertical structure showed significant difference. The plant height of Palak, amaranthus and mint were recorded at every fortnight (15, 30 and 45 days after planting). Palak grown in the vertical structure showed the maximum plant height (15.12 cm) at 45 DAP and the minimum plant height (7.20 cm) was recorded at 15 DAP. The amaranthus grown in vertical structure showed the maximum plant height of 26.50 cm was recorded at 45 DAP and the minimum plant height of 6.30 cm was observed at 15 DAP. The Mint grown in vertical structure showed the maximum plant height (13.80 cm) at 45 DAP and the minimum plant height (5.40 cm) was observed at 15 DAP. The plant height of brinjal was the maximum height (41.69 cm) at 90 DAP and the minimum (21.65 cm) at 30 DAP. As plants get the right amount of nutrition in vertical structure, plants tend to grow day by day. Similar research outcomes were found by Zekki *et al.* (1996) [10] in tomato plants grown under vertical NFT structure which resulted in maximum plant height. Kulkarni *et al.* (2016) [4] found similar results in spinach and coriander and confirmed that plants produced under soilless condition were found to be taller than plants grown under soil condition.

Table 1: Plant height of Palak, amaranthus and mint grown in vertical structure

Plant height (cm)			
Days after planting	**Palak**	**Amaranthus**	**Mint**
15 DAP	7.20	6.30	5.40
30 DAP	12.64	15.45	10.60
45 DAP	15.12	26.50	13.80
Mean	11.65	16.08	9.33
CD (0.05)	0.37	0.61	0.47
SE (d)	0.17	0.28	0.22

Table 2: Plant height (cm), Fresh weight of leaves (g), Length of roots (cm) and dry weight of leaves of brinjal grown under vertical structure

Days after planting	Plant height (cm)	Fresh weight of leaves (g)	Length of roots (cm)	Dry weight of leaves (g)
30 DAP	21.65	22.80	12.40	8.93
60 DAP	32.4	25.60	16.70	10.16
90 DAP	41.69	28.45	18.32	12.30
Mean	31.91	25.62	15.81	10.46
CD (0.05)	1.20	0.91	0.30	0.39
SE (d)	0.55	0.42	0.14	0.18

3.2 Fresh weight of shoot

The Palak plants grown in vertical structure showed the maximum fresh weight of shoot (9.51 g) at 45 DAP and the minimum fresh weight (3.40 g) at 15 DAP. The amaranthus plants grown under vertical structure showed the highest fresh weight of shoot (8.82 g) at 45 DAP and the lowest fresh weight of shoot (2.70 g) at 15 DAP. The mint grown in vertical structure recorded the highest fresh weight of shoot (5.45 g) at 45 DAP and the lowest fresh weight of shoot (1.70 g) was observed at 15 DAP. The fresh weight of brinjal leaves was the highest (28.45 g) at 90 DAP and the minimum fresh weight of leaves (22.80 g) was recorded at 30 DAP. This was identical to the findings of Baranauskienė *et al.* (2003) [1] in Thyme, who indicated that nitrogen fertilizer at an optimum level resulted in increased fresh biomass yield. Pan *et al.*

(2003) [6] stated that greater plant height might have helped to produce a greater number of branches per plant and number of leaves per plant, which ultimately resulted in maximum fresh weight production.

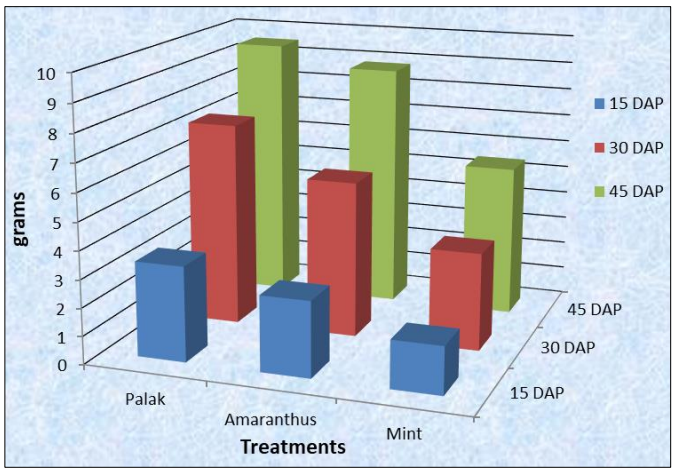

Fig 1: Fresh weight of Palak, amaranthus and mint grown in vertical structure

3.3 Length of roots

The Palak gown in vertical structure recorded the maximum root length (14.80 cm) at 45 DAP and the minimum root length (7.20 cm) recorded at 15 DAP. The amaranthus plants showed the maximum root length (10.20 cm) at 45 DAP and the minimum root length (5.40 cm) at 15 DAP. The mint grown in vertical structure showed the maximum root length (11.50 cm) at 45 DAP and the minimum root length (6.30 cm) recorded at 15 DAP. The brinjal plants recorded the maximum root length (18.32 cm) at 90 DAP and the minimum root length (12.40) was observed at 30 DAP. Brown *et al.* (2003) [2] reported similar findings in mint grown under soilless condition and Kotadia *et al.* (2012) [3] in leafy vegetables.

Table 3: Length of roots in Palak, amaranthus and mint grown under vertical structure

Length of roots (cm)			
Days after planting	**Palak**	**Amaranthus**	**Mint**
15 DAP	7.20	5.40	6.30
30 DAP	9.40	7.80	9.80
45 DAP	14.80	10.20	11.50
Mean	10.47	7.80	9.20
CD (0.05)	0.30	0.36	0.21
SE (d)	0.14	0.17	0.10

3.4 Dry weight of shoot

The Palak plants grown in vertical structure showed the highest dry weight of shoot (4.16 g) at 45 DAP and the lowest dry weight of shoot (1.50 g) at 15 DAP. The highest dry weight of amaranthus plants (3.70 g) was observed at 45 DAP and the lowest dry weight of shoot (1.16 g) was observed at 15 DAP. The mint grown under vertical structure showed the highest dry weight (2.03 g) at 45 DAP and the lowest dry weight of shoot (0.84 g) was observed at 15 DAP. The brinjal grown under vertical structure recorded the highest dry weight (12.30 g) recorded at 90 DAP and minimum dry weight of leaves (8.93 g) was recorded at 30 DAP. Similar results were found by Touliatos *et al.* (2016) [7] in lettuce.

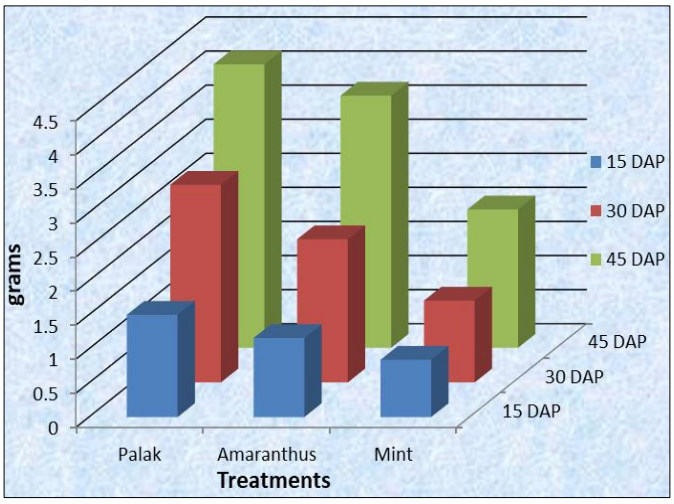

Fig 2: Dry weight of Palak, amaranthus and mint produced in vertical structure

3.5 Yield

Yield of leafy vegetables were analysed statistically and significant difference was observed among the treatments. The highest yield was observed in Palak (653.50 g/pot) grown in vertical structure, followed by mint (329 grams/netpot) and amaranthus (269.33 g/pot) resulted with minimum yield in vertical structure. Brinjal grown in vertical structure recorded an average yield of 535.10 g. As Palak and mint ratooned after each harvest, the yield was highest in these crops and they performed well in vertical structure. Melgarejo *et al.* (2007) [5] reported the opportunity of soilless cultivation in fig as it increased the production by 18-fold, as well as saved water up to 90% and lowered plant management costs including pesticides and fertilizers. Similar results were reported by Treftz and Omaye (2015) [8] in strawberries grown under hydroponics showed 17% increased yield when compared to conventional farming.

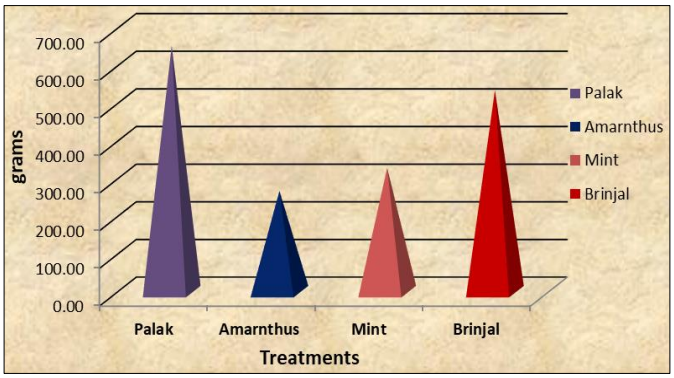

Fig 3: Mean Yeild of Palak, Amaranhus, mint and brinjal produced under the vertical structure

4. Conclusion

Vertical farming is a technology of growing crops in a limited space, where plants get the right amount of water and nutrition at regular intervals. The Green leafy vegetables like palak, amaranthus and mint are rapid growing crops that perform well in vertical structure. These leafy vegetables got the right amount of water and nutrition and hence they tend to grow faster and as a result good quality and high yield could be produced from vertical farming.

5. Future scope

The cultivable land is decreasing in urban areas and the availability of fresh and quality (residue free) vegetables becoming a serious issue in recent days. Hence vertical farming will be the best alternate solution for cultivating fresh leafy and fruit vegetables in future days.

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