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Performance Assessment of Japanese Mint Varieties for Growth under Open Field and Vertical A-Frame Structure

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Japanese mint (*Mentha arvensis* L.), is a member of the family Lamiaceae which is a perennial herbaceous aromatic plant but cultivated as an annual for culinary purpose as leafy vegetable and as natural menthol extraction. It is a major source of raw material for flavours and fragrance industry. Urban regions are losing cultivable land every day and it has become extremely difficult to produce fresh vegetables of high quality. By using vertical structures, vertical space can be utilized while increasing the quality of vegetable production. This experiment was conducted at Department of Vegetable Science, Horticultural College & Research Institute, Periyakulam during 2022-2023 to evaluate the performance of nine varieties *viz*., Kosi (V_1), CIM-Kranti (V_2), Himalaya (V_3), Kalka (V_4), MAS-1 (V_5), Saksham (V_6), Gomti (V_7), Seelayampatti local (V_8) and Bangalore hybrid (V_9) under open field (G_1) and vertical A-frame structure (G_2) condition. One vertical A-frame structure is

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used in this study which contain 516 holes for planting. Among the nine varieties, Saksham (V_6) showed increase in growth parameters in both conditions. The observations on growth parameters were recorded for plant height(cm), number of leaves, root length(cm), fresh weight of roots(g) and dry weight of roots(g). Saksham variety in vertical A-frame structure yielded maximum plant height (53.05 cm), number of leaves (112.73), root length (39.92 cm), fresh weight of roots (3.204g) and dry weight of roots (0.874g) followed by the variety CIM-Kranti in vertical A-frame structure (48.83cm, 77.61, 37.75cm, 2.582g and 0.648g). As a result, the interactive action of G_2V_6 showed maximum growth due to the availability of nutrients in the root system and timely application of water and nutrient helped in better plant parameters.

Keywords: Japanese mint; hydroponics; A-frame; growth parameters.

1. INTRODUCTION

Japanese mint (*Mentha arvensis* L.) is a herbaceous perennial plant which belongs to the Lamiaceae family and commonly known as Menthol mint or Japanese mint. Mint is indigenous to temperate parts of Europe, Eastern Siberia, Western and Central Asia, North America as well as Himalayas. It has a circumboreal range. At global level, India, China, Brazil and Vietnam are its top producers due to their strong economies. More than 80% of the crop in India is produced in Uttar Pradesh, which is the main growing location for *Mentha arvensis*. Punjab, Madhya Pradesh and Bihar which are the neighbouring states, are responsible for the remaining 20% [1].

Vertical farming is a process of planting or growing plants vertically which involves stacking them horizontally in layers. Vertical farming is a cutting-edge technique for intensive farming that can greatly boost the production of crops. It was made available in Singapore, Japan, Spain, United States and Europe [2].

In hydroponic, Dr. Allan Cooper created the nutrition film technique (NFT) in England in the late 1960's. The most advanced type, called NFT, involves the flow of a thin layer of nutrient solution through plastic PVC pipes or channels, where the nutrient pump pushes water from a hydroponic reservoir to a growing tray as a thin layer of solution. The water then flows through gravity to the plant's dangling roots, where it receives its nutrients. According to Domingues et al. [3], catchment pipes with nutrient solution are regularly checked for replenishing of solutions before it is drained off.

The main benefit of using vertical farming technology is the higher crop production that comes with a lesser requirement for land area per unit of land. Plants can be grown everywhere, i.e., in small places with a controlled growth environment in vertical farming, which increases their capacity for continuous production in a short growing period with less space [4]. The use of soilless farming method includes hydroponics, aquaponics and aeroponics as well as controlled-environment agriculture, which strives to maximize plant development [2]. For the benefit of urban dwellers, the present study was carried out to compare the yield and quality of different mint varieties in (A-frame) vertical structure and in open field condition.

2. MATERIALS

The Department of Vegetable Science, Horticulture College and Research Institute, Periyakulam, which is situated at a latitude of 10.13 North and longitude of 77.59 East, is the place where the experiment was conducted in the years 2022. The purpose of the experiment was to assess the potential of different mint cultivars with vertical farming and open field condition. This trial was laid out with the Factorial Randomized Block Design (FRBD) with three replications.

A vertical A-frame structure was used which was made out of 4-inch PVC pipe and fertigation was given through a 1hp pump which was regulated by an electronic timer. Netted pots of 3-inches were used for growing the mint varieties. The wick system was followed in vertical A-frame to maintain the water level for the plants. The compressed cocopeat blocks were soaked, washed twice and used as growing media. TDS ranged from 40 to 50 ppm, pH ranged from 6.5 to 7.0 and EC ranged from 0.4 to 0.5 dSm^{-1} were maintained in the water and reverse osmosis water was used in this study.

Factor – 1 (Growing conditions)

G_1 - Open field condition
G_2 – Vertical (A-Frame)

Factor – 2 (Varieties)

V_1 - Kosi
V_2 - CIM-Kranti
V_3 - Himalaya
V_4 - Kalka
V_5 – MAS-1
V_6 - Saksham
V_7 – Gomti
V_8 – Seelayampatti local
V_9 – Bangalore hybrid

2.1 Planting of Mint in Vertical A-Frame

Nodal cuttings of mint were used as the propagating material. In netted pots, 10-12 cm cuttings were planted. At the base of the net pot, a wick (cloth) was inserted to absorb water from the container and to hold on moisture for the plants. Cuttings were kept above the wick for faster sprouting and filled with cocopeat. An automated timer was attached to the fertigation tank and programmed to turn on the pump for 30 minutes each day. Once in 10 days, nutrients were fed to the nutrient reservoir after cleaning. The TDS was kept as 300 ppm for the stock solutions A and B.

2.2 Nutrient Preparation

Nutrient A: It contains 50g each of calcium nitrate and potassium nitrate which were weighed out and dissolved in one litre of distilled water.

Nutrient B: Magnesium sulphate and a blend of micronutrients was dissolved in one litre of distilled water separately and combined together. 50 ml of the nutrient A solution and 50 ml of nutrient B solution were added together and mixed thoroughly. The nutrient solution mixture was added to the fertigation tank slowly by checking the TDS of the water till it reaches 300 ppm.

3. RESULTS AND DISCUSSION

The performance of nine varieties was tested in two different growing conditions *viz*., open field (G_1) and vertical A Frame (G_2) and the morphological parameters like plant height (cm), number of leaves, root length(cm), shoot length (cm), fresh weight of roots (g/plant) and dry weight of roots (g/plant) were recorded on 45 days after planting and furnished in the Table 1 and Table 2.

3.1 Plant Height (cm)

The plant height of (44.36 cm) was the highest in A-frame vertical structure (G_2) when compared to open field (G_1) with 36.22 cm. Among the different varieties, the variety Saksham (V_6) have reached maximum plant height of (46.94 cm) and minimum plant height was registered in the variety Himalaya (V_3) with 36.12 cm. Among the interactive effect, the variety Saksham(V_6) registered the highest plant height of (40.83 cm) followed by Seelayampatti local (V_8) with 39.42 cm and the lowest plant height of (30.52 cm) was recorded in the variety Kalka (V_4) under the open field (G_1). In the A-frame vertical structure (G_2), the same variety Saksham (V_6) registered the highest plant height of (53.05 cm) followed by the variety CIM-Kranti (V_2) with 48.83 cm and it was lowest of (39.35cm) in the variety Bangalore hybrid (V_9) (Table 1). Reusing fertilizer solutions promotes better plant growth and development in this system. Similar research results was reported by Zekki et al. [5] in tomatoes, an NFT system with regular recycling of nutrient solutions resulted in higher plant height and productivity. Kulkarni et al., [6] recorded similar findings in spinach and coriander and stated that plants produced under soilless condition were found to be maximum in height than plants grown under soil condition.

3.2 Number of Leaves per Plant

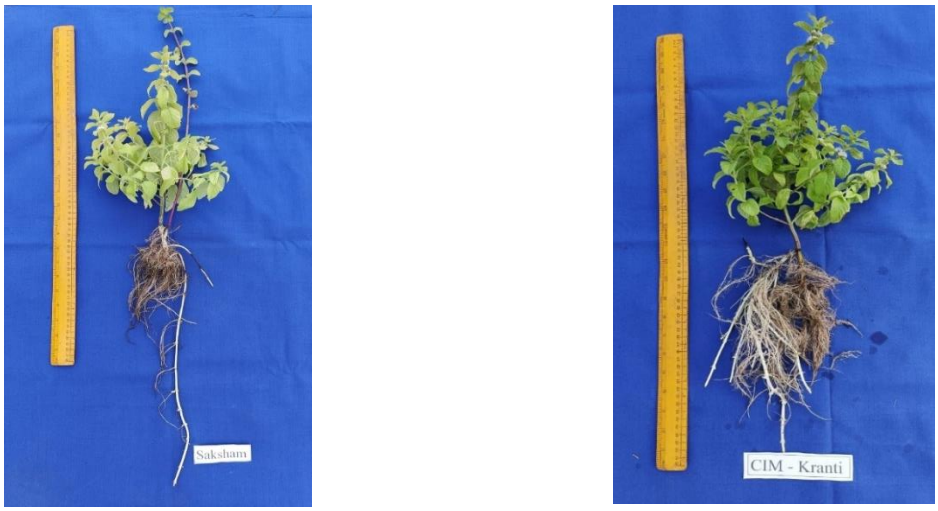
Significant variations were observed between different treatments under two different conditions on number of leaves per plant. The number of leaves per plant was the highest in A frame structure (72.29) whereas it was 55.96 in open field (G_1). The variety Saksham (V_6) had the maximum number of leaves among the different varieties, with 87.73, and the variety Kalka (V_4) had the lowest, with 54.69. Among the interaction effects, under the open field situation (G_1), the variety Saksham (V_6) reported higher number of leaves (62.73), followed by Seelayampatti local (V_8) with 59.33, and the variety Himalaya (V_3) recorded the lowest number of leaves (30.52). The same variety Saksham (V_6) recorded the maximum of (112.73) number of leaves in the A-frame vertical structure condition (G_2), followed by the variety CIM-Kranti (V_2) with 77.61, and the variety Bangalore hybrid (V_9) recorded the lowest (57.06) number of leaves (Table 1). Since the plant height was increased the number of leaves may also be increased in vertical A-frame structure. Shanmugabhavatharani et al., [7] reported the

Table 1. Performance of mint varieties under different conditions on plant height, number of leaves and root length

	Plant height (cm)				Number of leaves				Root length (cm)		
	Open field (G_1)	Vertical A-Frame (G_2)	Mean		Open field (G_1)	Vertical A-Frame (G_2)	Mean		Open field (G_1)	Vertical A-Frame (G_2)	Mean
V_1	33.46	45.67	39.56	V_1	55.38	72.55	63.96	V_1	31.08	35.83	33.45
V_2	38.37	48.83	43.61	V_2	58.46	77.61	68.03	V_2	32.65	37.75	35.22
V_3	31.89	40.34	36.12	V_3	50.89	62.92	56.92	V_3	28.68	31.51	30.09
V_4	30.52	41.77	36.14	V_4	49.21	60.17	54.69	V_4	26.55	30.76	28.65
V_5	34.72	42.96	38.84	V_5	53.94	71.84	62.89	V_5	27.21	31.62	29.41
V_6	40.83	53.05	46.94	V_6	62.73	112.73	87.73	V_6	34.83	39.92	37.37
V_7	38.12	45.41	41.76	V_7	56.52	65.32	60.92	V_7	31.15	33.98	32.56
V_8	39.42	41.88	40.65	V_8	59.33	70.45	64.89	V_8	33.02	32.34	32.68
V_9	38.66	39.35	39.01	V_9	57.19	57.06	57.12	V_9	31.98	29.77	30.87
Mean	36.22	44.36		**Mean**	55.96	72.29		**Mean**	30.79	33.72	
	S.Ed	**C.D (0.05)**			**S.Ed**	**C.D (0.05)**			**S.Ed**	**C.D (0.05)**	
G	1.253	2.547**		**G**	1.998	4.063**		**G**	1.011	2.056**	
V	2.658	5.404**		**V**	4.239	8.620**		**V**	2.145	4.362**	
G×V	3.759	7.642(NS)		**G×V**	5.995	12.190**		**G×V**	3.034	6.169*	

Table 2. Performance of mint varieties under different conditions on root fresh weight and root dry weight

	Root fresh weight (g/plant)				Root dry weight (g/plant)		
	Open field (G_1)	Vertical A-Frame (G_2)	Mean		Open field (G_1)	Vertical A-Frame (G_2)	Mean
V_1	1.085	2.241	1.663	V_1	0.364	0.531	0.447
V_2	1.108	2.582	1.845	V_2	0.452	0.648	0.551
V_3	1.074	1.583	1.328	V_3	0.321	0.386	0.353
V_4	1.058	1.478	1.268	V_4	0.385	0.357	0.371
V_5	1.053	1.712	1.382	V_5	0.317	0.466	0.391
V_6	1.125	3.204	2.164	V_6	0.673	0.874	0.773
V_7	1.096	1.887	1.491	V_7	0.548	0.514	0.531
V_8	1.112	1.811	1.461	V_8	0.599	0.507	0.553
V_9	1.105	1.436	1.272	V_9	0.475	0.379	0.427
Mean	1.091	1.992		Mean	0.459	0.518	
	S.Ed	C.D (0.05)			S.Ed	C.D (0.05)	
G	0.050	0.103**		G	0.015	0.030**	
V	0.107	0.219**		V	0.032	0.065**	
G×V	0.152	0.309**		G×V	0.045	0.092**	



a b

Fig. 1. Performance of mint in Vertical A-Frame a).G_2V_6 (Saksham) b).G_2V_2 (CIM-Kranti)

similar results, that the maximum number of leaves was observed in vertical A type with NFT system in mint.

3.3 Root Length (cm)

The statistical analysis on root length showed significant difference between different varieties. Between the growing conditions, highest root length (33.72 cm) was recorded in A-frame vertical structure (G_2) when compared to open field (G_1) with 30.79 cm. Among the different varieties, the variety Saksham (V_6) recorded maximum root length of (37.37 cm) and minimum root length was in the variety Kalka (V_4) with 28.65 cm. Among the interactive effect, the variety Saksham (V_6) registered the highest (34.83 cm) root length followed by Seelayampatti local (V_8) with 33.02 cm and the lowest root length of (26.55 cm) was recorded in the variety Kalka (V_4) under the open field condition (G_1). In the A-frame vertical structure condition (G_2), the same variety Saksham (V_6) registered the highest (39.92cm) root length followed by the variety CIM-Kranti (V_2) with 37.75 cm and it was lowest (29.77 cm) in the variety Bangalore hybrid (V_9) (Table 1). Kotadia et al., [8] recorded that the leafy vegetables are grown under different conditions resulted in increased root length. Kay et al., [9] reported that shorter roots are produced

due to high ammonium nitrogen which resulted in depressed root metabolism.

3.4 Fresh Weight of Roots (g/plant)

Significant variations were observed between different treatments for fresh weight of roots. In comparison with the growing conditions the A-frame vertical structure (G_2) recorded maximum root fresh weight (1.992 g) than the open field (G_1) with 1.091 g. Among the different varieties, the variety Saksham (V_6) recorded maximum root fresh weight of (2.164 g) and minimum fresh weight of root was in the variety Kalka (V_4) with 1.268 g. Among the interactive effect, under open field condition (G_1) variety Saksham (V_6) recorded the highest root fresh weight of (1.125 g) followed by Seelayampatti local (V_8) with 1.112 g and the lowest root fresh weight of (1.053 g) was recorded in the variety MAS-1 (V_5). In the A-frame vertical structure condition (G_2), the same variety Saksham (V_6) registered the highest (3.204 g) root fresh weight followed by the variety CIM-Kranti (V_2) with 2.582 g and the lowest root weight (1.436 g) was recorded in the variety Bangalore hybrid (V_9) (Table 2). The increased root weight may be increased due to the recycling of nutrient to the plant growth. Oagile et al., 2016 observed similar results in tomato and stated that tha plant height, root length and shoot length were increased due to bigger container size which enhanced tomato seedlings growth.

3.5 Dry Weight of Roots (g/plant)

The statistical analysis on dry weight of roots showed a significant difference for varieties. The A-frame vertical structure (G_2) recorded the highest root dry weight (0.518 g) than the open field (G_1), which had 0.459 g. The highest dry weight of root among the several varieties was recorded by Saksham (V_6) at 0.773 g, while the lowest dry weight of root (0.353 g) was found in Himalaya (V_3). Under open field condition (G_1), variety Saksham (V_6) recorded the highest root dry weight of (0.673 g), followed by Seelayampatti local (V_8) with 0.599 g, and variety MAS-1 (V_5) recorded the lowest root dry weight (0.317 g). The same variety Saksham (V_6) displayed the highest root dry weight of (0.874g) in the A-frame vertical structure condition (G_2) followed by the variety CIM-Kranti (V_2) with 0.648 g and lowest root dry weight (0.379 g) was recorded on variety Bangalore hybrid (V_9) (Table 2). Similar findings were recorded by Deekshith et al., [10] in leafy vegetables and fruit vegetables and stated that the vertical structure showed increase in both root fresh and dry weight of the plants [11,12].

4. CONCLUSION

The overall growth was increased in vertical A-frame structure when compared to open field condition. Under tropical conditions, the variety Saksham performed maximum growth in open field and vertical A-frame. With the use of hydroponics, crops can be produced in small spaces with the right amount of water and nutrients. The variety Saksham showed increase in growth characters since the nutrients are available to plants at regular intervals and the water usage is also reduced by recycling the nutrient solution to the plants. This results in good quality of plants with higher yield. Since the cultivable land is decreasing in urban areas, the hydroponic with vertical A frame structure will be an alternate solution to produce quality vegetables in future days to meet the requirement of increased population.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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