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Effect of container size on yield and root morphology of different fruit crops

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ABSTRACT

The experiment was conducted to standardize container gardening techniques for guava (*Psidium guajava* L), pomegranate (*Punica granatum* L.) and citrus (*Citrus aurantifolia* L.) to meet out the nutritional requirement of city dwellers. There was maximum average plant biomass (1072 g/plant) in guava and minimum (423g) in pomegranate. Maximum shoot biomass (1012.11g) was recorded in plant grown in 45 cm × 45 cm and minimum (402.78g/plant) in 30 cm × 30 cm container. Destructive method was used to extract the root mass for analysis. Significant variation in root biomass was also recorded. There was maximum root biomass (506.11g) in guava and minimum (239.86 g) in pomegranate, however root biomass was recorded significantly maximum (509.78 g) in 45 cm × 45 cm. Root to shoot ratio was recorded maximum (0.63) in Citrus crops. The root:shoot ratio had significant correlation with stem girth and negatively correlated with fruit weight, fruit yield and root hairs diameter. Collar diameter has significantly positive correlation with plant height, fruit weight and yield. The container size as well as growing media (substrate) influenced plant growth, root and shoot biomass, fruit yield and root morphology remarkably.

Key Words: Container gardening, Lime, Pomegranate, Guava, Root morphology, Shoot ratio

Container farming is one of the micro model of farming where a family unit or households can produces fruits and vegetables in containers. The container types and volume are most important characteristics because these factors have direct impact on plant quality and production cost. The growing media or substrate has direct impact on root morphology and topology. Srivastava *et al.* (2019), reported that 35 cm × 45 cm of container top area and depth are most suitable to grow guava (*Psidium guajava* L.), and lime (*Citrus aurantifolia* L.), Andhra Pradesh ranks first in terms of production of acid lime (18.62%) (Reddy *et al.* 2022), and pomegranate (*Punica granatum* L.). Fruit crops responds well to pruning in container gardening (Srivastava *et al*. 2022). Increased in container size led increased in canopy growth (Keever and Cobb, 1987) in pear (*Pyrus pyrofolia* L.) and peach (*Prunus domestica* L.), root coiling leads to canopy growth down. Since very scanty information are available, an experiment was conducted to standardize their production technology.

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MATERIALS AND METHODS

The experiment was conducted at ICAR-CISH, during 2017-20, including guava, kagazi lime and pomegranate. Black color, UV stabilized plastic bag with of 400 gauges thickness having 45 cm × 45 cm, 30 cm × 45 cm, and 30 cm × 30 cm container top diameter and depth, were utilized. Growing media comprised garden soil, and, FYM, vermicompost in equal proportion. All the four media components were properly mixed and sterilized through solarization process. The 400-500 g neem cake and 250 g bone meal were also added. The media was filled in containers leaving 10 cm top for irrigation cup. For planting, well feathered grafted and healthy plants were selected from nursery. Before final planting in pot the earth ball of plants were dipped in Carbendazim solution @2 g/ litre of water.

The plants were planted in varying size containers during February - March 2017, and trained on small bush form promoting scaffold branches after 8-10 cm, regular pruning, heading back and thinning out practised to maintain the plants. The plants of guava were pruned in December and January. Pruning was carried out to avoid fruiting of rainy season crop

in guava. All the cultural operations were practised uniformly. Plant height, collar diameter were recorded in during September-October. For root study, poly bag was removed and plant along with media ball was kept in 100 liter capacity tub and filled with water, the media become loose and washed carefully. The root biomass was measured after the separation of shoot mass. Root hairs diameter was recorded by screw gauge. The factorial RBD, replicated thrice with 4 plants per replication. Data on vegetative growth, fruit yield, tree spread, height, canopy spread, collar diameter were recorded during October-November. During summer 6-8 liters of water/pot was needed every second day, while as in autumn and winter at 7-15 days interval.

RESULTS AND DISCUSSION

Analysis of the variance showed that container sizes had significant effect on shoot weight. Overall maximum average shoot biomass (1072 g/plant) was recorded in guava, followed by citrus (519.33 g) and minimum (423g) in pomegranate. Irrespective of fruit kind maximum shoot biomass (1012.11g) was recorded in plants grown in 45 cm × 45 cm and lowest (402.78g/plant) in 30 cm × 30 cm container size. Destructive method was used to extract root mass from containerized plant. Significant variation in root biomass was recorded, maximum (506.11g) in guava, followed by citrus (356.44g) and minimum (239.86g) in pomegranate.

However, root biomass was significantly maximum (509.78g) in 45 cm × 45 cm container followed by 327.67 g in 30 cm × 45 cm, while minimum root biomass (264.97 g) was recorded in 30 cm × 30 cm container size. The root; shoot biomass was recorded maximum (0.67) in 30 cm × 30 cm container plants while it was minimum (0.52) in 45 cm × 45 cm container size. The maximum root to shoot biomass (0.63) recorded in Citrus and minimum (0.55) in guava (Table 1). Maximum plant height (117 cm) was noted in 45 cm × 45 cm container, followed by 30 cm × 45 cm, whereas lowest plant height (83.99 cm) noted in 30 cm × 30 cm containers. However, maximum average plant height (112.66 cm) recorded in guava, which was statically on a par to pomegranate and minimum height (86 cm) noted in citrus, irrespective of container size (Table 2). Significantly maximum root hairs diameter was (0.44 mm) noted in 30 cm × 45 cm, followed by root hairs diameter (0.39mm) in 45 cm × 45 cm container size and minimum root hairs diameter (0.32 mm) in 30 cm x 30 cm container size. Irrespective of container size maximum root hair thickness (0.43 mm) noted in pomegranate was on a par to citrus (0.37 mm) and minimum (0.36 mm) in guava (Table 3).

Positive effect of increased container size on plant growth was reported for many woody plant species, plant height, root collar diameter and biomass increased with increase in container size for different plant species (Apko *et al* 2014; Dumroese *et al.* 2011 and Vaknin *et al.* 2009. The fruit yield /plant revealed that irrespective of fruit kind maximum yield (3.14 kg/plant) was noted in 30 cm x 45 cm container which was on a par to 45 cm x 45 cm and 30 cm x 30 cm container size (Table 3). Haase (2008) also indicated that quality container seedlings must have shoot to root ratio of 2:1 or less.

Significant positive correlation was recorded between container size and plant biomass (R= 0.996) root mass (R= 0.989), collar diameter(R= 0.959), plant height, plant girth, root hairs diameter, root length as well as fruit yield. While it was negatively correlated



Kagazi Lime 3 years old grafted plant



Root morphology of guava



Root morphology of pomegranate

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Table 1: Effect of container size on media temperature and shoot and root weight in pomegranate, citrus and guava

Crop	Shoot biomass (g)				Root biomass (g)				Root:shoot ratio		
	Pot size										
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	486.00	401.33	381.67	423.00	287.33	209.67	222.57	239.86	0.59	0.52	0.58
Citrus	587.33	520.00	450.67	519.33	413.33	354.67	301.33	356.44	0.53	0.68	0.67
Guava	1963.00	878.00	376.00	1072.33	828.67	418.67	271.00	506.11	0.42	0.50	0.74
Mean	1012.11	599.78	402.78		509.78	327.67	264.97		0.52	0.56	0.67
For comparing means of			S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$		S.Em±	$LSD_{0.05}$
Variety			202.31	49.08			77.06	40.43		0.02	0.09
Pot size			179.52	49.08			73.42	40.43		0.04	0.09
Interaction (variety × pot size)			169.48	85.01			62.76	70.02		0.03	0.16

Table 2: Effect of container size on root-shoot ratio, collar diameter and plant height in pomegranate, citrus and guava

Crop	Stem girth (mm)				Collar diameter (mm)				Plant height (cm)		
	Pot size										
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	12.62	19.14	21.02	17.60	32.90	29.47	27.67	30.01	131.00	110.67	85.33
Citrus	13.12	18.10	21.00	17.41	35.18	29.16	29.47	31.27	105.00	96.33	56.67
Guava	22.92	20.22	14.27	19.14	38.42	32.10	20.28	30.27	115.00	113.00	109.97
Mean	16.22	19.15	18.76		35.50	30.24	25.81		117.00	106.67	83.99
For comparing the means of				S.Em±	$LSD_{0.05}$	S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$
Variety				0.55	3.48	0.38	3.87			8.34	7.99
Pot size				0.92	3.48	2.80	3.87			9.75	7.99
Interaction (variety × pot size)				1.27	6.02	1.70	6.71			7.11	13.84

Table 3: Effect of container size on plant girth, root hair diameter and root length in pomegranate, citrus and guava

Crop	Root hair diameter (mm)				Root length (cm)				Fruit yield (kg/plant)		
	45×45	30×45	30×30	Mean	45×45	30×45	30×30	Mean	45×45	30×45	30×30
Pomegranate	0.39	0.49	0.40	0.43	49.67	36.10	27.17	37.64	2.62	5.59	2.74
Citrus	0.42	0.42	0.28	0.37	56.47	35.50	40.17	44.04	1.53	1.45	0.90
Guava	0.37	0.40	0.29	0.36	51.67	56.00	35.33	47.67	1.85	2.39	3.19
Mean	0.39	0.44	0.32		52.60	42.53	34.22		2.00	3.14	2.27
For comparing means of		S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$			S.Em±	$LSD_{0.05}$
Variety		0.02	0.07			2.93	10.96			0.68	0.95
Pot size		0.03	0.07			5.31	10.96			0.34	0.95
Interaction (variety × pot size)		0.02	0.12			3.52	18.98			0.46	1.65

with root:shoot ratio. Similarly quantity of substrate has significant positive correlation with shoot weight (R= 0.992), root weight, collar diameter, plant height, root hairs diameter and fruit yield. Negative correlation was found between stem girth and plant root hairs diameter, root length and fruits yield. The plant height has significantly positive correlation with root hairs diameter and fruit yield. Plant biomass has positive correlation with root weight (R= 0.999), collar diameter, plant height, and root hairs diameter and fruit yield (R= 0.992), while as it was negatively correlated with root: shoot ratio.

Total root mass was significantly positive correlated with collar diameter, plant height, root hairs diameters and fruit yield. The root shoot ratio had significant correlation with stem girth and negatively correlated with fruit weight, fruit yield and root hairs diameter (R= -0.992). Collar diameter has significantly positive correlation with plant height, fruit weight and yield. Stem girth was negatively correlated with root hairs diameter, fruit weight and fruit yield. Similar correlation between shoot biomass and plant height was also reported by Apko *et al*. (2014). (Ning Tian *et al*. 2017).

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CONCLUSION

Thus, it can be concluded that container size as well as growing media (substrate) influenced plant growth, root and shoot biomass and root morphology. Root and shoot biomass both were high in larger container, while guava plants have high root and shoot biomass. Root-shoot ratio was higher in smaller size containers but collar diameter was noted in larger container size.

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