Research Article

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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 fruit crops to meet the nutritional requirement of city dwellers at ICAR-CISH, Lucknow, during 2017-20. The maximum average plant biomass (1072 g/plant) was noted in guava (*Psidium guajava.*) and minimum (423g) in pomegranate (*Punica granatum.*), 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. There was maximum root biomass (506.11g) in guava and minimum (239.86g) in pomegranate, however root biomass was recorded significantly maximum (509.78g) in 45 cm ×45 cm. Root to shoot ratio was recorded maximum (0.63) in Citrus lime (*Citrus aurantifolia swingle*). When the plant size is similar, high root to shoot biomass is preferred. 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, Root:shoot ratio

Container farming is one of the micro model of farming where a family unit or household is producing fruits and vegetables in special containers for personal consumption to help improve the income, health and well –being. The container types and volume are most important characteristics because these factors have direct impact on plant quality and production cost. Different container size have direct impact on plant growth, fruiting behaviour and canopy forms. The growing media or substrate has direct impact on root morphology and topology. To examine impact of growing media/substrate on rooting behavior of different fruit crops an experiment was initiated to document rooting characters. Srivastava *et al.* (2019) reported that 45 cm × 45 cm and 45 cm × 60 cm of container top area and depth are most suitable to grow guava, lime and pomegranate. In western Australia black polythene containers of 150 mm high and 100 mm diameter (1500ml), with potting mixture sand: peat: perlite in the ratio of 3:2:2 for *S. album* production have been tried (Radomiljac, 1998). Root pruning in the base of container favors more fibrous root formation (Jinks, 1994). Increased in container size led increased in canopy growth (Keever and Cobb, 1987) in pear and peach, root coiling leads to canopy growth down. Therefore an experiment was conducted on container fruit growing to standardize production technology.

Materials and Methods

The experiment was conducted at ICAR-CISH, Lucknow, during 2017-20., including 03 kinds of fruits viz. guava, kagazi lime and pomegranate. Black color, UV stabilized plastic bag with 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, sand, FYM, vermicompost, neem cake, bone meal in definit proportion on the volume basis. All the four media components were properly mixed and sterilized through solarization process finally 400-500 g neem cake, 250 g bone meal also added. The media was filled in containers leaving 10 cm top for irrigation cup. For planting, wellfeathered grafted, healthy plants were selected from nursery. Before final planting in pot the earth ball of plants were dipped in carbendazim solution @2 g/liter-1 of water. Guava, pomegranate and Kagazi lime plants were planted in varying size containers during February - March, 2017. The plants were trained on small bush form, promoting scaffold branches after 8-10 cm, regular pruning, heading back and thinning out practiced to maintain the plants,

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Most of the fruit plants were pruned in December-January in guava. May pruning carried out to avoid fruiting of rainy season in guava. All the cultural operations were practised uniformly. Plant height and collar diameter were recorded during September October by digital Vernier caliper (Table 1). For root study, the 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 away earthball. The root biomass was measured after separation of shoot mass. Root hairs diameter was recorded by screw gauge. The experiment was laid out in Factorial RBD, replicated thrice with 04 plants per replication. Data on vegetative growth, fruit yield, tree spread, height, canopy spread, collar diameter, were recorded during Octber-November. During summer 6-8

Three years old Kagazi Lime

Collar diameter of Kagazi Lime

Kagazi Lime in full bearing

Rooting morphology in pomegranate

Rooting morphology in guava

liters of water/pot was needed every 2nd day, while as in autumn and winter 7-15 days interval.

Table A: Dimension of containers and media/substrate weight

Container size (cm)	Media (soil-FYM-vermi-sand) in equal proportion (Kg)
45*45	55.00
30*45	28.00
30*30	14.00

Results and Discussion

Analysis of variance showed that container sizes had significant effect on shoot weight of plants. Overall maximum average shoot biomass (1072 g/plant) was noted in guava followed by citrus (519.33 g) and in pomegranate (423g). Irrespective of fruit kind maximum shoot biomass (1012.11g) in plant grown in 45 cm × 45 cm and lowest (402.78g/plant) in 30 cm × 30 cm container size. Destructive method was used to extract the 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 recorded significantly maximum (509.78g) in 45 cm × 45 cm container followed by 327.67 g in 30 cm ×45 cm, while as minimum root biomass (264.97 g) was recorded in 30 cm × 30 cm container size. The data revealed that irrespective of fruit kind, root to shoot biomass ratio was recorded maximum (0.67) in 30 cm × 30 cm container plants while as minimum (0.52) in 45 cm × 45 cm container size. As for as fruit type concerned maximum root to shoot biomass (0.63) recorded in Citrus and minimum (0.55) in guava (Table 1). These results are in conformity with those of Niang Tian *et al* (2017). Fruit plants grown in larger container had more extended root system compared to smaller container. Significant variations in plant height was recorded in varied container size. 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 container, however maximum average plant height (112.66 cm) in guava which was statically on par to pomegranate and minimum height (86 cm) noted in citrus, irrespective of container size (Table 2). Significantly maximum root hairs diameter (0.44 mm) were noted in 30 cm × 45 cm which was closely followed by root hairs diameter (0.39 mm) in 45 cm × 45 cm container size and minimum

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	Mean
Pomegranate	486.00	401.33	381.67	423.00	287.33	209.67	222.57	239.86	0.59	0.52	0.58	0.57
Citrus	587.33	520.00	450.67	519.33	413.33	354.67	301.33	356.44	0.53	0.68	0.67	0.63
Guava	1963.00	878.00	376.00	1072.33	828.67	418.67	271.00	506.11	0.42	0.50	0.74	0.55
Mean	1012.11	599.78	402.78		509.78	327.67	264.97		0.52	0.56	0.67	
For comparing means			S.Em±	LSD0.05			S.Em±	LSD0.05		S.Em±	LSD0.05	
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	Mean
Pomegranate	12.62	19.14	21.02	17.60	32.90	29.47	27.67	30.01	131.00	110.67	85.33	109.00
Citrus	13.12	18.10	21.00	17.41	35.18	29.16	29.47	31.27	105.00	96.33	56.67	86.00
Guava	22.92	20.22	14.27	19.14	38.42	32.10	20.28	30.27	115.00	113.00	109.97	112.66
Mean	16.22	19.15	18.76		35.50	30.24	25.81		117.00	106.67	83.99	
For comparing the means				S.Em±	LSD0.05	S.Em±	LSD0.05			S.Em±	LSD0.05	
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	

root hairs diameter (0.32 mm) in 30 cm × 30 cm container size. Irrespective of container size maximum root hair thickness (0.43 mm) was in pomegranate which was on a par in citrus (0.37 mm) and minimum (0.36 mm) in guava (Table 3). Positive effect of increased container size on plant growth was reported in many woody plant species. The 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; Vaknin *et al.,* 2009 & and Dominguez-Lerena *et al.,* 2006). The fruit yield was maximum (3.14 kg/plant) was noted in 30 cm × 45 cm container which was on par to 45 cm × 45 cm and 30 cm × 30 cm container size (Table 3).

The container type and growth medium significantly affected the growth biomass and root morphological characters. When plant size is similar, high root to shoot biomass is preferred. Haase (2007) also indicated that quality container seedlings must have shoot : root ratio of 2:1 or less. Brissette *et al* (1991) reported higher root to shoot biomass ratio.

Significantly 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 and fruit yield while as it was negatively with root shoot ratio. Similarly growing media weight has significantly positive correlation with shoot weight (R= 0.992), root weight, collar diameter, plant height, root hairs diameter and fruit yield. Significantly negative correlation between stem girth and plant root hairs diameter, root length and fruits yield. While 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 roots hoot ratio. Total root mass was significantly positive correlation 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 (Table 4). 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), he observed that total seedling biomass having highest correlation with

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	Mean
Pomegranate	0.39	0.49	0.40	0.43	49.67	36.10	27.17	37.64	2.62	5.59	2.74	3.65
Citrus	0.42	0.42	0.28	0.37	56.47	35.50	40.17	44.04	1.53	1.45	0.90	1.29
Guava	0.37	0.40	0.29	0.36	51.67	56.00	35.33	47.67	1.85	2.39	3.19	2.48
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±	LSD0.05			S.Em±	LSD0.05			S.Em±	LSD0.05	
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	

Table 4: Pearson correlation analysis between different parameters

	PS	SB	RB	RSR	CD	PH	SG	RHD	RL	NF	FW	FY
PS	1											
MW	1.000**											
MP	0.439											
SW	0.974	1										
RW	0.845	0.945	1									
RSR	0.245	0.46	0.725	1								
CD	.998*	0.986	0.877	0.306	1							
PH	0.984	0.918	0.737	0.069	0.971	1						
PG	-0.981	-.999*	-0.932	-0.427	-0.991	-0.932	1					
RHD	-0.204	-0.423	-0.696	-.999*	-0.266	-0.028	0.389	1				
RL	1.000**	0.974	0.847	0.248	.998*	0.984	-0.982	-0.208	1			
NF	0.157	-0.073	-0.396	-0.919	0.094	0.329	0.036	0.935	0.153	1		
FW	-0.633	-0.793	-0.949	-0.906	-0.68	-0.486	0.77	0.887	-0.636	0.665	1	
FY	-0.15	-0.372	-0.656	-0.995	-0.212	0.028	0.338	.998*	-0.154	0.953	0.86	1

Note: * Correlation is significant at 0.05 level (2-tailed); ** Correlation is significant at 0.01 level (2-tailed); n = 3. PS = Pot size, SB = Shoot biomass, RB= Root biomas, RSR = Root-shoot ratio, CD = Collar diameter, PH = Plant height, SG = stem girth, RHD = Root hair diameter, RL = Root length, NF = Number of fruits, FW = Average individual fruit weight, FY = Fruit yield.

plant height. Seedling root collar diameter and height were positively and significantly correlated with plant biomass (Ning Tian *et al.*, 2017).

Conclusion

Thus, it is concluded that container size as well as growing media (substrate) influenced the plant growth, root and shoot biomass and root morphology. Root and shoot biomass both were high in larger containers. Guava plants have high root and shoot biomass. Root:shoot ratio was higher in smaller-sized container but collar diameter was noted in larger container size. Fruit bearing in containers started early as compared to field planted saplings. The medium and large containers gave higher yield. Kagazi Lime, guava and pomegranate fruit crops do well in container. Correlation matrix showed that container size has highly significant and positive correlation with fruit yield, shoot and root biomass, collar diameter, plant height.

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