The Bioscan 13(1): 317-321, 2018 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EVALUATION OF ROOT TRAINERS AS ALTERNATIVE CONTAINERS TO POLYBAGS FOR RAISING LITCHI AIR LAYERS USING VARIOUS POTTING MEDIA

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KEYWORDS
Litchi
Potting media
Polybag
Root trainer

Received on :
02.02.2017

Accepted on :
15.02.2018

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ABSTRACT
A study was done to evaluate the growth and survival raising litchi air layers in root trainers, polybags and nursery beds with different containers *viz*. small sized polybags (10x5.5inch), large sized polybags (12x8.5inch) and root trainers (500cc). Each type of container was filled with four different growing media *viz*., soil: sand: compost in the ratio of 1:1:1 and 1:1:2 and soil: sand: sphagnum moss in the ratio of 1:1:1 and 1:1:2. Among various treatments, large sized polybags containing soil: sand: sphagnum moss in the ratio of 1:1:2, showed maximum plant height (28.55cm), stem diameter (0.84cm), number of leaves (27.58), and shoots (6.47), shoot fresh weight (20.47g) and dry weight(10.48g), leaf fresh (4.61g) and dry weight (2.65g) and maximum survival (95.5%) after six months of transplanting. Root trainers (500 cc) containing soil: sand: sphagnum moss in the ratio of 1:1:2, shows highest length of primary root (22.68 cm), number of primary roots (31.74), and secondary roots (32.36), root fresh (4.58 g) and dry weight (0.47g). Although root trainers show less survival (73.3%) than polybags (95.5%), but because of their eco-friendly, reusable and light nature these can prove a profitable technology for raising litchi air layers in the current scenario of environmental hazard.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is an important sub-tropical evergreen fruit of family Sapindaceae. Litchi is becoming more popular due to its distinct flavour, good taste, juicy aril giving cooling effect during hot summer (Chauhan *et al*., 2008). Due to its high economic returns and ever increasing demand in the domestic markets, the crop is gaining momentum in Punjab, Himachal Pradesh, Assam, Tripura, and Orissa (Kumar *et al*., 2014). Litchi is also economically important as it has excellent export potential. The fruit of litchi comes to the market in May or early June when very few other fruits are available, thus, it fetches remunerative price in the market. Thus there is a lot of demand of quality planting material for commercial production of this cash crop. But, due to high mortality of litchi air layers in nursery the supply of planting material with respect to demand is not met which causes scarcity of quality planting material. Growing of litchi air layers in polybags with different media is practised in India. However, since polybags nurseries use larger containers, the potting, nursery handling and transportation are costly. The other problems of moisture, aeration, temperature variation which exist in polybag containers can cause higher incidence of nursery diseases. The poor health of tree root system of the stock leads to root diseases as well as reduction in the general health of plant and slow growth rates which in turn will increase nursery gestation time and mortality rate. Poor survival in plantations is another problem that may occur due to deformed root system. This results in failure to realise the potential productivity and associated returns. Thus overall cost-effectiveness of polybag container is much lower than what is possible by using some of the modern containers such as root trainers. The container sizes required are, in general, much smaller in volume (often 5 to 8 times smaller than polybag) (Wilson, 1986; Josaih and Jones, 1992). This coupled with use of artificial potting media having only half to one third the weight of soil making the container nursery stock very light. This helps in keeping more number of containers/ unit area of nursery. The cost of filling potting media will also be quite less. Nutrient and water use efficiency is enhanced considerably. The handling and transportation cost are also much less. The smaller volume required, along with facilities available for reusing root trainers helps in reducing the use of plastic. Seedlings grown in root trainers have more vigorous and rapid root growth than seedlings grown in polybags (Bora *et al*., 2006). Plants raised in root trainers showed better sturdiness (height: diameter ratio) and uniform distribution of roots than polybag plants (Soman *et al*., 2002). The lateral roots were also found to be significantly higher in root trainer plants than polybag plants (Soman and Saraswathy, 2005). Survival rates at out planting and in the long term are much higher. Plants grown in root trainer systems are often ready for planting out when they are still substantially smaller than those in conventional polybags. As the root system of root trainer grown stock is of high root growth potential, the stock gets established in the planting site at a much faster rate with early subsequent growth. This enhances post planting survival and further growth and development. Besides, suitable root trainer

(container size) Potting media is the important input for containerized seedling production. It is responsible for the healthy and uniform seedling production. Apart from the selection of proper ingredients, it is necessary to maintain the porosity of the potting mixture so that proper development of root takes place (Srivastava *et al*., 1998). The media should be rich enough to sustain seedling for about a year. A good potting medium is characterized by light weight friability, easy blandability, good water holding capacity, drainage, porosity, low bulk density, free from fungal spores and insects and low inherent fertility etc.It is imperative to determine the size of container or standardize the growing medium to provide best physio-chemical environmental attributes for growth of cost effective production of quality planting material. Keeping above all facts in view, the present study was aimed to compare the growth attributes and survival of litchi airlayers in different size polybags and root trainers by using different potting media.

MATERIALS AND METHODS

The present experiment was carried out at Fruit plant nursery, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Udheywalla, Jammu during the year 2012-13. The experiment was laid in Randomized Block Design. There were thirteen treatments with three replication of each. In single treatment there were 90 plants and observations were recorded on 10 randomly selected plants per treatment. The plant growth analysis was done as per the Bora *et al*. (2006) in litchi. The data generated during the study was subjected to statistical analysis by using Panse and Sukhatme (2000) method.

Media

Compost and sphagnum moss in different ratios were used as amendment sources for preparation of media with sand and soil (Table 1).

Containers

Three type of containers were used *viz*., polybags with holes of sizes 10 x 5.5 inch and 12 x 8.5 inch and root trainers of volume 500cc.

Plant growing conditions

Litchi plants of cv. Dheradun were air layered in the month of July. For air layering, the branches of well mature plant trees were selected. The branches selected were ¼ inch in diameter. A ring of bark of 1 inch wide was removed from the branch at the point where root formation was desired. The thin cambium layer beneath the bark was scrapped away, and moss grass was applied evenly around the barked area. A polyethylene strip of 150 gauges was then wrapped around the wound for rooting. After 3 months, they were transplanted in different containers and nursery bed. Raised beds were prepared and containers were kept on it for 6 months. The containers were filled with different combinations of growing media. At the time of filling of containers uniform litchi air layers were selected. Each litchi air layer had approximate height of 15 cm, stem diameter of 0.55mm, 5 number of leaves and one shoot per layer.

Plant growth analysis

Shoot growth

The data for shoot growth characteristics *viz*. plant height, stem diameter, number of leaves and number of shoots were recorded every three months of transplanting of litchi air layers, whereas, fresh and dry weight of leaves and shoot were recorded after 6 months of transplanting. Plant height was measured from the ground to top of the plant with the help of meter scale and stem diameter was recorded at 2 cm above the ground using vernier calliper. Total number of leaves and number of shoots were counted on each plant. Fresh weight of leaves and shoot were weighed on digital balance. For measuring dry weight of leaves and shoot, they were first placed in oven at 60° C (±2 C) for drying, and after 48 hours of drying, weight of leaves and shoot were recorded (Bora *et al*., 2006).

Root growth

The data for root growth characteristics *viz*. number of primary roots and number of secondary roots were recorded every three months of transplanting of litchi air layers, whereas, length of primary root, fresh and dry weight of roots were recorded after 6 months of transplanting. Total number of primary roots and secondary roots were counted on each plant. Length of primary root was recorded after 6 months of planting and the marked seedlings were uprooted carefully without causing any damage to root system. The roots were washed in water. The length of primary root was measured with the help of a centimetre scale. . Fresh weight of roots were weighed on digital balance whereas for measuring dry weight, fresh roots were first placed in oven at 60ºC (±2º C) for drying, then dry weight was recorded after 48 hours of drying (Bora *et al*., 2006).

RESULTS AND DISCUSSION

Effect of plant containers on growth and development of air layered litchi plants.

Among various treatments, layers planted in large sized polybags (12x 8.5 inch) (Table 2) showed maximum shoot growth in terms of plant height (28.55cm), stem diameter (0.80cm), number of leaves (27.58), number of shoots per layer (6.47), shoot fresh weight (20.47g) and dry weight(10.48g) , leaf fresh weight (4.61g) and dry weight(2.65g) after 6 months of planting. The increase in growth parameters with increase in container size could be attributed to more growing media and space for root development, higher water retention and more availability of nutrients which resulted in more absorption of moisture and nutrient in the polybags as compared to root trainers. These results are in conformity with the findings of Gera *et al*. (2001) who have reported that seedling attained lower height in root trainers as compared to polybags. Ferdousee *et al*. (2010) also reported an increase in seedling fresh and dry weight with increase in container size. Zalzaleh Al (2009) in his study also reported that seedling height, collar diameter and number of leaves increased with increase in container size in *Terminalia bellirica* and *Acacia saligna*.

Root characteristics (Table 3) *viz*. number of primary roots (31.74), number of secondary roots (32.36), length of primary root (22.68cm), root fresh weight (4.58g) and dry weight(0.47g) were recorded to be highest in treatment T_{12} ie. Root trainer (500cc) with potting mixture of Soil: Sand: Sphagnum moss in the ratio of (1:1:2). This is due to structural peculiarity of root

Table 1: Treatment combinations

Treatment	Container	Media composition
T_1	Polybag(10 x 5.5inch)	Soil:Sand:Vermicompost(1:1:1)
T_2	Polybag(10 x 5.5inch)	Soil:Sand:Vermicompost(1:1:2)
T_3	Polybag(10 x 5.5inch)	Soil:Sand: Sphagnum moss(1:1:1)
T_4	Polybag(10 x 5.5inch)	Soil:Sand: Sphagnum moss(1:1:2)
T_5	Polybag(12 x 8.5inch)	Soil:Sand:Vermicompost(1:1:1)
T_6	Polybag(12 x 8.5inch)	Soil:Sand:Vermicompost(1:1:2)
T_7	Polybag(12 x 8.5inch)	Soil:Sand: Sphagnum moss(1:1:1)
T_8	Polybag(12 x 8.5inch)	Soil:Sand: Sphagnum moss(1:1:2)
T_9	Root trainer(500cc)	Soil:Sand:Vermicompost(1:1:1)
T_{10}	Root trainer(500cc)	Soil:Sand:Vermicompost(1:1:2)
T_{11}	Root trainer(500cc)	Soil:Sand: Sphagnum moss(1:1:1)
T_{12}	Root trainer(500cc)	Soil:Sand: Sphagnum moss(1:1:2)
T_{13}	Nursery bed (Control)	

Table 2: Effect of various containers and growing media on shoot growth of air layered litchi plants

Number of treatments	Plant height (cm)		Stem diameter (cm)		Number of leaves		Number of shoots/ layer		Fresh weight(g)		Dry weight(g)	
	After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months	After 6 months		After 6 months	
									leaves	shoot	leaves	shoot
T_1:Polybag A +M1	21.45	23.10	0.66	0.69	14.51	22.41	3.07	4.59	3.10	18.21	1.96	8.22
T_2:Polybag A + M2	21.70	23.36	0.68	0.71	15.22	22.63	3.15	4.77	3.24	18.41	2.15	8.32
T_3:Polybag A + M3	22.46	24.21	0.70	0.74	16.77	23.59	3.30	5.38	4.04	19.09	2.28	9.56
T_4:Polybag A + M4	22.75	24.99	0.72	0.76	17.48	23.93	3.41	5.78	4.33	19.37	2.34	9.92
T_5:Polybag B + M1	23.65	25.62	0.69	0.72	15.51	25.40	3.29	5.44	3.26	19.22	2.21	9.45
T_6:Polybag B + M2	23.91	26.15	0.71	0.75	16.93	25.52	3.48	5.81	3.48	19.55	2.44	9.60
T_7:Polybag B + M3	24.22	28.19	0.74	0.78	17.41	26.58	3.67	6.26	4.38	20.29	2.52	10.37
T_8:Polybag B + M4	24.66	28.55	0.78	0.80	18.52	27.58	3.77	6.47	4.61	20.47	2.65	10.48
T_9:Roottrainer + M1	19.15	21.18	0.55	0.58	11.74	19.55	2.55	4.18	2.62	16.41	1.44	6.33
T_{10}:Root trainer + M2	20.12	21.63	0.57	0.61	12.58	21.15	2.75	4.26	2.64	16.63	1.54	6.64
T_{11}:Root trainer + M3	20.93	22.20	0.60	0.63	13.15	21.90	2.84	4.36	2.78	17.00	1.74	7.29
T_{12}:Root trainer + M4	21.26	22.77	0.62	0.65	13.60	22.10	2.91	4.46	2.99	17.48	1.77	7.45
T_{13}:Nursery bed	21.37	23	0.64	0.67	14.22	22.33	3.00	4.51	3.03	17.84	1.88	7.92
C.D at 5%	0.57	0.88	0.12	0.12	0.77	0.54	0.30	0.28	0.48	0.41	0.47	0.26

T_1:Polybag A +M1, T_2:Polybag A + M2, T_3:Polybag A + M3, T_4:Polybag A + M4, POLYBAG A = Polybag size (10x 5.5 inch), POLYBAG B = Polybag size (12x 8.5 inch
T_5:Polybag B + M1, T_6:Polybag B + M2, T_7:Polybag B + M3, T_8:Polybag B + M4, M1 = Soil (1): sand (1) :Compost(1) M2 = Soil (1): sand (1) :Compost(2)
T_9:Root trainer + M1 T_{10}:Root trainer + M2, T_{11}:Root trainer + M3, T_{12}:Root trainer + M4, M3 = Soil (1): sand (1) :Sphagnum moss (1), M4 = Soil (1): sand (1) :Sphagnum moss (2)

Table 3: Effect of potting media, containers and time interval on root characteristics of air layered litchi plants.

Number of treatments	Number of primary roots		Number of secondary roots		Length of roots	Fresh weight	Dry weight
	After 3 months	After 6 months	After 3 months	After 6 months	After 6 months	of roots	of roots
T_1:Polybag A +M1	19.15	20.33	21.18	23.18	17.18	2.74	0.31
T_2:Polybag A + M2	19.92	20.78	21.38	23.45	17.73	2.81	0.33
T_3:Polybag A + M3	20.33	20.92	22.67	24.29	18.48	3.11	0.34
T_4:Polybag A + M4	20.92	21.46	23.11	24.41	19.57	3.29	0.35
T_5:Polybag B + M1	21.46	22.15	22.14	26.15	19.24	3.33	0.37
T_6:Polybag B + M2	23.37	24.22	23.14	26.55	19.59	3.44	0.38
T_7:Polybag B + M3	23.98	24.49	26.37	27.25	20.25	3.62	0.39
T_8:Polybag B + M4	25.11	26.26	26.66	27.52	21.89	3.70	0.40
T_9:Root trainer + M1	25.42	27.00	27.48	29.20	20.19	3.89	0.41
T_{10}:Root trainer + M2	26.66	29.41	27.63	31.22	20.67	4.21	0.44
T_{11}:Root trainer + M3	28.67	30.41	29.55	31.99	21.76	4.44	0.46
T_{12}:Root trainer + M4	29.19	31.74	30.55	32.36	22.68	4.58	0.47
T_{13}: Nursery bed	18.44	20.00	20.55	23.66	15.57	2.45	0.28
C.D at 5%	2.02	1.36	0.24	0.89	0.80	0.31	0.04

T_1:Polybag A +M1 T_2:Polybag A + M2 T_3:Polybag A + M3 T_4:Polybag A + M4, POLYBAG A = Polybag size (10x 5.5 inch), POLYBAG B = Polybag size(12x 8.5 inch
T_5:Polybag B + M1 T_6:Polybag B + M2 T_7:Polybag B + M3 T_8:Polybag B + M4, M1 = Soil (1): sand (1) :Compost(1) M2 = Soil (1): sand (1) :Compost(2)
T_9:Root trainer + M1 T_{10}:Root trainer + M2 T_{11}:Root trainer + M3 T_{12}:Root trainer + M4, M3 = Soil (1): sand (1) :Sphagnum moss (1), M4 = Soil (1): sand (1) :Sphagnum moss (2)

trainers which improved morphology and physiology of roots and also encouraged the number of roots to grow and absorb more nutrients. Vertical ridged structure of root trainers encouraged roots to grow straight without getting intermingled

Table 4: Effect of potting media containers and time interval on survival percentage of air layered litchi plants

Number of treatments	1 month after planting	2 months after planting	3 months after planting	4 months after planting	5 months after planting	6 months after planting
T_1:Polybag A +M1	100	100	96.6	93.3	92.2	91.1
T_2:Polybag A+M2	100	100	97.7	94.4	93.3	92.2
T_3:Polybag A+M3	100	100	100	96.6	95.5	93.3
T_4:Polybag A+M4	100	100	100	97.7	96.6	94.4
T_5:Polybag B+M1	100	100	97.7	95.5	94.4	92.2
T_6:Polybag B+M2	100	100	98.8	96.6	95.5	93.3
T_7:Polybag B+M3	100	100	100	97.7	96.6	94.4
T_8:Polybag B+M4	100	100	100	98.8	97.7	95.5
T_9:Root trainer+M1	100	100	85.5	67.7	66.6	63.3
T_{10}:Root trainer+M2	100	100	88.8	69.8	68.8	64.4
T_{11}:Root trainer+M3	100	100	93.3	76.6	75.5	72.2
T_{12}:Root trainer+M4	100	100	94.3	77.7	76.6	73.3
T_{13}:Nursery bed	100	100	95.3	90.6	77.7	76.3
C.D at 5%	NS	NS	4.40	3.34	5.00	3.25

T_1:Polybag A +M1 T_2:Polybag A+M2 T_3:Polybag A+M3 T_4:Polybag A+M4, POLYBAG A = Polybag size (10x 5.5 inch), POLYBAG B = Polybag size(12x 8.5 inch
T_5:Polybag B+M1 T_6:Polybag B+M2 T_7:Polybag B+M3 T_8:Polybag B+M4, M1 = Soil (1): sand (1) :Compost(1) M2 = Soil (1): sand (1) :Compost(2)
T_9:Root trainer+M1 T_{10}:Root trainer+M2 T_{11}:Root trainer+M3 T_{12}:Root trainer+M4, M3 = Soil (1): sand (1) :Sphagnum moss (1), M4 = Soil (1): sand (1) :Sphagnum moss (2)

which ultimately resulted in improved morphology and physiology of the root and finally survival of the plants (Bora *et al*., 2006 and Saroj *et al*., 2000). Similar results were obtained by Bora *et al*. (2006) and Kumar *et al*. (2002) who observed that root weight increased when layers were planted in root trainers than polybags or nursery beds in litchi. On the basis of physiological point of view the plants growing in root trainers are in a state of physiological stress due to lesser nutrient medium and want of space (Sumesh *et al*., 2015). So in this case more number of roots are produced at the cost of shoot growth.

Effect of potting media on growth and development of air layered litchi plants.

The potting media exhibited significant effect on all studied parameters (Table 2 & 3). All the values of growth parameters *viz* plant height (28.55 cm), stem diameter (0.80 cm), number of leaves (27.58), number of shoots per layer (6.47) were recorded to be highest in M_4 (soil: sand: sphagnum moss, 1:1:2) after 6 months of transplanting. The values of all studied growth parameters followed a trend: M_4 (soil: sand: sphagnum moss,1:1:2) > M_3 (soil: sand: sphagnum moss , 1:1:1) > M_2 (soil :sand:vermicompost1:1:2) > .M_1 (soil :sand: vermicompost 1:1:1).The seedlings in M_4 and M_3 were superior to those grown in other potting mixture in terms of morphological growth parameters such as height, stem girth, number of leaves, and number of shoots of each air-layers may be due to general improvement in physical and chemical properties of the potting media (Singh *et al*., 2000). Similar results were also reported by Kumar *et al*. (2011) in litchi (*Litchi chinensis* Sonn) and Prasana *et al*. (2013) in mango (*Mangifera indica* L.). Khan *et al*. (2006) also reported that sphagnum moss holds more water as compared to compost. Sphagnum moss results in better establishment of root system, which might cause better absorption of water and mineral nutrients from the soil and ultimately retaining higher percentage of survival, leading to better growth characters of plantlets. Similarly Ma *et al*. (2000) reported maximum plant growth and stem diameter of citrus seedlings in media containing peat + Sand (4:1). Rymbai *et al*. (2010) also reported that high percentage of rooting and root characters of air layers of guava was found in media containing moist sphagnum moss.

Effect of potting media and containers on survival percentage of air layered litchi plants.

All the air layered litchi plants showed 100 percent survival irrespective of containers and growing media for the first 2 months (Table 4). Thereafter, air layered plants of litchi showed various degrees of mortality among various containers and growing media. Maximum survival percentage (95.5%) of litchi air layers was obtained in large size polybags (12 x 8.5inch) while minimum survival percentage was recorded in litchi air layers growing in root trainers (63.3 %) . Polybags being bigger in size contained more potting material as compared to root trainers (500cc) which resulted into better growth and survival of air layered litchi plants in polybags as compared to root trainers. These results can be attributed to difference in growing media holding capacity of different containers. These results are in accordance with the results of Nayital *et al*. (1995) who reported that potting material influences all the growth parameters because of different container volumes which reduced root restriction and led to increased dry matter production resulting in increased survival percentage. Ryambai and Reddy (2010) also reported that survival of rooted air layers of guava was also found maximum with sphagnum moss. These results are in also in agreement with Prasana *et al*. (2013) and Shamet *et al*. (1994). Growing media containing soil: sand: sphagnum moss in 1:1:2 ratio showed maximum survival of litchi air layers irrespective of containers followed by growing media containing soil : sand : sphagnum moss in the ratio of 1:1:1. Ryambai and Reddy (2010) also reported that survival of rooted air layers of guava was found maximum with sphagnum moss. These results are in also in agreement with Prasana *et al*. (2013) and Shamet *et al*. (1994). These results can be explained in the light of fact that sphagnum moss has more water holding capacity than compost.

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