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Efficacy of Biodegradable Containers in Nursery Raised with Teak Seedlings

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***Abstract*:** An investigation was carried out at College of Forestry, Kerala Agricultural University, Thrissur, India in 2020 to determine efficacy of six types of biodegradable containers such as nonwoven cloth bag, coco pot, mud pot, bamboo splits, cashew nut shell liquid treated cardboard and coir root trainer. Each container had equivalent capacity of 12cm x 15cm filled with soil mixture of soil: coir pith: vermicompost @ 2:1:1 by volume in which 15 days old uniform sized teak seedlings were grown for 5 months. Excepting 1st month in all other months, seedling quality index varied significantly among the containers (0.46 to 1.03) at 5-month age. Nonwoven bag was most efficient producing superior quality seedling followed by bamboo splits, coco pot, cashew nut shell liquid treated cardboard, coir root trainer and mud pot. The economics of raising teak seedling of 5-month old in six biodegradable containers differed significantly and was compared with conventional polythene bag. The benefit: cost ratio varied remarkably among different containers ranging from 0.30 to 2.60.The value was highest in case of seedlings raised in polythene bag (non-biodegradable) followed by bamboo splits, nonwoven bag, cashew nut shell liquid treated cardboard, coir root trainer, coco pot and mud pot.

Keywords: Biodegradable, Container, Nursery, Seedling, Teak

The plastic based materials are widely used in the nursery production sector both in forestry and agriculture primarily as seedling containers. The conservative estimates suggest that roughly 0.35 million tonnes of plastic is used in agricultural sector annually in India (Patel and Tandel 2017). In the last six decades, the massive production of plastics has led to an enormous amount of waste worldwide (Tomadoni et al 2020). Over 320 million tons of polymers were produced across the globe in 2015, but unfortunately, less than 10% of the manufactured plastics are actually recycled, and a huge amount is gathering in landfills or thrown away into the environment as litter (NatGeo 2019). Approximately, 500 million plant containers and seed trays are produced every year worldwide. The vast majority are either disposed in landfill or burnt in an uncontrolled manner. A large quantity of fossil fuel is used to manufacture plastic pots, which takes around 500 years to decompose (Tomadoni et al 2020). The excessive use of non-biodegradable plastic has started impacting the environment in serious proportions. Biodegradable containers or biopots are a sustainable alternative to petroleum-based pots that could easily adjust to agriculture and forestry reducing the enormous amount of plastic waste, and providing outstanding marketing opportunities. The main disadvantages include: biodegradable containers are fragile and require careful handling during transportation of seedlings. They also lack a solid wall which prevent in training the roots to the lower part of the container. Being bio-materials, chances of the container being infested with algae and fungi are more which may affect the growth of seedlings and overall hygiene. Yet another factor of concern is the high cost of biodegradable containers. However, consumer demand for environmentally conscious products and practices is on the rise and consumers are willing to pay more for eco-friendly products, such as plants grown in biodegradable containers (Behe et al 2013). In the present study, the efficacy of some locally available biodegradable containers has been studied in a forest nursery raising teak seedlings.

MATERIAL AND METHODS

The investigation was carried out at College of Forestry, Kerala Agricultural University, Thrissur, Kerala, India in 2020. The experimental site is located at $10^0$32' N latitude and $76^0$26'E longitude with an altitude of 40 m above mean sea level which comes under the humid tropical zone. The area receives an annual rainfall ranging from 2650 to 3200mm with almost bulk share of the rain during June-August. The mean maximum temperature during the study period was 36^0C (March) and mean minimum temperature 23^0C (January). Six types of biodegradable containers were taken for the trial: nonwoven cloth bag, coco pot, mud pot, bamboo splits, cashew nut shell liquid treated cardboard and coir root traineer. The experiment was done in complete randomized design with 4 replications. Each treatment included 30 plants per replication. The data were compared under DMRT. For this, 15-days old uniform sized teak seedlings were transplanted in different containers in March 2020. Each container had equivalent capacity of 12cm x 15cm filled with soil mixture of soil: coir pith: vermicompost @ 2:1:1 by volume. The efficacy of different containers was studied in terms of growth and quality of seedlings monthly for 5 months and economics of raising seedlings in them. The quality of planting stock was determined in terms of Quality Index (QI) (Dickson et al 1960).

$$QI = \frac{\text{Total dry matter (g)}}{\frac{\text{Shoot height (cm)}}{\text{Collar diameter (mm)}} + \frac{\text{Shoot dry matter (g)}}{\text{Root dry matter (g)}}}$$

RESULTS AND DISCUSSION

Height of seedlings: Different containers imparted significant effect on height growth of seedlings (Table 1). At the age of 5-month, varied from 17.4 to 31.5 cm. The seedlings in nonwoven bag registered significantly higher height over others followed by bamboo split (29.5 cm). Mud pot witnessed significantly lower height. Seedling height in containers is often strongly influenced by the container type especially the shape and cubic contents (Aghai and Davis 2014, Tian et al 2017). Such factors again influence the root development especially root elongation and spread. Ideally tree seedling containers with reasonably larger size (height) and moderate diameter are preferred which ensure deep root production and training of roots by the side walls. Nonwoven bags are similar to polythene bags in terms of durability and physical sturdiness to hold soil. The possible reason is that the nonwoven container is permeable and allows water and soluble nutrients to move laterally, which could affect the water and nutrient availability for each seedling and thus impact the seedling growth (Tian et al 2017). The container walls are strong enough to train the roots to the deeper soil. Bamboo splits also had high durability and better length to diameter ratio which permit the faster growth of the root system. This could be reason for the better height growth of teak seedlings in these two types of containers. Furthermore, better soil aeration, ability to hold water and minerals may also have contributed to the better height growth. Interestingly height growth of teak seedlings in the mud pot was the lowest despite its physical soundness. Probably, the short stature and broad base of the mud pots may have adversely affected the root and shoot growth.

Collar diameter of seedlings: Various containers significantly influenced the collar diameter of teak seedlings in every month (Table 2). At 5-month age it ranged from 5.2 to

Table 1. Height of teak seedlings in different biodegradable containers

Type of containers	Seedling height of teak seedling (cm)				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	3.7[a]	10.2[a]	17.6[a]	24.9[a]	31.5[a]
Coco pot	3.5[a]	8.3[c]	13.6[bc]	20.1[c]	24.9[c]
Mud pot	3.2[a]	5.8[e]	9.0[e]	14.1[f]	17.4[f]
Bamboo split	3.6[a]	9.2[b]	15.2[ab]	21.5[b]	29.5[b]
CNSL treated cardboard pot	3.5[a]	7.8[c]	12.2[cd]	18.4[d]	22.1[d]
Coir root trainer	3.4[a]	6.9[d]	10.6[de]	16.5[e]	20.0[e]
CV	14.6	7.3	14.2	7.7	13.8

Values with at least one common letter are not significantly different

Table 2. Collar diameter of teak seedlings in different biodegradable containers

Type of containers	Collar diameter of teak seedlings (mm)				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	1.8[a]	3.0[a]	6.2[a]	8.4[a]	10.6[a]
Coco pot	1.7[ab]	2.4[bc]	4.5[bc]	6.2[c]	7.9[c]
Mud pot	1.2[c]	1.7[e]	2.8[d]	3.8[e]	5.2[e]
Bamboo split	1.8[a]	2.7[ab]	5.2[b]	7.6[b]	9.7[b]
CSNL treated cardboard pot	1.5[abc]	2.2[cd]	4.1[c]	5.6[cd]	7.3[cd]
Coir root trainer	1.4[bc]	1.8[de]	3.2[d]	5.2[d]	6.8[d]
CV	12.5	11.6	11.3	8.2	7.6

Values with at least one common letter are not significantly different

10.6 mm. Nonwoven bag recorded highest value while mud pot the lowest diameter. Optimal collar diameter is inevitable for healthy growth of the plants which should be proportional to the height growth (Mohapatra et al 2008, Nayak et al 2017). A larger collar diameter also indicates a larger root system and a larger stem volume (Haase 2008). The poor collar diameter and faster height growth often lead to weaker seedlings which may eventually topple with increase in biomass. The better radial growth of teak seedlings in the non-woven bag followed by bamboo splits suggest their ability to maintain better soil biophysical conditions especially for optimal root growth in addition to their enhanced physical suitability and durability. Most of the remaining container types exhibited varying levels of degradation due to infestation by fungi and termites. This might has further influenced the general health of the seedlings.

Shoot dry weight of seedlings: The biodegradable containers resulted significant variation in shoot dry weight in each month of evaluation (Table 3). At the age of 5-month, varied from 1.95 to 4.00 g per seedling. In consistent with the general trends observed so far, the non-woven bag and bamboo splits grown seedlings had higher shoot weight while the mud potted seedlings had the lowest value. Shoot weight often reflects the total aboveground biomass allocation potential by plants with progressive time. The rate of shoot weight accumulation may vary with advancement in time for variable container types consequent to the changes in biophysical conditions. The variation in shoot dry weight under different container types may be attributed to difference in shoot growth in terms of height, diameter, number of leaves and leaf area.

Root dry weight of seedlings: At 5-month age, ranged from 0.78 to 1.63 g and nonwoven bag recorded maximum which was at par with bamboo split pot (1.49 g) (Table 4). Mud pot demonstrated the minimum root growth. The seedlings with larger root dry weight tend to grow more and survive better than those with smaller root mass. The higher root biomass associated with seedlings grown in non-woven bag and bamboo splits suggest physical suitability of the container material to facilitate root growth. The variations in root biomass with container types have also been reported before (de Oliveira and Milioranza 2015). The faster root production is often a continuation of the better aboveground biomass accumulation. However, the size, shape and wall flexibility of the containers may limit the root growth considerably despite the better soil properties and moisture regimes.

Table 3. Shoot dry weight of teak seedlings in different biodegradable containers

Type of containers	Shoot dry weight of teak seedlings (g)				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	0.20	1.26[a]	2.34[a]	3.25[a]	4.00[a]
Coco pot	0.18	0.84[c]	1.70[c]	2.25[c]	3.15[b]
Mud pot	0.13	0.46[d]	0.90[e]	1.4[d]	1.95[c]
Bamboo split	0.19	0.99[b]	2.00[b]	2.75[b]	3.65[a]
CNSL treated cardboard pot	0.16	0.72[c]	1.40[d]	2.15[c]	2.85[b]
Coir root trainer	0.15	0.55[d]	1.10[e]	1.65[d]	2.35[c]
CV	11.20	10.70	9.99	10.45	8.10

Values with at least one common letter are not significantly different

Table 4. Root dry weight of teak seedlings in different biodegradable containers

Type of containers	Root dry weight of teak seedlings (g)				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	0.14[a]	0.52[a]	1.00[a]	1.30[a]	1.63[a]
Coco pot	0.11[bc]	0.35[bc]	0.72[bc]	1.00[b]	1.25[b]
Mud pot	0.09[c]	0.18[e]	0.34[d]	0.54[c]	0.78[d]
Bamboo split	0.12[ab]	0.41[b]	0.89[ab]	1.17[a]	1.49[a]
CNSL treated cardboard pot	0.11[bc]	0.29[cd]	0.61[c]	0.87[b]	1.09[bc]
Coir root trainer	0.10[bc]	0.24[de]	0.46[c]	0.68[c]	0.95[cd]
CV	11.10	7.90	6.20	10.82	12.77

Values with at least one common letter are not significantly different

Total dry weight of seedlings: The total dry weight of teak seedlings varied from 2.73g (mud pot) to 5.63g (nonwoven bag) at 5-month age and (Table 5). The highest total biomass production in the nonwoven bagged seedlings is on account of the cumulative higher shoot and root biomass production. Similarly mud pot positioned last because of its minimum shoot and root weight. The variation of dry weight under different container types has also been reported by various authors (Koeser et al 2013, Castronuovo et al 2015, de Oliveira and Milioranza 2015).

Quality index of seedlings: The six different biodegradable containers resulted seedlings of different qualities. Except in 1st month, in all other months seedling quality index varied significantly among the containers (Table 6). The quality index differed from 0.46 to 1.03 at 5-month age. Nonwoven bag was most efficient producing superior quality seedling followed by bamboo splits. Mud pot witnessed to be the least efficient among the containers tested. The order of performance with regard to seedling quality was: nonwoven bag> bamboo splits> coco pot> cashew nut shell liquid

Table 5. Total dry weight of teak seedlings in different biodegradable containers

Type of containers	Total dry weight of teak seedlings (g)				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	0.34[a]	1.78[a]	3.34[a]	4.55[a]	5.63[a]
Coco pot	0.29[abc]	1.19[bc]	2.42[c]	3.25[c]	4.40[c]
Mud pot	0.22[d]	0.64[d]	1.24[e]	1.94[e]	2.73[f]
Bamboo split	0.31[ab]	1.40[b]	2.89[b]	3.92[b]	5.14[b]
CNSL treated cardboard pot	0.27[bcd]	1.01[c]	2.01[d]	3.02[c]	3.94[d]
Coir root trainer	0.25[cd]	0.79[d]	1.56[e]	2.33[d]	3.30[e]
CV	8.70	10.45	5.29	6.10	6.97

Values with at least one common letter are not significantly different

Table 6. Quality Index of teak seedlings in different biodegradable containers

Type of containers	Quality Index of teak seedlings				
	1-month old	2-month old	3-month old	4-month old	5-month old
Nonwoven bag	0.10[a]	0.30[a]	0.64[a]	0.83[a]	1.03[a]
Coco pot	0.08[a]	0.20[bc]	0.45[b]	0.59[c]	0.77[c]
Mud pot	0.05[a]	0.10[e]	0.22[d]	0.30[f]	0.46[f]
Bamboo split pot	0.09[a]	0.24[b]	0.56[a]	0.75[b]	0.93[b]
CNSL treated cardboard	0.07[a]	0.16[cd]	0.38[bc]	0.52[d]	0.69[d]
Coir root trainer	0.06[a]	0.13[de]	0.29[cd]	0.41[e]	0.60[e]
CV	15.39	13.80	14.90	6.25	4.30

Values with at least one common letter are not significantly different

Table 7. Economics of raising teak seedlings (5-month-old) in different bio degradable containers

Name of container	Cost of one container (Rs)	Cost of soil mixture for one teak seedling (Rs)	Cost of labour and other inputs for one teak seedling (Rs)	Survival percentage of seedlings in 5 months (Rs)	Total cost of raising one 5-month-old teak seedling (Rs)	Sale price of one 5-month-old teak seedling(Rs)	Benefit: cost ratio
Nonwoven bag	4.0	1.5	5.0	94	11.10	20.00	1.80
Coco pot	55.0	1.5	5.0	98	62.70	20.00	0.31
Mud pot	40.0	1.5	5.0	68	68.40	20.00	0.30
Bamboo split pot	7.0	1.5	5.0	100	13.50	27.00	2.00
CNSL treated cardboard	8.0	1.5	5.0	88	16.50	20.00	1.21
Coir root trainer	20.0	1.5	5.0	90	29.44	20.00	0.70
Polythenebag (check)	0.50	1.5	5.0	90	7.70	20.00	2.60

treated cardboard> coir root trainer> mud pot. Seedling quality is often considered as the net effect of growth potential and the effective allocation of biomass to the aboveground and belowground. The containers with higher seedling quality index indicate their better efficiency to support higher shoot growth, root growth as well as higher shoot biomass and root biomass.

Economics of raising seedlings: The economics of raising teak seedling of 5-month-old in six biodegradable containers differed significantly (Table 7). The benefit: cost ratio of raising 5-month age teak seedling varied among different containers and ranged from 0.30 to 2.60. The highest of 2.60 was in polythene bag (non-biodegradable) followed by degradable containers such as bamboo split pot, nonwoven bag, treated card board, coir root trainer, coco pot and mud pot. This was primarily due to the variation in the cost of containers and survival percentage of seedlings in different containers.

CONCLUSION

The efficacy of different biodegradable containers was different with regard to raising quality seedlings in nursery. Their performance varied remarkably with respect to height, diameter, shoot dry weight, root dry weight, total dry weight and seedling quality. Nonwoven bag was best closely followed by bamboo split pot among the biodegradable containers tested. Polythene bag seedlings were cheaper having higher benefit: cost ratio than biodegradable containers. Further research is necessary to find out cheaper biodegradable containers having stability during nursery period.

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