ASIAN JOURNAL OF AGRICULTURE
Volume 3, Number 1, June 2019
Pages: 26-32

E-ISSN: 2580-4537
DOI: 10.13057/asianjagric/g03010505

Effect of container and potting media on raising quality seedlings of *Acacia auriculiformis* in the nursery

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Manuscript received: 21 February 2019. Revision accepted: 11 April 2019.

Abstract. *Islam MDA, Rahman MDA, Hossain MK. 2019. Effect of container and potting media on raising quality seedlings of* Acacia auriculiformis *in the nursery. Asian J Agric 3: 26-32.* This study elucidates the effect of container and potting media on raising quality seedlings of *Acacia auriculiformis* in the nursery of the Institute of Forestry and Environmental Sciences, University of Chittagong to find out a suitable container and potting media for raising large scale quality seedlings. The seedlings were evaluated by testing five containers and seven potting media treatments for eight months. A Completely Randomized Block Design (CRBD) was adopted for the study with three replications for each treatment. The Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was tested for the analysis to explore the possible treatment variations. However, the study reveals nodulation with growth parameters; shoot and root dry biomass production and quality index were highest in 20 cm × 15 cm size polybags whereas the highest root length and shoot-root ratio was observed in 15 cm × 10 cm and 15 cm × 13 cm size polybag respectively. Considering the potting media, highest nodulation, growth parameters, shoot dry and fresh weight, shoot- root ratio and biomass were found in combination of soil + cow dung + phosphorus (0.16 g/polybag). Highest root length, root fresh and dry weight, and quality index were found in the combination of soil + cow dung (3:1). Therefore, it is recommended that containers of 20 cm × 15 cm size polybag and with a potting media of soil + cow dung + phosphorus (3 parts soil, 1 parts cow dung + 0.16 g/polybag) combination produce quality *A. auriculiformis* seedlings in the nursery.

Keywords: Akashmoni, Bangladesh, quality index, nodulation, shoot-root ratio

INTRODUCTION

Demand for different land uses and continual deforestation are responsible for decreasing natural forestland. As a result, continuous supply of wood from natural forests is becoming very difficult for different purposes (Asif et al. 2017). Plantations of fast-growing species must be established as a compensation package for the declining supply from natural forests (Sharma et al. 2011).

Akashmoni (*Acacia auriculiformis* A. Cunn. ex Benth.) is an evergreen, exotic, heavily branched, forked bole species, mostly planted on roadsides and railway embankments, parks and gardens because of its ornamental and shade bearer qualities in Bangladesh (Das and Alam 2001; Hossain et al. 2009; Girijashankar 2011; Islam et al. 2013). It is a multipurpose tree species and is considered one of the most promising plantation species because of its ability to survive on a wide range of degraded environmental conditions (Alam et al. 1991; Das and Alam 2001; Jahan et al. 2008). Globally, in good soil conditions, the species can reach a height up to 35 m (Orchard and Wilson 2001). Where in consequence, transmission poles and posts can be made from rounded timber (Sattar et al. 1999). Considering the growth, short rotation, non-palatability to grazing animals, nowadays, *A. auriculiformis* is also preferred for afforestation, reforestation, and agroforestry purposes in Bangladesh (Hossain et al. 1994; Uddin et al. 2007; Azad et al. 2011). Good quality durable heartwood of *Acacia* is suitable for being used to create furniture and for other constructional purposes (Pinyopusarerk 1990). In addition, *Acacia* wood is ideal for fuelwood, charcoal making, and it has also been proved as a good pulpwood species (CABI 2013; Islam et al. 2013). To fulfill the high demand, many organizations are producing akashmoni seedlings in nurseries in Bangladesh to supply those in the plantation programs (Khan et al. 2014). However, the productivity of the plantations is not up to the mark. The main reason for lower productivity includes declining soil fertility and suppression of growth due to competing of seedlings especially in the nursery (Hulikatti and Madiwalar 2011).

Nursery establishment is the first and foremost obvious task in raising a successful plantation. Direct seeding results in wastage of improved seeds while planting in the nursery including losses and possible mortalities (Adu-Berko et al. 2011; Adu-Yeboah et al. 2015). In current forest nursery practices, container size of all dimensional features like, volume, height, diameter, and shape with different pre-sowing treatment are required to get good germination, required and desired quantity of seedlings in the nursery (Annapurna et al. 2004; Farhadi et al. 2013; Mozumder et al. 2018).

A lot of studies have been conducted to determine enhanced germination, growth performance and survivability of seedlings using different pre-sowing treatments (Napier 1987; Palani et al. 1995; Alamgir and Hossain 2005; Iqbal et al. 2007; Khan et al. 2014; Mridha et al. 2016) and container (Bharathia 1999; Natarajn 1999;

Annapurna et al. 2004; Biradar et al. 2014) of different species. But a detailed experiment on both (container and potting media) aspects of *A. auriculiformis* has not been conducted yet. Therefore, the present study was aimed to evaluate the suitable shape and size of containers and potting media to ensure production of quality seedlings of *Acacia auriculiformis* in nursery.

MATERIALS AND METHODS

Study site

The study was conducted from April 2017 to December 2017 in the nursery of Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU), Bangladesh. It lies approximately at the interaction of 91°50´E longitude and 22°30´N latitude (Figure 1) (Hossain et al. 2005). The altitude of this area is 14 m to 87 m above from the mean sea level (Mridha et al. 2016). The nursery site enjoys tropical monsoon climate characterized by hot, humid summer and cool, dry winter. The average annual rainfall of this area is about 2500-3000 mm, which mostly takes place between June and September. There is a mean monthly maximum temperature of 29.75°C and a monthly minimum of 21.24°C. The highest temperature usually occurs in May as 32.60°C, and minimum in January as 14.10°C (Peel et al. 2007).

Seed collection and experimental design

Seeds of *A. auriculiformis* were collected from Seed Production Areas (SPAs) of Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh. The soils used in the experiment were collected from the forest floor of the University campus. To determine suitable container for *A. auriculiformis* seedling, the soil was sieved well (<3 mm sieve) and mixed with dried cow dung in a ratio of 3:1. For another experiment soil, cow dung, sand, sawdust, and phosphorus were used where polybags (15 cm × 13 cm) were filled with different combinations of mixture. To facilitate aeration and proper drainage, holes were made in the polybag by punching before filling with prepared mixture of soils. A Completely Randomized Block Design (CRBD) was adopted for the study with three replications for each treatment. There were five treatments of different containers and seven treatments of different mixtures used for the experiment. The treatments and containers type and size and their combination are given in Table 1 and Table 2.

Seed treatment and sowing

Seeds of *A. auriculiformis* were treated by soaking in hot water for 30 seconds, followed by being placed in cold water overnight before sowing in the pre-filled polybags and root trainer. Seeds were sown in the polybags and root trainers filled with growing media. Two seeds were sown in each polybag and root trainer directly. Seeds were dibbed to 0.5 cm under the soil by pressing them with thumb. Afterward, they were covered with a thin layer of soil.

Assessment of physiological growth performance

Three seedlings from each treatment were randomly selected and uprooted carefully during harvesting seedlings. All three seedlings were used to assess nodule number and to estimate growth. After taking records of shoot length, root length, collar diameter, fresh weight of shoots and roots separately, then oven-dried at 70ºC for 24 hours. Afterward, the dry weight of shoots and roots was taken. Average height of the seedlings for each treatment was also recorded. All the data were recorded monthly from the three months till to the eight months.

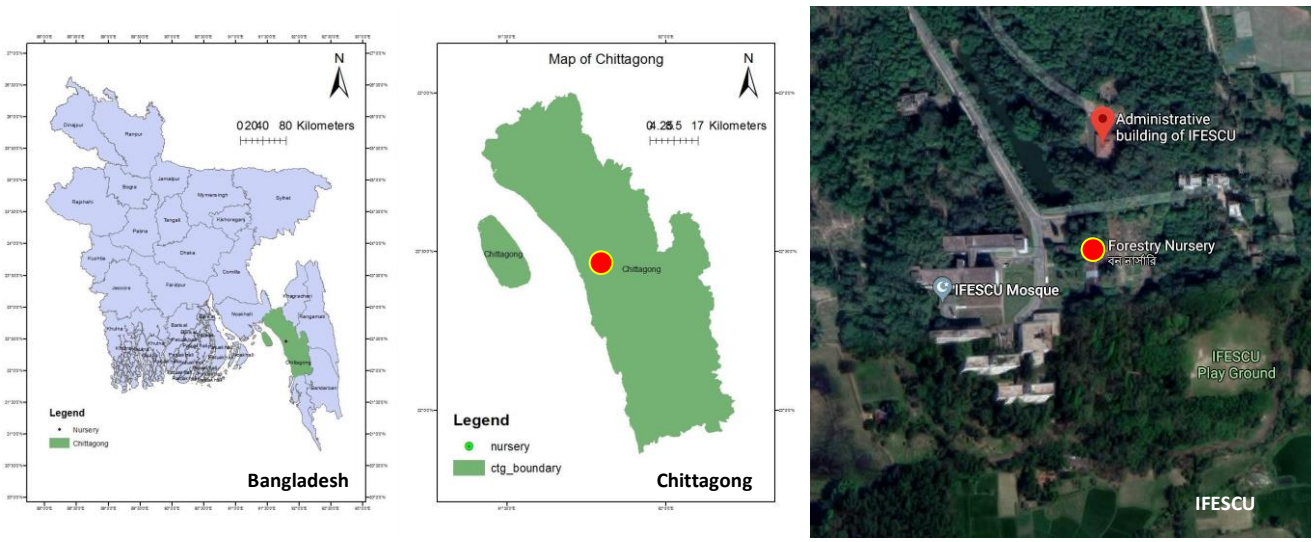

Figure 1. Map shows the location of the nursery of Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU) in Bangladesh where the experiment was conducted (Hathazari Upazila 2018; Google Maps 2019).

Table 1. Treatments and container type and size used to carry out the experiment.

Treat-ments	Containers type and size	No. of replication	No. of seedlings
T_1	13 cm × 10 cm (polybag)	3	60
T_2	15 cm × 10 cm (polybag)	3	60
T_3	15 cm × 13 cm (polybag)	3	60
T_4	20 cm × 15 cm (polybag)	3	60
T_5	Root trainer (20 cm × 5 cm)	3	60

Table 2. Treatments and their combination used to carry out the experiment.

Treat-ments	Combination	No. of replication	No. of seedlings
T_1	Sand only	3	60
T_2	Soil only	3	60
T_3	(Soil: Cowdung = 3:1)	3	60
T_4	Sawdust only	3	60
T_5	Soil + Cowdung + Phosphorus (0.16 g/polybag) @ 120 kg/ha	3	60
T_6	Soil + Phosphorus (0.16 g/polybag) @ 120 kg/ha	3	60
T_7	(Soil: Cowdung = 4:1)	3	60

Collection of root and shoot samples

During harvesting, soil around the seedling was loosened using hand softly, and all fine and coarse roots were collected carefully from the ground. To avoid damage, collected roots with adhered soil were immersed in water, in a clean white bowl, to allow soil particles to separate away. Water was changed several times for a complete wash.

Shoot-root ratio

Shoot-root ratio is the value obtained by dividing shoot (leaf and stem) with the root.

Quality index

The quality index (QI) as developed by Dickson et al. (1960) to quantify seedlings morphology was calculated as follows:

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

Statistical analysis

Recorded data related to seed germination and seedling growth attributes were analyzed statistically by using computer software SPSS ver.20.00. The Analysis of variance (ANOVA) and Duncan's Multiple Range test (DMRT) were tested for the analysis to explore the possible treatment variations.

RESULTS AND DISCUSSION

Physical parameters of the seedlings, e. g. height was recorded monthly from the age of three months and continued to eight months. At the end of 8-month average height, shoot length, root length, collar diameter, nodule number, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and shoot-root ratio, biomass, and quality index of the seedlings of *A. auriculiformis* were measured and calculated.

Height of the seedlings grown in different containers

Initial height (cm) growth was taken after three months of sowing the seeds. Treatment T_4 showed highest height (37 cm) at the age of three months followed by treatment T_3. However, T_4 showed the average maximum height growth starting from three months till the end of the experiment, whereas it reached an average height of 136.2 cm at the end of the experiment followed by treatment T_3 (129.6 cm) and T_2 (117.3 cm) (Figure 2).

Height of the seedlings grown in different potting media

For potting media used in the nursery, the study revealed the difference between the average height of the seedlings with the respective treatment at the age of 8 months (Figure 3). At the age of 3 months, Treatment T_5 attained maximum height (27.2 cm) followed by T_6 (26.5 cm). However, T_5 showed the average maximum height (128.9 cm) from the beginning of the measurement to till the end of the experiment followed by the treatment T_6 (115 cm) (Figure 3).

Morphological growth parameters of the seedlings grown in different containers

The 8 months old seedlings grown in different containers showed highest shoot length **(**137.5 cm) in T_4 followed by T_3 (125.2 cm), they were significantly ($P<0.05$) different from others where the lowest shoot length (81.1 cm) was found in T_5 (Table 3). Considering the growth of root length, highest root length was also recorded in T_4 (38.1 cm) followed by T_2 treatment (29.6 cm). However, similar trends of results were observed for collar diameter and nodule number count whereas the highest collar diameter was found in treatment T_4 (9.5 mm) followed by T_3 (7.3 mm) and maximum nodule number (71) was observed in the treatment T_4 followed by T_3 (55 mm).

Effects of containers on fresh and dry matter production of the seedlings

Fresh and dry matter production, e.g., shoot fresh weight, shoot dry weight, root fresh weight and root dry weight of 8 months old *A. auriculiformis* seedlings are shown in Table 4. Maximum shoot fresh weight (56.16 g) was found in treatment T_4 followed by T_3 (36.83 g) which is significantly different from other treatments except for T_3. Besides, maximum root fresh weight (12.66 g) was found in treatment T_4 followed by T_2 (6.83 g). In the case of dry weight, shoot dry weight was maximum (26.10 g) in T_4 followed by T_3 (16.38 g) whereas maximum root dry weight (6.80 g) was found also in T_4 followed by T_2 (3.43 g) and T_3 (3.28 g).

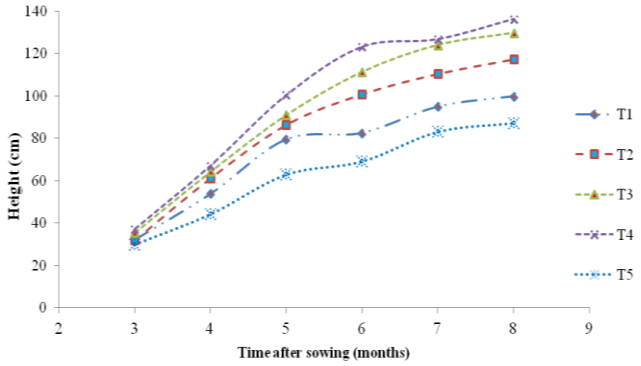

Figure 2. Height of *A. auriculiformis* seedlings at the age of 3 to 8 months grown in different containers in the nursery.

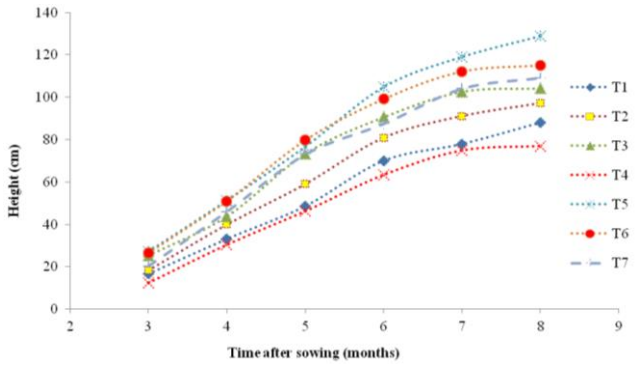

Figure 3. Height of *A. auriculiformis* seedlings at the age of 3 to 8 months grown in different potting media in the nursery.

Effects of container on shoot-root ratio, biomass (g) and quality index

The highest shoot-root ratio was found in treatment T_3 (5.05) followed by T_2 (4.10), this was significantly different ($P<0.05$) from other treatments. Biomass production of 8 months old *A. auriculiformis* seedlings were highest (32.90 g) in T_4 treatment followed by T_3 (19.67 g). Similarly, the highest value of quality index was found in treatment T_4 (1.81) followed by T_3 (0.89) and it was significantly different from other treatments (Table 4).

Morphological growth parameters of the seedlings grown in different potting media

For 8 months old seedlings, shoot length was highest (133.8 cm) in T_5 followed by T_6 (121.6 cm) and is significantly different ($P<0.05$) with other treatments (Table 5). Considering the root length, highest root length was recorded in T_3 (40.1 cm) followed by T_5 treatment (39 cm). In addition, the highest collar diameter was recorded in T_3 treatment (7.9 mm). However, T_6 (7.4 mm) and T_5 (7.3 mm) showed promising growth performance for collar diameter where the least was recorded in T_4 (5.1 mm). Similarly, maximum nodulation was observed in T_5 (68) followed by T_3 (61) and T_6 (55) respectively (Table 5).

Effect of potting media on fresh and dry weight (g) of shoot and root of the seedling

Maximum shoot fresh weight (45.16 g) was recorded in T_5 followed by T_3 (37.16 g) (Table 6) while root fresh weight was maximum (9.16 g) in T_3 followed by T_5 (8.83 g). An almost similar trend of results found for shoot dry weight production and highest value (19.22 g) was found in T_5 treatment followed by T_3 (16.87 g). However, maximum root dry weight (4.72 g) was found in T_3 treatment followed by T_5 (4.64 g).

Table 3. Effect of containers on shoots and root length, collar diameter and nodule number of 8 months old *A. auriculiformis* seedlings.

Treatments	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Nodule number
T_1	93.4^{bc*}	26.4^{b}	6.4^{b}	37^{c}
T_2	117.9^{ab}	29.6^{b}	7.0^{b}	45^{bc}
T_3	125.2^{a}	26.2^{b}	7.3^{b}	55^{b}
T_4	137.5^{a}	38.1^{a}	9.5^{a}	71^{a}
T_5	81.1^{c}	24.4^{b}	6.0^{b}	42^{bc}

*Means followed by the same letter (s) in the same column do not vary significantly at $P<0.05$, according to Duncan's Multiple Range Test (DMRT).

Table 4. Effect of containers on fresh and dry weight of shoot and root, shoot- root ratio, biomass (g) and quality index of 8 months old *A. auriculiformis* seedlings.

Treatment name	Fresh weight (g)		Dry weight (g)		Biomass (g)	Shoot: root	Quality index
	Shoot	Root	shoot	Root			
T_1	23.50b*	5.16b	10.80b	2.78b	13.58b	3.87b	0.73b
T_2	31.83b	6.83b	14.39b	3.43b	17.82b	4.10b	0.86b
T_3	36.83ab	6.33b	16.38b	3.28b	19.67b	5.05a	0.89b
T_4	56.16a	12.66a	26.10a	6.80a	32.90a	3.80b	1.81a
T_5	17.33b	4.83b	7.34b	2.62b	9.97b	2.78c	0.61b

*Means followed by the same letter (s) in the same column do not vary significantly at $P<0.05$, according to Duncan's Multiple Range Test (DMRT)

Effect of potting media on shoot-root ratio, biomass (g) and quality index

In the case of 8 month old seedlings, highest shoot-root ratio was found in T_5 (4.05) followed by T_6 (3.93). But this was not significantly different with other treatments (Table 6). Similarly, biomass production was highest (23.86 g) in T_5 followed by T_3 (21.59 g) and maximum (1.16) quality index was found in T_3 treatment followed by T_5 (1.06).

Discussion

Successful germination and raising seedlings are mandatory steps for conservation and enlargement of plant communities (de Melo et al. 2015). A vital ingredient for the success of plantation programs is the availability of adequate supplies of quality seedlings. However, the present study indicates that the growth parameters (shoot and root length, collar diameter, fresh and dry weight of shoot and root, shoot root ratio, quality index and biomass) and nodule number of seedlings recorded from different combinations of container and potting media treatments in *A. auriculiformis* varied significantly compared to control.

Considering the container type and size, the present study revealed that the average maximum height of *A. auriculiformis* seedlings from 3 months was found in T_4 treatment of 20 cm × 15 cm polybags. Seedlings at the age of 3 months attained a height of 37 cm and 136.2 cm at the age of 8 months. Similarly, the study revealed longest shoot length (137.5 cm), root length (38.1 cm) and collar diameter (9.5 mm) in T_4 treatment. Venkatesh et al. (2002) reported collar diameter of 5 months old *Acacia nilotica* seedlings was maximum (7 mm) in 25 × 15 cm polybag and not supported by present study. Maximum nodule number (70) was also found in 20 cm × 15 cm size polybag. This is because T_4 treatment contains much-growing media which supplies more nutrients to the seedlings and the results support the findings of Hossain et al. (2009).

In case of dry matter production, maximum shoot weight (26.10 g) and root weight (6.80 g) were also recorded in the same treatment (T_4). However, the result also coincided with Venkatesh et al. (2002) who reported highest shoot and root dry weight of 5 months old *Acacia nilotica* seedlings were 6.68 g and 3.42 g in 25 × 15 cm polybags. Moreover, it was also found that if polybag size increased then the value of fresh and dry matter also increased.

The shoot-root ratio was highest (5.05) in treatment T_3 (15 cm × 13 cm size polybag). The biomass 32.9 g and quality index 1.81 of the seedlings was highest in T_4 and are significantly different from other treatments whereas Annapurna et al. (2004) reported the highest biomass and quality index was 3.08 g and 0.37 of 6 months old sandalwood seedlings in root trainer (black) which partially supported the present study.

In the study, except shoot-root ratio, all the parameters showed best performance in 20 cm × 15 cm size polybag. However, several researchers found suitable container sizes for species, such as 30 cm × 20 cm for Cocoa (Keshavachandran and Larson 1985), 30 cm × 13 cm for *Santalum album* (Karivaradharaaju et al. 1999), 26 cm × 12.6 cm for *Azadirachta indica* (Bharathia 1999) and 25 cm × 15 cm for *Albizia lebbek* (Natarajn 1999).

The seedlings raised on good media will ensure better establishment and growth when planted in the main field. The ultimate advantage of good potting mixture is good drainage, water holding capacity and thereby, it gives excellent disease-free growth of the seedlings (Noble 1993). In the case of a balanced potting mixture, the present study indicated that the average maximum height of *A. auriculiformis* seedlings from 3 months till the end of the experiment was found in treatment T_5, soil + cow dung + phosphorous (0.16 g/polybag) mixture. In treatment T_5, at the age of 3 months, highest height was 27.2 cm and at the age of 8 months, it was 128.9 cm. Ramesh (2007) reported highest seedling height (36.36 cm) of 4 months old *Pongamia pinnata* in Black soil + Black sand + Vermicompost mixture where the media was different from present study.

Table 5. Effect of potting media on shoot and root length, collar diameter and nodule number of 8 months old *A. auriculiformis* seedlings.

Treat-ments	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Nodule number
T_1	88.8c*	36a	6.9ab	47ab
T_2	92.6bc	37.7a	5.7bc	33b
T_3	118.7ab	40.1a	7.9a	61a
T_4	66.6c	32.6a	5.1c	37b
T_5	133.8a	39a	7.3ab	68a
T_6	121.6ab	32a	7.4a	55ab
T_7	109.6ab	26.2a	6.4abc	48ab

Note: *Means followed by the same letter (s) in the same column do not vary significantly at P<0.05, according to Duncan's Multiple Range Test (DMRT)

Table 6. Effect of potting media on fresh weight and dry weight of shoot and root of 8 months old *Acacia auriculiformis* seedlings

Treatment name	Fresh weight (g)		Dry weight (g)		Biomass (g)	Shoot: root	Quality index
	Shoot	Root	shoot	Root			
T_1	26ab*	7ab	11.71abc	3.63ab	15.35abc	3.12a*	0.96a
T_2	18.83b	4.83ab	8.36bc	2.87ab	11.23bc	2.94a	0.59a
T_3	37.16ab	9.16a	16.87ab	4.72a	21.59ab	3.56a	1.16a
T_4	15.16b	3.33b	6.54c	1.93b	8.47c	3.38a	0.56a
T_5	45.16a	8.83a	19.22a	4.64a	23.86a	4.05a	1.06a
T_6	32.66ab	7.16ab	15.07abc	3.77ab	18.84abc	3.93a	0.93a
T_7	24.83ab	6.83ab	12.45abc	3.92ab	16.37abc	3.11a	0.81a

Note: *Means followed by the same letter (s) in the same column do not vary significantly at P<0.05, according to Duncan's Multiple Range Test (DMRT).

More shoot length (133.8 cm), nodule number (68), shoot fresh weight (45.16 g), shoot dry weight (19.22 g), shoot- root ratio (4.05) and biomass (23.86 g) was found in T_5, soil +cowdung + phosphorus (0.16 g/polybag) mixture. Hossain et al. (2009) found highest shoot length (79.7 cm), shoot fresh weight (24.85 g), shoot dry weight (24.85 g) and nodule number (46) in soil and residential sludge combination 2:1 of 3 months old *A. auriculiformis.* Uddin et al. (2007) reported highest shoot length (57.67 cm) and nodule number (56.67) was found in 80-day old, fertilized seedling of *A. auriculiformis.* The present result shows the similarity with their findings. Similarly, Uddin et al. (2012) found a positive correlation between seedling growth and the different doses of organic fertilization. So, it is evident that phosphorus enhances the seedlings growth as well as seedling quality in the nursery.

In other cases, more root length (40.1 cm), collar diameter (7.9 mm), root fresh weight (9.16 g), root dry weight (4.72 g) and quality index (1.16) was found in T_3 (soil: cow dung = 3:1). Uddin (2007) also reported highest root length (28.33 cm) and collar diameter (7 mm) was found in 80-day old, fertilized seedling of *A. auriculiformis*. Belen (1987) reported phosphorus fertilization increased the total P, Mg content and P uptake, where the study agreed with the present results.

In conclusion, availability of planting stock in proper time with adequate quantity and proper quality is a challenge for plantation establishment. To overcome the problems of poor-quality seedlings, the study of containers and effect of mixture growing on seedlings in the nursery is of great importance. Quality seedlings can ensure better survival and successful establishment of plantations, acclimation to variable of environment and reduce rotation by increased yield. Therefore, the study revealed maximum growth parameters including nodule formation was highest in 20 cm × 15 cm polybag than other types and size of container and containing soil + cow dung + phosphorus (0.16 g/polybag) mixtures than other potting media. However, the people of our country are hardly conscious of the impact of container and potting media on quality seedling raising programs in nursery. So, there is a need to have further investigation of established plantations raised with quality seedlings of *A. auriculiformis* by using the present containers and potting media.

ACKNOWLEDGEMENTS

The authors are highly thankful to the Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU), Bangladesh for providing seeds, creating space and opportunities to do this research.

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