

Growth and Quality of *Acacia nilotica* Seedlings Raised in Root Trainers with Potting Media Varying in Physical and Chemical Properties in Arid Zone

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Abstract: A nursery experiment was conducted to assess the effect of eight different potting media varying in physical and chemical properties, on growth and quality of *A. nilotica* seedlings raised in root trainer containers. Data relating to plant height, collar diameter, root CEC, root nodulation and production of biomass have been discussed. Seedling quality parameters like sturdiness, root shoot ratio, Dickson Quality Index and comparison index were calculated. Based on seedling growth and quality parameters, the medium comprising of soil:compost (20:80) was found most superior followed by medium comprising of compost:rice husk:pearl millet husk (60:20:20). The correlation matrix between seedling parameters and properties of treatment mixture revealed that many seedling growth and quality traits are influenced significantly by the physical and chemical properties of the potting mixtures. Results of the study indicate that one has to be careful in choosing right combination of different ingredients so that the physical and chemical properties of the medium remain desirable and favorable for the growth of seedlings.

Key words: Root trainers, potting medium, *Acacia nilotica*, arid zone.

The most important step in production forestry is to produce quality seedlings, in nursery having high performance potential. For any kind of seedling production system, type of containers and potting media are key components influencing quality of the seedlings. In India, at present most of the forest nurseries use polybag for raising planting stock. However, nursery experts have concluded that polybag is a technically poor choice for raising planting stock as it has many disadvantages. The major disadvantage with polybags is coiling of roots which hampers the establishment and growth of seedlings when planted in fields (Josiah and Jones, 1992).

To deal with the problem of root coiling special containers, known as root trainers, have been developed. In India, root trainers have been introduced in late 1990s (Khedkar and Subramanian, 1996, 1997) and are increasingly being adopted by most of the state forest departments including Rajasthan and Gujarat constituting major arid region. The root trainers involve less cost on handling, filling of potting media in containers, weeding, watering and transportation. They are durable and can be used repeatedly for several years. The technology is eminently suitable for large scale planting programs. They produce homogeneous superior quality planting

stock thereby increase the productivity of the plantations (Josiah and Jones, 1992).

Potting mixture is the most important component for raising seedlings in root trainers. The primary ingredient for potting mixture is high quality compost, which can be made from vegetative waste/agricultural waste and weeds. It has been suggested to make use of indigenous locally available waste material (Josiah and Jones, 1992). Khedkar and Subramanian (1996) used soil, sand and compost in 1:2:2 ratio for black cotton soil and 1:3:3 for sandy loam soil for raising seedlings in root trainers in Maharashtra. For arid zone conditions little information is available on suitable potting media for root trainers. In view of these considerations, the present study was conducted to evaluate and standardize potting mixtures. The basic objective of the present study was to find out effects of potting media of varying physical and chemical properties on growth and quality of *A. nilotica* seedlings raised in root trainers in arid environment.

Materials and Methods

Nursery trial was conducted during April to July 2000 in central nursery of Arid Forest Research Institute, Jodhpur, using 250 cm³ block type root trainer pots with eight treatments of potting mixture viz., T1 soil:sand:compost (25:25:50), T2 soil:sand:compost (20:20:60), T3 soil:compost (20:80), T4 compost:rice husk (66.6:33.4), T5 compost: pearl millet husk locally called Dura (66.6:33.4), T6 soil:compost:rice husk (25:50:25), T7 soil:compost:pearl millet husk (25:50:25) and T8 compost:rice husk:pearl millet husk by adopting completely randomized design

with three replications, each having 24 seedlings. Each ingredient of potting media was sundried, pulverized and sieved through a wire mesh before mixing them as per composition of the treatments. Before mixing, the rice husk and dura (pearl millet husk) were roasted to the stage of half-burnt by heating in iron pan, meshed to fine particles after cooling and sieved. The potting mixtures were analyzed for physical and chemical properties following standard procedures (Jackson, 1978).

Before sowing, seeds of *A. nilotica* were kept in boiling water for 4 minutes and then soaking in warm water for 24 hours and pre-germinated in moistened clothes. The pre-germinated seeds were sown in root trainer cells in the first week of April 2000. The seedlings were watered twice a day and protected from scorching heat with agro-shade net. For recording observations on height and collar diameter 10 seedlings from each replication were randomly tagged and observations recorded at an interval of one month.

The biomass was recorded at 90-day stage on three seedlings from each replicate. The root plugs, containing potting medium, were carefully washed with water till all the adhering particles of medium were removed from root system. The observations were recorded for nodulation and biomass production. The root and shoot samples were dried at 70°C. The quality parameters viz., root:shoot ratio, sturdiness (ratio of height in cm to collar dia in mm) were calculated for each treatment. Dickson Quality Index (DQI) was calculated following Chauhan and Sharma (1997) as $DQI = \text{total seedling biomass (g)}/\text{sturdiness (height in cm/diameter in mm)}$. The

comparison index was worked out with formula, Comparison Index (CI) = $X_i/M \times 100$ where, X_i is the value of Dickson Quality Index [$i = 1, n$ ($n = \text{No. of treatment}$)] and M is maximum value of DQI. The cation exchange capacity (CEC) of roots was estimated following Crooke *et al.* (1960). The data were analyzed statistically for analysis of variance (ANOVA).

Results and Discussion

Physical and chemical properties of potting media

The analyses of the different potting media for their physical and chemical properties are given in Table 1. The pH of all the potting media was in neutral to slightly acidic range having EC between 0.84 to 1.80 mmhos cm^{-1} . The OC and CEC varied from 1.47 to 4.57% and 43.1 to 79.67 meq per 100 g, respectively. The bulk density and porosity ranged from 0.70 to 1.46 g cm^{-3} and 12.42 to 42.5%, respectively. Water holding capacity at 1 and 15 bar varied between 10.33 to 27.63 and 4.45 to 15.63%, respectively. Matrix correlation has revealed that many physical

and chemical characteristics of potting media correlated significantly among themselves (Table 5). Significant negative correlation existed between bulk density and porosity ($P < 0.05$, $r = -0.816$), water holding capacity at 1 and 15 bar ($P > 0.05$, $r = -0.786$ and -0.813) and organic carbon ($P < 0.01$, $r = -0.840$). Porosity significantly correlated to organic carbon ($P < 0.01$, $r = 0.893$). The water holding capacity both at 1 bar ($P < 0.05$, $r = 0.792$) and 15 bar ($P < 0.05$, $r = 0.815$) was significantly influenced and directly related to organic carbon.

Growth parameters of seedlings

The effects of different potting mixtures were significant in respect of height, collar diameter, root nodulation and biomass production (Table 2). However, the treatments had no significant effect on length of the tap roots (Table 3).

At 90 days, maximum seedling height (43.13 cm) was observed in T3 followed by statistically at par T5, T6 and T8 treatments. The minimum height (31.03 cm) was observed in T7, which was at par with T1 treatment. The highest collar diameter (3.39 mm) was recorded in T3

Table 1. Physical and chemical properties of different potting media

Treatment	pH	EC (mmhos/ cm)	Organic carbon (%)	CEC (meq/ 100 g)	Bulk density (g cm^{-3})	Porosity (%)	Water holding capacity (%)	
							1 bar	15 bar
T1	7.22	1.00	1.47	43.10	1.46	12.42	10.33	4.45
T2	7.06	1.26	1.86	68.61	1.13	25.06	13.48	6.29
T3	6.83	0.84	4.57	79.67	0.93	42.50	27.63	15.63
T4	6.96	1.15	3.68	45.92	0.70	37.50	26.29	14.09
T5	6.77	1.80	4.16	56.40	0.79	35.24	26.24	13.81
T6	6.66	1.37	2.73	46.83	1.19	34.97	15.75	7.46
T7	6.80	1.26	2.45	48.32	1.23	27.07	18.75	8.93
T8	6.38	1.29	4.36	71.33	0.69	36.81	23.63	12.63

Table 2. Effect of different potting media on growth parameters of *Acacia nilotica* seedlings

Treatment	Seedling height (cm)			Collar diameter (mm)		
	Days after sowing			Days after sowing		
	30	60	90	30	60	90
T1	6.29b	21.77b	32.63cd	2.44a	2.66c	2.97c
T2	7.14ab	23.13b	34.38c	2.49a	2.68c	3.02bc
T3	7.91a	27.38a	43.13a	2.30b	2.92a	3.39a
T4	8.42a	25.57ab	35.13c	2.35a	2.86ab	3.26a
T5	8.60b	23.39b	38.13b	2.45a	2.82b	3.14bc
T6	7.02b	26.10a	38.73b	2.35a	2.94ab	3.19b
T7	6.88b	25.80a	31.03d	2.44a	2.95a	3.16b
T8	8.89a	26.23a	38.67b	2.33a	2.75bc	3.09bc
CD at 5%	1.78	2.66	2.75	0.18	0.125	0.177

Means followed by same letter do not differ significantly.

treatment though it was at par with T4 treatment. The collar dia of T2, T5, T6, T7 and T8 treatment was statistically at par. The minimum collar dia (2.97 mm) observed in T1 was at par with T2, T5 and T8 treatments. The growth pattern of height revealed that irrespective of the treatments, increase in plant height was steady over a period of three months with more pronounced increase between 30 and 60 days. The collar diameter grew maximum in first 30 days and thereafter, its growth was less and steady. In respect of root nodulation, T6 gave maximum number of nodule (15.11) followed by T4 (7.78) treatment though the T4 was at par with T1, T2, T3 and T8 treatments. Minimum number of nodules was observed with T7, which was at par with T1, T2, T3, T5 and T8 treatments.

The different potting mixtures influenced production of shoot, root and total biomass significantly. The maximum shoot biomass (2.25 g seedling⁻¹) was observed in T3, which was at par with T8 followed by T4 treatment. The T4 was statistically at

par with T2, T4, T5, T6, T7 and T8 treatments. The minimum shoot biomass (1.21 g seedling⁻¹) was observed in T1 treatment, which was at par with T2, T5 and T7 treatments. In case of root biomass similar trend was observed with T3 giving highest biomass (1.13 g) which was at par with T8 treatment. Treatments T3 and T8 continued to produce maximum total biomass (3.37 g and 2.99 g seedling⁻¹) followed by T4 treatment (2.53 g). However, T4 was at par with lowest biomass (1.86 g seedling⁻¹) produced in T1 which was again at par with T2, T5, T6 and T7 treatments.

Quality parameters of seedlings

Looking to the growth and biomass parameters it appears that different treatment combinations did not influence some of the seedling traits significantly. In view of these considerations the superiority of one treatment over the other for drawing final inferences and selection of the best combination becomes difficult. Hence, the comparison of all treatments based on seedling quality parameters is more

Table 3. Effects of different potting media on production of biomass in *Acacia nilotica* seedlings after 90 days

Treatment	Tap root length (cm)	Nodules/seedling	Shoot weight/seedling (g)	Root weight/seedling (g)	Total biomass/seedling (g)
T1	11.21	3.67bc	1.21c	0.65b	1.86c
T2	9.98	3.22bc	1.40bc	0.40c	1.80c
T3	10.15	7.01bc	2.25a	1.13a	3.37a
T4	12.63	7.78b	1.70b	0.74b	2.53b
T5	12.25	1.10c	1.44bc	0.56bc	2.01bc
T6	12.16	15.11a	1.63b	0.68b	2.31bc
T7	10.13	1.00c	1.54bc	0.68b	2.22bc
T8	12.66	5.33bc	1.94ab	1.05a	2.99a
CD at 5%	NS	6.103	0.407	0.228	0.573

Means followed by same letter do not differ significantly; NS = Non-significant.

authentic rather than on actual values of height or collar diameter. Seedling quality specification based on certain morphological characteristics including sturdiness (height/dia ratio), root:shoot ratio and some other features have been used (Cleary *et al.*, 1978; Lavender and Cleary, 1974; Schmidt-Vogt, 1974). Root surface area is considered as an important physiological parameter to judge the quality of the seedling. In present study instead of root surface area the CEC of root has been used as a quality parameter of seedling. The root CEC is an indication of pectin substances located on the root surface and solely responsible for attraction of the cations and their subsequent absorption into the plant system (Crooke and Knight, 1962).

The quality parameters of seedlings for different treatments have been presented in Table 4. From these quality indices, it appears that the sturdiness varied between 10.78 in T4 to 12.72 in T3 treatment. The diameter being the denominator, very high value of sturdiness indicates that the seedling is very tall and will not be able to stand

straight when planted out. The maximum root/shoot ratio was found in treatment T8 followed by T1. The seedlings raised under T3 treatment have maximum root CEC (32.84 meq per 100 g) followed by 28.08 meq per 100 g in T8. The DQI which indicates the over all quality of the seedlings produced by different treatments of potting mixtures revealed that T3 treatment consisting of soil:compost (20:80) is superior followed by medium comprising of compost:rice husk:pearl millet husk (60:20:20). To see the relative performance of other treatments in comparison to T3, the comparison index was worked out considering performance of the T3 as 100%. Based on this index the relative performance of the treatments have been found to be in the order of $T3 > T8 \geq T4 > T7 > T6 > T1 \geq T5 \geq T2$.

Growth and quality of seedlings in relation to properties of potting media

To assess the effect of different physical and chemical properties of treatment mixture on growth and quality of seedlings,

Table 4. Seedling quality parameters of *Acacia nilotica* after 90 days

Treatment	Sturdiness	Root/shoot ratio	Root CEC meq/100 g	Dickson quality index	Comparison index
T1	10.98	0.537	16.92	0.1693	63.91
T2	11.38	0.285	15.44	0.1587	59.72
T3	12.72	0.512	32.84	0.2649	100.00
T4	10.78	0.435	22.76	0.2347	88.60
T5	12.14	0.338	22.60	0.1656	62.51
T6	12.25	0.417	18.16	0.1886	71.19
T7	9.82	0.442	14.20	0.2261	85.35
T8	12.51	0.541	28.22	0.2390	90.22

correlation matrix between seedling parameters of 90 days and properties of treatment mixtures was worked out (Table 5). As revealed from significant positive and negative correlations, many seedling growth and quality traits have been significantly influenced by the physical and chemical properties of treatment mixtures. The height of seedlings was significantly influenced and directly related to porosity ($P < 0.05$, $r = 0.771$) and organic carbon ($P < 0.05$, $r = 0.767$). The plant height was also influenced by the root CEC ($P < 0.01$, $r = 0.854$) of the seedlings. Similarly the collar diameter of the seedlings was significantly influenced and directly related to the porosity ($P < 0.01$, $r = 0.822$) and water holding capacity at 1 bar ($P < 0.05$, $r = 0.805$) and at 15 bar ($P < 0.01$, $r = 0.845$). The root CEC of the seedling was significantly and positively correlated with the porosity ($P < 0.05$, $r = 0.733$) and organic carbon ($P < 0.01$, $r = 0.882$). Non-significant but positive correlation was also found between root CEC and CEC of the mixtures ($r = 0.677$). Total biomass production was influenced significantly by porosity ($P < 0.05$, $r = 0.751$), organic carbon ($P < 0.05$, $r = 0.782$), root CEC ($P < 0.01$, $r = 0.884$) and plant height ($P < 0.05$, $r = 0.727$).

Based on seedling growth and quality parameters, the treatment T3 comprising of soil:compost (20:80) was found most superior for raising seedlings of *A. nilotica* in root trainers under arid zone conditions. However, the performance of T8 treatment comprising of compost:rice husk:pearl millet husk (dura) (60:20:20) was very close (90.22%) in relation to T3 followed by T4 (88.6%) and T7 (85.35%) treatments. The over all superior quality seedlings produced by the treatment T3 may be attributed to its physical and chemical properties, viz., high porosity, water holding capacity, organic carbon and cation exchange capacity. The high root CEC of seedlings produced by T3 treatment indicated accumulation of more pectin substances at root surface which would help in minimizing the transplanting shock in fields. Thus, these seedlings have good potential to perform in field. The high water holding capacity of this combination particularly at 15 bar indicate that plant would not suffer moisture stress and be capable to regenerate new roots in short time when planted out in the fields.

Results suggest that the potting mixture to be used for root trainers should be

Table 5. Matrix correlation amongst seedling parameters and physical and chemical properties of the potting media

	Height	Collar dia	No. of nodule	Root biomass	Shoot biomass	Total biomass	Root CEC	Sturdiness	D Q Index
Height									
Collar dia	0.629								
No. of nodule	0.455	0.380							
Root biomass	0.636	0.594	0.251						
Shoot biomass	0.779*	0.794*	0.341	0.884**					
Total biomass	0.727*	0.746*	0.319	0.957**	0.979**				
Root CEC	0.854**	0.636	0.177	0.848**	0.866**	0.884**			
Sturdiness	0.923**	0.285	0.408	0.481	0.564	0.522	0.726*		
D Q Index	0.380	0.722	0.215	0.868**	0.858**	0.902**	0.647	0.106	
pH	-0.500	-0.276	-0.317	-0.509	-0.549	-0.539	-0.423	-0.508	-0.391
EC	-0.057	-0.260	-0.190	-0.491	-0.386	-0.443	-0.256	0.085	-0.564
Bulk density	-0.502	-0.553	-0.025	-0.308	-0.522	-0.475	-0.627	-0.355	-0.363
Porosity	0.771*	0.822*	0.377	0.570	0.824*	0.751*	0.733*	0.561	0.596
WH ₁	0.507	0.805*	-0.048	0.410	0.550	0.531	0.649	0.222	0.474
WH ₂	0.566	0.845**	0.003	0.425	0.615	0.574	0.674	0.275	0.502
OC	0.767*	0.686	0.100	0.695	0.790*	0.782*	0.882**	0.609	0.587
CEC	0.657	0.299	-0.114	0.504	0.683	0.601	0.677	0.638	0.366

	pH	EC	Bulk density	Porosity	WH ₁	WH ₂	Organic Carbon
pH							
EC	-0.361						
Bulk density	0.390	-0.294					
Porosity	-0.652	0.119	-0.816*				
WH ₁	-0.131	0.054	-0.786*	0.728*			
WH ₂	-0.177	0.042	-0.813*	0.794*	0.991**		
OC	-0.626	0.135	-0.840**	0.893**	0.792*	0.815*	
CEC	-0.314	-0.205	-0.351	0.487	0.230	0.316	0.534

** Significant at 1% level, * Significant at 5% level.

WH₁ = Water holding capacity at 1 bar; WH₂ = water holding capacity at 15 bar, OC = Organic carbon and ECE = Cation exchange capacity.

lightweight, porous, rich in organic carbon and have high CEC and water holding capacity. One has to be careful in choosing right combination of different ingredients so that the physical and chemical properties

of the medium remain suitable and favorable for better growth of the seedlings. The vegetative compost undoubtedly remains an important constituent of the potting mixture for root trainers. It will be desirable to use

only tested combination for raising seedlings of different species in root trainers as there cannot be uniform potting medium for all the species due to variation in their root architecture and nutritional requirement. Further investigations are needed to quantify effects of different ingredients of potting media in relation to critical level of porosity, organic carbon, water holding capacity, cation exchange capacity, etc., for raising quality seedlings in root trainers in arid zone.

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