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Impact of Soil composition on Seedling growth of *Pongamia pinnata* (L.) Pierre

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ABSTRACT

Soil composition is an important factor affecting germination, growth, bio-mass production, and nursery quality of planting material. The present study examines the impact of different qualities of soil on the performance of six-month-old seedlings of *Pongamia pinnata* (L.) Pierre. Experimental treatments consisted of four different soils: sand, black soil, red soil, and Padua soil, which were combined in 15 different potting media compositions. The seedling performance was evaluated according to morphological traits and bio-mass indicators. There was considerable variability of seedling growth depending on the composition of potting media. The highest values of average shoot length (15.235 cm), root length (29.8 cm), total plant length (38.8), and total biomass (0.816 g) were reported in the Sand + Black soil treatment, whereas maximum values for root dry weight (0.516 g) and photosynthetic area (45.6 cm²) were obtained in the Red + Black soil treatment. Seedling growth was absent in the Red + Padua + Sand treatment. The results of the study show that the success of *P. pinnata* growth is determined by potting soil composition. The Sand + Black soil provided stable conditions for the optimal growth of seedlings and probably contributed to the improvement of aeration and nutrition of seedlings, thus it is a good choice for raising healthy *P. pinnata* saplings in nursery conditions.

Introduction

Soil is one of the most important ecological factors. Plants depend for their nutrients, water supply and encourage upon the soil. For production of quality planting stock, ideal potting mixture should have better aeration, good water holding capacity, porosity, low bulk density, low in silt, clay and ash content and promote firm plug formation (Miller and Jones, 1995; Chakrabarti *et al.* 1998,). In modern forestry, it is important to produce quality seedlings by inducing morphophysiological changes in the plants for making them competent enough to bear the shock of field planting and enhance their productivity.

Potting medium is the most important input for containerized seedling production as it play a key role in producing uniform and healthy seedlings. Apart from the selection of proper ingredients, it is necessary to maintain the porosity of the potting mixture so that proper development of roots could occur. The media should be rich enough to sustain seedlings for about 90-120 days. A good potting medium is characterized by light weight, friability, easy blendability, good water holding capacity, drainage, porosity, slight acidity, low bulk density, free from fungal spores and insect and low inherent fertility etc. The growth and quality of forests, whether naturally occurring or artificially created depends basically on the physical and the nutrient status of the soil, work on seedling establishment, survival and soil characteristics in relation to seedling growth is lacking.

Different ratio of soil mixtures have been recommended by various workers for different species viz. Nayital, *et al.*, (1995) in *Bauhinia variegata*; Srivastave, *et al.*, (1998) in *Eucalyptus*; Woods, *et al.*, (1998) in *Sweitenia macrophylla*; Savio, *et al.*, (1999) in *Casurina equisetifolia* and Ginwal, *et al.*, (2001) in *Acacia nilotica*. According to Sharma, *et al.*, (2004), soil, sand and FYM at a volumetric ratio of 2:1:2 was found to be best among the tried combination for *Acacia auriculiformis* seedlings. FYM was found to be best medium for raising healthy and vigorous seedling of

Leucaena (Dhar, *et al.*, 1992). Bhatnagar (1965) worked on the growth behavior of soil seedlings in different Sal forest soils. Yadav, *et al.*, (1982) observed better growth performance of *Tectona grandis* seedlings in Black soil.

Common problems associated with traditional nursery practices are bulky and poor nutrient mixture, poor water holding capacity, root coiling, less root fibrosity, more variability in seedling growth and anticipated poor survival and after growth in field. The above limitations can be overcome by raising seedlings organic rich potting mixtures. Ginwal, *et al.*, (2002), worked on *Delbergia sissoo* and pointed out that plant grows very well in sand and compost combination (20% Sand+ 80% Compost) followed by other combination of Sand, Soil and Compost in the ratio of 1:1:3. Tiwari and Sexana (2003) reported that soil, sand and FYM in 1:2:2 and 1:2:1 ratio indicated higher growth, dry weight and quality index of seedlings of *Dalbergia sissoo*. Singh, *et al.*, (2000) studied the effect of soil media on germination of three species and concluded that mixture of sand, FYM and soil in equal ratio (1:1:1) shows maximum germination percentage in *Delbergia sissoo* (91%), in *Prosopis cineraria* maximum percentage (90%) was recorded in 2: 1:1 and in *Acacia nilotica* maximum germination percentage (84%) was observed in 1:2:1 ratio.

Bahar and Singh (2007) studied the influence of media on germination of *Mesua ferrea* and recommended that sand is good medium for germination the species in controlled conditions. Verma, *et al.*, (2006) studied the effect of lime stone mine spoil and forest soil based potting media on growth performance of different tree species (*Bauhinia variegata*, *Robinia pseudoacacia*, *Eucalyptus hybrid*, *Grewia optiva* and *Toona ciliata*) and observed that 1:5 and 1:2 was found to be most effective with regard to survival, growth and biomass production parameters for all the five species. The potting medium consisting Sand: Soil: Compost in the ration of 40: 10: 50 shows best seedling growth of *Santalum album* in terms of

height, collar diameter, total dry weight, shoot dry weight, root dry weight and root/shoot ratio (Annapurna, *et.al*, 2007).

Material and Methods

Four soil type viz., Sand, Black soil, Red soil and Padua soil were considered in the experiment. These four soil types were mixed in different volume proportions. Thus, in all 15 soil compositions were prepared. These were filled in perforated polythene bags of 25X10cm. size. Each media was filled in 15 polythene bags which were placed in open sin light (Joseph and Freezaillag, 1969). Only two seeds and imbibe seeds were sown in each polythene bags of all potting mixture. Sufficient and regular watering was done daily. The experiment was continued for six months and then seedlings were removed from polythene bags with intact root system for further analysis of fresh and dry weight, shoots length, root length, S/R length ratio and Photosynthetic area (PSA). The seedlings were dried in oven at 60oC for 3 days (72 hours) and weighed separately to determine the percentage of moisture content of root and shoot and dry weight of the seedling.

To quantify the morphological quality of seedlings, the quality index (QI) was calculated following Dickson *et. al*, (1960). Where TW is the total dry weight of seedling (gms), H is the Seedling height (cm.), D is the collar Diameter (mm.), SW is the seedling shoot dry weight (gm) and RW is the root dry weight (gm.) of seedling.

Sturdiness Quotient (SQ) was calculated dividing the seedling height (cm.) by collar diameter (mm.) according to Roller (1977).

Results and Discussion

The data of seedling growth in relation to different Potting media is given in Table-2 (A to G) and Figure- 1 to 4. Which revealed that the average maximum length of root (29.1cm.) was in sand+ black (1:1 ratio by volume) and it was minimum (7.15cm.) in black+ Padua (1:1 ratio by volume). During the course of study no growth of seedlings was detected in the potting medium no. S13, and no plausible interpretation can be given for such discrepancy, but it is inferred that the lacking of growth of seedling in the said mixture, the reason should have associated with insect damage at early stage of seedling emergence. S13 [Red: Padua:Sand (1:2:1)] has been disturbed and performance of seedlings could not be evaluated. The maximum average dry weight of root (0.516gm.) was observed in a soil mixture Red+ Black (1:1 ratio by volume) followed by 0.496gm. (Sand+ Black) whereas the minimum root dry weight (0.264gm.) was recorded in Red + Padua mixture (1:1 ratio by volume). It is known that a number of environmental factors affect the growth of dry weight of plants. In black soil, it was high as such soils have high percentage of organic matter, minerals, water and aeration which are most favorable condition for growth of any plants. The maximum moisture percentage (123.043%) in root obtained in pure red and it was minimum (63.5%) in Sand + Red (1:1 ratio by volume). The maximum moisture percentage

(128.611%) in shoot was recorded in Sand and Padua (1:1 ratio by volume) and it was minimum (53.04%) in Red +Black (1:1 ratio by volume).

The growth in the initial phase of plant is observed in the form of length, it is normally seen in shoot height. Experiment under different soil composition declared that a mixture of Sand + Black soil (1:1 ratio by volume) was best in attaining the maximum average shoot length (15.235 cm.) and dry weight (0.315gm.) while as contrary the poorest dry weight was recorded in a composition of Pure Padua. The seedlings grown in this media also produce minimum shoot length (5.753 cm.) and dry weight (0.171 gm.).

The Photosynthetic area (PSA) (cm²), which is a good indicator of photo absorptive surface, helps the seedlings in early establishment and better growth after planting. The highest average photo synthetic area (45.6cm²) was reported in the seedling grown in mixture of Red+ Black soil (1:1 ratio by volume) followed by 41.155 cm² with a mixture of Red + Black soil (1:1 ratio by volume) and a minimum 15.05cm² was observed in Sand + Red (1:1 ratio by volume).

Awing and Hamzah (1986) found that effect of potting mixture on height, diameter, root/shoot ratio and total dry weight of *Acacia mangium* seedlings varied with various soil mixtures. The total length of seedling (38.8cm.) was maximum in a mixture of Sand+ Black (1:1 ratio by volume) followed by 37.4cm. in Red + Black (1:1 ratio by volume) and biomass were also maximum (0.816gm.) in a mixture of Sand + Black(1:1 ratio by volume). The minimum (12.65cm.) total length of seedlings was reported in Black + Padua (1:1 ratio by volume).

The maximum shoot/root length ratio (1.53cm) was reported in the seedling grown exclusively in Pure Sand and it was minimum (0.325) in pure Padua, whereas the maximum (0.991) Shoot/Root dry weight ratio was observed in Red + Black+ Padua (1:2:1 ratio by volume) and same was minimum (0.489) in Red+ Black (1:1 ratio by volume).

The seedling growth and dry weight parameter indicated wide response on the gradient of soil mixture. The range of Collar diameter (CD) did not show much variation. It is evident from the observations Sand + Black (1:1 ratio by volume) followed by Red +Black (1:1 ratio by volume) which largely favoured the growth of roots and number of secondary roots along with shoot in the initial stage of seedling growth. It will be highly porous and will allow better growth of roots by allowing deeper penetration in such soil medium. The enhanced growth of roots will also help in the favourable growth of above ground parts of seedling by supplying them water and appropriate nutrients. The better performance of overall growth of seedlings in potting media No.9 could be explained with better aeration, appropriate moisture supply and sufficient nutrient status of the composition of the medium.

Table-1 Abbreviations Used In The Experiments Performed At Nursery To Represent Growth Parameters Of Seedlings In Relation To Different Treatments.

S. No	Soil Composition
1-	(S ₁) Pure Padua
2-	(S ₂) Pure Red
3-	(S ₃) Pure Sand
4-	(S ₄) Pure Black
5-	(S ₅) Black+ Padua
6-	(S ₆) Red+Padua
7-	(S ₇) Sand+ Padua
8-	(S ₈) Sand + Black
9-	(S ₉) Red+ Black
10-	(S ₁₀) Sand+ Red
11-	(S ₁₁) Sand+Red+Black
12-	(S ₁₂)Red+Black+Padua
13-	(S ₁₃)Red+Padua+Sand
14-	(S ₁₄)Red+Sand+Black
15-	(S ₁₅)Red+Sand+Black+Padua

Table-2 Growth performance of seedlings of *Pongamia pinnata* at the age of six months in relation to different potting media. (A)

Various seedling measurement	Pure Paduaa (S ₁)	Pure Red (S ₂)
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	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	16	4	11.6±2.016	17	5	9.1±2.278
SL(cm.)	6	4.25	5.73±0.396	15	8	11.34±2.429
RL(cm.)	29.5	14.2	23.01±5.07	24	11	17.4± 3.294
PL(cm.)	35.5	19.9	30.53±5.95	39	19	28.74±5.734
S/R L ratio	0.338	0.423	0.325±0.178	0.625	0.727	0.662±0.728
SDW (gm.)	0.36	0.05	0.171±0.035	0.40	0.15	0.249±0.031
RDW (gm.)	0.57	0.08	0.269±0.080	0.79	0.1 2	0.323±0.056
PDW (gm.)	0.93	0.13	0.443±0.137	1.19	0.27	0.576± 0.089
S/R DW ratio	0.64	0.625	0.648±0.450	0.506	1.25	0.572± 0.89
Collar Diameter	6	2	4.09±1.177	7	4	6±2.812
%M.C. in Shoot	81.834	48.4	67.019±1.813	89.545	44.81	65.730±2.110
%M.C. in Root	69.352	47.57	58.197±3.893	75.57	32.151	68.043±2.309
PSA (cm ²)	51.5	28.5	31.1±17.154	57.65	21.25	15.275±3.107

(B)

Various seedling measurement	Pure Sand (S ₃)			Pure Black (S ₄)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	25	5	11.33±4.809	11	9	7.5±2.025
SL(cm.)	21	8.5	9.7±0.784	13	6	11.5±0.625
RL(cm.)	34	5.6	20.28±4.179	21	12	16.35±4.64
PL(cm.)	55	14.1	23.58±4.973	34	18	27.85±5.425
S/R L ratio	1.20	1.51	1.53±0.191	0.619	0.51	0.715±0.152
SDW (gm.)	0.47	0.15	0.266±0.050	0.310	0.07	0.234±0.032
RDW (gm.)	0.69	0.12	0.369±0.115	0.528	0.12	0.320±0.046
PDW (gm.)	1.08	0.26	0.6380.170	0.802	0.19	0.484±0.072
S/R DW ratio	0.681	1.25	0.720±0.434	0.643	0.583	0.515±0.712
Collar Diameter	9	2.3	4.42±1.905	6	2	4.02±1.189
%M.C. in Shoot	81.5	38.297	63.108±2.414	80.584	46.465	69.420±3.130
%M.C. in Root	71.303	48.230	59.519±1.573	81.527	25.526	59.026±3.202
PSA (cm ²)	73.71	24	23.925±5.508	51.5	2.5	31.52±4.29

(C)

Various seedling measurement	Black+Padua (S ₅)			Red+Padua(S ₆)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	10	4	6.5±1.074	16	9	13.5±2.047
SL(cm.)	10	5.7	7.52±0.245	11	5	8.65±0.379
RL(cm.)	24	6	7.15±4.040	19	7	12.05±4.025
PL(cm.)	34	11.7	12.65±4.345	30	12	20.61±4.429
S/R L ratio	0.461	0.45	0.706±1.30	0.578	0.714	0.724±0.099
SDW (gm.)	0.310	0.15	0.210±0.307	0.380	0.110	0.205±0.354
RDW (gm.)	0.566	0.19	0.375±0.427	0.581	0.181	0.264±0.181
PDW (gm.)	0.874	0.340	0.586±0.739	0.960	0.29	0.469±0.630
S/R DW ratio	0.554	0.789	0.564±0.718	0.655	0.62	0.776±1.960
Collar Diameter	6	2	5.4±1.438	5	3	3.25±1.003
%M.C. in Shoot	88	29.457	64.559±3.041	81.845	31.575	56.070±4.182
%M.C. in Root	70.578	38.752	53±2.021	68.578	35.827	55±3.022
PSA (cm ²)	38.25	10.5	15.40±1.540	51.5	11.6	19.65±4.31

(D)

Various seedling measurement	Sand+Padua (S ₇)			Sand+Black (S ₈)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	20	7	13.4±1.943	24	9	15.9±3.756
SL(cm.)	13.5	10	11.75±0.597	31.7	6.5	15.235±1.517
RL(cm.)	33	12	20.9±4.036	38.5	11	29.1±8.502
PL(cm.)	46.5	22	32.64±4.657	70.2	17.5	38.8±10.11
S/R L ratio	0.409	0.83	0.562±0.149	0.445	0.723	0.42±0.125
SDW (gm.)	0.451	0.110	0.275±0.053	0.520	0.14	0.315±0.068
RDW (gm.)	0.730	0.171	0.368±0.078	0.841	0.12	0.496±0.1317
PDW (gm.)	1.22	0.38	0.643±0.136	1.36	0.23	0.816±0.198
S/R DW ratio	0.616	0.447	0.572±0.218	0.559	1.67	0.635±0.518
Collar Diameter	9	3	4.56±0.999	11	3.1	6.59±1.146
%M.C. in Shoot	96.034	56	81.611±2.596	88.833	54.548	75.004±1.460
%M.C. in Root	72.176	38.727	61.968±1.527	76.176	34.584	58.190±0.130
PSA (cm ²)	62.75	31.25	27.5±5.875	71.25	21.5	41.55±4.824

(E)

Various seedling measurement	Red+Black (S ₉)			Sand+Red(S ₁₀)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	19	12	15.7±1.047	15	12	13.45±2.135
SL(cm.)	19.5	6	8.35±0.397	8	3	6.25±0.278

RL(cm.)	35	13.5	22.51±3.836	15	8	18.35±3.025
PL(cm.)	54.5	19.5	37.4±4.45	23	11	24.60±3.343
S/R L ratio	0.285	0.445	0.438±0.105	0.534	0.374	0.340±0.198
SDW (gm.)	0.48	0.14	0.251±0.351	0.370	0.17	0.247±0.367
RDW (gm.)	0.93	0.17	0.516±0.131	0.492	0.19	0.295±0.131
PDW (gm.)	1.41	0.35	0.77±0.525	0.860	0.36	0.545±0.502
S/R DW ratio	0.571	0.84	0.489±2.35	0.760	0.894	0.837±2.80
Collar Diameter	9	2	4.92±1.312	7	2	4.35±2.055
%M.C. in Shoot	90.548	64.285	53.04±2.796	94.425	36.430	56.402±5.250
%M.C. in Root	71.588	28.862	49.790±1.012	58.571	21.817	35.5±1.012
PSA (cm ²)	79.5	21.5	45.6±7.449	29.25	13.65	15.05±2.525

Various seedling measurement	(F) Sand+Red+Black(S ₁₁)(1:2:1)			Red+Black+Padua (S ₁₂) (1:2:1)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	11	7	10.10±2.05	15	9	14.5±2.051
SL(cm.)	17.5	8	12.3±2.650	11	6	8.67±0.378
RL(cm.)	24	12	20.9±4.036	19	7	12.51±4.250
PL(cm.)	41.5	20	33.25±3.666	30	13	20.61±4.429
S/R L ratio	0.729	0.667	0.689±0.731	0.578	0.857	0.693±0.189
SDW (gm.)	0.41	0.17	0.275±0.051	0.380	0.111	0.261±0.355
RDW (gm.)	0.73	0.19	0.368±0.078	0.580	0.190	0.266±0.162
PDW (gm.)	1.14	0.36	0.554±0.087	0.96	0.310	0.528±0.528
S/R DW ratio	0.561	0.895	0.748±0.879	0.655	0.584	0.991±0.785
Collar Diameter	6	3	5.5±0.789	6	4	5±1.01
%M.C. in Shoot	96.545	47.430	78.034±2.745	95.846	32.567	56.070±3.182
%M.C. in Root	51.134	26.151	47.986±2.342	68.582	37.715	52.01±1.031
PSA (cm ²)	52.65	22.28	19.55±4.824	53.54	23.710	2.66±5.33

Various seedling measurement	(G) Red+ Sand+Black(S ₁₄)(1:2:1)			Red+Sand+Black+Padua (S ₁₅) (1:1:1:1)		
	Max.	Min.	AV±SE	Max.	Min.	AV±SE
Total no. leaves of Seedlings	13	8	10.25±2.047	15	11	13.44±2.135
SL(cm.)	11	6	8.65±0.378	7	3	6.25±0.289
RL(cm.)	18	8	11.05±3.051	15	9	19.35±3.025
PL(cm.)	29	14	18.81±3.429	22	12	24.70±3.414
S/R L ratio	0.611	0.75	0.782±0.134	0.467	0.333	0.322±0.155
SDW (gm.)	0.380	0.11	0.207±0.355	0.371	0.17	0.247±0.367
RDW (gm.)	0.57	0.19	0.265±0.184	0.566	0.19	0.375±0.427
PDW (gm.)	1.15	0.30	0.472±0.540	0.937	0.36	0.624±0.749
S/R DW ratio	0.667	0.579	0.782±0.718	0.655	0.894	0.659±0.894
Collar Diameter	5	2	4.25±2.43	6	3	4.5±2.001
%M.C. in Shoot	95.854	31.755	56.919±4.184	96.425	36.430	56.402±5.250
%M.C. in Root	81.512	39.827	65±1.022	80.578	35.752	61.5±2.021
PSA (cm ²)	50.25	12.6	23.65±5.31	39.35	28.45	19.65±7.156

Table-3 Represents the value of Quality Index and Sturdiness Quotient of Seedlings in different potting media.

Potting Media	Quality Index	Sturdiness Quotient
S ₁	0.0421	9.8802
S ₂	0.1039	4.791
S ₃	0.0556	10.746
S ₄	0.0632	6.927
S ₅	0.2019	2.342
S ₆	0.0658	6.341
S ₇	0.0813	7.157
S ₈	0.1075	6.953
S ₉	0.0950	7.601
S ₁₀	0.0839	5.655
S ₁₁	0.0813	6.063
S ₁₂	0.1039	4.122
S ₁₃	-----	-----
S ₁₄	0.0906	4.425
S ₁₅	0.1039	5.489

Figure 1. Effect of Soil Composition on Shoot Length

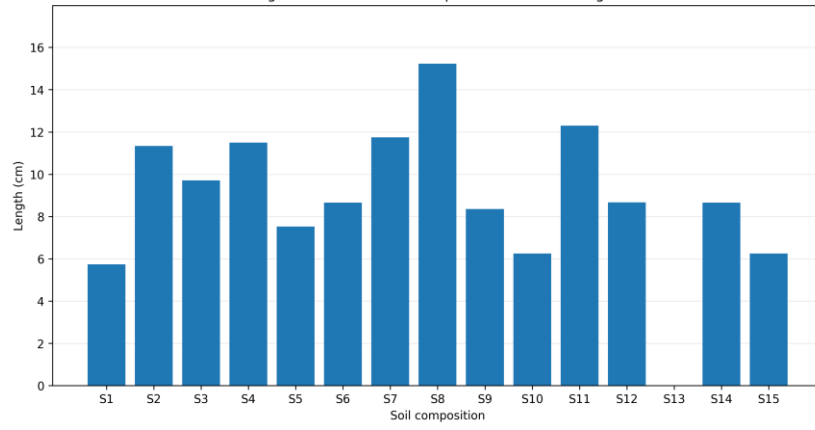


Figure 2. Effect of Soil Composition on Root Length

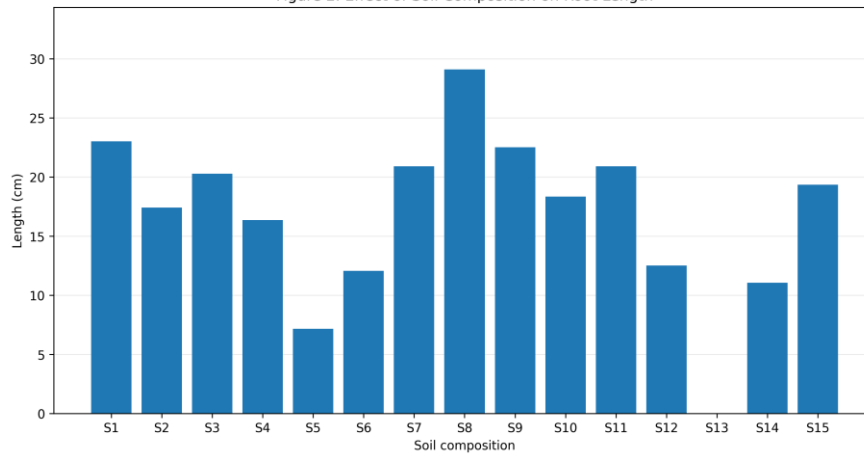
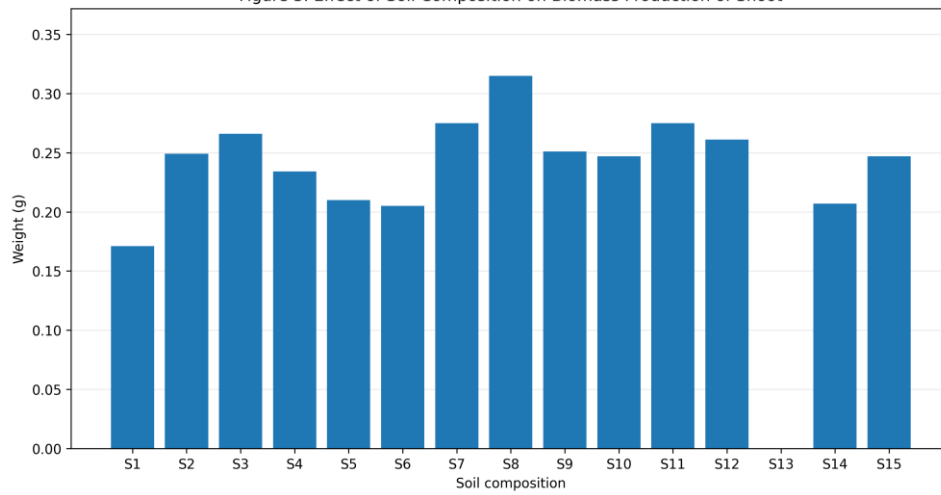
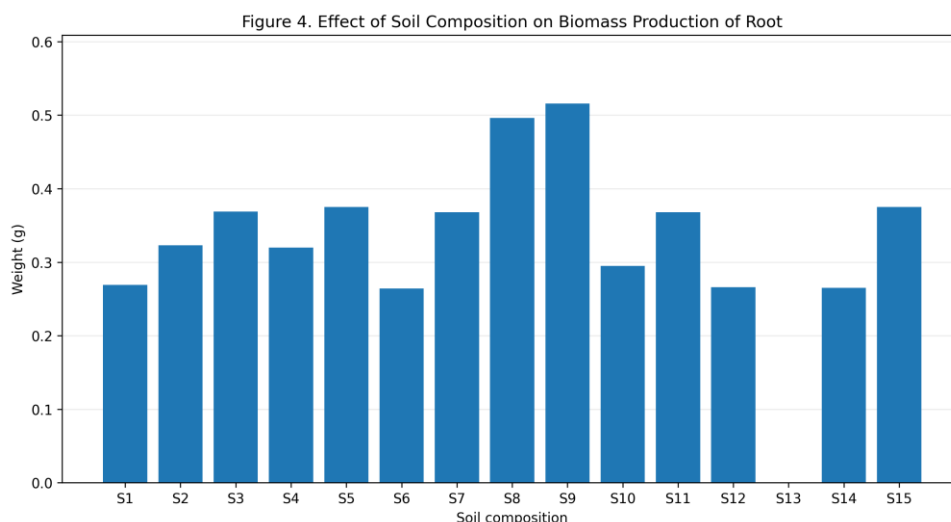


Figure 3. Effect of Soil Composition on Biomass Production of Shoot





Conclusion

In conclusion, the results of the present research indicate that the configuration of potting media greatly impacts the growth as well as the biomass of seedlings of the *Pongamia pinnata* (L.) Pierre in nursery conditions. Significant differences were evident in respect of the soil compositions used and the growth of seedlings in terms of their shoots and roots and other parameters related to the seedlings. Among the media tested, the mixture of Sand plus black soil in the volume ratio of 1:1 made the best results in the overall indicators as it gave the biggest average length of shoots (15.235 cm), roots (29.1 cm), and overall lengths of plants (38.8 cm) as well as the total dry biomass (0.816 g) produced by seedlings. The

mixture of red and black soils in the same ratio showed good results too and was characterized by the best root dry weight (0.516 g) and the biggest area of leaf photosynthesis (45.6 cm²). However, for the mixture of red, Padua, and sand (1:2:1), no growth of seedlings was noted at all, which indicates that not all soil compositions suit seedlings of the *Pongamia pinnata* (L.) Pierre. It is possible that better results achieved with the seedlings of mixed soil of Sand and black soil can be explained with better aeration, water conditions, and root penetration. Thus, among the media tested, the mixed soil of Sand and black soil in the volume ratio of 1:1 appears to be the most suitable for the development of seedlings of *Pongamia pinnata* (L.) Pierre.

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