Effect of Soll Composition on Seedling Growth and Quality of Cordia Africana at Holetta in the Central High Lands of Ethiopia

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Abstract
The study was conducted at Holetta Agricultural Research Center (HARC) at forestry tree nursery site. The objective of the experiment was to determine the best soil media and soil mixtures or substrate for the growth and seedling quality of cordia Africana around Holeta. The experiment comprised 10 treatments with different mixing ratios of local /agricultural/ soil, animal manure and sand. The primary goal of seedling quality assessment was to quantify levels of morphological and physiological attributes that result in an accurate assessment of tree seedlings conditions and potentials for vigorous growth and development. The results indicated of shoot height and root collar diameter, total dry matte yield and its partitioning (leaves, petioles, stems and roots), Leaf Weight Ratio (LWR) and Weight to Height Ratio (WHR, Estimated Leaf Area (ELA) and Actual Leaf Area (ALA) showed the highest values in the soil mixture having none local soil, two parts of animal manure and one part of sand. The seedlings showed a growth function after 160 days of planting assuring the fast growing character of Cordia africana seedlings. Shoot height, root length and root collar diameter showed strong positive correlation with each other, total dry biomass yield, actual and estimated leaf area.
Keywords: nursery, substrate, seedling, manure, sand

1. Introduction

Forests provide a multitude of goods and services including the regulation of the hydrological cycle, climate, the conservation of soil & nutrients, carbon sequestration, pollination & detoxification (Girma, 2002). Trees in rural landscape have several advantages (FAO, 1986); they provide products that can be marketed for cash or used domestically and services that increase crop yields and environmental resilience (Rocheleau *et al*., 1988; ICRAF, 1998). The natural ecosystems and the natural vegetation of Ethiopia have been greatly altered over the years. The forests (not including the woodland and other vegetation cover) were reduced from the original 35% to 16% in 1952 (Sayer *et al*., 1992) and to 3.6% (Anonymous, 2004). According to the World Bank, forest area in Ethiopia was last measured at 12.16 % in 2011.

In the highlands of Ethiopia, the indigenous tree species have largely been replaced by a few exotic species, notably eucalyptus. Certainly, those exotics are essential for the life of the rural populations today, but they cannot provide such a wide variety of products and services as do indigenous trees (Azene *et al.*, 1993).

Cordia africana is a versatile multipurpose tree species commonly growing scattered as a forest remnant on cultivated fields and other rural landscapes (Fitchtl and Admasu, 1994). *Cordia africana Lam.* (Synonym: *Cordia abyssinica R. Br.)* is a tree, rarely shrubby, species. Its English common names are East African *cordia* or large-leafed *cordia* or Sudan teak (ICRAF, 1998).In Ethiopia it is known in various vernacular names such as *wanza* (Amharic) and *wadessa* (Afan Oromo). On average, it attains a height between 14 and 21meters and a Diameter at Breast Height (DBH) is between 0.60 and 0.90 cm. It shows great morphological variation and requires five to seven months in nursery before planting it out (Azene *et al.*, 1993).

Generally, the species grows in areas with altitudes between 550 and 2600 m. a.s.l. and annual rainfall of 700 to 2000mm (Friis, 1992). It is a fast- growing and highly valued timber tree used for high-quality furniture, doors, windows, cabinet-making, drums, beehives, joinery, interior construction, mortars, paneling and veneering (ICRAF, 1988).

The contribution of scattered trees of *Cordia africana* to various soil properties and its importance as a coffee shade tree in traditional agro forestry systems has been documented (Teketay and Tegineh, 1991; Yadessa *et al.*, 2001). Despite its several uses, land clearings for farming, fuel wood and commercial logging have resulted in rapid destruction of forests where cordia has been dominant (Legesse, 1995). Thus *Cordia. africana* was proclaimed endangered (Negarit, 1994). Therefore, today the progressive natural resource degradation calls for good nursery practices to produce quality tree seedlings.

All nursery managers have their own favorite growth substrates. These vary depending on availability of those materials; however, in developing countries they are mainly soil from agricultural or forest areas, sometimes mixed with sand and/or manure. Since the mixture depends on the quality of the soil available, global recommendation doesn't exist.

The silviculture of most indigenous species is not yet very well known. The problem related with their silvicultural characteristics, nursery technique, long rotation, late economic return discourages many foresters from using indigenous species on large-scale plantation (Feyissa *et al*. 1994). Similarly, farmers prefer not to plant indigenous tree species, because they have less information about their nursery technique, silviculture and management method.

To raise quality seedlings nursery technique begins from knowing the appropriate soil composition for each tree species. However, only little of such vital information on *Cordia africana* is present. In view of filling up such a technical gap, this piece of research work was conducted with the following objectives:

- To determine the best soil media & soil mixtures for the growth and seedling quality of *Cordia africana* around Holeta .
- To compare pattern of seedling growth in *Cordia africana* on different media and soil mixture
- To study interrelationship among seedling growth characteristics in *Cordia africana* grown on different media.

2. Material and Methods

2.1. Site description

The study was conducted at Holetta Agricultural Research Center (HARC) forestry research process tree nursery site. HARC is located about 30 km west of Addis Ababa along Wollega road. It is located at 09^0 04' N longitudes & $38^0$30' E latitude and average altitude of 2400 m. a.s.l. Holetta is a high altitude area experiencing a weakly bimodal rainfall pattern extending from February to April and with the effective rain being from June to September. It is called weakly bimodal because the rainfall of February to April never supports crop growth. From the 39 years average, the annual total rainfall is about 1100 mm with a peak in August and mean annual temperature fall between 6.2°c and 22.3 °c.

Mean monthly Rainfall, Relative humidity and Maximum and minimum temperature for the growing period is given on table 1.

Table 1. Mean monthly Rainfall, Relative humidity, Maximum and minimum temperature for the growing period

Month	Temperature (°c)			RF (mm)	RH (%)
	Max.	Min.	Mean		
December	22.99	7.06	15.03	45.40	59.48
January	23.74	5.34	14.54	6.00	54.45
February	23.99	8.80	16.40	40.20	56.89
March	24.99	8.95	16.97	83.20	43.55
April	24.18	10.45	17.32	60.30	55.03
May	23.90	10.96	17.43	74.30	65.08

2.2. Experimental Design and Procedure

Seedlings were raised in polythene tubes having 10cm diameter and 12cm height. Treatments of the experiment used equal amount of container fillings with different ratios. These fillings were agricultural /local soil (A), animal manure (M) and sandy soil(S):

1. 3 part of agricultural soil, none of both manure and sandy soil (3A:0M:0S)
2. 2 part of agricultural soil, none of manure and 1 part of sandy soil (2A:0M:1S)
3. 2 part of agricultural soil, 1 part of manure and none of sandy soil (2A:1M:0S)
4. 1 part of agricultural soil, none of manure and 2 part of sandy soil (1A:0M:2S)
5. 1 part of agricultural soil, 2 part of manure and none of sandy soil (1A:2M:0S)
6. 1 part of agricultural soil, 1 part of manure and 1 part of sandy soil (1A:1M:1S)
7. None of agricultural soil, 1 part of manure and 2 part of sandy soil (0A:1M:2S)
8. None of agricultural soil, 2 part of manure and 1 part of sandy soil (0A:2M:1S)
9. None of agricultural soil, 1.5 part of manure and 1.5 part of sandy soil (0A:1.5M:1.5S)
10. Control

The experiment was laid out with ten treatments (9 soil mixtures and 1 control) in randomized complete block design in three replications. The control treatment was by simulating from farmer's practice i.e. the grass & leafy materials were burnt at some corner in the nursery site, and simply took the ash mixed soil and filled with the polythene tubes without considering the mixing ratio.

Growth media preparation: Each substrate was first air-dried and sieved with 2-mm sieve in order to remove roots, macroscopic litter, stones and gravel. Samples were taken from local/agricultural soil, sand, and manure separately for soil analysis. For all treatments, mixing of (manure, sand & agricultural soil) was done accordingly as of a preset ratio. The soil samples were taken along treatments and their physico-chemical properties were analyzed at Holeta Agricultural Research Center (HARC) Soil and Plant Tissue Analysis Laboratory.

Soil parameters were analyzed following standard procedures. Soil texture was determined by the Boucoucos hydrometer method (Day, 1965); Soil pH by pH meter in a 1:1 (v/v) soil: water suspension; total nitrogen by the kjeldahl method (Jackson, 1958), available phosphorus using acidic ammonium fluoride extracting solution, Bray - II method (Bray and Kurtz 1945), exchangeable potassium by flame photometry (IITA, 1978).

Each mixture was moistened, and polythene tubes were filled by hand. At the middle of the polythene tube a hole was first pressed into the soil by a picking stick to facilitate seeding. The polythene tubes were placed in an upright position and not be squeezed but maintain their round shape and space was left for rain & excess water to drain off easily.

A seed collected in 2007 having 71% initial germination percentage was used, and its germination percentage on petri-dish was 54%. Two seeds per polythene tube were sown on December 01/2009. The polythene tubes were watered & mulched just after sown to create a warm condition for seed. In the first two weeks the polythene tubes were watered twice a day about 10 Lt/ m^2. For the rest periods watering was done at field capacity level as per necessary. Mulching extended for more than two months and shade was made after seedlings were fully emerged. Thinning was done after seedlings were fully emerged i.e. 63 days after planting.

To protect the seedlings, all sides of the polythene tubes were surrounded by the sacks and top covered with wheat straw. The seedlings attained uniform emergency at 63 days after planting, which was assumed as time when all seedlings were fully carried out photosynthesis. Weeds grown were uprooted by hand; Pest and disease assessment was carried out periodically. At early seedling stage the pest damage was controlled by Carbaryl WP at the rate of 1.5gm/Lt.

Up to the date of destructive sampling total days that the seedlings were under effective growth were 112days. Therefore, Dry Matter Accumulation per Day (DMAPD) was determined by dividing the Total Dry Matter to the effective growth period.

Estimated leaf area (cm^2) was determined by multiplying the midrib length by leaf width. Whereas actual leaf area (cm^2) was determined by using leaf area meter. Leaf Area Index (LAI) was calculated by dividing the actual leaf area to polythene tube area. Leaf Area Correction Factor (LACF) was calculated by the equation:

ELA x CF = ALA

Where, ELA is Estimated Leaf Area, CF is Leaf Area Correction Factor and ALA is Actual Leaf Area.
Data analysis was executed by using SAS software (SAS, 2001). This statistical software was also used to group parameter means using LSD.

3. Result and Discussion

The emergency percent at 63 days after planting was 45.47%. This indicated that *Cordial africana* was a slow germinating type as stated by Azene *et al.* (1993).

The physical and chemical properties of the growth media were determined (Table 2). N and P content of the control treatment were high as compared to the others. This was because unknowingly the grass and leafy materials burnt at some corner in the nursery site was a piece of land on which unused manures were damped over years, and this ash mixed soil was taken as control treatment.

Table 2. Physical and chemical characteristics of the soil mixtures.

Treatment	Parameters						
	PH (1:1) H_2O	N %	P (ppm)	K (meq/100g)	Silt %	Clay %	Sand %
3A:0M:0S	5.81	0.16	6.80	1.4441	17.50	67.50	15.00
2A:0M:1S	6.15	0.09	7.20	1.1502	13.75	45.00	41.25
2A:1M:0S	6.02	0.37	176.00	5.9000	20.00	65.00	15.00
1A:0M:2S	6.98	0.08	8.80	1.6112	12.50	32.50	55.00
1A:2M:0S	6.54	0.59	320.00	13.4270	27.50	47.50	25.00
1A:1M:1S	6.65	0.21	160.00	5.1023	17.50	37.50	45.00
0A:1M:2S	7.11	0.28	224.00	6.4450	15.00	15.00	70.00
0A:2M:1S	7.08	0.39	288.00	8.3247	20.00	15.00	65.00
0A:1.5M:1.5S	7.27	0.20	192.00	4.8337	15.00	12.00	72.50
Control	7.64	0.33	576.00	36.2529	32.50	47.50	20.00
Manure	**	1.29	512.00	21.4832	*	*	*
Sand	7.72	0.02	9.00	0.9713	15.00	7.50	77.50

**Unless treated with hydrogen peroxide Organic matter would settle together with sand particle that is why not analyzed.*
***For manure 1:1 ratio never forms a saturation paste, (i.e. 1: 2.5 or 1:5 v/v is recommended).*
A = stands for agricultural soil, M = stands for manure, S = stands for sand

Results from analysis of variance were showed as follows:

3.1) Shoot height and Root Collar Diameter

Treatments with high animal manure ratio (both 0A: 2M: 1S and 1A: 2M: 0S) achieved the highest shoot height (cm) and root collar diameter (mm) at 175 days of planting as compared to the other treatments. This treatment gave 39.69% and 39.88% comparative advantages of shoot height and root collar diameter over the control respectively (Table 3).

Treatments 1A: 1M: 1S, 0A: 1M: 2S, 0A: 1.5M: 1.5S and the Control were the next best in performance. Treatments without animal manure showed the least shoot height and root collar diameter (Table 3). Root length showed non significant difference, this might be probably because of the difficulty in uprooting the roots, which were grown beyond the pot length by penetrating through the pot hole. Much of the fibrous and tip of tap root were cut during pulling up. As quality parameter all treatments showed a better sturdiness quotient (Table 3).

Johnson, 1992 and Pope, 1993; stated that for northern red Oak (Quercus rubral) seedlings having root collar diameter (RCD) greater than 8 mm and shoot height (Ht) greater than 50cm were more competitive than smaller stock when planted on a variety of sites. Similarly, in case of *cordia africana* this study revealed that seedlings having root collar diameter (RCD) greater than 7mm and Shoot Height (Ht) greater than 40cm showed a good seedling quality character.

Table 3. Mean shoot height (cm) and RCD (mm) at 175 days of planting

SN	Treatment	Ht (cm)	RL (cm)	RCD (mm)	Sturdiness	Comparative Advantage over the Control [CA] (%)
1	3A:0M:0S	12.80c	19.73	3.21c	4.00	
2	2A:0M:1S	20.47bc	19.87	4.28bc	4.70	
3	2A:1M:0S	27.47abc	16.93	5.32abc	5.30	
4	1A:0M:2S	12.87c	16.73	3.26c	4.00	
5	1A:2M:0S	38.53a	19.67	6.82a	5.70	
6	1A:1M:1S	33.00ab	20.93	5.98ab	5.30	
7	0A:1M:2S	34.53ab	22.00	6.06ab	5.70	
8	0A:2M:1S	40.33a	23.47	7.12a	5.70	Ht= 39.69, RCD= 39.88
9	0A:1.5M:1.5S	31.87ab	21.07	6.14ab	5.70	
10	Control	28.87ab	20.00	5.09abc	5.70	
	Mean	28.07	20.04	5.33		
	CV (%)	30.57	24.19	23.73		
	LSD (5%)	14.72	NS	2.17		

Means in a column followed by the same letter don't differ significantly

Reason why *Cordia africana* seedlings perform well on substrates having high animal manure and less or none agricultural soil and/or sandy soil was probably due to high amount of nitrogen and available phosphorus content of manure (Table 2**).**

Moreover,the agricultural soil used were taken from the adjacent nursery site with moderately acidic range, hence as stated by Eghball 1999 and Whalen *et al*. 2000 the application of manure to acid soil increases soil pH and decrease in Al solubility and also attributes to high Ca and Mg carbonate content which may fever seedling performance..

3.2) Total dry matter yield and its partitioning to leaves, petioles, stems, roots and dry matter accumulation per day

Total dry matter yield and its partitioning (leaves, petioles, stems, roots) and dry matter accumulation per day of treatment 0A: 2M: 1S was recorded the highest value. This gave a comparative advantage of dry matter accumulation per day 51.42% over the control.

Shoot dry weight of treatments 1A: 2M: 0S, 1A: 1M: 1S and 0A: 1M: 2S were significantly bigger as of treatment 0A: 2M: 1S. Dry Matter Accumulation per Day (DMAPD) of treatments 1A:2M: 0S, 1A: 1M: 1S and 0A: 1M: 2S were the next best. Treatments without animal manure gave the least value of DMAPD (Table 4).

Table 4. Mean Total dry matter yield at 175 days of planting

SN	TREATMENT	LDW	SDW	PDW	RDW	TDW	DMAPD	CA (%)
1	3A:0M:0S	1.71de	1.07c	0.38d	0.91d	2.24d	0.21d	
2	2A:0M:1S	2.14cde	1.31bc	0.52cd	1.04cd	2.78cd	0.26cd	
3	2A:1M:0S	2.86abcd	2.34ab	0.62bcd	1.59abc	4.08abc	0.39abc	
4	1A:0M:2S	1.64e	1.04c	0.33d	0.83d	2.14d	0.20d	
5	1A:2M:0S	3.65ab	2.82a	0.98ab	1.75ab	5.03ab	0.47ab	
6	1A:1M:1S	3.39ab	2.58a	0.87abc	1.69ab	4.67ab	0.44ab	
7	0A:1M:2S	3.33ab	2.45a	0.89abc	1.62abc	4.52ab	0.43ab	
8	0A:2M:1S	3.99a	3.13a	1.14a	1.99a	5.58a	0.53a	DMAPD= 51.42
9	0A:1.5M:1.5S	3.31abc	2.41ab	0.81abc	1.57abc	4.46abc	0.42abc	
10	Control	2.65bcde	2.08abc	0.66bcd	1.32bcd	3.68bcd	0.35bcd	
	Mean	9.09	5.25	0.61	2.26	17.21	0.15	
	CV (%)	23.95	30.38	33.38	24.22	25.74	25.73	
	LSD (5%)	7.60	5.48	0.63	1.99	15.56	0.14	

Means in a column followed by the same letter don't differ significantly

3.3) Growth parameters attribute

Weight to Height ratio (WHR) of 0A: 2M: 1S was significantly bigger than the other treatments, and those treatments with high local soil and none manure ratio attained least Weight to Height ratio (WHR). But the highest measure of leafiness i.e., Leaf Weight Ratio (LWR) was recorded by treatment 2A: 0M: 1S (Table 5).

Table 5. Mean of Growth parameters at 175 days of planting

SN	TREATMENT	LWR	WHR	SLW	CA (%)
1	3A:0M:0S	0.58abc	0.33c	0.02	
2	2A:0M:1S	0.61a	0.33c	0.02	
3	2A:1M:0S	0.49d	0.53ab	0.02	
4	1A:0M:2S	0.59ab	0.32c	0.02	
5	1A:2M:0S	0.53bcd	0.58ab	0.02	
6	1A:1M:1S	0.53bcd	0.58ab	0.02	
7	0A:1M:2S	0.54bcd	0.52abc	0.02	
8	0A:2M:1S	0.52cd	0.68a	0.02	WHR= 65.85
9	0A:1.5M:1.5S	0.55abc	0.55ab	0.02	
10	Control	0.52cd	0.41bc	0.02	
	Mean	0.55	0.48	0.02	
	CV (%)	6.60	24.39	32.31	
	LSD (5%)	0.06	0.20	NS	

Means in a column followed by the same letter don't differ significantly

3.4) Estimated and Actual leaf area

Among all treatments the one with two-third of manure and one-third of sand (0A: 2M: 1S) scored the highest estimated and actual leaf area (Table 6**).**

Table 6. Estimated and actual leaf area among treatments

	Treatment									
	1	2	3	4	5	6	7	8	9	10
Estimated Area(cm)2	251.9	439.7	496.0	269.3	1220.7	809.9	1025.0	1426.4	928.7	647.9
Actual Area(cm)2	182.5	270.5	325.3	164.9	809.0	565.1	689.1	1004.8	612.9	425.8
LACF = ALA / ELA	0.72	0.62	0.66	0.61	0.66	0.70	0.67	0.70	0.66	0.66

Treatments: 1,2,3,4,5,6,7,8,9,10 were as stated above on table 2,3,4,5.

Mean Leaf Area Correction Factor (LACF) was determined by dividing the sum of all LACF to the number of treatments.

$$\text{Mean LACF} = \frac{\sum \text{(all LACF)}}{\text{\# of treatments}} = \frac{6.7}{10} = \mathbf{0.67}$$

Estimated Leaf Area (ELA) and Actual Leaf Area (ALA) showed a strong positive association (Figure 1).

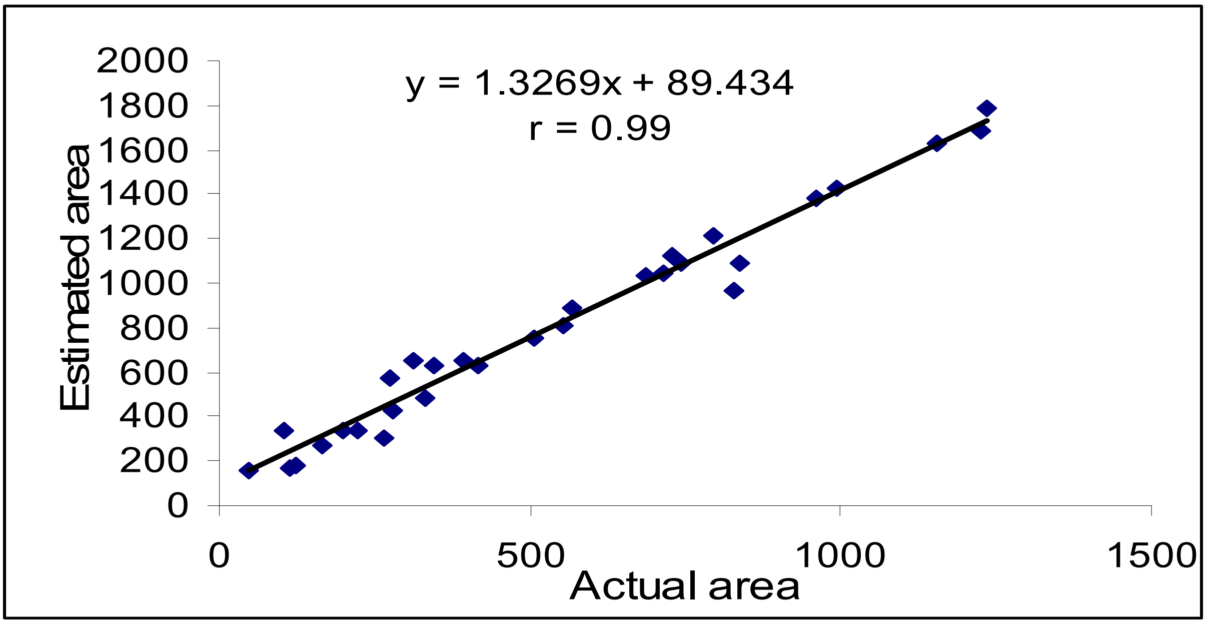

Figure1. A bi-plot of actual and estimated leaf areas in c.africana showing strong positive association

Thus, the strong positive association between estimated and actual leaf area confirmed that the above determined leaf area correction factor may fill the technical gap for further study of *cordia africana* seedlings where leaf area meter is a problem.

3.5) Shoot height measurement

Height measurement was taken at100days, 130days, 160day and 175days, but for convenience the last measurement was manipulated to 190days (Table 6.)

Table 6 Mean shoot height at different durations of measurement.

Treatment	Ht (cm) 100days	Ht (cm) 130days	Ht (cm) 160days	Ht (cm) 175days	Ht (cm) 190days[manipulated]
1	3.87	6.33	8.87	12.80	16.73
2	4.40	7.13	13.73	20.47	27.20
3	5.67	13.27	22.47	27.47	32.47
4	3.40	5.53	9.00	12.87	16.73
5	3.93	12.47	27.67	38.53	49.40
6	4.87	11.73	23.80	33.00	42.20
7	4.20	10.93	23.60	34.53	45.47
8	4.40	14.73	29.33	40.33	51.33
9	4.60	10.87	22.40	31.87	41.33
10	3.87	10.60	21.20	28.87	36.53

Treatments that do have manure ratios reach an excellent plantable size with six months of growing period (Table 6).Using mean height measurement of the four durations a growth curve was constructed (Figure 2). The seedlings showed a growth function after 160days of planting; this assures the fast growing character of cordia africana seedlings as stated by Azene et.al, 1993.

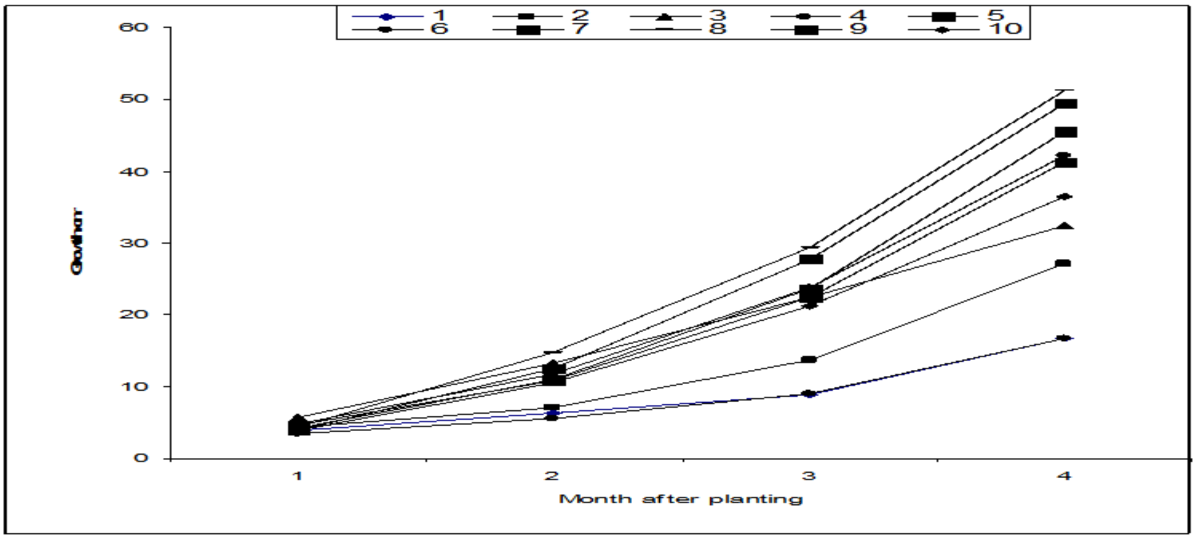

Figure 2. Shoot height Growth Pattern of *cordial africana* seedlings.

3.6) Interrelation of seedling growth characteristics

Shoot height, root length and root collar diameter showed strong positive correlation with each other, with total dry biomass yield, with estimated and actual leaf area, positive correlation with leaf area correction factor. But not correlated with leaf area ratio and specific leaf weight and strong negative correlation with leaf weight ratio.
Leaf area ratio and specific leaf weight were none correlated with most seedling growth characteristics except leaf weight ratio, specific leaf weight and leaf area correction factor (Table 7).

Table 7. Estimates of correlation coefficient among seedling growth characteristics of *cordia africana*

	HT	RL	RCD	LDW	SDW	PDW	RDW	TDW	DMA	LAR	LAI	WHR	LWR	SLW	LACF	ELA
HT																
RL	0.56**															
RCD	0.92**	0.56**														
LDW	0.94**	0.66**	0.94**													
SDW	0.93**	0.66**	0.92**	0.98**												
PDW	0.91**	0.63**	0.91**	0.96**	0.96**											
RDW	0.88**	0.68**	0.91**	0.97**	0.97**	0.94**										
TDW	0.93**	0.67**	0.94**	0.99**	0.99**	0.96**	0.98**									
DMA	0.93**	0.66**	0.94**	0.99**	0.99**	0.97**	0.98**	0.99**								
LAR	0.08	0.10	0.01	0.01	0.02	0.04	-0.05	-0.01	-0.01							
LAI	0.95**	0.66**	0.92**	0.97**	0.97**	0.96**	0.94**	0.97**	0.97**	0.15						
WHR	0.81**	0.63**	0.90**	0.93**	0.93**	0.87**	0.95**	0.94**	0.93**	-0.07	0.89**					
LWR	-0.53**	-0.30	-0.57**	-0.53**	-0.61**	-0.50**	-0.62**	-0.57**	-0.58**	0.36*	-0.53**	-0.63**				
SLW	-0.29	-0.25	-0.23	-0.22	-0.22	-0.22	-0.18	-0.22	-0.21	-0.73**	-0.35*	-0.2	0.04			
LACF	0.39*	0.41*	0.38*	0.39*	0.38*	0.39*	0.36*	0.39*	0.38*	0.81**	0.51**	0.38*	-0.11	-0.76**		
ELA	0.96**	0.63**	0.94**	0.99**	0.97**	0.96**	0.96**	0.98**	0.98**	0.05	0.98**	0.91**	-0.54**	-0.27	0.39*	
ALA	0.95**	0.66**	0.92**	0.98**	0.97**	0.96**	0.94**	0.97**	0.97**	0.15	0.99**	0.90**	-0.53**	-0.35*	0.51**	0.98**

** ** r values were significant at probability level of 0.05 and 0.01 respectively*

HT shoot height(cm), RL root length (cm), RCD root collar diameter(mm), LDW leaf dry weight (g), SDW stem dry weight(g), PDW petiole dry weight(g), RDW root dry weight(g), TDW Total dry weight(g), DMA dry matter accumulation per day(g), LAI leaf area index, WHR Weight height ratio, LWR leaf weight ratio, SLW specific leaf weight (g), LACF leaf area correction factor, ELA estimated leaf area, ALA actual leaf area LAR leaf area ratio.

4. Conclusion

The result of the study revealed that a treatment with none of agricultural soil, 2 part of manure and 1 part of sand soil (0A:2M:1S) showed the best performance in shoot height and root collar diameter, total dry matter production and its partitioning (leaves, petioles, stems and roots), growth and leaf area parameters. Using manure and sandy soil as a substrate can also decrease time of seedling staying in a nursery; therefore, it is advisable to use two-third of manure and one-third of sand to raise quality seedlings of *Cordia africana* around Holeta. Trends of NPK values showed high in those soil mixes having more manure ratios. As well known local soil has a better contribution of NPK than sand, but vigorous growth of seedlings was observed on 0A: 2M: 1S than 1A: 2M: 0S. This probably related to the higher relative proportion of sand which might increase the porosity of growth media and thereby allowed good gas exchange in the root zone. Since Estimated Leaf Area (ELA) and Actual Leaf Area (ALA) showed a strong positive association it is possible to use 0.67 as a Leaf Area Correction Factor (LACF) to determine Actual Leaf Area (ALA) for *Cordia africana* seedlings where getting an instrument leaf area meter is a problem.

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