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Research Article

The Effects of Seed Pretreatment on Seed Germination and Bio-Char Soil Mixture on Early Survival of Seedlings of *Faidherbia albida (Del) Chev* in Nursery

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ABSTRACT

Appropriate pretreatment of seed and soil mixture of nursery are required for proper seed germination and seedlings growth, respectively. *Faidherbia albida (Del) Chev* (*syn. Acacia albida* [Del.]) is a useful tree species that improve soil fertility, and supply dry season livestock fodder in some climatic zones of Africa. However, it is difficult to grow *F. albida* in clay soils and methods to improve the cultivation conditions are highly required. Although bio-char can be a potential ingredient of nursery soil mixture in deforested areas, information is lacking about its effect in clay soil nursery sites. Seeds of *F. albida* are also difficult to germinate in short period of time. Accordingly, the present study was conducted to determine the effects of nicking, and warm and cold water stratification seed pretreatments on improving the seeds germination. Then different proportional ratios of bio-chars of saw dust, chat (*Catha edulis Forsk*) leaves and coffee (*Coffea arabica L*) husks pyrolysed at 300 and 350°C temperature were mixed with local soil, and compost to grow transplanted seedlings in the first year of eight months and then continued to second year totally 20 months old. Among the presowing seed treatment, stratification resulted in greatest number of germination of the seeds, about 76%. The effect of the soil mixtures on the Root Collar Diameter (RCD) growth was greater than the corresponding stem height growth. The greatest RCD and height growth was obtained from local soil, about 0.84 cm, and 28 cm, respectively. The minimum growth of RCD was obtained in soil mixtures of local soil, compost and bio-char of sawdust 350°C. However, 25% bio-char of saw dust 300°C showed maximum RCD growth in eight months. In the first year, although, the soil mixture that contained only local soil was the best in increasing the growth of RCD and height of seedlings, it was the least in the number of seedlings survived. In 20 months, the highest survival about 94%, root collar diameter of 0.88 cm and height of 30.85 cm was obtained from the mixture of local soil and bio-char of sawdust 300°C in the ratio of 03:01, while the least survival and growth was obtained from unmixed local soil. Soil mixtures that contained bio-char in all cases improved the survival of seedlings. Therefore, seedling growing in clay loam soils should include bio-char pyrolysed at appropriate temperature for better survival of seedlings of *F. albida*.

Keywords: Bio-char; Height; Root collar diameter; Seedlings; Soil mixture; and Survival

INTRODUCTION

Faidherbia albida ((Delile) A. Chev) belongs to the family *Fabaceae*. Its common names are Apple-ring acacia or winter thorn. The apple-ring acacia was previously called *Acacia albida Del.*, but currently named as *Faidherbia albida* (Delile) A. Chev.). It is a deciduous legume tree, up to 30 m height and has deep taproot, down to 40 m [1] *F. albida* is native to arid or semi-arid areas of Africa and is widespread on the continent, commonly found in the Middle-East and in South-East Asia, India, Pakistan, Cyprus, Cape Verde and Peru. It grows well in sandy areas with 250-1800 mm annual rainfall and long dry seasons, with 6°C to 42°C temperatures.

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F. albida is nitrogen fixing leguminous tree species and its nutrient rich leave shed add nutrients like nitrogen, potassium, and organic carbon to the soil [2]. It is a fertilizer tree used in Semi-Arid Africa and in Ethiopia [3] (Figure 1). It is one of the best agroforestry tree species because of its reverse phenology of shedding leaves at the onset of the rainy season where crops are growing and the tree mature leaves in dry season and pods ripen, then. The phenology and character of the tree species made it valuable in periods of scarcity as fodder and famine food (edible seed). The tree allows satisfactory production of crops under a full stand [4]. The tree takes 15 to 30 years of growth to obtain the full benefit of new planting.

Figure 1: Scattered Faidherbia albida trees in farmlands of Semi-Arid Ethiopia

The ability of *F. albida* as shade of trees in hot weather and the ability to fix nitrogen make it a valuable asset in maintaining soil fertility. Although *F. albida* tolerates occasional water logging, it was difficult to grow the tree in clay vertisols. Previous observations in Southern Ethiopia in Enemorina Ener district revealed that growing seedlings of *F. albida* in nursery and field was difficult because of poor seed germination, and poor aeration of rooting soil media. The difficulty in growing *F. albida* in clay soils requires methods to improve the cultivation practices. *F. albida* is also a potential tree species for soil nutrient and livestock feed supplementing species.

Quality, vigorously germinated seedlings, determine the survival and growth of seedlings and future trees. Appropriate pretreatment or presowing seed treatment and soil mixture are management factors determining the growth of seedlings in nursery [5].

The strong seed coat of *F. albida* shows the presence of seed dormancy. The seeds are covered by waterproof cuticle which ensures their preservation for several years [5] seed dormancy can artificially be removed by nicking or warm -cold water stratification. Nicking large number of seeds is time consuming, tedious and could damage the internal part of endosperm [6].

Tree seed nursery as an area where young trees are grown for future planting out in the field need to be equipped with appropriate soil mixture that have sufficient nutrient, and water. The appropriate soil mixtures are well decomposed forest soil; manure; sand and local soil [7]. It is known that forest soil supplies optimal microbial composition and organic nutrient for the growing seedlings, manure supplies nutrient, sand supplies air space in the root, and local soil has the appropriate space for water holding. Soil mixtures are prepared to simulate natural forest soils which provide the seedlings with good drainage, good nutrient content and mechanical support by holding the roots together. However, there are nursery sites that face shortage of forest soil because of the deforestation and replacement of forests by other land uses. Therefore, appropriate seedlings growth in the nursery requires a replacement of the short running forest soil and reduced supply of sand in clay soils.

F. albida poorly grows in clay soil where air supply is not sufficient. Bio-char has a characteristic of nutrient retention and aeration. Bio-char is a fine-grained and porous charcoal which is distinguished from other charcoals in its high surface area per unit of volume and low amounts of residual resins. It is produced by heating biomass organic material under limited or no oxygen [8]. Bio-char has been be used as soil amendment in different parts of the world. The high surface area and porosity of bio-char adsorb nutrients and water and also provide a habitat for beneficial microorganisms when compared to other soil amendments [9].The quality of bio-char is affected by the temperature level and the type of feedstock. The major feed stocks for bio-char production are toxic free waste biomass, including forestry, or agriculture crop residues and urban food and paper wastes. Bio-char catalyzes the plant uptake of nutrients and water [10]. When bio-char is buried in soils, it takes carbon out of the atmosphere and traps it underground for hundreds of even thousands of years [11].

Bio-char is incorporated in to soil by spreading in to the soil surface, mixing with compost or mulch, or pouring as liquid slurry. The soil type and type of crop affects the application rate for bio-char. Previous studies showed that bio-char applications of 5 to 20 % by volume of soil have positive and noticeable results [10].

The effect of bio-char in the soil depends on the soil type, presence of other ingredients and the type of plant. Newly formed fresh bio-char applied in to soil can retard plant growth the first year. The benefit of bio-char to the soil is detected when bio-char undergo a few changes in the soil before it can serve as a soil and root media. The best way to prepare bio-char for soil amendment is to mix with or blend with fertilizer, rock dust, or compost [11]. The mixtures of bio-char and compost have synergistic benefits including increasing microbial activity, and reducing nutrient losses [12]. The combination of bio-char with compost improves the performance of plants grown as bio-char adsorbs gases (ammonia and volatile nutrients), absorbs water, nutrient ions, and bio-char provides stable refugee for microbes and compost provides immediate nutrient. Bio-char is beneficial for growing crops and improves crop yield in acidic and highly weathered tropical field soils [13].

The potential of bio-char in improving soils properties and enhancing the growth of plants has mainly been addressed in laboratory studies, and in non woody plant species, but rarely in the field woody plants like tree seedlings. Although there are a number of researches on *F. albida*, [14] the effect of bio-char on its seedlings growth was scanty. In Ethiopia, *F. albida* is a well-known parkland agroforestry tree species in some dry lands. However, its distribution is limited by poor germination capacity of the seed, and poor management that reduce its survival in areas where the sandy texture of the soil is low.

Although bio-char can be a potential ingredient of nursery soil mixture in deforested areas, information is lacking about bio-char effect in clay loam soils nursery sites of *F. albida*. Seeds of *F. albida* are also difficult to germinate in short period of time. Seed germination of *F. albida* is facilitated by nicking or soaking in warm and cold water. However, nicking is time taking and probable cause of seed damage. The seedlings grow best in sandy soils. Therefore, presowing treatment of soaking seeds and method of improving the soil aeration in non-sandy soils is highly important. Accordingly, the objective of the present study was to compare pretreatment of nicking and warm and cold water stratification and early growth performance of F. albida tree seedlings grown in different soil mixture of bio-char.

MATERIAL AND METHODS

Description of *faidherbia albida (delile) a. Chev.*

F. albida is synonymous with Acacia albida Del. (USDA, 2009). It is a deciduous legume tree that coppices readily and can grow to a large size. The indehiscent pods are ring shaped and contain 10-20 dark brown seeds, which can remain viable for many years. It is well established in sandy alluvium and sandy clay in the West Africa and on alluvial soil in Eastern and Southern Africa.

F. albida is commonly found in the Middle-East and in South-East Asia, in sandy areas with 250 to 1800 mm annual rainfall and long dry season's temperatures ranging from 6°C to 42°C [15]. Stem diameter at breast height can exceed 1-2 m [16]. The tree can live to an age of 70 to 90 years with individuals being reported as old as 150 years [17].

Study site description

The study was conducted in Gemede nursery site, close to Gunchire town of Enemorina Ener district (woreda) in Southern Ethiopia (Figure 2). The nursery site is close to a perennial river which is used for watering the site. The nursery site is surrounded by Eucalyptus plantation forest in the Eastern direction and by natural forests in all other directions [18, 19]. The local soil type was clay loam. The agroecology of the study site was midland with Tepid to cool submoist - plains (SM2-1), altitude: 1600-2400, latitude: 8°4'1.8"; longitude: 37°48'53"; mean annual precipitation: 1150 mm and Temperature: 18.5°C (Figure 3). Dominant woody plants are *Acacia abyssinica* Hochst. ex Benth, *Eucalyptus camaldulensis* Dehnh., *Juniperus procera* Hochst. ex Endl., *Olea species*, *Phoenix reclinata* Jacq., *Syzygium guineensis Willd. DC.*, *Bersama abyssinica Fresen.*, *Croton macrostachyus* Hochst. ex Delile. and *Acacia tortilis* (Forssk.) Hayne.

In 2005-2013 the mean monthly rainfall in Enemorina Ener district, Gunchire town was 21.65 to 266.5 mm, with annual mean of 1290 mm. The main rainy season is June to September. In 2005-2013, the neighboring district's maximum monthly temperature was 21.7 to 26.8°C and minimum temperature was 6.7 to 11.9°C as obtained from Ethiopian Meteorological Agency (Figure 3).

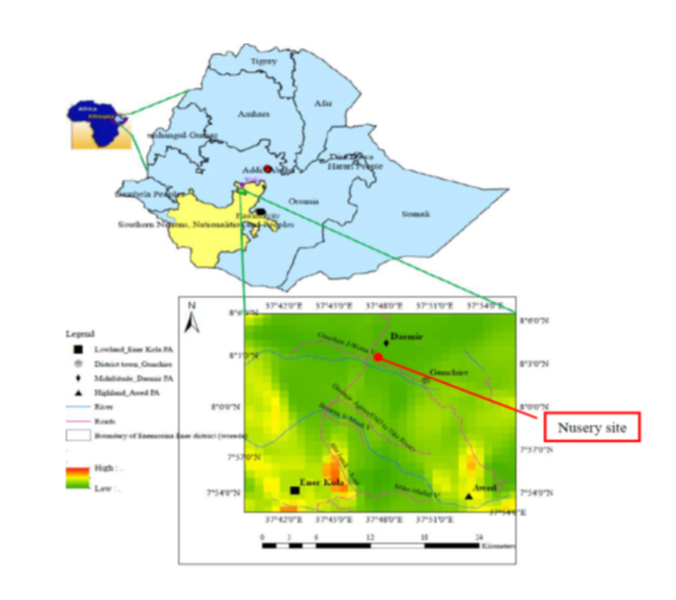

Figure 2: Location map of the study area (Author)

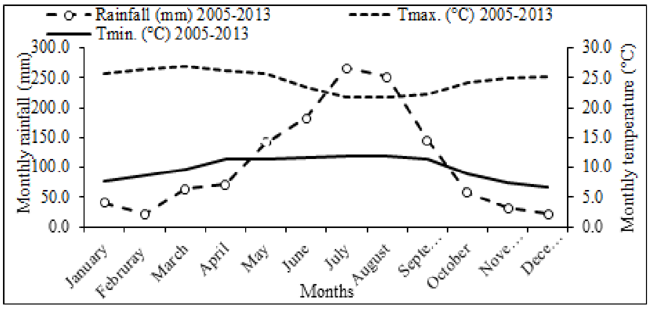

Figure 3: Rainfall and temperature (2005-2013) of the studied Gunchire town closer to the nursery site

(The temperature is from neighboring district in 2005-2013).

Soil mixture preparation for seedling growing media

Three types of soil mixture ingredients were used which were obtained from the nearby area including local soil, compost, and bio-char. The compost was made from local soil, cattle dung, and local grass, green leaves of *S. guineensis*, and *C. macrostachyus* and dry stalk of maize (Figure 4). First 1.2 m deep, 1 m wide and 2 m long pit was dug [20,21]. The bottom layer of the pit to the thickness of 10 cm was filled with long dry maize stalk that had no moisture, then a 10 cm layer of 1 cm, chopped undried grasses and green leaves were added, then uniformly and equally mixed dung and local soil was added for 15 cm thick layer [22]. Then layers were repeated as depicted in Figure 4. Local soil was obtained from the eastern direction close to the Eucalyptus plantation, and cattle dung was collected from the nearby grazing land. The compost in the pit was kept for three months, about two months in one side and returned to be kept in another side in the next one month. The pit with compost was watered about 20 m^3 water every second day [23].

Figure 4: The components mixture used in making local compost in 1.2 m deep pit (side view).

Bio-char was prepared from locally available biomass feed stock that include urban waste of chat leaves (*Catha edulis*), coffee husk (*Coffea arabica*), and sawdust (*Cupressus lusitanica*).

Chat leaves and coffee husk were heated at 350°C temperature and the saw dust by 300 and 350°C using pyrolysis kiln for 4 hours.

The local soil, compost and bio-char were completely mixed at a required volume proportion, for example 3 m^3 local soils with 1 m^3 bio-char and 1 m^3 compost (as ratio 3:01:01) before filling polythene tubes of 12 cm diameter and 20 cm length.

During polythene tube filling the mixtures was moistened by tap water and 0.125 m^3 pure sand was added for each of 1 m^3 local soil. Then two months old seedlings were transplanted [24].

Table 1: Treatments of bio-char and compost preparation for nursery seedling growing soil mixtures.

No.	Treatment (T) of soil mixture composition	Proportion		
		% Bio-char	% Compost	% Local soil
T1	Local soil and bio-char of sawdust 350°C in ratio: 03:01	25	0	75
T2	Local soil, compost and bio-char of sawdust 350°C in ratio: 03:01:01	20	20	60
T3	Local soil and bio-char of chat leaves 350°C in ratio: 03:01	25	0	75
T4	Local soil, compost and bio-char of chat leaves 350°C in ratio: 03:01:01	20	20	60
T5	Local soil and bio-char of sawdust 300°C in ratio: 03:01	25	0	75
T6	Local soil, compost and bio-char of sawdust 300°C in ratio: 03:01:01	20	20	60
T7	Local soil and bio-char of coffee husk 350°C in ratio: 03:01	25	0	75
T8	Local soil, compost and bio-char of coffee husk 350°C in ratio: 03:01:01	20	20	60
T9	Compost and local soil in ratio 01:01	0	50	50
T10	Local soil			100

Note: treatments 1 and 2 are sawdust at 350°C; 3 and 4 are chat leaves at 350°C; 5 and 6 are sawdust at 300°C; and 7, and 8 are coffee husk at 350°C; treatment 9 to 10 local soil and compost.

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Seed germination

The seeds of *F. albida* collected from forest within six months were obtained from Central Ethiopia Environment and Forest Research Center.

About 1200 pure, uninfected seeds were randomly sampled from the bulk of seeds received and presowing treatment was made in three different ways. The first 400 seeds were nicked by file, the other 400 seeds were first warm water, and then cold water stratified and occasionally shaked for 24 hours and the rest were not treated. Then all the seeds were buried in seed bed at the depth down the diameter of each seed. The seedbeds were covered with grasses mulch to avoid direct sunlight reaching the seeds, and watered daily. At day 60 after sowing, the germinated seeds were counted and the percentage was calculated. Germination of seed was considered when the radicle extended 1 cm beyond the testa [25].

Seedling survival and growth performance

The survival and growth performance of eight months (December 2019 to July 2020) and 20 months (December 2019 to July 2021) seedlings were measured the root collar diameter (RCD), stem height (H), and survival. The RCD was measured by graduated caliper and H by graduated ruler. The survival of 25% the seedlings was also counted.

Data analyses

The generalized linear model (GLM) and partial correlation procedure of SPSS (SPSS 20 Copyright: SPSS Inc.) was employed for analysis of variance (ANOVA) and correlation. The analysis variance of means of seedlings survival, root collar diameter, and stem height was determined using Student-Newman-Keuls test based on the following fixed effect model:

Where Yij is seedling trait of jth replication of the ith treatment, μ is the overall mean, Pi the effect due to ith treatment (i = 1 . . . 10) and eij is the error.

RESULTS

Seed germination

The number of germinated seeds in the case of warm and cold water stratification was 76% while that of the nicked treatment was 45%. This indicated the ability of warm and cold water stratification in supplying optimum moisture and air to initiate the germination of the seeds of *F. albida* (Table 2). The use of stratification was preferable not only in increasing the number of seeds germinated but also to reduce the tedious work of nicking seeds and risk of damaging the embryo of the seed.

Table 2: Germination of F. albida seed under different presowing treatment.

Pre sowing treatment		
Nicking (%)	**Warm and cold water stratification (%)**	**No treatment (%)**
45	76	17

Growth performance of seedlings

The survival, root collar diameter (RCD) and stem height (H) growth of seedlings of *F.albida* were statistically different under different soil mixture treatments at $p<0.05$. The effect of the soil mixtures on survival and root collar diameter growth was greater than the corresponding height growth because the significance level of survival and RCD was $P<0.001$ while that of height was $P<0.002$. However, in year two, the stem height growth was not significant among the treatments. Therefore, root collar diameter was the most important parameter for the seedlings that showed the effect of soil mixture treatments (Table 3).

Table 3: The analysis of variance of root collar diameter and height growth of F. albida seedlings in the first and second year.

Year one						
		Sum of squares	Df	Mean square	F	Sig.
Survival (%)* treatment	Between groups	6774.967	9	752.774	1881.935	0
	Within groups	8	20	0.4		

	Total	6782.967	29			
RCD (cm)* treatment	Between groups	6.61	9	0.735	181.318	0
	Within groups	1.01	250	0.004		
	Total	7.62	259			
Stem height (cm)* treatment	Between groups	154.63	9	17.181	3.052	0.002
	Within groups	1407.52	250	5.63		
	Total	1562.15	259			
Year two						
		Sum of Squares	df	Mean Square	F	Sig.
Survival (%)* treatment	Between groups	8327.2	9	925.244	62.517	0
	Within groups	296	20	14.8		
	Total	8623.2	29			
RCD (cm)* treatment	Between groups	7.383	9	0.82	156.534	0
	Within groups	1.31	250	0.005		
	Total	8.693	259			
Stem height (cm)* treatment	Between groups	48.777	9	5.42	1.243	0.269
	Within groups	1089.909	250	4.36		
	Total	1138.686	259			

Root collar diameter of seedlings

In the first year, the greatest RCD growth was obtained from treatment 10 (T10) soil mixtures that composed only local soil, about mean RCD of 0.84 cm, ranging from 0.66 to 1.03 cm. Comparatively, the soil mixtures that composed of local soil and bio-char of sawdust 300°C in ratio: 03:01 (T5) or 25% bio-char of sawdust 300°C; compost and local soil in ratio 01:01 (T9) or 50% compost; and simple local soil (T10) or 100% local soil showed relatively better growth of RCD of *F.albida* seedlings (Figure 5). The minimum growth of RCD was obtained in treatment 2 (T2) soil mixtures that composed of local soil, compost and bio-char of sawdust 350°C in ratio: 03:01:01 or 20% bio-char, about 0.37 cm RCD growth. In statistical analysis of the grouping in the growth of RCD was obtained in decreasing order of group 1: T10, T5 and T9; group 2: T4; group 3: T7, T8, T6; group 4: T3; and the least RCD growth was obtained in group 5: T1 and T2 (Figure 5). In the second year, the greatest mean root collar diameter growth about 1.09 cm was obtained from treatment 1 (T1) that composed the mixture of local soil and bio-char of Sawdust 350°C in ratio: 03:01, followed by the local soil and the minimum about 0.65 cm from treatment 3, (T3) that composed the mixture of local soil and bio-char of chat leaves 350°C in ratio: 03:01. This showed the need for additional growth to get clear distinction about the effect of bio-char on the growth of the seedling.

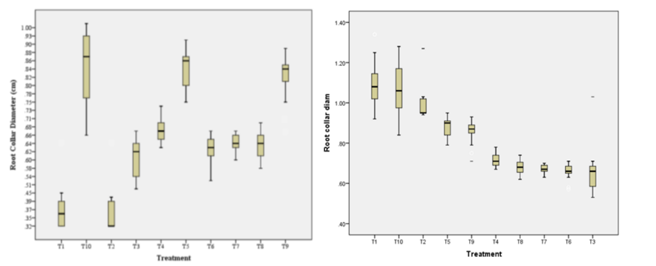

Figure 5: Root collar diameter growth of *F.albida* seedlings under bio-char, compost and local soil mixture in eight months (left) and 20 months (right).

T 1: Local soil and Bio-char of Sawdust 350°C in ratio: 03:01; T 2: Local soil, Compost and Bio-char of Sawdust 350°C in ratio: 03:01:01; T 3: Local soil and Bio-char of Chat leaves 350°C in ratio: 03:01; T 4: Local soil, Compost and Bio-char of Chat leaves 350°C in ratio: 03:01:01; T 5: Local soil and Bio-char of Sawdust 300°C in ratio: 03:01; T 6: Local soil, Compost and Bio-char of Sawdust 300°C in ratio: 03:01:01; T 7: Local soil and

Bio-char of Coffee husk 350°C in ratio: 03:01; T 8: Local soil, Compost and Bio-char of Coffee husk 350°C in ratio: 03:01:01; T 9: Compost and local soil in ratio 01:01; T 10: Local soil.

Seedlings height

In the first year, the greatest height growth was obtained at treatment 10 (T10) soil mixtures that composed only local soil, about mean height of 28 cm, ranging from 25.96 to 29.73 cm. Comparatively, the soil mixtures that composed of local soil, bio-char and compost from treatment 2 up to treatment 10 (T2 to T10) showed relatively better growth of height of *F.albida* seedlings. That is the minimum growth in height was obtained in treatment 1 (T1) soil mixtures that composed of local soil and bio-char of sawdust 350°C in ratio: 03:01, about mean height of 24.85 cm growth, ranging from 20 to 30 cm (Figure 6). This indicated the necessity of adding compost in the soil mixtures of bio-char for seedling growth.

In the second year, the greatest mean stem height growth about 31.2 cm was obtained from treatment 8 (T8), that composed local soil, compost and bio-char of coffee husk 350°C in ratio: 03:01:01, and the minimum about 29.7 cm from treatment 7 (T7) that composed of local soil and bio-char of coffee husk 350°C in ratio: 03:01. That is the presence of compost in the mixture improved the height growth of seedlings.

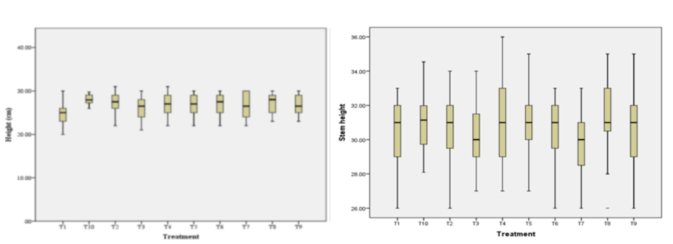

Figure 6: The height growth of *F.albida* seedlings under bio-char, compost and local soil mixture in eight months (left) and 20 months (right).

T 1: Local soil and Bio-char of Sawdust 350°C in ratio: 03:01; T 2: Local soil, Compost and Bio-char of Sawdust 350°C in ratio: 03:01:01; T 3: Local soil and Bio-char of Chat leaves 350°C in ratio: 03:01; T 4: Local soil, Compost and Bio-char of Chat leaves 350°C in ratio: 03:01:01; T 5: Local soil and Bio-char of Sawdust 300°C in ratio: 03:01; T 6: Local soil, Compost and Bio-char of Sawdust 300°C in ratio: 03:01:01; T 7: Local soil and Bio-char of Coffee husk 350°C in ratio: 03:01; T 8: Local soil, Compost and Bio-char of Coffee husk 350°C in ratio: 03:01:01; T 9: Compost and local soil in ratio 01:01; T 10: Local soil.

Survival of seedlings the first year

The average survival of seedlings of *F.albida* varied among the soil mixtures. The maximum survival about 100% was observed in many of the soil mixtures including local soil and bio-char of sawdust 350°C in ratio: 03:01 (T1); local soil and bio-char of chat leaves 350°C in ratio: 03:01 (T3); local soil and bio-char of sawdust 300°C in ratio: 03:01 (T5); local soil and bio-char of coffee husk 350°C in ratio: 03:01 (T7); and local soil , compost and bio-char of coffee husk 350°C in ratio: 03:01:01 (T8) (Figure 7 and Figure 8). Many of the soil mixtures that had bio-char regardless of the type of bio-char showed better survival than the other soil mixtures without bio-char. The local soil (T10) which was used without any other mixture showed the lowest survival rate of about 51% (Figure 7). Therefore, the local soil is poor to support the survival of seedlings and then additional ingredient is needed for the survival of seedlings of the species. In the second year in the nursery stay, the highest survival about 94% was obtained from the mixture of local soil, saw dust bio-char at 300°C (with proportion of 3:01) in treatment 5 (T5), the lowest about 36.7% was obtained from local soil (T10) as shown in Figure 7. That is in local soil the survival of seedlings was low and then it is important to use additional ingredients.

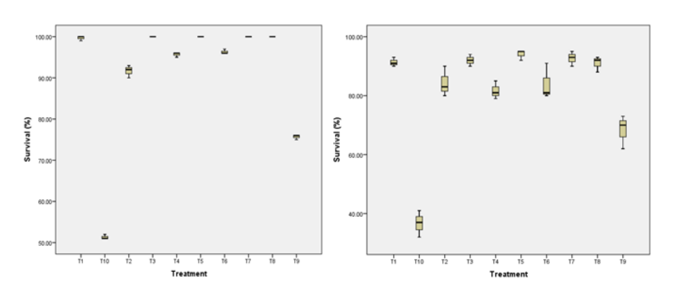

Figure 7: The survival of *F.albida* seedlings under bio-char, compost and local soil mixture in 8 months (left) and 20 months (right).

T 1: Local soil and Bio-char of Sawdust 350°C in ratio: 03:01; T 2: Local soil, Compost and Bio-char of Sawdust 350°C in ratio: 03:01:01; T 3: Local soil and Bio-char of Chat leaves 350°C in ratio: 03:01; T 4: Local soil, Compost and Bio-char of Chat leaves 350°C in ratio: 03:01:01; T 5: Local soil and Bio-char of Sawdust 300°C in ratio: 03:01; T 6: Local soil, Compost and Bio-char of Sawdust 300°C in ratio: 03:01:01; T 7: Local soil and Bio-char of Coffee husk 350°C in ratio: 03:01; T 8: Local soil, Compost and Bio-char of Coffee husk 350°C in ratio: 03:01:01; T 9: Compost and local soil in ratio 01:01; T 10: Local soil.

Figure 8: Seedling growth in Gemede nursery sites of Enemorina Ener district, Southern Ethiopia.

In the first year of eight months of survival and growth of seedlings in the nursery, the mixture of local soil and bio-char of sawdust 300°C in ratio 03:01 (T5) showed the greatest performance followed by the mixture of local soil, compost and bio-char of coffee husk 350°C in ratio 03:01:01 (T8); local soil and bio-char of coffee husk 350°C in ratio: 03:01 (T7); local soil and bio-char of chat leaves 350°C in ratio 03:01 (T3); and the mixture of local soil and bio-char of sawdust 350°C in ratio 03:01 (T1). The lowest performance was observed from local soil (T10) and the mixture of compost and local soil in ratio 01:01 (T9). In the second year of 20 months of survival and growth of seedlings in the nursery the mixture of local soil and bio-char of sawdust 300°C in ratio 03:01 (T5) also showed the greatest performance followed by the mixture of local soil and bio-char of coffee husk 350°C in ratio 03:01 (T7); local soil and bio-char of Chat leaves 350°C in ratio 03:01 (T3); local soil, compost and bio-char of Coffee husk 350°C in ratio 03:01:01 (T8); and local soil and bio-char of sawdust 350°C in ratio 03:01 (T1). The lowest performance was observed from local soil (T10) and the mixture of compost and local soil in ratio 01:01 (T9).

Correlation of the growth parameters of seedlings in the first year

The survival and height growth of the seedling was correlated with the g rowth of the root. Moreover, the root collar diameter was correlated with the root length at P=0.024 which is P< 0.05 probability level (Table 4). The root to shoot ratio of the seedlings was ranged from 0.47 to 0.51, the lowest in soil mixture of local soil, compost and bio-char of sawdust 350°C (T2) and the highest in compost and local soil (T9). This indicated that local soil was necessary for the immediate growth of seedling roots which was the media before transplanting seedlings.

Table 4: Correlations analysis of the growth of different parts of seedlings of F.albida in the first year.

		Stem height (cm)	Survival (%)	Root length
Root collar diameter (cm)	Pearson correlation	0.608	-0.473	.700*
Height (cm)	Sig. (2-tailed)	0.062	0.167	0.024
	Pearson correlation		-0.574	.786**
	Sig. (2-tailed)		0.083	0.007
Survival (%)	Pearson correlation			-.733*
	Sig. (2-tailed)			0.016

DISCUSSION

Successful initial seed germination of *F. albida* determines the vigorousity and healthiness of seedlings. Fast germination also results in greater number seedlings with strong root and shoots development [5]. About 76% of the seeds from warm and cold water stratification were germinated, which was greater than the other studies conducted elsewhere in [18], about 69.7% for a number of F. albida variety but lower than the study made by Bekele (2007) about 60-90%. Therefore, warm-cold water stratification was preferable for softening the seed coat and initiation of the germination of *F. albida* seeds as studied in [6]. However, the local people personally communicated in nursery site had no warm and cold water stratification knowledge in sowing the seeds of the species and this simple technique should be introduced. The number of seeds germinated by the locally practice of nicking was lower either because of damage or inappropriateness. Similarly, laboratory test of the use of the locally available warm and cold water stratification 24 hours with occasional shaking is needed to confirm the potential of seed germination of *F. albida* because at the nursery beds some seedlings could be lost or damaged without being counted.

Compost and manure are options in the place of natural forest soils, in soil mixture preparation for nursery seedling growth. Moreover, it is found that bio-char is a possible ingredient in nursery soil mixture so as to supplement the forest soil and sand shortage. Then bio-char is necessary to grow sandy soil demanding *F. albida* tree [14]. Bio-char is a fine-grained and porous charcoal which supplies aeration for root growth. Previous studies confirmed that bio-char and compost mixtures have synergistic benefits of supporting the growth of seedlings [12].

In eight months, the average growth in root collar diameter (RCD) from 0.39 to 0.84 and height from 25 to 28 cm observed from seedlings of *F. albida* were lower than the other studies conducted elsewhere in Africa by [18]. The lower growth of seedlings at early stage could be observed due to bio-char application which can be attributed to imbalances in temporary levels of pH, volatile matter, and/or nutrient associated with fresh bio-char [19]. The impact of bio-char on seedlings increases as the bio-char interact with soil through time. The effect of the soil mixtures on the root collar diameter growth was greater than the corresponding height growth (Figure 5 and 6). The soil treatment that contained only local soil was the best in increasing the growth of RCD and height of few seedlings of *F. albida*. Those well grown seedlings are naturally favoured in the same homogenous mixture of soil which could be attributed to the inherent characteristics of the seeds and therefore, require further study. Soil mixture containing 25% bio-char of saw dust 300°C, 50% compost with local soil and 100% local soil showed better RCD growth than the other soil mixtures as stated in [10]. Moreover, in 20 months growth of seedlings, the height growth to 31.2 cm and root collar diameter to 1.1 cm was favourable for planting out, which showed the effect of bio-char as compared with the local soils of height growth 29.7 cm and root collar diameter to 0.65 cm

It was found that the temperature level of pyrolysis bio-char making of 300°C was better in RCD development and survival than the 350°C in the case of saw dust feedstock (Figure 5 and Figure 6).

Although greater proportion of local soil mixture about 100% (T10) was better for the growth of RCD and height of seedlings of *F. albida* (Figure 5 and Figure 6), the survival of seedlings was lower about 51% (Figure 7). Soil mixtures that contained bio-char in all cases improved the survival of seedlings which is in line with the study by [13]. All seedlings of *F. albida* grown in mixtures of bio-char survived above 90%. Therefore, mere local soil is poor to support the survival of seedlings and then additional ingredient is needed to increase the survival of seedlings *F. albida* species. Bio-char is easily obtainable from pyrolysis of local biomass materials and therefore, it can be used to increase the survival of seedlings. Moreover, the local soils' improvement of the growth of RCD and height is not continuous because of the depletion of local soil nutrient [7], but bio-char had increased the survival and then expected growth of seedlings through time as stated by David (2014). The 25% bio-char in soil mixtures resulted in 100% survival better than the lower proportion of bio-char (Figure 7). Therefore, the present study confirmed the proportion 25% bio-char is better for survival of seedlings as studied in Hunt et al. (2010). The survival and height growth of the seedling was correlated with the growth of root, and therefore, the presence of bio-char was correlated with the survival and growth of seedling *F. albida*.

CONCLUSION

Greater number of seeds of *F.albida* was germinated under the presowing treatment of warm and cold water stratification with occasional shaking for 24 hours instead of the usually known nicking which could damage the embryo, which is tedious and time consuming. The number of seedlings of *F.albida* grown in local soil mixture generally showed better early growth than the seedlings in bio-char mixed soils. The overall performance of on the survival and growth of the eight and 20 months observation revealed that the mixture of local soil and bio-char of sawdust 300°C in ratio of 03:01 (T5) was the best followed by the mixture of local soil, compost and bio-char of coffee husk 350°C in ratio of 03:01:01 (T8). The least performance on the survival and growth was obtained from local soil (T10) followed by compost and local soil in ratio of 01:01 (T9), which showed that through time, the compost decomposed and the mixture maintained the character of local soil. Therefore bio-char addition was highly important for the survival and growth of seedlings of *F.albida*. However, it is generally believed that seedlings grown under bio-char mixture are expected to have better future growth because they showed greater number of survival than mere local soil. Bio-char addition that share around 25% of the potted soil mixture comprising local soil, and compost can easily be obtained by pyrolysing local biomass material in the absence of forest soil which at least was in short supply in many nurseries because of deforestation and land use change. Moreover, local biomass use to make bio-char is a way to dispose waste from agricultural and wood processing residues. Bio-char use is highly important to increase the survival of seedlings because of the moisture and nutrient adherent properties of bio-char. The bio-char improved the clay loam local soil and therefore, bio-char has the potential to make possible the growth of *F.albida* in dry land clay soils. Moreover, bio-char should be made locally to use in nursery soil mixture and to grow seedlings in clay loam soils that lack fertile forest soil and sand because bio-char has the potential to provide aeration to the soil. Bio-char also has soil carbon increment potential that should be used to mitigate emission of greenhouse gases created by easily decomposing raw biomass like compost and dung. On the other hand bio-char should be used in combination with fast decomposing compost and dung in growing seedlings so as to supply the seedlings with readymade nutrient. The place of getting bio-char in rural areas is diverse either from the charcoal making areas, where fine dusty charcoals can be used as a bio-char for soil amendment or simply pyrolysing local biomass materials like agricultural and wood residues or even urban nontoxic food and paper wastes. Therefore, local seedling raising nursery workers should be trained on the ways of local bio-char preparation to promote the survival of seedlings of tree species especially in clay soils and for agricultural crops and to promote organic farming. Moreover, it is highly recommendable to study the nutritive content of the different biomasses that to be used for bio-char making in the presence of well-equipped laboratory.

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