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Effect of Spacing on Above-Ground Biomass and Some Wood Properties of Leucaena (*Leucaena leucocephala* Lam.) in Upper Egypt

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Abstract

There is no doubt that the tree density is the main property used as a wood quality index for various end uses**.** The wood quality results from interaction between genotype of the trees and the silvicultural conditions to which they were subjected. Based on these interactions, research on the factors that add values to the woody raw materials has an influence on production of the various forest products. The present investigation was aimed to study the effects of different plant spacing on the above-ground biomass and some physical and chemical wood properties of *Leucaena leucocephala* trees. Three planting space for *L. leucocephala* namely, 1×1, 1×2 and 2×3 m was used. The obtained results indicated that the higher increment in above-ground biomass i.e. plant height, stem diameter at breast height, fresh and dry weight of woody stem, branches and leaves as well as fresh and dry weight of biomass were due to planting at the wider spacing, while the least values as result of the narrow spacing. Also, the higher α- cellulose (64.30 %), holocellulose (75.09 %), the higher extractive percentage (17.98 %), lignin (23.79%), and ash content (1.40 %) were registered with the wider spacing. Moreover, applying 1 × 1 m spacing proved to be most effective to produce the lowest value (50.0%) of moisture content, while the highest content (56.0%) was detected with the wider space. The maximum value (0.70 g/cm^3) of specific gravity was attained with the wider distance (2×3 m), while the minimum value (0.67g/ cm^3) was attained from trees that planting at 1×1 m. Therefore, to obtain higher above-ground biomass and wood quality characteristics from leucaena trees, the study recommends planting these trees at a distance of 2×3 m under the study conditions.

Keywords: *Leucaena leucocephala*, plant spacing, above-ground biomass, wood properties.

Introduction

Biomass is one of the most world's natural resources, which provides with the opportunity to use it for energy purposes, as fuels, heat, power generation, electricity and chemical products **(Jeeban and Sea, 2012).** Forest biomass is related to the carbon sources and sinks in the forest ecosystems **(Zhu *et al.*, 2020).** Then, accurate estimation of the forest biomass is necessary basis to monitor and assess forest carbon sinks (**Fang and Wang, 2001)** and its effect on the ecosystem-level carbon cycle and feedback on the climate change **(Yu *et al*., 2022).** However, biomass is defined as the mass of living organisms in the forest. It is simply the weights of all organisms living precisely in a specific area by putting it on a scale. Mostly, the biomass in trees is focus on the methods for estimating biomass by measuring the above-ground portion of trees **(Condit, 1998).**

Chemical analysis of wood is often used to determine the chemical composition of wood. The chemical components of wood extremely influence the characteristics of natural composites and opportunities for their uses. Wood is composed of cellulose, holocellulose, lignin, and extraneous materials (Miller, 1999). The basic wood properties of Leucaena leucocephala will help support suitability and use of raw materials in wood composite (Nazri et al., 2009). Wood ash is the inorganic and organic residue remaining after the combustion of wood or unbleached wood fiber. The physical and chemical properties of wood ash vary significantly depending on many factors. The chemical composition of wood gives an idea of how feasible the tree is as raw material for papermaking (Haygreen and Bowyer, 1996).

The physical wood properties as moisture content of green wood vary considerably among species. However, the moisture content of green wood is important because of its direct relation to the weight of logs and green lumber. Therefore, it is of concern to those who design harvesting and transport equipment, purchase wood on a weight basis, or must ship or transport green wood. Also, specific gravity of wood is its single most important physical property. The mechanical properties of wood are closely correlated with specific gravity and density. The strength of wood, as well as its stiffness, increases with specific gravity. The yield of pulp per unit volume is directly related to specific gravity. Moreover, the heat transmission of wood increases with specific gravity as well as the heat per unit volume produced in combustion (Haygreen and Bowyer, 1996).

Leucaena leucocephala Lam. is one of the most fast-growing multipurpose tree species and is planted as a forage or fodder crop. It also planted to produce timber and lumber, fence posts, fuel wood, charcoal (Brewbaker, 1997), human food after certain processing, pulp, paper (Parrotta, 2000). Environmentally, Leucaena displayed substantial role, since it is used in sand dune fixation and soil conservation (Ragab, 1998), in desertification control and to ameliorate nutritive status of soil throughout its role in bio fixation of nitrogen by aid of symbiotic nitrogen fixing bacteria in poor sites (Parrotta, 2000).

In Egypt, some industries face major challenges, such as the manufacture of paper and medium density fiberboard (MDF) due lack of raw materials needed for these industries. L. leucocephala tree is an ideal green manure crop; it is grown for animal feed and fodder, ground cover, firewood, providing wood and other uses. Its fibers are harsh, coarse and shiny in appearance but lack elasticity. It is an ideal green manure crop and they are grown for animal feed and fodder, ground cover, providing wood, firewood and other uses in traditional agroforestry systems. In addition, its fibers are harsh, coarse and shiny in appearance but lack elasticity (Singh and Rani, 2014). Extracted fiber is suitable for nonwoven fabric and used for making fish net and rope, carpets, sackcloth, sailcloth and cordages, paper pulp (Singh and Rani, 2013).

For producing sufficient and sustainable quantities of electricity generation, plantation managements must identify the important factors that have an impact on the growth and productivity after harvesting trees. Plant spacing is one of the most crucial factors affecting the growth of leucaena. (Van den Beldt, 1983). In this respect, Chotchutima et al. (2013) determined the effect of plant spacing on the growth, biomass production and wood quality of leucaena. They revealed that wider spacing resulted in greater plant height, stem diameter and sprout number, while the narrowest spacing (1 × 0.25 m) produced the highest total dry weight of leaf, woody stem and biomass yield. However, some of chemical compositions as C, O, P, K and Ca content show significant different with the different spacing. Therefore, this study aimed to measure above- ground biomass, physical and chemical wood properties of Leucaena leucocephala trees grown under different plant spacing in Qena Governorate, Egypt.

Material and methods

This investigation was carried out on a private farm in Qena Governorate, Southern Egypt (26° 9' N, 32° 42' E), for the purpose of studying the effect of plant spacing on above-ground biomass and some physical and chemical wood properties of the fast-growing leguminous tree i.e. *Leucaena leucocephala* Lam. The soil analysis of the study area was characterized as loamy sandy, pH 8.4, organic matter (0.40%), and electrical conductivity 0.65 mmhos. The field experiment was assigned for each species in a completely randomized design with three replicates. Three planting spaces 1×1, 1×2 and 2×3 m was used for *L. leucocephala* trees. The field of the experimental area was manually cleared and ridged; each experimental unit area included four ridges each of 50 cm width, and 3.5 m length. Seeds of the tree species were obtained from healthy trees neighboring the experimental area. Fresh seeds were sown in hills on February 10th of 2021. Four weeks after, only one healthy seedling remained in each hill. All cultural practices were carried out on tree seedlings, including irrigation and weeding, up to 2- year- old.

In February 10th 2023, two years after planting, above-ground biomass and some chemical and physical wood properties of *Leucaena leucocephala* trees were evaluated in the study. Ten trees from each spacing treatment were selected and used to evaluate the different parameters.

Above- ground biomass characteristics:

Data on the above-ground biomass parameters of the tree species under varying plant spacing were determined i.e. stem diameter (cm), plant height (m), woody stems fresh and dry weight (kg), fresh and dry weights of branches and leaves (kg) as well as the fresh and dry weights of above-ground biomass (kg).

Chemical properties of wood:

Cellulose:

Cellulose content of the *Leucaena* wood was estimated as described by **Sadasivam and Manikam (2005)**. For this finely powdered pre extracted saw dust were taken after the pre extracted saw dust, prepare Acetic/Nitric Reagent by mixing 150 ml of 80% acetic acid and 15 ml of conc. Nitric acid. Prepare fresh Anthrone reagent by dissolving 200 mg anthrone in 100 ml concentrated sulphuric acid and chill for 2 hours before use. Prepare 67% sulphuric acid by mixing 68 ml Conc. Sulphuric acid and 32 ml distilled water. After preparing the above solutions add 3 ml acetic/nitric reagent to a known amount (100 mg) of the sample in a test tube and mix in a vortex mixer for 5 minutes. Place the tube in a water bath at 100 ºC for 30 minutes and then centrifuge the contents for 15-20 minutes, discard the supernatant, and wash the residue with distilled water. Then add 10 ml of 67% Sulphuric acid and allow it to stand for 1 hour, and dilute 1 ml of the above solution to 100 ml. To 1 ml of this diluted solution, add 10 ml of anthrone reagent and mix well, heat the tubes in a boiling water bath for 10 minutes, cool and measure the colour at 630 nm in spectrophotometer by setting a blank with anthrone reagent and distilled water. Then, take 100mg cellulose powder in a test tube and proceed the steps of creating the standard by addition of sulphuric acid to anthrone reagent as above procedure.

Holocellulose:

Five grams of oven dried sample pre-extracted with alcohol-benzene (1:2 v/v) was taken in a conical flask and 160 ml of distilled water was added to it. Then contents were treated with 1.5 gram of Sodium chlorite and 10 drops of acetic acid at 70-80 ˚C on a water bath for one hour. The process was repeated four times till the meal became white. Then contents were filtered through IG-2 crucible, washed with water and finally with acetone. The sample was dried in an oven at 105 ± 2 ˚C to a constant weight. The holocellulose content was calculated on the basis of the oven dry weight **(Anonymous, 1959 a).**

Lignin content:

Two grams oven dry sample pre-extracted with alcohol-benzene (1:2 v/v) was treated with 15 ml of 72% sulphuric acid for two hours at 18-20 ˚C with constant stirring. The material was brought down to 3 % by adding 345 ml of double distilled water. The solution was refluxed for 4 hours and then allowed to settle. The contents were filtered, washed with hot distilled water and dried in an oven at 105 ± 2 ˚C till constant weight and expressed in percentage on oven dry weight basis **(Anonymous, 1959 b)**.

Eextractives content:

Two grams oven dry powdered wood sample was placed in a porous thimble (oven dried and weighed). The thimble was placed in a Soxhlet Apparatus and extracted with 200 ml of alcohol-benzene (1: 2 v/v) for six hours. Then, porous thimble was taken out and allowed to dry in open air and finally in an oven at 105 ± 2 ˚C till constant weight. The alcohol-benzene solubility was determined by calculating the loss in weight of the sample taken and expressed in percentage (**Anonymous (1959 c).**

Physical wood properties:

Moisture Content (%):

In order to measure moisture content, the samples of wood were weighed in a weighing balance and then dried in a hot air oven at 103±2°C till a constant weight. Then, the final weight has been taken as oven dry weight. The moisture percentage of the samples was calculated as **ASTM (1989)** formula**:**

Moisture content (%) =Mi−Mo/ Mo ×100.

Where, Mi = initial weight of sample (g), Mo = Oven dried weight of sample (g).

Specific gravity (g/ cm^3):

The specific gravity was measured based on air dried weight (12-14% MC) and volume of wood as described by **Haygreen and Bowyer (1996).** Ten blocks (2×2×5cm) from the wood sampled of each spacing treatment were weighed, made air-tight with plastic foils, and volumes were determined by water displacement. The specific gravity of each sample was calculated by dividing the conditioned air-dried weight by the volume of water it displaced in the formula:

SG (*g/ cm^3*) *= W ÷ (Vb-Va),* where, *W* = air-dried weight of wood sample at 12-14% MC, *Va* = volume of water after immersion, *Vb* = volume of water before immersion.

Statistical analysis:

Data of the above-ground biomass, physical, and chemical wood properties were pooled to compute the range, average and standard deviation of stem diameter. Meanwhile, data of the other characteristics were tabulated and statistically analyzed according to the method by **Snedecor (1956)** and L.S.D mentioned by **Little and Hills (1978).**

Results and discussion

Above-ground biomass:

The effect of plant spacing on some above-ground biomass i.e. stem diameter, plant height, woody stem fresh weight and woody stem dry weight of 2-year-old *Leucaena leucocephala* was shown in Table (1). There were significant effects of plant spacing on these traits. Stem diameter of *L. leucocephala* was gradually increase by increasing spacing from 1×1 m up to 2×3m. However, higher stem diameter (6.20 cm) was recorded with the wider space, while the least one (4.23 cm) was obtained with the narrow spacing (1×1 m). The plant height was significantly affected by plant spacing. The increment in plant height was associated with the increase in plant spacing. The tallest plant (7.58 m) was attained with the spacing of 2×3 m, followed by 7.10 m for 1×2 m space, while the shortest plants (6.63 m) were with the narrow spacing. Woody stem fresh weight/ tree was significantly increased by increasing plant spacing. Maximum fresh weight (9.03 kg) was obtained with 2×3 m space, while the minimum (5.08 kg) was due to 1×1 m interval. Also, woody stem dry weight/ tree was significantly affected by plant spacing. Planting *L. leucocephala* seedlings at 2×3 m spacing recorded the higher value of woody stem dry weight (5.06 kg), while planting at the narrow spacing attained the least one (2.85 kg).

Table 1. Average stem diameter, plant height, woody stem fresh weight/ tree (WSFW) and woody stem dry weight/ tree (WSDW) of *Leucaena leucocephala* at 2- years old.

Tree spacing (m)	Stem diameter (cm)	Plant height (m)	WSFW (kg)	WSDW (kg)
1x1	4.23	6.63	5.08	2.85
1x2	5.41	7.10	7.42	4.15
2x3	6.20	7.58	9.03	5.06
LSD 5%	0.78	0.14	0.47	0.26

The effects of plant spacing 2 years after planting of *L. leucocephala* were significantly different for branches and leaves fresh and dry weight, as well as fresh and dry weight of above-ground biomass as shown in Table (2). The higher values of these characters were produced with application of 2× 3 m spacing, but the lower values were noticed with 1×1 m spacing. As plant spacing increased, parameters of branches and leaves fresh and dry weight, and fresh and dry weight of above-ground biomass of *L. leucocephala* increased. The higher fresh weight of branches and leaves/ tree (5.45 kg) was attained with planting trees at 2x3 m, while the least value (3.05 kg) was due to 1×1 m spacing. The maximum dry weight of branches and leaves/ tree (2.83 kg) was produced with 2×3 m spacing, while minimum value (1.59 kg) as a result of planting leucaena at 1×1 m. Generally, aboveground biomass in terms of fresh and dry weight biomass of *L. leucocephala* was affected by spacing treatments. The higher increment in biomass production was 14.48 and 7.89 kg/ tree occurred in fresh and dry weight, respectively due to planting at the wider spacing. Meanwhile, the least values of 8.14 and 4.43 kg/ tree of the fresh and dry weight of above-ground biomass as result of the narrow spacing as shown in Table (2).

Table 2. Average branches and leaves fresh weight/ tree (BLFW), branches and leaves dry weight/ tree (BLDW), above-ground biomass fresh weight/ tree (BFW) and above-ground biomass dry weight/ tree (BDW) of *Leucaena leucocephala* at 2- years old.

Tree spacing (m)	BLFW (kg)	BLDW (kg)	BFW (kg)	BDW (kg)
1×1	3.05	1.59	8.14	4.43
1×2	4.62	2.40	12.03	6.55
2×3	5.45	2.83	14.48	7.89
LSD 5%	0.37	0.19	0.34	0.18

Chemical characteristics of wood:

The effects of plant spacing on two years old of *L. leucocephala* were significantly different for the chemical compositions' traits in terms α- cellulose (%), holocellulose (%), extractive (%), lignin content (%) and ash (%) as shown in Table (3) and Figs 1&2. The higher contents of these characters were noticed with application of 2× 3 m spacing, while the least ones were attained with 1×1 m spacing. Also, increasing in plant spacing caused improving in chemical compositions of *L. leucocephala* wood. The higher α- cellulose (64.30 %) was recorded with the wider distance (2×3 m), while the lowest value (56.56 %) was due to 1×1 m spacing. Maximum holocellulose (75.09 %) was produced with 2×3 m spacing, while minimum value (71.17 %) as a result of planting leucaena at 1×1 m. The higher extractive percentage (17.98 %) in leucaena wood was due to the wider distance, while the narrow space registered the least (14.87 %). The higher and lower values of lignin (23.79 and 18.67 %) of leucaena wood were registered with the wider and narrow spacing, respectively. Also, ash content was improved as a result of the wider spacing and attained the highest (1.40 %), while it reduced with the narrow distance between leucaena trees and obtained the least one (1.15 %).

Table 3. Effect of plant spacing on chemical wood characteristics of *Leucaena leucocephala* at 2- years old.

Tree spacing (m)	α- Cellulose (%)	Holocellulose (%)	Extractive (%)	Lignin content (%)	Ash (%)
1×1	56.56	71.17	14.87	18.67	1.15
1×2	60.25	73.02	16.08	21.45	1.25
2×3	64.30	75.09	17.98	23.79	1.40
LSD 5%	2.13	2.02	0.89	2.21	0.06

Physical characteristics of wood:

The effects of different plant spacing for *Leucaena leucocephala* wood on some physical properties in terms specific gravity and moisture content is presented in Table (4) and Figs 1&2. Significantly differences were noticed among the moisture content percentage of wood as a result of different plant spacing. Applying 1 × 1 m spacing with *L. leucocephala* proved to be most effective to produce the lowest value (50.0%) of moisture content. Meanwhile, the highest content (56.0%) was detected with planting *L. leucocephala* at the wider space compared to other treatments. On the other hand, significant differences were detected for the specific gravity due to plant spacing. The maximum value (0.70 g/cm^3) of specific gravity was attained with planting *L. leucocephala* at the wider distance (2x3 m). While, the minimum value (0.67g/ cm^3) was attained from trees that planting at 1 × 1 m.

Table 4. Effect of plant spacing on moisture content (%) and specific gravity (g/ cm^3) of *Leucaena leucocephala* wood at 2- years old.

Tree spacing (m)	Moisture content (%)	Specific gravity (g/cm^3)
1×1	50.0	0.67
1×2	54.0	0.68
2×3	56.0	0.70
LSD 5%	0.02	0.01

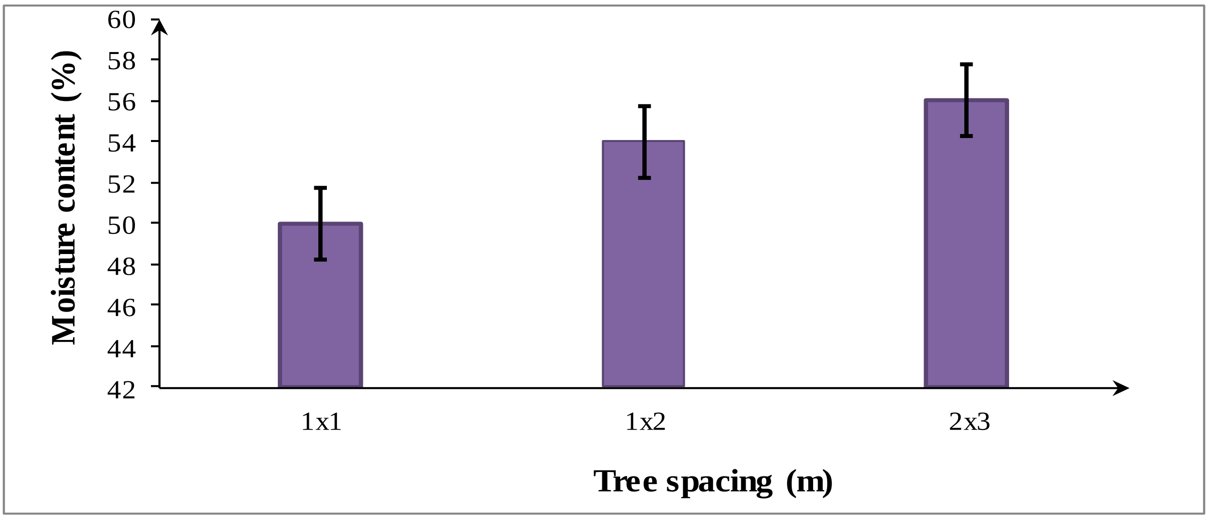

Fig. 1. Moisture content (%) of *L. leucocephala* wood as affected by plant spacing.

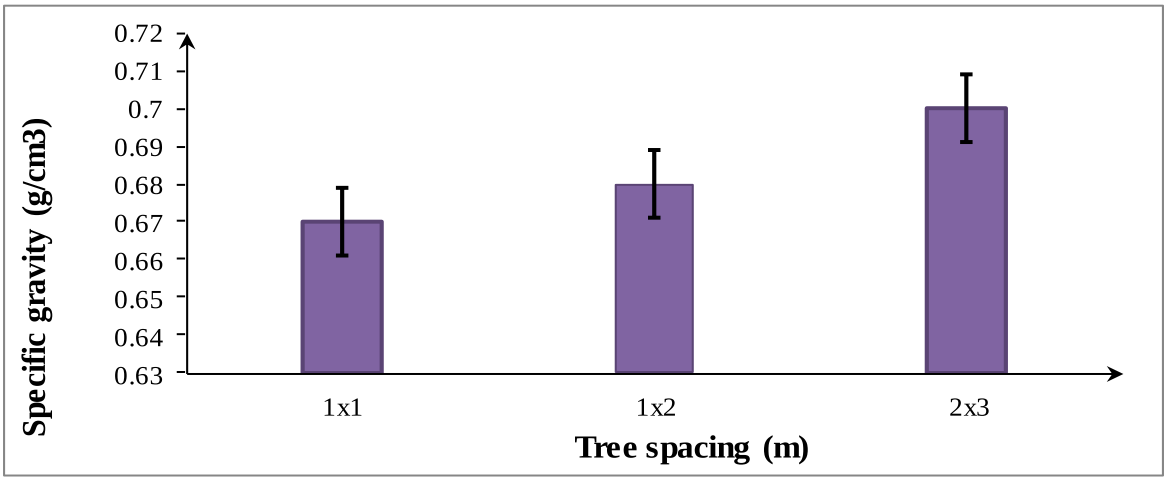

Fig. 2. Specific gravity (g/ cm^3) of *L. leucocephala* wood as affected by plant spacing.

Discussion

The influence of different plant spacing on the growth, biomass production and wood properties of *L. leucocephala* were evaluated in Qena governorate, Egypt. Increasing in plant spacing was accompanied with improving in fresh and dry weights of above-ground biomass in terms plant height, stem diameter and woody stem fresh and dry weight. In this respect, individual plant performance was superior at the low plant density as compared to the high plant density **(Sayed *et al*., 2015). Beldt *et al*. (1982)** also observed decrease in diameter at breast height with increase in density (narrow spacing) from 5,000 to 40,000 plants/ha in leucaena and due to interplant competition. In this study, plant height of leucaena was relatively higher at the wider spacing and lower at the narrow spacing. The height of this species was significantly affected by competition which has been due to the extremely high planting densities **(Verma and Misra, 1989).** The higher densities resulted in decreased plant height which was caused by the failure of sprouts to grow after emergence due to the lack of solar radiation. Also, plant spacing had an enormous effect on the stem diameter. Leucaena trees responded to the wider spacing and lower competition by producing greater stem diameter with the wider spacing and produced the largest trees, while the narrow spacing reduced the stem diameters. The increasing in stem diameter at the wider spacing may be due to the higher availability of moisture, soil and light resources **(Prasad *et al*., 2011).** Previous studies on other tree species have also reported an increase in plant density resulted in reduce in stem diameter of trees such as eucalyptus **(Bernando *et al*., 1998)** and poplar **(Armstrong *et al*., 1999).** Moreover, the sprout growing from the different spacing recorded variations in their regrowth. However, the sprout number increased with the decrease in stand density and there were significantly differences in large-sized stumps. With small-sized stump of narrow spacing could cause a decrease in sprouting from such stumps **(Prasad *et al*., 2011),** because small area of stump led to low sprout number. The high sprout number of wide spacing resulted in increased fresh and dry of above- ground biomass yield **(Chotchutima *et al*., 2013).** It is clearly from our results that the spacing had an influence on the fresh and dry weight of woody stem yield. The spacing had distinctly difference in weight of woody stem yield. The results showed that better performance contributed to a higher branches and leaves and woody stem yield in the wider spacing of as compared to that of the narrow spacing of *L. leucocephala* at two –year-old. In accordance with **Proe *et al*. (2002)** who stated that the widest spacing may be suitable for obtaining high yield. The previous study of **Mitchell (1995)** was in accordance with our results, which proved that the widest spacing tended to produce the high woody stem yield and biomass yield. Therefore, the wider spacing would be more desirable; it decreased a number of seeds and allows of weed control **(Gathaara *et al*., 1991).** The differences of above-ground biomass with regard to plantation spacing seem to result from the early growth stage by developing a longer living crown at the widest spacing compared with the narrowest spacing. Diameter growth has been positively related to photosynthetic biomass and its efficiency **(Zhang *et al*., 2013; Hébert *et al*., 2016).** Plant spacing affects the growth of leucaena and, consequently, the properties of its wood. Our result proved that as plant spacing increased the chemical composition and specific gravity of wood was occurred. These results were in agreed with the findings **Rocha *et al*. (2016),** who indicated that plant spacing significantly influence key properties of wood and bark. They proved that clones of *Eucalyptus grandis* × *E. camaldulensis* planted at wider spacing had wood density approximately 8% higher than the same clones planted in the narrow spacing. Also, lignin content from wood of wider spacing was approximately 12% higher than wood from narrow spacing. Holocellulose and extractives percentage was also affected by plant density. They added that, for Eucalyptus clones, plantations with the wider spacing could lead to produce of raw materials with the characteristics more suitable for energy purposes. On the other hand, some studies on conifers reported lower wood density with the greater spacing **(Kennedy, 1995; Hapla, 1997).** This result was consistent with reports by **Moulin *et al.* (2015)** who reported that *Eucalyptus* wood cultivated at wider spacing produced the highest lignin content compared to the narrow spacing. Moisture content and specific gravity of wood are vital determinant of the wood quality and dry weight yield per volume of woody material. Density of wood decreases as moisture content decreases, but below the fiber saturation point the specific gravity of a sample increases as the moisture content decreases **(El-Baha *et al*., 2009).** Moreover, by increasing the growth rate, wide spacing of some woody trees tends to increase its density **(Haygreen and Bowyer, 1996).** Moreover, with respect to wood quality and plant spacing, **Naji *et al.* (2014)** reclaimed that the wood formed at the low plant density is characterized by heavier wood density. The results of **Nasser (2008)** indicated that the variation of extractives, holocellulose, lignin and ash contents among the plant spacing treatments were highly significant. **Abdel-Aal and Kayad (2007)** concluded that heavy thinning gave higher value of extractive contents, while moderate thinning had the lowest extractive content value on *Cordia myxa*, *Citharexylum quadrangular* and *Eugenia cumini*. This means that the heavy thinning or the wider distances between trees led to an increase in extractives (**Nasser, 2008).** Our result pointed out that increasing plant distance led to improve cellulose content of leucaena wood. This result was in agreement with the finding of **Shupe *et al.* (1996)** who found that lower stand density yielded greater cellulose values in *Pinus taeda* wood. **Abdel-Aal and Kayad (2007)** concluded that heavy thinning (wide space) had the highest average value (44.97%) followed by moderate thinning (44.68%), while the least value of cellulose was for control (43.28%). **Washusen *et al*. (2005)** also concluded that there is an influence of thinning on crystallite width of cellulose for *Eucalyptus globulus* wood, which was increased with thinning intensity. Also, the obtained results recorded that increasing of plant spacing between *L. leucocephala* trees led to increase holocellulose content. **Shupe *et al.* (1996)** reported that lower stand density yielded greater holocellulose and cellulose contents, which means that hemicellulose content was decreased. Lignin content in wood of leucaena was increased as the plant spacing increased. These results were in agreement with those reported by **Abdel-Aal and kayad (2007)**, who proved that the wide spacing was the higher in lignin content, while the narrow spacing was the lowest. **Poo *et al*. (1995)** stated that the widely spaced trees led to higher value for lignin. Also, ash content of wood was increased with increasing plant spacing. These results were in contrary with the study of **Nasser (2008)**, who reclaimed that narrow spacing, had the higher ash content (2.75%), followed by mediate spacing (2.41%), while the lowest value of ash was noticed with wide spacing (2.17%) of *Conocarpus erectus* wood. He added that the effect of spacing levels on specific gravity was significant. By increasing spacing from 0.7 to 2.1 m, specific gravity of *Conocarpus* was increased (0.63 to 0.66, respectively). Similar results were obtained by **DeBell *et al*. (2001)** for *Eucalyptus saligna*, who reported that wider spacing increased mean diameter and wood density.

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الملخص العربي:

ليس هناك شك في أن كثافة الأشجار هي الخاصية الرئيسية المستخدمة كمؤشر لجودة الخشب لمختلف الاستخدامات النهائية. وتنتج جودة الخشب من التفاعل بين التركيب الوراثي للأشجار وظروف زراعة الغابات التي تعرضت لها. وبناء على هذه التفاعلات، فإن البحث عن العوامل التي تضيف قيمة إلى المواد الخام الخشبية لها تأثير على إنتاج المنتجات الحرجية المختلفة. يهدف البحث الحالي إلى دراسة تأثير اختلاف

المسافات بين النباتات على الكتلة الحيوية فوق سطح الأرض وبعض الخواص الخشبية الفيزيائية والكيميائية وهي L. leucocephala تم استخدام ثلاث مساحات لزراعة نبات .Leucaena leucocephala لأشجار ١×١، ١×٢ و ٢×٣ م. أشارت النتائج التي تم الحصول عليها إلى أن الزيادة الأعلى في الكتلة الحيوية فوق الأرض، أي ارتفاع النبات وقطر الساق عند ارتفاع الصدر والوزن الطازج والجاف للساق الخشبية والفروع والأوراق وكذلك الوزن الطازج والجاف للكتلة الحيوية كانت بسبب الزراعة على نطاق أوسع. التباعد، بينما أقل السليلوز الأعلى (٦٤.٣٠٪)، والهولوسيلوز $\alpha-$ القيم نتيجة التباعد الضيق. أيضا، تم تسجيل نسبة (٧٥.٠٩٪)، والنسبة الاستخراجية الأعلى (١٧.٩٨٪)، واللجنين (٢٣.٧٩٪)، ومحتوى الرماد (١.٤٠٪) مع التباعد الأوسع. علاوة على ذلك، أثبت تطبيق مسافة ١ × ١ متر أنه الأكثر فعالية لإنتاج أقل قيمة (٥٠.٠٪) من محتوى الرطوبة، في حين تم اكتشاف أعلى محتوى (٥٦.٠٪) مع المساحة الأوسع. تم الحصول على القيمة القصوى (٠.٧٠ جم/سم٣) للكثافة النوعية مع المسافة الأوسع (٢×٣ م)، بينما تم الحصول على القيمة الدنيا (٠.٦٧ جم/سم٣) من الأشجار التي تمت زراعتها على مسافة ١×١ م. لذلك، للحصول على خصائص أعلى للكتلة الحيوية فوق الأرض وجودة الخشب من أشجار الليوسينا، توصي الدراسة بزراعة هذه الأشجار على مسافة ٢ × ٣ متر تحت ظروف الدراسة.

الكلمات المفتاحية: تباعد النباتات، الكتلة الحيوية فوق الأرض، خصائص الخشبLeucaena leucocephala