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Leucaena leucocephala: EFFECT OF SPACING AND AGE ON GROWTH, BIOMASS AND SOME PHYSICAL AND ANATOMICAL CHARACTERISTICS OF WOOD

El - Baha, A. M. A. ; H. A. Abu - Gazia; A. A. A. El - Settawy and M. Z. A. Zayed
Forestry and Wood Technology Department, Fac. Agric., Alex. Univ., El-Shatby, Alexandria, Egypt.

ABSTRACT

This study was carried out in Experimental Station of Forestry and Wood Technology Department, Fac. Agric., Alexandria Univ., El-Shatby, Alexandria, Egypt in 2006- 2008. The study dealt with the effect of spacing and time of cutting on the growth, yield, nutritional value of soft edible parts for animals and seed, some physical and anatomical properties of the wood of *Leucaena leucocephala* trees. Four month old aged transplants of *L. leucocephala* transplants were planted in 0.5 × 0.5 (D1) 1.0 × 1.0 (D2) and 2.0 × 2.0 (D3) m apart. Growth parameters (Pole height and stem diameter) were monthly determined. Plants were cut after one year (Y_1) and two years (Y_2) of planting date. To study the effect of spacing and age of plants, RCPD design was followed. The most important results can be presented as follows: total dry biomass was 14.1, 12.74 and 11.15 ton/ feddan for D1, D2 and D3 treatment of cut plants after one year of planting date (Y_1) and 30.66, 28.53 and 27.30 tons/ feddan for those cut after 2 years of planting date (Y_2), respectively. Dry weight of soft-edible parts (as forage for animal) was 5.03, 4.25 and 3.58 ton/ feddan of D1, D2 and D3, respectively in " Y_1", while it was 10.33, 9.63 and 8.70 tons/ feddan in " Y_2".Analysis of edible parts of plant revealed that it was contained 1.07, 0.88 and 0.74 ton of crude protein/ feddan in D1, D2 and D3 of Y_1 plants, respectively, while it was amounted for 2.26, 2.04 and 1.85 tons of crude protein/ feddan in Y_2. However, moisture content of wood was averaged 96.18 and 106.91% for Y1 and Y_2, respectively. Fiber length was 1.1 and 1.21 mm for Y_1 and Y_2, respectively. Microscopic examination of anatomical elements (vessels, fibers, rays and longitudinal- parenchyma) distribution revealed that there were no significant influences of spacing (D1, D2 and D3) and age of cut (Y_1 and Y_2) on the percentage of each element. Annual cut recommended for forage production pulp paper and particle board, fuel production. It is recommended also to extend plantation of *L. leucocephala* to capitalize on its environmental and economic benefits.

INTRODUCTION

Leucaena leucocephala Lam. is one of the most fast growing nitrogen fixing and multipurpose tree species. The tree is planted as a forage or fodder crop (Yates*,* 1982 and Duke, 1983), to produce timber and lumber, fence posts, fuelwood, charcoal (Brewbaker, 1997), human food after certain processing, pulp, paper (Saikia and Sarma, 1994 ; Owofadeju and Onilude, 2005; Lefroy *et al*. 1992, NAS, 1977; Brewbaker 1997 and Parrotta 2000). Environmentally, *L. leucocephala* displayed substantial role, since it is used in sand dune fixation and soil conservation (Ragab, 1998), in desertification control programs and to ameliorate nutritive status of soil throughout its role in biofixation of gaseous nitrogen by aid of symbiotic nitrogen fixing bacteria in poor sites (Parrotta, 2000).

The impact of stand density on quantitative and qualitative yield of tree biomass is a matter of debate. Some authors found the wider the spacing, the higher the obtained yield per certain area (Khot *et al*. (1991). Others obtained contradictory results (Jiang *et al*.,1991; Malimbwi, *et al.*, 1992).

Nutritional value of leaves and fruits of *Lucaena leucocephala* was studied by many authors (Lowry, 1982; Yates, 1982; Castillo *et al*., 1997 and Gupta *et al*., 1988). Meissner (1997) found that *Leucaena leucocephala* shoots are rich in protein, minerals and β carotene. The crude protein of edible material (leaves and small stems) of *L. leucocephala* ranged from 14 – 30%, (Khanseekhiew *et al*., 2001; Sallam, 2005 and Atawodi *et al.*, 2008). Rajendran *et al*. (2001) found that crude fiber of *L. leucocephala* was about 11.84% and dry matter yield was 81.36%. Aganga and Tshwenyane (2003) found that the average of neutral detergent fiber, acid detergent fiber and acid detergent lignin amounted for 34.5, 24.7 and 15.5%, respectively (on dry matter basis). The wood of leucaena contained 5.89 cellulose and 20.58% hemicellulose (Sallam, 2005).

El- Baha (2002) found that the leaves *L. leucocephala* contained highly mineral contents (12.5 and 14%). Alabi and Alausa (2006) found that *L. leucocephala* seeds contained lipid 12.5±0.5, crude protein 8.40±0.15, carbohydrate 40.56±1.20,crude fiber 4.33±0.26 and ash content 21.46±1.20%.

The foregoing findings have prompted many workers to use shoots and pods of *L. leococephala* as forage for animal feeding either singly in dry season or mixed with common diet. However, there is a limitation of using leaves and pods as forage for long time because of the presence of mimosine which may negatively impact on animal health. Wibaut and Klipool (1950) isolated mimosine from *Leucaena leucocephala* and gave it the name "leucaenine".

The density or specific gravity (SG) of wood is primarily a measure of the amount of cells wall material and other extraneous materials per unit volume. John (2000) found that the specific gravity of *L. leucocephala* wood was 0.700 ± 0.035. Specific gravity is typically increased from the pith to the outer heartwood and then decreases towards the cambium (Zobel and van Buijtenen, 1989), whilst Ismail *et al*. (1999) found that the average SG of the heartwood was significantly higher than the sapwood.. Nonetheless specific gravity of wood is governed by genetic agent; silvicultural practices may affect its value. However, any silvicultural treatment, e.g., fertilization and thinning leads to relegate specific gravity of wood (Haygreen and Bowyer, 1982).

This work aimed to study the effect of spacing treatments and age on growth performance, yield of woody and non-woody biomass, nutritional value, some physical and anatomical properties of wood after one and two years of planting.

MATERIALS AND METHODS

An experiment was conducted in the Experimental Station of Forestry and Wood Technology Department, Faculty of Agriculture, Alexandria University, during the period from 1st January 2006 until 1st January 2008 to study the effect of stand stocking and age of *Leacaena leucocephala* trees on growth and yield of woody and nonwoody products, nutritional values of shoots and fruits , physical and anatomical properties on produced wood . To achieve these objectives it was followed the following:

1. Soil Analysis

oil samples were collected before planting the transplants from the experimental area to determine some physical (particle size distribution) and chemical characteristics (Nitrogen, phosphorus and calcium contents). Particle size distribution was determined by the hydrometric method described by Black, (1965). Calcium was determined according to the method described by Cheng and Bray, (1951). Phosphorus was extracted by ammonium bicarbonate then spectrophotometrically measured using ascorbic acid at wave length 660um (Black 1965). Total nitrogen was determined by Kieldjahi method as described by Jackson (1973). The chemical and physical characteristics of the soil used in this work presented in Table (1).

Table (1): Chemical and physical characteristics of the soil in Abies-Alexandria.

Depth (cm)	Particle size distribution %			Textural class	PH	E.C mhos/cm	N^{3+} mg/100g	P^{2+} (ppm)	K^{+} mg/100g
	Sand	Silt	Clay						
0-30	59	19	22	Sandy Clay Loam	8	1.41	20.2	7.0	0.03
30-60	53	27	20	Sandy Loom	8.2	2.3	19.6	7.3	0.035
60-90	52	30	18	Loam	8.4	2.4	16.5	7.4	0.04

2. Transplant preparing

Certified seeds of *Leucaena Leucocephala* were soaked in water for two days at room temperature (25- 32 °C) then planted in seed beds in August 2005. Cultivation practices were followed to keep seedling fit.

3. Transplanting and cultivation care

Before transplantation of the transplants, soil was perfectly ploughed, then 30x30x50 cm holes were made at different spaces (according to treatment). When the transplants attained 4 months old they were transplanted at 3 spaces (Treatments 1); 0.5m x 0.5m, 1m x 1m and 2m x 2m. All cultivation practices were followed, such as; replanting of missed holes, weeding and irrigation every two weeks in winter and every week in summer. Growth performance, expressed in pole height and stem diameter were monthly recorded till harvesting. Two replicates of each spacing treatment were harvested above ground in January 2007 and the other two replicates were harvested in January 2008. Herewith we have poles of two ages (treatments 2), 16 and 28 months, i.e. one and two years after transplantation date in permanent soil. The design used in this work was RCBD and the data obtained were analyzed as described by Snedecor (1956). Each treatment consisted of two replicates. The differences between or among the obtained mean values of treatments were calculated following the Duncan's multiple range test.

4. Sampling

All cut plants were carefully handled, washed, and then green weight was directly determined after the parts of plants had portioned to leaves, twigs less than 6mm and fruits. The parts of leucaena trees were dried to constant weight at 72ºC for 24 hrs to determine the dry weight. Five samples were taken for each chemical analysis and nutritive value.

5. Determination of nutritive value

Ground Samples of leaves, twigs and fruits were analyzed for dry weight (DW), crude protein (CP), crude fat (CF), crude fiber (CFR), and total ash (TA), as described by A.O.A.C. (1990).

Crude protein was determined in one- gram samples of leaves, twigs and fruits by titration method.

Determination of crude fat (EE) was done using 2.5 g of the sample using Soxhlet-type Extractor. Crude fiber (CF) was determined using 3 gram samples of all treatments. Samples were submitted to chain of extraction processes according to A.O.A.C. (1990). The crude fiber content (g/kg DM) was estimated by the following equation:

$$CF = (a - b / w) \times 1000$$

Where: *a*= loss of weight (g) of sample after ashing during the determination,
b= loss of weight (g) after ashing during the blank test and
w= sample weight (g DM).

Determination of total ash (TA) was calculated by tarring of 5.0 g of samples of all treatment in muffle-furnace set at 550+5^0 C.Total ash content (g/kg DM) using the following equation:

$$TA = (a - b/w)^* 1000$$

Where *a* = mass (g) of crucible after ashing
b = mass (g) 0f dry tarred crucible
W = mass (g) of dry sample

6. Moisture content (MC %) and specific gravity (SG) of wood

Moisture content (MC %) and specific gravity (SG) using isodimensional 2cm- sample strip length, free from any natural defects. Moisture content was determined according to Smith (1954), using the following equation:

$$G = \frac{1}{Mm + 1/Gs}$$

Since, *G* = Specific gravity of wood specimen
Gs = Specific gravity of wood substance = (1.53).
Mm = Maximum water content in grams of water per gram of oven dry wood.

7. Determination of fiber length (FL).

Wood Samples weighed about 10 g of all treatments were fragmented, macerated and delignified in mixture of glacial acetic acid and 30% hydrogen peroxide (1:1) at 60º C for approximately 24 hrs, then carefully rinsed by distilled water several times, stained by 2% safranin then finally fixed with glycerin. However, FL was measured to the nearest 0.01mm by using a projecting microscope. Fifty readings per each sample were taken and averages were calculated.

8. Anatomical Structure

Cross, radial and tangential sections of hot-water softened wood samples were made on a sliding microtome, stained by 2% safranin stain, dehydrated in successive increased concentrations of alcohol (50, 60, 70, 80, 90 and 100%) and fixed with Canada balsam, to determine the distribution of anatomical elements. Five sections (replicates) were examined in each treatment using stereological techniques based on counting of points and intersections for microscopic images on screen of projection microscope.

The data obtained pertaining nutritional value of useful forage fraction as well as physical and anatomical properties of wood were statistically analyzed using split-plot arrangement, where the main plot was the age of plants (2 treatments) and sub one was spacing (3 treatments). The analysis of data was done according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

1. Growth parameters

Statistical analysis of variance revealed no significant effects of spacing treatments; 0.5X0.5m (D1), 1.0 X1.0 m (D2) and 2.0X 2.0m (D3), on height of *Leucaena leucocephala* plants cut after one year of planting (Y_1), while the D3-spacing brought forth the highest height of plant height after 2 years of planting (Y_2) as compared with D1 and D2. On the other hand, there were no significant differences between plant height of D1 and D2. There were no significant influences of spacing treatments on stem diameter of both Y_1 and Y_2 (Table 2).

2. Total dry matter

Both dry weight of forage useful (FUF) and hard stem fraction (HSF) were significantly affected by spacing treatment either after one and two years of planting. The D1- treatment resulted in FUF and HSF significantly higher than those of D3. However, either after one or two years of planting, there were no significant differences between D2 and D1 on one hand and between the first and D3 on the other hand. after one year or two ones of planting. However, the wider the spacing, the lower the total dry matter (Table 2). Percentage of FUF was also affected by spacing, since D1> D2> D3. However, average total yield of above ground dry matter was 14.10, 12.74 and 11.15 tons/ feddan in Y_1 at spacing (0.5 x 0.5 m), (1x1m) and (2x2m), respectively, however, they were 30.66, 28.53 and 27.30 ton/ feddan for Y_2 at the same order (Fig. 1). From these findings, it is concluded that the height, stem diameter and total dry matter of Y_2 were 1.5, 3 and 2.5 fold those of Y_1.

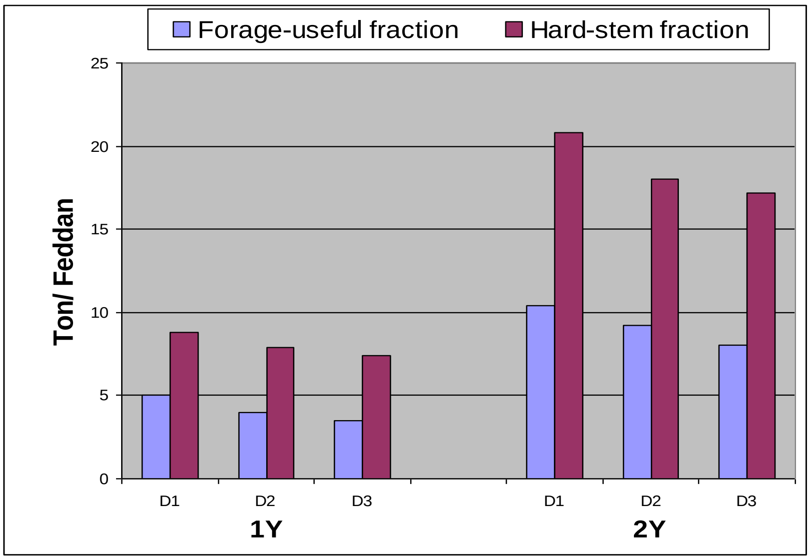

Fig. 1: Forage useful- and hard stem fractions of *Leucaena leucocephala* plants after one and two years of transplanting using 3 spacing treatments.

The results obtained are in agreement with Jiang and Guodao (1991); since they found that yields of *L. leucocephala* increased with increased density. In addition, they found that the spacing of 60 X 20 cm displayed yield higher than that of 100 X 100 cm and the annual yield was 41.6 and 26.8 tons/ha, respectively, while the leaf/stem ratio was 1.64/1 and 1.28/1, respectively. However, wood yield was the highest at the low densities. Under local conditions, a similar trend was reported by Abd EL-Sattar and EL-Settawy (1998) who found that the total dry weight of *L. leucocephala* plants at ages of one, two and three years and grown in loamy soil at highly density (0.3X 0.7m) was 14, 78 and 98 tons/feddan, respectively, however, the dry edible forage was 2.8, 12.96 and 10.88 tons/feddan, respectively. Singh and Toky (1995) found in India that the four-year old-aged stands of *L. leucocephala* planted at 0.6 X 0.6 m produced 112 t/ha of dry matter (28 ton/ha/year). An optimum planting density of 10-15 trees/m^2 for *L. leucocephala* was recommended by Hedge (1989) to produce the highest leaf and wood yield. Khot *et al*. (1991), regrow leucaena under optimum growing conditions and different spacings where *Leucaena leucocephala* stands have yielded extraordinary amounts of wood. They found that the wood dry weights were; 18, 24.3, 78.8, 163.6 and 182.1 tons/ha for five durations (1, 2, 3, 4 and 5 years) as a mean of three spacing (3× 0.25m, 3×0.5m and 3×1m), respectively. Abbas *et al*. (2001) obtained similar results from their study on the intercropping of Sesbania (*Sesbania sesban*) and leucaena (*L. leucocephala*) with five annual grasses under semi-arid conditions as affected by inoculation with specific *Rhizobia* and associative diazotrophs. They found that *Leucaena* is promising for marginal soils as it is characterized by a longer tap root and a high rate of annual leaflet drop amounting to 1.2 tons dry matter. Tudsri *et al*. (2002) studied the effect of cutting intervals on the growth of *L. leucocephala* and three associated grasses in Thailand and found that the maximum dry matter yield (41.5 tons/ha) was produced by *Leucaena* dwarf Napier.

Table (2): Growth and above ground dry matter production (tons/feddan) of *Leucaena leucocephala* trees at different ages and spacing planted in Experimental Station at Abies,

Time of cutting after planting (year)	Spacing (m)	Height (m)	Stem diam. (cm)	Above ground dry matter production (ton/ feddan)			Forage-useful fraction (%)
				Forage-useful fraction	Hard-stem fraction	Total yield	
1	0.5x0.5	2.28[a]	1.38[a]	5.03[a]	9.07[a]	14.10[a]	35.68[a]
	1x1	1.83[a]	1.50[a]	4.25[ba]	8.49[a]	12.74[b]	33.36[b]
	2x2	1.78[a]	1.56[a]	3.58[b]	7.57[b]	11.15[c]	32.11[c]
Mean		**1.96**	**1.48**	**4.29**	**8.38**	**12.66**	**33.71**
2	0.5x0.5	3.20[a]	3.66[a]	10.33[a]	20.33[a]	30.66[a]	33.69[a]
	1x1	3.16[a]	4.33[a]	9.63[ba]	18.90[ba]	28.53[ba]	32.75[a]
	2x2	2.53[b]	5.00[a]	8.70[b]	18.60[b]	27.30[b]	31.86[b]
Mean		**2.96**	**4.33**	**9.55**	**19.28**	**28.83**	**32.77**

Within column, values of the same small postscript litters are not significantly different at the probability of 0.05 by Duncan's Multiple Range Test.

3. Nutritive value

Statistical analysis of variance revealed that neither spacing nor age of plant influenced crude protein (CP) content in forage useful fraction analyzed of the *L. leucocephala* trees (leaves, twigs and fruits). The data in Table (3) showed that the leaves contained 29.48, 29.46 and 29.44% crude protein (CP) for the Y_1 at spacing of 0.5 x 0.5 (D1), 1x1 (D2) and 2x2m (D3), respectively, while, they were 31.38, 31.36 and 31.35 % for the second year. However, the twigs contained 8.23, 8.21 and 8.20 CP % for in Y_1 at D1, D2 and D3, respectively (Table 3), while, they were 9.34, 9.32 and 9.31% for Y_2, at the same order. Friut crude protein contents (%) in Y_1 plants at D1, D2 and D3 were 23.99, 23.97 and 23.96%, respectively and 24.71, 24.69 and 24.68% for Y_2, at the same order. Protein yield (PY), expressed in ton/ feddan, was decreased with the age of the plant and with the spacing as well; i.e. D1> D2> D3 in 1Y and D1> D2= D3 in Y_2 treatments.

The crude protein of edible material (leaves and small stems) of *L. leucocephala* ranged from 14 – 30%, it is generally accepted that *L. leucocephala* can constitute up to 30% of the diet of unadapted ruminants without toxicity. Masama *et al*. (1997) found that *L. leucocephala* contained 24% crude protein based on the dry weight. Meissner (1997) found that *L. leucocephala* is ever green forage rich in protein. Khanseekhiew *et al*. (2001) found that *L. leucocephala* is the most widely used species as a valuable fodder for enhancing animal production in the tropics. On the other hand, Wheeler *et al*. (1996) found that the dry matter digestibility (DMD) of *L. leucocephala* was 57.7%. The comparative study by Maw *et al* (2006) pertaining crude protein contents revealed also that the *L. leucocephala* CP% is comparable with many other tree and shrub species, since they found that it contained about 22.0± 0.3% CP based on the dry weight of leaves, i.e., higher than that of *Fluggia virosa* (5.0 ± 1.3), *amarindus indica* (13.1± 2.5), *Cassia Siamea* (12.8±2.6), *Jatropha* spp. (8.6±2.9), *Vouhaemia* (14.5±3.1), and *Dolicahndrone spathacea* (13 .4±1.2), yet less than that of *Albezzia lebbek* (32.4±2.1%). However, regardless spacing treatments, the average of PY was 0.9 and 2.05 in Y_1 and Y_2, respectively (Table 3). Hence, it is of beneficial to exploit *L*. *leucocephala* potential as complementary source of forage.

Concerning crude fiber (CF) content (%), there were significant differences between Y_1 and Y_2 in all useful forage fraction components under all spacing treatments. However, the leaves contained 7.73, 7.71 and 7.70 CF % in Y_1 at D1, D2 and D3, respectively, and 10.23, 10.21 and 10.20 CF % in Y_2, at the same order. However, the twigs contained 50.94, 50.92 and 50.91 CF % in Y_1 at D1, D2 and D3, respectively, and 54.36, 54.34 and 54.33% CF in Y_2, at the same order. Fruits contained 32.49, 32.47 and 32.46 CF% in Y_1 at D1, D2 and D3, respectively and 35.40, 35.20 and 35.10 CF % in 2Y, at the same order. It can be said that the CF increased with the age because of increasing lignification of fiber and vessel cells with the time. Castillo *et al*. (1997) indicated that the cell wall materials, lignin concentration and condensed tannin that being complex with both protein and fiber may govern the quality of forage. Thus, they considered the quality of *L. leucocephala* useful forage fractions as higher than that of *L. pallida* and *L. diversifolia* because of its simplicity and readily digestibility.

Crude fat (CFT) content (%) increased significantly with the age of plants for all useful forage fraction components under all spacing treatments. Leaves of *L. leucocephala* contained 1.39, 1.37 and 1.36 CFT % in Y_1 at D1, D2 and D3, respectively and 3.36, 3.34 and 3.33% in Y_2 at D1, D2 and D3, respectively. The twigs contained 0.72, 0.70 and 0.69 CFT % in Y_1 at D1, D2 and D3, respectively, while they were 2.09, 2.07 and 2.06 CFT % in Y_2 at D1, D2 and D3, respectively. Fruits had 2.92, 2.90 and 2.89% CFT in Y_1 at D1, D2 and D3, respectively, while, they contained 4.90, 4.70 and 4.60 CFT % in Y_2 at D1, D2 and D3 (Table 3).

Total ash (TA) content (%) was significantly increased with the age of plants in all useful forage fraction components under all spacing treatments. The leaves of plants contained of 8.03, 8.01 and 8.00 TA % in Y_1 at D1, D2 and D3, respectively, while, they contained 6.97, 6.95 and 6.94% TA in Y_2, at the same order (Table 3). Twigs contained 4.57, 4.55 and 4.54 TA % in Y_1 at D1, D2 and D3, respectively and contained 1.77, 1.75 and 1.74% TA % in 2Y at D1, D2 and D3, respectively. Fruits contained 5.93, 5.91 and 5.90 TA % in 1Y at D1, D2 and D3, respectively, while they comprised 2.20, 2.18 and 2.17% TA % in Y_2 at D1, D2 and D3, respectively.

4. Physical and anatomical properties of wood

4.1. Moisture content and specific gravity.

Moisture content (MC %) of *L*. *leucocephala* wood differed significantly according to age of plants (Table 4). The highest MC% was detected in the wood of Y_1 compared with Y_2 ones. It was 106.91and 96.18%, respectively.

3

4

This can be attributed to the beginning of heartwood formation. MC% of heartwood is always lower than that of sapwood (Panshin and Dezeew, 1980).

As for specific gravity (SG) of *L. leucocephala* wood, there was no significant effect of spacing, but it was increased with the age of plants (Table 4). Clark *et al*. (2008) found that the SG of loblolly pine at age 21 years increased generally with the decrease in spacing and was not found to be statistically significant at the 0.05 level, but was significant at the 0.10 level. Tomazello *et al.* (2008) traced wood density from pith to bark of *E. grandis x urophylla* and found that there an increase of density from pith outward. This finding is in agreement with our results. Generally, SG of *L. leucocephala* wood is relatively moderate and reached 0.6. However, the average SG of *L. leucocephala* wood determined in this work came in the trend, since it ranged between 0.5 and 0.7 (John, 2000). Edward *et al*. (2009) found that there was a stiffness increase (around 11%) between 714 and 1,250 stems/ha for some *Eucalyptus* spp, but thereafter differences between stockings were not always significant. It is well known that there are appositive relationships between SG and strength properties (Panshin and Dezeew, 1980 and Mascia and Cramer, 2009). Accordingly, the expected strength properties are moderate. At the same time, it is expected that such wood would be easy to dry and treat with wood preservatives (Wood Handbook, 2000). The increase percentage of fiber concomitant with a decrease in axial parenchyma brings about increasing SG (McDonald *et al*., 1995).

4.2- Fiber length (FL)

The fiber length of wood for *L. leucocephala* was not affected by spacing treatment, yet significantly increased with age, since it is averaged 1.1 to 1.21 mm in Y_1 and Y_2, respectively (Table 4). However, these fiber length values are relatively accepted as it compared with other hardwoods especially multipurpose leguminous trees. Average fiber length for three years aged *Acacia saligna*, *A. ampliceps, A. strenophylla, A. karroo, Parkinsonia aculata* and *Prosopis juliflora* were 0.94, 0.91, 1.00, 1.13, 0.75 and 0.95 mm, respectively (Megahed *et al*., 1998). The minimum short fiber length of hard wood was 0.7 mm and the maximum fiber length of hard wood was 1.6 mm (Thomas *et al*., 1999). Fiber length of wood for the plants aged one and two years are nearly the same and ranged from 1.18 to 1.25 mm, respectively (El Baha, 2002). However there is a possibility of using fibers of *L. leucocephala* in pulping and fiber industry. Abd EL-Sattar and EL-Settawy, (1998) mentioned that seasonal harvest of *L. leucocephala* could be convenient for fiber production in pulp and fiber industries, since fiber percent is higher and silica grain content (which cause problems in the industry of paper) is low.

4.3. Anatomical properties.

Microscopic scanning of anatomical elements (vessels, ray, parenchymatous cells and fibers) of the wood of all spacing treatments and age of plant were the same. Generally, percentages of anatomical elements were as follows: vessels, 15%; rays, 7%; parenchyma cells, 30 % and fibers, 48 %. (Table 4 and Figs. 2 and 3).

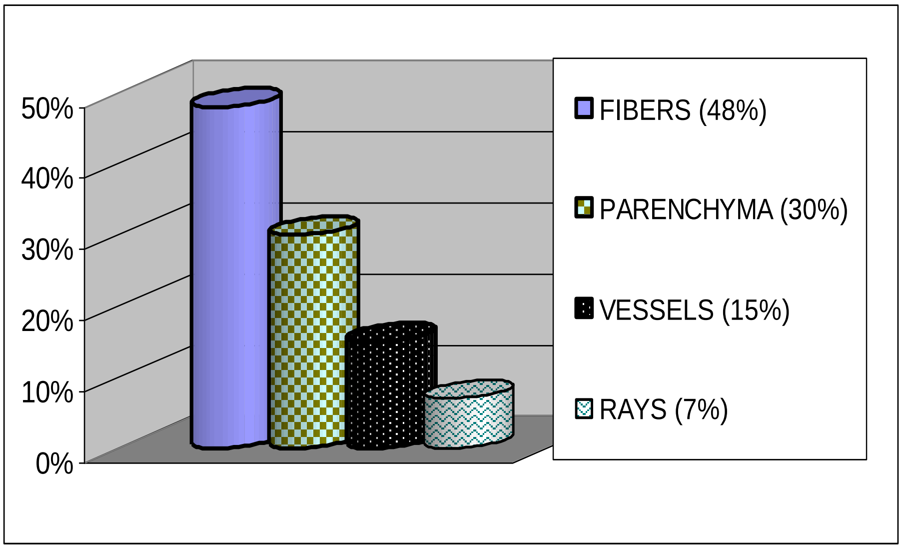

Fig. 2: Anatomical element distribution (%) of *Leucaena leucocephala* wood.

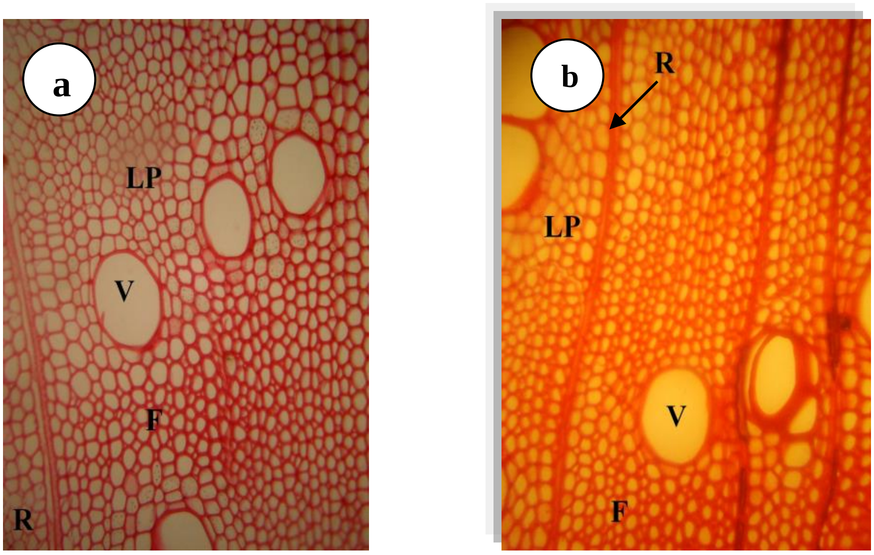

Fig. 3. Transverse section of *L. Leucocephala* wood of after one year (a) and two years of transplanting (b), where, F: fibers, V: vessels, LP: longitudinal parenchyma and R: rays. Scale: 100 µm.

These results are in agreement with Abd El-Sattar and El-Settawy (1998) who found that fiber elements represent the highest percentage of the wood tissue at the different ages of *L. leucocephala* trees. However, there is a relationship between SG and anatomical characteristics. The increased percentage of fiber concomitant with a decrease in axial parenchyma was the most important to increase in SG (McDonald *et al*., 1995).

Conclussions

- Spacing factor can be significantly effective only on above ground dry mater components and percentage of forage useful fraction (%). Such parameters were indirectly proportional related with spacing. So, it would be of practical to decide annul clipping of stand if the key objective of the management is forage production or grazing.
- Age of plants can significantly affect nutritional value (Crude fiber, fat, ash content, protein yield per feddan of forage useful fraction, yet did not affect crude protein).
- Crude fiber, crude fat and protein yield per feddan were directly proportional to age. Total ash was indirectly proportional with the age of plant.
- There was significant increase of wood properties with age, amongst which, moisture content, specific gravity and fiber length of wood.
- Percentages of the anatomical elements of wood were not significantly affected by the age, thus the decision of use wood of the plants of one year old would be appropriate if the key goal is to produce pulp and paper, yet it would not be advisable for timber option.
- Nevertheless clearcutting of stand has environmentally detrimental effects, notably erosion, and fortunately *Leucaena leococephala* can readily regrow, compromising of economic and environmental option should be emphasized.

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الليوسينا ليوكوسيفالا: تأثيرالعمر ومسافة الزراعة على القيمة الغذائية ومحصول الكتلة الحيوية وبعض صفات الخشب الطبيعية والتشريحية

أحمد محمد عبد النبى البحة، حسنى عبد العظيم أبو جازية، أحمد على عامر الستاوى ومحمد زكى عبد اللطيف زايد سعداوى
قسم الغابات وتكنولوجيا الأخشاب- كلية الزراعة- جامعة الإسكندرية- الشاطبى- الأسكندرية- مصر

أجريت هذه الدراسة فى محطة بحوث التجارب بقسم الغابات وتكنولوجيا الأخشاب، كلية الزراعة جامعة الإسكندرية فى الفترة من ٢٠٠٥- ٢٠٠٨ وقد تناولت الدراسة تأثير مسافات الزراعة وعمر الأشجار فى المراحل الأولى على صفات النمو والمحصول والقيمة الغذائية للأغصان الغضة والأوراق والبذور ومحصول الخشب وبعض الصفات الفيزيقية والتشريحية للخشب لأشجار الليوسينا.

تم زراعة الشتلات فى عمر ٤ أشهر فى الأرض المستديمة على مسافات ٠,٥ × ٠,٥، ١ × ١، ٢ × ٢ م، وقد تم تسجيل لبيانات النمو شهرياً وقد تم قطع النبات بعد عام وعامين من الزراعة وقد درس تأثير كل من مسافات الزراعة وميعاد قطع الأشجار (بعد عام وعامين من الزراعة)، تم تقدير الكتلة الحيوية للمعاملات مقدرة على أساس الوزن الجاف فكانت ١٤,١، ١٢,٧٤، ١١,١٥ طن/ فدان للنباتات التى قطعت بعد عام من الزراعة فى الأرض المستديمة (١ع) على مسافات الزراعة ٠,٥ × ٠,٥، ١ × ١، ٢ × ٢ م على التوالى أما النباتات التى قطعت بعد عامين من الزراعة فى الأرض المستديمة (٢ع) فقدر محصولها بنحو ٢٠,٣٣، ١٨,٩٠، ١٨,٦٠ طن على نفس ترتيب المسافات أعلاه، بلغ الوزن الجاف للأجزاء الغضة (العلفية) ٥,٠٣، ٤,٠٢٥، ٣,٥٨ طن/ فدان للنباتات "١ع" و ٢٠,٣٣، ١٨,٩٠، ١٨,٦٠ طن للنباتات "٢ ع" والمنزرعة على مسافات ٠,٥ × ٠,٥، ١ × ١، ٢ × ٢ م على التوالى، وبتحليل الأجزاء الغضة كيميائياً وجد أنها تحتوى على ١,٠٧، ٠,٨٨، ٠,٧٤ طن بروتين خام/ فدان للنباتات "١ ع" ونحو ٢,٢٦، ٢,٠٤، ١,٨٥ طن بروتين خام/ فدان للنباتات "٢ ع" والمنزرعة على مسافات ٠,٥ × ٠,٥، ١ × ١، ٢ × ٢ م على نفس الترتيب، ووجد أن متوسط قيم المحتوى الرطوبى لأخشاب الليوسينا كان ٩٦,١٨، ١٠٦,٩١ للنباتات "١ ع"، "٢ ع" على التوالى ومتوسط طول الألياف ١,١، ١,٢١ على التوالى، وقد وجد من واقع الفحوصات الميكروسكوبية لتوزيع نسب العناصر التشريحية للأخشاب (الأوعية- الألياف- الأشعة- البرانشيمة الطولية) أن مسافات الزراعة وعمر النباتات لم تؤثر معنوياً فى نسب توزيعها، ويتضح من ذلك أن يمكن إجراء القطع سنوياً أو كل عامين للحصول على نفس الصفات التكنولوجية للأخشاب كما أن أطوال الألياف تعد مناسبة لتصنيع الأوراق ويوصى بالتوسع فى زراعة الأشجار لفوائدها المتعددة بيئياً واقتصادياً.

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Table (3): Means percentage of nutritive value *based on dry weight* of forage useful fraction of two year aged Leucaena leucocephala *trees planted at different spaces at Experimental Station at Abies, Alexandria, from January 2006 to January 2008.*

Time after trans-planting (year)	Spacing (m)	Crude protein (CP)			Crude fiber (CF)			Crude fat (CFT)			Total ash (TA)			Protein yield (ton/ fed.)
		Leaves	Twigs	Fruits	Leaves	Twigs	Fruits	Leaves	Twigs	Fruits	Leaves	Twigs	Fruits	
1Y	1/2x1/2	29.48^{a}	8.23^{a}	23.99^{a}	7.73^{b}	50.94^{b}	32.49^{b}	1.39^{b}	0.72^{b}	2.92^{b}	8.03^{a}	4.57^{a}	5.93^{a}	1.07^{b}
	1x1	29.46^{a}	8.21^{a}	23.97^{a}	7.71^{b}	50.92^{b}	32.47^{b}	1.37^{b}	0.70^{b}	2.90^{b}	8.01^{a}	4.55^{a}	5.91^{a}	0.88^{b}
	2x2	29.44^{a}	8.20^{a}	23.96^{a}	7.70^{b}	50.91^{b}	32.46^{b}	1.36^{b}	0.69^{b}	2.89^{b}	8.00^{a}	4.54^{a}	5.90^{a}	0.74^{b}
	Mean	**29.46^{A}**	**8.21^{A}**	**23.97^{A}**	**7.71^{B}**	**50.9^{B}**	**32.47^{B}**	**1.37^{B}**	**0.70^{B}**	**2.90^{B}**	**8.01^{A}**	**4.55^{A}**	**5.91^{A}**	**0.90^{B}**
2Y	1/2x1/2	31.38^{a}	9.34^{a}	24.71^{a}	10.23^{a}	54.36^{a}	35.40^{a}	3.36^{a}	2.09^{a}	4.90^{a}	6.97^{b}	1.77^{b}	2.20^{b}	2.26^{a}
	1x1	31.36^{a}	9.32^{a}	24.69^{a}	10.21^{a}	54.34^{a}	35.20^{a}	3.34^{a}	2.07^{a}	4.70^{a}	6.95^{b}	1.75^{b}	2.18^{b}	2.04^{a}
	2x2	31.35^{a}	9.31^{a}	24.68^{a}	10.20^{a}	54.33^{a}	35.10^{a}	3.33^{a}	2.06^{a}	4.60^{a}	6.94^{b}	1.74^{b}	2.17^{b}	1.85^{a}
	Mean	**31.36^{A}**	**9.32^{A}**	**24.69^{A}**	**10.2^{A}**	**54.3^{A}**	**35.2^{A}**	**3.34^{A}**	**2.07^{A}**	**4.70^{A}**	**6.95^{A}**	**1.75^{A}**	**2.18^{B}**	**2.05^{A}**

Within column, values of the same small postscript letters are not significantly different at the probability of 0.05 by Duncan's Multiple Range Test and mean values within the same column of same capital postscript letter are not significant as well.

Table 4: Moisture content (%), Specific gravity, fiber length (mm) and percentages of anatomical elements of

wood of *Leucaena leucocephala* after one and two years of transplanting under three spacing treatments.
Within column, values of the same small postscript litters are not significantly different at the probability of 0.05 by Duncan's Multiple

Time of harvesting after transplanting (year)	Spacing (mxm)	Moisture content %	Specific gravity	Fiber length, mm	Anatomical elements (%)			
					Vessels	Rays	Parenchyma	Fibers
1	0.5x0.5	96.10[b]	0.585 [b]	1.06 [b]	14.96[a]	7.04 [a]	30.0 [a]	48.0 [a]
	1x1	96.194 [b]	0.585 [b]	1.14 [b]	15.076 [a]	6.94 [a]	30.06 [a]	48.02 [a]
	2x2	96.176 [b]	0.585 [b]	1.1 [b]	14.964 [a]	7.02 [a]	30.0 [a]	47.99 [a]
Mean		**96.156** [B]	**0.58** [B]	**1.1** [B]	**15.0** [A]	**7.0** [A]	**30.00** [A]	**48** [A]
2	0.5x0.5	106.92 [a]	0.629[a]	1.19 [a]	15.004 [a]	7.016 [a]	30.02 [a]	48.0 [a]
	1x1	106.9 [a]	0.629[a].	1.21 [a]	14.996 [a]	6.984 [a]	30.02 [a]	48.04 [a]
	2x2	106.92 [a]	0.62 [a]	1.23 [a]	15 [a]	7.0 [a]	29.98 [a]	47.96 [a]
Mean		**106.92** [A]	**0.628** [A]	**1.21** [A]	**15** [A]	**7**.0 [.7]	**30.00** [A]	**48** [A]

Range Test and values within column of the same capital postscript are not significant as well.