

Pattern of Above-Ground Biomass Production and Allocation in *Leucaena leucocephala* Trees When Planted at Different Spacing

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Abstract. The pattern of production and distribution of biomass was measured in two year-old *Leucaena leucocephala* (Lam.) de Wit trees grown from seeds. Trees were planted in field with three spacing regimes viz. 0.70, 1.40 and 2.10 m. The total biomass of individual trees increased with increasing spacing; as a consequence of increasing weight of main stem, branches and foliage. On the other hand, biomass production per unit area did not change significantly. The proportion of biomass allocated to branches increased from 25 to 37 and to 45 percent with increasing space from 0.70 to 1.40 and to 2.1 m. This increases were at the expense of allocation to main stem which decreased by a quite similar magnitude (*i.e.* 47 to 33 and 22 percent). Planting *Leucaena* in closer spacing in arid areas, therefore, will be preferred for maximizing stem biomass production per unit ground area, for which the intention is paid when firewood is needed.

Key Words: *Leucaena leucocephala* (Lam.) de Wit, biomass production, biomass allocation, spacing, firewood and forage.

Introduction

In spite of the accelerated development in heat energy resources, use of firewood still has a great attention in Saudi Arabia. It is mainly used for cooking and warming during winter. Therefore, huge amounts of fuelwood are handled every day within specific markets throughout the country. Most of present firewood production is

from acacia trees and other few forest species and shrubs grown in scattered forests around certain cities or in valleys and lowlands overall the country. Using firewood has been practiced for centuries without any regeneration to maintain the vegetative cover and secure continuity of production or ameliorating productivity. However with increasing population the demand for firewood is expected to increase

and exceed production unless reliable efforts will take place.

Unfortunately, the existed plantations that provide firewood have not received the deserved care regarding its survival and regeneration. On the other hand, planting trees for firewood production has not been practised. Before suggesting systematic and proper cutting cycles for the existing trees, there must be more dense vegetative cover that allows enough and sustainable material for continuous production of fuelwood. Efforts to resolve the problem and stop deterioration of forests that producing firewood should have two directions. Firstly, improving the existing stands through applying elaborated silvicultural programmes. In this direction, the first step has already started, where experiments concern with evaluating endemic species of acacias are carried out in the Plant Production Department, King Saud University. Secondly, introducing of fast growing tree species with potential resource for short rotation firewood production.

In humid tropics *Leucaena* tree grows fast and resprouts rapidly after being cut. In addition, it gives rather hard wood with short cycle. Therefore, it is suitable species for firewood production. Moreover, when estimations were made of above-ground biomass for firewood production, *Leucaena leucocephala* produced two-fold higher than

Acacia nilotica in 4-year-old plantation (Sing and Toky 1995). In other studies, its biomass production was greater than that of *Eucalyptus teriticoris* (Mishra *et al.* 1992) and that of *Acacia auriculiformis* (Swaminath 1988). The value of *Leucaena* as forage is well known. The tree is used widely in range lands (NAS, 1980). *Leucaena* forage is highly palatable, digestible and nutritive. It is suited mainly to cattle, water buffalo and goats.

The present study is an attempt to find out the possibility of increasing production of firewood and maintaining existed forests in Saudi Arabia at the same time. Therefore, *Leucaena leucocephala* is introduced as a suitable tree species for firewood production with investigating its growth, yield per tree and per unit area through using varied distances between trees (spacing) as a management tool.

Materials and Methods

Seeds of *Leucaena leucocephala* (Lam.) de Wit. were collected from a 12 year-old vigour tree in the University Experiments Station near Dirab, Riyadh, Saudi Arabia. The collected seeds were sown in April 1995 in wooden boxes and transplanted into polyethylene bags after two months. In October 1995, seedlings were planted in the field using a randomized

complete block design with three blocks. Each block had 108 seedlings distributed into three experimental plots; where seedlings were planted in 6 rows with spacing either 0.70 or 1.40 or 2.10 meter. The soil was sandy loam with average 61, 23 and 15% of sand, silt and clay, respectively (Aref, 1987). The site where the trees were planted has the following characters: 24° 6 N, altitude; 46° 5 E, attitude; 650 m, elevation; 0 °C in Winter and 37 °C in Summer (as averages); and 50 mm rainfall, annually. The seedlings were irrigated flooded once a week, In March 1996 two trees were randomly chosen for biomass estimation from each plot excluding the outer border rows. Those trees were felled and separated into leaves, branches and stem. Stem diameter at 30 cm above soil surface and total tree height were measured for each tree. Thereafter, the components of each tree were weighed and samples for dry weight determination were taken.

The obtained data were statistically analyzed through analysis of variance for a randomized complete block design using SAS computer programme.

Results

The statistical analysis of the data revealed increasing the average diameter of *Leucaena* trees significantly from 3.50 to

5.10 and to 6.2 cm with increasing the distance between trees from 0.70 to 1.40 and to 2.10 m, respectively (Table 1). Significant increase was also noticed for tree height (Table 1).

The average above-ground dry weight of *Leucaena* trees increased significantly from 3.1 to 3.52 and 7.3 kg tree⁻¹, as the distance between trees increased from 0.70 to 1.40 and to 2.10 m, respectively (Table 1). These significant increases resulted form increases in all other above-ground components (*i.e.* leaves, branches and stem). The biomass of main stem when calculated per unit ground area decreased markedly with increasing distance between trees. In the widest spaced plots the biomass of main stem per unit ground area accounted for *ca.* half that in the medium spaced ones, and a quarter that in the closest spacing. However, no significant differences were noticed as a result of varied spacing regimes used either between the averages of whole-tree foliage or between those of branches, and consequently between the averages of whole-tree above-ground biomass (Table 1).

Allocation pattern of above-ground biomass to the different tree components was altered according to the distance between trees. With increasing spacing the allocation of biomass to branches increased at the expense of stem biomass, while the allocation of biomass to foliage remained

Table 1. Mean values of stem growth (height, m tree⁻¹ and diameter, cm tree⁻¹) and biomass production (per tree, kg tree⁻¹ and per unit area, kg ha⁻¹) of young *Leucaena leucocephala* trees under 0.70, 1.40 and 2.1 m spacing.

Trait	Spacing (m)		
	0.70	1.40	2.10
Stem diameter (cm tree ⁻¹)*	3.50 ^a	5.10 ^{ab}	6.20 ^b
Tree height (m tree ⁻¹)	4.04 ^a	4.70 ^b	5.01 ^b
Biomass production (per tree)			
Foliage (kg tree ⁻¹)	0.37 ^a	1.06 ^a	2.34 ^b
Branches (kg tree ⁻¹)	0.33 ^a	1.31 ^b	3.16 ^b
Main stem (kg tree ⁻¹)	0.60 ^a	1.16 ^b	1.53 ^b
Total dry weight (kg tree ⁻¹)	1.30 ^a	3.52 ^b	7.03 ^c
Biomass production (per unit area)			
Foliage (kg ha ⁻¹)	7.45 ^a	5.41 ^a	5.32 ^a
Branches (kg ha ⁻¹)	6.81 ^a	6.66 ^a	7.16 ^a
Main stem (kg ha ⁻¹)	12.32 ^a	5.91 ^b	3.47 ^b
Total dry weight (kg ha ⁻¹)	26.58 ^a	17.98 ^a	15.94 ^a

* Diameter at base.

¹ Values followed by the same letters are not significantly different at 0.05 level according to Duncan's multiple range test.

almost constant (Fig. 1).

Discussion

Increasing stem height and diameter of *Leucaena* trees with increasing spacing in the present study was simply a result of exploiting same available below-ground resources (water and nutrients) by less number of trees. Enhanced growth of individuals may also be attributed to reduced competition for light; that was reflected as more carbon assimilation through photosynthesis. Similar results were obtained for *Leucaena leucocephala* (Van den Beldt 1983; Maiti *et al.* 1991; and Mishra *et al.* 1986), and for other tree species; for *Acacia mangium* and *Albizia falcataria* (Jones 1983); and for *Terminalia superba* (Okojie *et al.* 1988). Contradictory,

Sahoo *et al.* 1996 and Xie *et al.* 1995 reported increasing height with closer spacing in *Leucaena* and pine respectively. Jonstone (1985) interpreted such observations saying "Since wide spacing may induce extremely rapid crown expansion so that diameter growth accelerates at the expense of height growth."

Increasing total above-ground biomass of *Leucaena leucocephala* with increasing distances between trees in this study concurs with previous results reported for the same species by Sudhir *et al.* (1985) and Mishra *et al.* (1986), and for other tree species (*e.g.* Kushalapa 1987 for *Casuarina equestifolia*). Decreasing biomass production per tree in high density plots is not surprising because most of the trees in

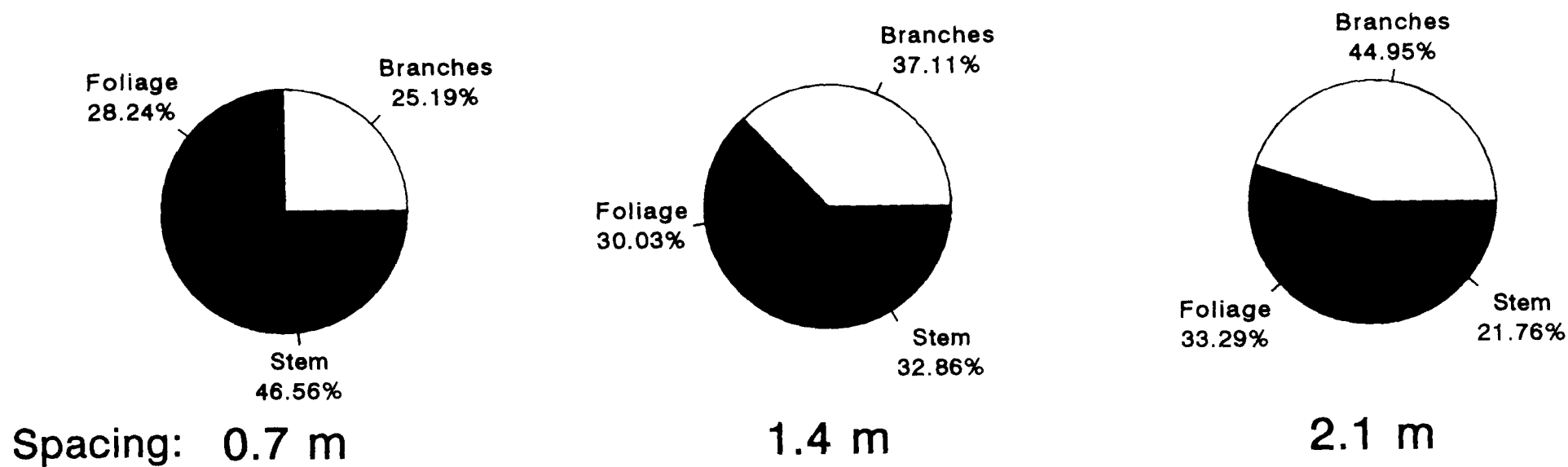


Fig 1. Allocation of biomass to stem, branches and foliage of *Leucana leucocephala* trees planted in field at three different spacings viz. 0.70, 1.40 and 2.10 m.

such plantation if not all had small diameters and were shorter in height.

Calculating biomass production per unit area of a stand seems to be more sound when dealing with short rotation or intensive culture plantations. In the present study, although the production of biomass per unit area (tone per hectare) was higher in the close spacing plots comparing with the wide spacing ones, differences were not statistically significant. This because the increase in number of stems with few and thin branches at dense plots was compensated for by less number of stems with a quite numerous larger branches in wider spacing. Similarly, the case of Sahoo *et al.* (1996) who found no differences in biomass production of *Leucaena leucocephala* at age 30-month but at age 42-month old the dense plots gave significantly the highest dry biomass yield. Increasing biomass production at closer spacing was also reported for *Leucaena leucocephala* (e.g. Kushalapa 1987; Maiti *et al.* 1991; Kalyan Ch. And Chakrabarti J. 1993; Saikia and Sarma 1994, and Sahoo *et al.* 1996).

Increasing biomass production of individual *Leucaena* trees with increasing space between trees and, increasing main stem biomass (dry weight) per unit area in dense plots are promising. It well enables using *Leucaena* as an additional resource

for firewood production in such an arid area. However, the recommended spacing for *Leucaena* will depend on the utilization of its products. Plantation density and period of rotation are most important factors for obtaining maximum yield. As closer spacing plantation has a high potential for the production of biomass per unit area, thus great emphasis should be laid on production capacity in a unit area, particularly when intention is paid to obtaining firewood. On the other hand, wide spacing will be recommended if planting *Leucaena* was mainly to use its foliage and shoots as fodder.

Acknowledgements

The authors would like to thank Mr. A.O. El-Wakeel, Mr. G. Khalaf and Mr. M. Nurrunnaby for assistance during field work and in the laboratory and with data analysis.

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طراز إنتاج و توزيع الكتلة الحيوية فوق سطح الأرض في أشجار الليوسينا
الصغيرة عند زراعتها على مسافات مختلفة

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الملخص : تم تحديد نظام إنتاج و توزيع الكتلة الحيوية في أشجار ليو سينا (*Leucaena leucocephala*) عمرها سنتين أنتجت من البذور وزرعت بمحطة التجارب الزراعية بديراب التابعة لجامعة الملك سعود بالرياض بهدف تقويم إنتاج شجرة الليوسينا للكتلة الحيوية عند زراعتها على مسافات مختلفة تحت ظروف منطقة الرياض ، وقد زرعت شتلات الليوسينا في عمر ستة أشهر في الأرض المستديمة على مسافات مختلفة هي بالتحديد ٠,٧٠ و ١,٤٠ و ٢,١٠ متر وقد أوضحت نتائج الدراسة أنه مع زيادة المسافة بين الأشجار زاد إجمالي الكتلة الحيوية الناتجة بالنسبة للأشجار المفردة ، وذلك نتيجة الزيادة في وزن كل من الساق الرئيسية للشجرة والفروع والأوراق . ومن ناحية أخرى لم يتغير إنتاج الكتلة الحيوية في وحدة المساحة معنوياً باختلاف مسافات الزراعة ، إلا أن الكتلة الحيوية للساق الرئيسية منسوبة إلى وحدة المساحة ازدادت في الأشجار المترعة على مسافات ضيقة عن تلك التي زرعت على مسافات أوسع . ومن ناحية أخرى أدت زيادة المسافة بين الأشجار من ٠,٧ إلى ١,٤ إلى ٢,١ متراً إلى زيادة حصة الكتلة الحيوية المخصصة للفروع من ٢٥ إلى ٣٧ إلى ٤٥% ، على التوالي بينما قلت تلك المخصصة للساق الرئيسية في نفس الوقت من ٤٧ إلى ٣٣ إلى ٢٢% على التوالي أيضاً . وتخلص نتائج هذه الدراسة إلى أن المسافات التي تزرع عليها أشجار الليوسينا تتوقف على الغرض من زراعتها . فزراعة الليوسينا على مسافات ضيقة تعتبر مناسبة إذا كان الغرض من زراعتها إنتاج أخشاب الوقود ، بينما زراعتها على مسافات واسعة تناسب وإنتاج العلف .