Performance of *Leucaena leucocephala* and *Albizia lebbeck* trees under low irrigation water in the field

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Abstract

Growth of *Leucaena leucocephala* and *Albizia lebbeck* trees was investigated under low water supply in the field using a complete randomized block design at the Research and Experiments Station of the College of Food Science and Agriculture, Riyadh, Saudi Arabia. The trees were irrigated at either 160 (well water supply) or 500 mm (low water supply) of a class "A" evaporation-pan records for two years. Differences were occurred between *L. leucocephala* and *A. lebbeck* trees across irrigation treatments with greater values for *L. leucocephala* in most of the growth characteristics measured. Comparing with *L. leucocephala*, leaves of *A. lebbeck* comprises only small proportion of the total weight of tree while allocated equal proportions to their branches and roots (41%).while *L. leucocephala* trees allocated almost similar proportions to their branches, stem and roots (27-28%). Low water supply decreased stem by 19.5% with stem diameter was unaffected. Leaf, branches, stem, root and consequently total dry weight of the trees decreases by 42, 51.5, 45, 51 and 94% in low water supply. However, the performance of *L. leucocephala* and *A. lebbeck* trees endured low irrigation conditions in terms of survival and maintaining reasonable growth.

Introduction

Harsh environmental conditions characterize the majority of Saudi Arabia that makes the need for more tree plantations to alleviate such conditions of the most priority. Although many tree species were imported to the country and planted during the last three decades, however, the most suitable tree species to be planted in the central part of the country is still not defined. We thought that adopting a tree species to be planted over a large scale must take in consideration its ability to cope with prevailing environmental conditions in terms of survival and growth and offers additional benefits and uses to community. Multipurpose tree species that bring subsoil nutrients to the surface, provide shade, slow erosion, provide fodder, living fence-posts, fruit and other edible parts, fuelwood, woods for domestic affairs, have some role in soil stabilization and offer quality-of-life benefits like beauty is recommended for planting in arid and semi-arid regions. Among tree species that have these characteristics or some of them are leguminous tree. In addition, they have the ability to fix the atmospheric nitrogen. Leucaena is the most common leguminous tree for intensive forage, fuel, stabilizing sloping soils and providing green manure (Brewbaker 1987). Leucaena is also attractive because of its adaptation to a wide range of soil and conditions, fast growth and ease of propagation (Hulman *et al*. 1983). The genus *Leucaena* is reported to contain 16 species (Brewbaker and Sorensson 1993) of which *Leucaena leucocephala* is the most widely planted species and known as leucaena (Shelton and Jones 1994). *Albizia lebbeck* is one of several *Albizia* species that are very important in many tropical regions with monsoonal climates. It can grow five m in one year and produce 100-120 kg edible dry matter per year (Lowry 1989). *Albizia lebbeck* is particularly promising as a fodder tree for semi-arid regions in the tropics and subtropics, and it has many other uses as well (Prinsen 1988). Its seedlings develop a long, stout taproot at an early age and are drought-tolerant (Parrotta 2003). Although *Albizia lebbeck* tree is a well known in the Indian subcontinent for its range of uses and geographical widespread, little is known about the species outside India (Lowry *et al*.1998).

The aim of the present study is to examine the performance of *Leucaena leucocephala* and *Albizia lebbeck* under low water supply in the open field.

Materials and methods

Site description

The site where the experiment was conducted has temperature ranged between 10ºC in winter and 37ºC in summer (as an average of season) and 50 mm rainfall, annually. The soil of the site was sandy loam with average content of 61, 23 and 15% for sand, silt and clay, respectively (Aref, 1987).

Plant material

Six months old seedlings of *Leucaena leucocephala* (Lam.) de Wit. and *Albizia lebbeck* L. (Benth) grown from seeds were planted in a field trial at the Agricultural

Research and Experiments Station of King Saud University, 50 km southwest Riyadh city, Saudi Arabia.

Statistical design and treatments

Six seedlings of *Leucaena leucocephala* and other six of *Albizia lebbeck* were planted in six experimental plots (10 × 10 m) in a randomized complete block design with three blocks. Each block had two plots. Each plot had two parallel ditches with three meters apart, which were designed to receive two different irrigation levels with four seedlings planted in each ditch. The spacing between each two consecutive seedling within the plot was three meters. In April 1999, half of the seedlings were irrigation at 160 mm and the other half at 500 mm of cumulative readings of Class-A evaporation pan representing well water supply (WWS) and low water supply (LWS) treatments.

Tree harvesting and sampling

In April 2001, all the trees were felled for biomass data collection. Total tree height and diameter at base (10 cm aboveground) were recorded. Each tree was separated into leaves branches, stem and roots. The number of roots was counted and representative samples from each tree component were taken for dry biomass determination. The samples of leaves were oven dried at 70ºC for 24 h, while those of branches, stems and roots were dried at 102±3ºC. Total dry biomass of each tree was calculated and biomass allocation to each component was determined.

Statistical analysis

The collected data were organized in a factorial experiment design with two factors included species and irrigation treatments with two levels each. Data were analyzed using analysis of variance statistical method through SAS computer program (SAS, 1987). The means of treatments were distinguished using Duncan's Multiple Range Test (Steel and Torrie 1982).

Results

Analysis of variance procedure showed that *Leucaena leucocephala* and *Albizia lebbeck* trees differed significantly across treatment in most of the growth characteristics measured in the present study. *L. leucocephala* trees had greater number of root (*P*=0.02), total leaf area (*P*=0.002), leaf area ratio and specific leaf area (*P*<0.0001) than *A. lebbeck*. It also had greater leaf (*P*<0.0001), branch (*P*=0.004) and total dry weight (*P*=0.02) than *A. lebbeck*. Both species had almost similar values for stem height and diameter (Table 1). *L. leucocephala* trees had mean leaf, branch and total dry weights were 5, 3 and 2 folds as much as those of *A. lebbeck* trees (Fig. 1). Dry matter partitioning to tree parts also differed significantly between the two species. *L. leucocephala* trees had greater leaf and stem weight ratio (*P*<0.0001) and lower branch and root weight ratio (*P*<0.0001) than *A. lebbeck*. The variation in dry matter partitioned to different tree parts between the two species reflects the growth habit of both (Fig. 2).

Low water supply treatment significantly decreased stem height (*P*=0.04) (Table 1), leaf, branch, stem (*P*<0.05), root (*P*=0.006) and total dry weight (*P*<0.01) of trees. Leaf, branch, stem, root dry weights of trees decreased by 42, 52, 45 and 51% due to low water supply and resulted in 94% reduction in their total dry weight (Fig. 1). Total leaf area also decreased in low water supply treatment but to a lower extent (*P*=0.08). Dry matter partitioning did not change due to irrigation treatments.

There were species × treatment interactions for only leaf dry weight (*P*=0.07) suggesting changing the magnitude of treatment effect on this trait with either tree species. The absence of species × treatment interactions for the other variables measured indicating that both factors had independent effects on these variables.

Discussion

L. leucocephala surpassed *A. lebbeck* trees in some growth traits measured across irrigation treatments. The mean values of total leaf area and the number of roots of *A. lebbeck* trees were 33 and 32% of those of *L. leucocephala*. Comparing with *L. leucocephala*, leaves of *A. lebbeck* comprises only small proportion of the total weight of tree. This may reflect the growth nature of *A. lebbeck* as it has a spreading umbrella-shaped crown of thin foliage (Parrotta 2003). The estimated foliage production (dry weight) of *L.* leucocephala trees in the present study was 2976 kg/ha/year comparing with 599 kg/ha/year for that of A. lebbeck trees. However, *Albizia lebbeck* stands in hedgerows at a row distance of 3 m produced 2500 kg/ha/yr as foliage that compares favorably with a leucaena yield of 1500 kg/ha/yr in the same region, which indicates that *A. lebbeck* could serve as an alternative to leucaena in the lower rainfall tropics and subtropics (Prinsen1988). This estimate seems to be lower than the foliage production of the present study and that of two years-old *L. leucocephala* grown at 2.1 m spacing in Riyadh, Saudi Arabia which was 2260 kg/ha/year (Aref *et al*. 1999). This discrepancy may result from the variation in site characteristics where the trees were grown. Shelton and Brewbaker (1994) asserted that the edible forage yields (leaves and young stems) of *L. leucocephala* trees depending on soil fertility, row spacing, rainfall and temperature. On the other hand, while *L. leucocephala* trees allocated almost similar proportions to their branches, stem and roots (27-28%) *A. lebbeck* trees allocated equal proportions to their branches and roots (41%) which were fairly larger than those of *L. leucocephala*. Root biomass of *Albizia lebbeck* trees was the greatest among nine 6-year-old tree species from arid north-western India evaluation for Above-ground and below-ground biomass allocation (Toky and Bisht 1993).

Effects of water stress on the growth of trees has been well documented (Koslowski 1982). However, the level of stress that results in a reduction in growth varies with the condition under which the plants are grown (Begg, 1982). Decreasing stem height in low water supply concurs with other results for *L. leucocephala* (El-Juhany and Aref 1999), some acacias (Aref and El-Juhany 1999). Benson *et al*. (1992) found that stem growth of *Pinus radiata* was very sensitive to tree water stress at mild and moderate levels. Many workers have reported on decreasing tree height due to water stress in seedlings (*e.g*. Ibrahim *et al*. 1997, 1998) and in mature trees (*e.g*. Snowdon and Benson 1992). Although the reduction in both height and diameter in low water supply (19.5%) across both *L. leucocephala* and *Albizia lebbeck* trees was similar, however, the later was not statistically significant. Contradictory, decreasing stem diameter of woody species due to water stress was extensively reported (*e. g*. El-Juhany and Aref 1999, for *L. leucocephala* and Aref and El-Juhany 1999, for some acacias and Pokhriyal *et al*., 1997, for *Acacia nilotica*).

Low water supply caused decreases of 42, 51.5, 45, 51 and 94% in leaf, branches, stem and root dry weight across *L. leucocephala* and *Albizia lebbeck* trees. Similar results were obtained previously (Ibrahim et al., 1997, 1998). El-Juhany and Aref (1999) reported decreases of 72, 65, 29 and 64% in leaf, stem, root and total dry weight of *L. leucocephala* after 12 weeks of water stress treatment. However**,** Sampet and Pattaro (1987) found that the growth of three legumes included *L. leucocephala* was decreased by water stress during the dry season but *L. leucocephala* appeared to have better growth during the dry season. In an investigation of the effects of watering every 1, 4 or 7 days on five multipurpose tree species in the nursery for four month, *Albizia lebbeck* had the greatest root growth among those species and their stem height and root growth were affected due to treatment (Mohan *et al*., 1999). Moreover, among 14 tree species grown from seeds and subjected to water stress for six weeks, *Albizia lebbeck* with other two tree species had high productivity under favourable and unfavourable water relations therefore, they were recommended for planting in semiarid regions (Bimlendra *et al*. 1992). This supported by the work of Paliwal and Kannan (1999) who concluded that *Albizia pavonina* and *A. lebbeck* have become well adapted to the climatic conditions of the semi-arid zones of India. Leucaena is very drought tolerant even during establishment (Lowry *et al*. 1998). Studies have confirmed that leucaena exhibits better drought characteristics than a number of other tree legumes (Swasdiphanich 1992). Recently, Reddy et al. (2000) postulated that L. leucocephala withstood drought better than the other legume species.

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Table 1. Effects of irrigation treatments at 160 mm (Well water supply, WWS) and at 500 mm (Low water supply, LWS) according to the records of Class "A" evaporation pan on some growth traits of *Leucaena leucocephala* and *Albizia lebbeck* trees after 24 month.

Trait	Species		Treatments	
	L. leucocephala	*A. lebbeck*	WWS	LWS
Stem height (m $tree^{-1}$)	*3.94 ^{a}	3.47 ^{a}	4.10 ^{a}	3.30 ^{b}
Stem diameter (cm $tree^{-1}$)	7.11 ^{a}	7.11 ^{a}	7.82 ^{a}	6.32 ^{a}
Total leaf area (cm^2 $tree^{-1}$)	165145 ^{a}	54652 ^{b}	140704 ^{a}	82148 ^{a}
No. roots (root $tree^{-1}$)	13.1 ^{a}	8.9 ^{b}	11.9 ^{a}	10.1 ^{a}

*Means followed by the same superscript letter within each two consecutive boxes are not statistically different according to Duncan's Multiple Range Test.

Table 2. Dry matter production (kg ha^{-1}) by *Leucaena leucocephala* and *Albizia lebbeck* trees after 24 month of irrigation at 160 mm (Well water supply, WWS) and at 500 mm (Low water supply, LWS) according to the records of Class "A" evaporation pan

Species	Irrigation treatment	Dry matter (kg ha^{-1})				
		Leaves	Branches	Stem	Roots	Total
L. leucocephala	WWS	2976	5760	4716	5112	18564
	LWS	1608	2832	2664	2412	9516
A. lebbeck	WWS	599	2064	3888	3576	10116
	LWS	248	696	1992	1740	4440

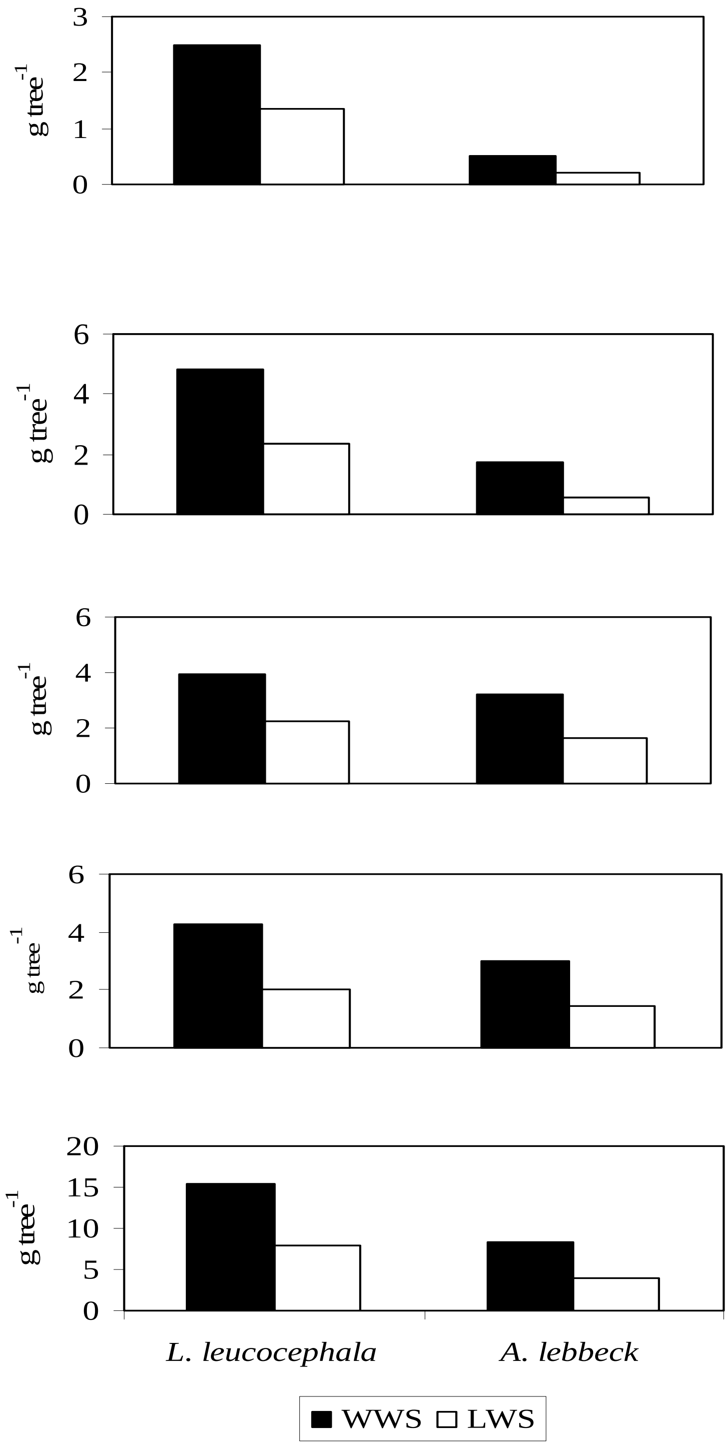

Figure 1. (a) Leaf, (b) branch, (c) stem, (d) roots and (e) total dry weight of *Leucaena leucocephala* and *Albizia lebbeck* trees as affected by irrigation either at 160 mm (Well water supply, WWS) or at 500 mm (Low water supply, LWS) according to records of a Class "A" evaporation pan.

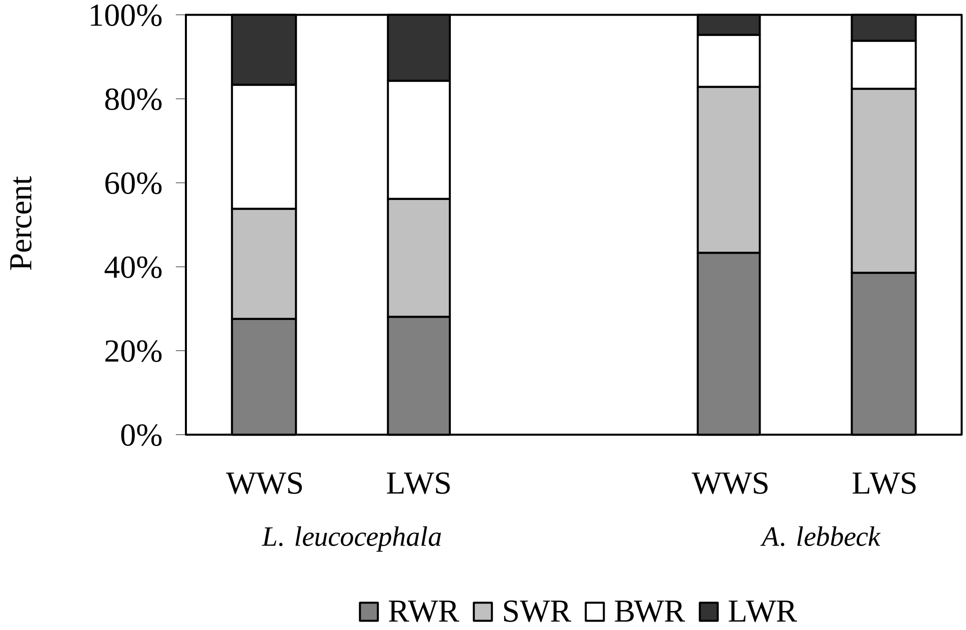

Figure 2. Partitioning of dry matter of Leucaena leucocephala and Albizia trees into leaves (leaf weight ratio, LWR), branches (branch weight ratio, BWR), stem (stem weight ratio, SWR) and roots (root weight ratio, RWR) after 24 month of irrigation at 160 mm (Well water supply, WWS) and at 500 mm (Low water supply, LWS) according to the records of Class "A" evaporation pan.