ACACIAS: VARIATION BETWEEN SPECIES IN EARLY GROWTH AND A FEW DROUGHT-ADAPTIVE ATTRIBUTES

P.S. Srinivasan, R.S. Vinaya Rai & R. Jambulingam

Forestry Research Station, Tamil Nadu Agricultural University, Mettupalayam - 641 301, India

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SRINIVASAN, P. S. , VINAYA RAI, R. S. & JAMBULINGAM, R. 1989. Acacias: Variation between species in early growth and a few drought-adaptive attributes. Fifteen species of *Acacia*, one each from Guatemala, Papua New Guinea and Kenya, and five from Australia were field-planted in a statistically designed experiment in 2 *m* squares. Three years after planting, height and growth plus bark moisture content, total chlorophyll content, stomatal resistance and transpiration rate were recorded. Differences between species were significant in respect of all variables. *Acacia auriculiformis* possessed the least value for transpiration rate and maximum values for other variables. *Inter se* correlation among the variables revealed height growth to be associated positively with bark moisture content and total chlorophyll content and negatively with transpiration rate. Transpiration rates showed inverse relationships with all variables except diameter at breast height.

Key words: Acacias - bark moisture content - total chlorophyll content - stomatal resistance - transpiration rate

Introduction

Acacias have high economic utility. They grow relatively quickly, and possess many desirable attributes such as pulpwood quality and coppicing ability (Burley 1980, Moss & Morgan 1981). Being legumes, most acacias are probably a source of nitrogen in forest ecosystems and agroforestry land use systems. They also serve as browse plants, the pods of some species being relished by cattle. Soil conservation authorities have used the genus for many years for stabilisation of shifting sand (Roux & Middlemiss 1963, Barr 1965, Aveyard 1968, Barr & Alkinson 1970). Being adaptable to harsh environments they are extensively planted in arid and semiarid areas.

Exploitation of the wide natural genetic diversity is vital to tree improvement programmes (Good 1984). Precise information on species differences in the performance under moisture-stress conditions in forest trees is inadequate (Gerold & Sacksteder 1982). This study was designed to explore the variation in growth performance of 15 species, both indigenous and exotic, and to relate this with four physiological parameters, namely bark moisture content, total chlorophyll content, stomatal resistance and transpiration rate.

Materials and methods

The experiment was carried out at the Forestry Research Station, Mettupalayam, India, (11° 19' N; 76° 56' E; 300 *m* a.s.l; annual precipitation 830 *mm*; soil pH 7.1). Five-month-old containerised seedlings of 15 *Acacia* species (Table 1) were field-planted in a randomised block design replicated thrice in 2 *m* squares in plots measuring 10 × 10 *m* (25 plants per replicate). Three years after planting, the following parameters were recorded: height; diameter at breast height, [1.37 *m* from ground level (DBH)]; bark moisture content; total chlorophyll content; stomatal resistance and transpiration rate. Bark moisture content was recorded in an electronic moisture meter (ASCU Hickson Ltd. Calcutta) and expressed as percentage. Total chlorophyll was determined colorimetrically, after Arnon (1949) and the amount of chlorophyll in $mg\ g^{1}$ fresh weight was calculated using the nomogram of Kirk (1968). Stomatal resistance and transpiration rates were measured on the abaxial surface of fully expanded top leaves (Kuo *et al.* 1977) during noon hours in a steady state porometer (Li-Cor, USA) and expressed respectively as $s\ cm^{1}$ and $\mu g\ H_2O\ s^{1}\ cm^{1}$. Data were subjected to analysis of variance and treatment differences tested (t-test) for significance ($P \leq 0.05$) following Panse & Sukhatme (1967). Total correlation coefficients among the parameters were drawn following Al-Jibouri *et al.* (1958).

Table 1. Variation in growth and physiological parameters in species of *Acacia*

Species	Source	Seed lot number	Height (m)	DBH (cm)	Bark moisture content (%)	Total chlorophyll content ($mg\ g^{1}$ fresh weight)	Stomatal resistance ($s\ cm^{1}$)	Transpiration rate ($\mu g\ H_2O\ s^{1}\ cm^{1}$)
Acacia nilotica	Local	-	3.25	4.46	10.4	1.55	1.21	22.6
A. leucophlocea	Local	-	2.80	6.20	8.9	0.70	0.74	28.2
A. planifrons	Local	-	3.08	6.00	10.0	1.21	0.86	27.4
A. suma	Pondicherry	-	2.33	4.10	9.4	1.22	0.72	28.9
A. mellifera	Local	-	2.92	6.20	10.3	1.07	0.98	26.7
A. tortilis	Jhansi	-	3.25	5.76	10.7	1.29	0.99	26.4
A. seyal	Sourou, Onagadougon	-	2.92	3.26	11.2	1.46	1.68	15.9
A. fermesiana	Guatemala	OFI 9/83	2.75	4.33	9.4	1.19	0.79	28.7
A. albida	Kenya	-	3.33	5.60	11.0	1.52	1.86	21.7
A. holosericea	Northern Territory, Australia	13853	3.50	6.30	8.8	1.40	1.11	24.4
A. auriculiformis	Papua New Guinea	1611*	4.33	7.03	11.6	1.88	1.96	13.7
A. platycarpa	Northern Territory, Australia	14626	3.58	7.96	10.6	1.58	1.42	18.4
A. victoriae	Queensland	13437	3.42	3.90	10.3	1.28	0.96	27.4
A. pendula	Queensland	13482	2.75	4.50	9.8	0.96	0.88	29.6
A. stenophylla	Queensland	14670	2.52	4.80	10.9	1.36	1.21	23.1
Standard Error Deviation			0.44	1.03	0.40	0.22	0.23	0.46
Critical Difference ($P \leq 0.05$)			0.90	2.11	0.82	0.45	0.48	0.96

* Batch number, Department of Forestry

Results and discussion

Significant differences between the species were discernible in respect of all parameters investigated (Table 1). While *A. auriculiformis, A. holosericea* and *A. platycarpa* were tallest in respect of height, these along with four more species (*A. leucophloea, A. mellifera, A. albida* and *A. planifrons*) possessed greater DBH than others. Ability to retain high moisture potential in plant tissues is a factor associated with resistance to moisture stress and in forest trees, a fall in bark moisture content below a threshold value makes some trees susceptible to canker disease (Bier 1964). In the present study, four species (*A. auriculiformis, A. albida, A. seyal* and *A. stenophylla*) had high bark moisture content. High rates of stomatal resistance is yet another regulatory mechanism to minimise water loss. This parameter was the highest in three species namely, *A. auriculiformis, A. albida* and *A. seyal* suggesting that in these species, excess moisture loss at noon tends to increase stomatal resistance resulting in mitigation of transpiration (Turner & Begg 1981). Chlorophyll stability index was correlated with drought tolerance in pines (Kolyoreas 1958) and rice (Murty & Majumdar 1962). In the present study, five species (*A. nilotica, A. auriculiformis, A. albida, A. seyal* and *A. platycarpa*) were characterised by maximum chlorophyll content. Increased crop yields are generally associated with decreased transpiration rates (Florence 1986) and C_3 plants invariably have higher transpiration rates than C_4 plants (Rawson *et al.* 1977). Transpiration rate was significantly low in *A. auriculiformis.* Although several species thus exhibited their superiority in one or more of the parameters, it was *A. auriculiformis* which excelled others by possessing the least value for transpiration rate and maximum values for other variables.

To conclude a wide genetic variation exists among the 15 species of *Acacia*, and *A. auriculiformis* was found to be the most suitable for arid conditions at the age of 3 *y*. In an evaluation of five species, (Chandra Babu *et al.* 1987) *A. auriculiformis* was also found to possess maximum values for bark moisture content and stomatal resistance and least value for transpiration rate. *A. auriculiformis,* a native to Queensland and Northern Territory (Australia), Papua New Guinea and Indonesia has since been introduced to several countries in south and southeast Asia (Wiersum & Ramlan 1982). It is an important species with several uses, the principal one being as fuelwood with a specific gravity of 0.62 and a calorific value of 4805 to 4907 $kCal\,kg^{1}$ (Hellinga 1950). The present study indicates it to possess drought-adaptive attributes as well. Other exotic species like *A. albida* and *A. platycarpa* too proved more promising than local species in their performance under extreme habitats.

Table 2. *Inter se* correlation among growth and physiological attributes in species of *Acacia*

Variable		DBH (X_1)	Bark moisture content (X_2)	Total chlorophyll content (X_3)	Stomatal resistance (X_4)	Transpiration rate (X_5)
Height	(Y_1)	0.568*	0.433	0.686*	0.639*	-0.635*
DBH	(Y_2)		0.044	0.199	0.229	-0.279
Bark moisture content	(Y_3)			0.688*	0.784*	-0.736*
Total chlorophyll content	(Y_4)				0.807*	-0.823**
Stomatal resistance	(Y_5)					-0.917*

* significant at P \ 0.05 and ** at P ≤ 0.01

Regression equations: $Y_1 = 0.718 + 1.489\ X_1$, $Y_1 = 0.090 + 0.391\ X_3$, $Y_1 = -0.455 + 0.517\ X_4$, $Y_1 = 43.96 - 6.341\ X_5$

$Y_3 = -1.076 + 0.233\ X_3$, $Y_3 = -2.707 + 0.378\ X_4$, $Y_3 = 68.9 - 4.376\ X_5$

$Y_4 = -0.344 + 1.146\ X_4$, $Y_4 = 43.0 - 14.388\ X_5$

$Y_5 = 37.302 - 11.308\ X_5$

Inter se correlation coefficients among the variables revealed tree height correlated positively with DBH, total chlorophyll content and stomatal resistance but negatively with transpiration rate (Table 2). Diameter was not correlated with any of the physiological parameters. Transpiration rate exhibited a negative association with bark moisture content, chlorophyll content and stomatal resistance. The main factors affecting transpiration are leaf area index, stomatal conductance and vapour pressure difference between leaf and atmosphere (Florence 1986). Stomatal movement in trees depends on both morphological and physiological factors. Morphologically, trees differ in the extent to which their root systems explore the soil fabric and their ability to exploit available soil moisture at depth during drought may be a major factor in their survival and growth; and hence in their water use as well (Pereira & Kozlowski 1976, Carbon *et al.* 1980). However there are instances where morphological differences cannot explain differences in water use between species or provenances of the same species (Grunwald & Karschon 1982, Colquhoun *et al.* 1984). Physiological controls of water use appear to be important. Thus, *A. auriculiformis* with low transpiration rates during noon hours may prove a comparatively better drought tolerant species.

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