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Growth and Biomass Production Potential of *Acacia jacquemontii* Benth. in Different Soil Conditions in Hot Arid Region of India

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Abstract: The growth and biomass production potential of *Acacia jacquemontii*, an endangered shrub of Indian arid zone, was studied under deep, medium and shallow soils. Maximum plant growth and above-ground biomass was obtained in deep soil, where as it was least in shallow soil. Polynomial linear relationship existed between the age and plant height, stem diameter and number of stems/thicket. Soil conditions had no significant bearings on proportionate allocation of different components of total accumulated biomass. Accumulation of stem wood and branches/twigs biomass was the maximum in deep soil followed by medium and shallow soils. However, foliage yield was at par in medium and shallow soils. Its profuse growth habit and multi-stem character make it suitable species for sand dune stabilization, as flank rows in shelterbelt plantations and for social forestry programs.

Key words: Multipurpose shrub, Thar Desert, above-ground biomass, *Acacia jacquemontii*, threatened species, soil depth.

Acacia jacquemontii Benth., member of Mimosaceae family, occurs naturally in arid regions of Australia, India, Pakistan, Afghanistan, Iran and Iraq. In India it occurs in Gujarat, Punjab, Rajasthan, Delhi, and Saurashtra (Bhandari, 1990). Due to multiple uses, it has attained special significance among desert dwellers. Its small poles are used for making frames of thatched houses and huts and young shoots/branches for making baskets, granaries and other household articles (Prasad *et al.*, 2005). The plant annually yields 100-150 g edible gum, which is highly priced in pharmaceuticals. The tender green branches and leaves provide good browse for camel. For all these uses the plant is extensively exploited and uprooted. Continuous gum extraction by local people coupled with its poor natural regeneration has threatened its existence (Singh, 2004). Growth performance and biomass production potential of *A. jacquemontii* was studied in different soil conditions in hot arid region of India.

Materials and Methods

The study was conducted at research farm of CAZRI-RRS, Jaisalmer, located at N 26° 55′ 15.1" and E 70° 57′ 32.9" at an elevation of 242 m above MSL. Climatically, Jaisalmer has been categorized as extremely arid with mean moisture index of –90.7 (Chatterjee and Kar, 1992). The annual rainfall of the region varies from 130 to 210 mm with a mean of 188 mm. The rainfall is highly erratic with a coefficient of variation of 49 to 60%. The bulk of the annual rainfall is received during monsoon between July and September. The annual precipitation is far less than evaporation (2069 mm).

For assessing performance of out-planted seedlings, a topo-sequence slightly sloping (1-3%) toward south was selected for field layout. Based on the soil classification (Soil Survey Staff, 1992) the topo-sequence was divided into deep (>100 cm deep, calcareous, Typic Torripsamment), medium (50-100 cm deep, calcareous, Typic Torripsamment) and shallow (<50 cm deep, sandy skeletal, calcareous, Lithic Torriorthents). The soil at experimental site was low in soil organic carbon, available nitrogen, medium in phosphorus and potassium and poor in water holding capacity. The trial was conducted in randomized block design, along the contour lines in all the three soils with five replicates. In each plot 15, eight-month-old seedlings of uniform height (53.2 cm), were planted with the onset of monsoon at 3 x 3 m spacing during July 1999. In first year seedlings were watered every month while in second year water was given only in summer months (April to June) and thereafter saplings were maintained on rainwater. The annual rainfall received was 174 mm in 2000, 340 mm in 2001 and 82 mm in 2002.

In each treatment five plants were randomly selected and tagged for recording growth observations on plant height, canopy spread, number of shoots per plant and diameter of stems in the month of June every year. The mean of five plants were subjected to statistical analysis adopting DMRT test (Gomez and Gomez, 1984) and production function. At the end of fifth year in June 2004, randomly selected one plant from each plot was cut at ground level to record above-ground biomass. Small poles were classified into different height and diameter classes based on their preference for various uses by locals.

Results and Discussion

Field performance

The survival percentage ranged from 92 to 95% and remained unaffected by the site conditions. However, the site conditions significantly influenced the seedling growth. Highest growth was recorded in deep soil, whereas least was in shallow soil. Plants attained maximum mean height (4.5 m), stem diameter (23.8 mm), canopy spread (22.4 m^2) and basal cover (141.6 cm^2) in deep soil followed by medium and shallow soils. Except stem diameter, other plant growth parameters were at par in medium and shallow soils (Table 1). Wide variation in all the growth attributes was noticed. Profuse growth in deep soil in comparison to that in moderately deep and shallow soils can probably be attributed to its preference for sandy plain or high dune habitat where the roots could easily penetrate and use sub-surface soil moisture available for longer period. Apparently water supply could not meet plant water requirement in medium and shallow soils resulting in water stress, which, resulted in poor plant growth. Vigorous growth due to efficient moisture utilization ability makes *A. jacquemontii* useful species for planting in sand dune fixation program and as outer or flank rows of shelterbelt plantation (Tewari *et al.*, 2000).

Growth behavior

Deep soil yielded maximum number of stems whereas, under medium and shallow soils these were comparable. Development of number of stems at ground level

Table 1. Growth parameters of five-year-old A. jacquemontii in Indian arid zone

Soil	Plant height (m)	Stem diameter (mm)	Number of stem/ thicket	Canopy spread (m^2/thicket)	Basal cover cm^2/ thicket
Deep (100 cm)	4.5a	23.8a	31.4a	22.4a	141.6a
Medium (50-100 cm)	2.7b	18.3b	11.4b	10.5b	30.8b
Shallow (<50 cm)	2.2bc	14.0c	9.8bc	8.2bc	17.4bc

Mean followed by same letter in a column do not differ significantly.

(multi-stems plant is referred hereafter as thicket) gave the plant a typical shrubby look. Growth behavior of plants in different soil conditions was studied by working out relationships between the age and mean height, stem diameter and number of stems/ thicket that grew over a period of five year. Polynomial linear model fitted the best (Fig. 1). The maximum growth rate in height and number of stems developed were noticed between 2nd and 4th year and thereafter, these became static. The trend of proportionate annual increase in stem diameter was similar at all sites. Large influence of soil conditions on annual increment of plant height, stem diameter and number of stem/thicket was evident. Deep soil registered maximum annual growth rate in plant height (0.9 m), stem diameter (4.8 mm) and number of stems per thicket (6.3 stems) while shallow soil recorded the least with corresponding values of 0.44 m, 2.8 mm and 2.0 stems, respectively. Irrespective of site, a typical shrubby growth behavior yielding polynomial linear relationships between age and plant height, stem diameter, and number of stems/thicket appears to be comparable with other perennial shrubs like *Acacia bevinosa* and *Prosopis juliflora* grown in the region. At better sites *Prosopis juliflora* reportedly grew well with an average annual growth rate of 30-60 cm in height and 2.5-4.0 mm in stem diameter (Tewari *et al.*, 2005).

Biomass yield

Total above ground biomass was highest in deep soil, whereas it was least in shallow (Table 2). Soil conditions had no significant bearings on proportionate allocation of different components of total biomass viz. stem wood, twigs/branches, and leaves. On an average stem wood accounted major share of above-ground biomass (49%) followed by twigs/branches (42%) and foliage (~10%). Accumulation of stem wood and branches/twigs was the maximum in

Table 2. Biomass yield of five-year-old A. jacquemontii

Soil	Green biomass yield (kg/thicket)			
	Stem wood	Twigs	Leaves	Total
Deep (<100 cm)	80.0a (48.9)	69.0a (42.2)	14.7a (9.0)	163.7a
Medium (50-100 cm)	9.0b (48.6)	7.0b (37.8)	2.5b (13.5)	18.5b
Shallow (<50 cm)	2.2c (48.8)	1.8c (40.0)	0.5bc (11.1)	4.5c

Mean followed by same letter in a column do not differ significantly. Figures in parenthesis indicate percentage of total biomass yield.

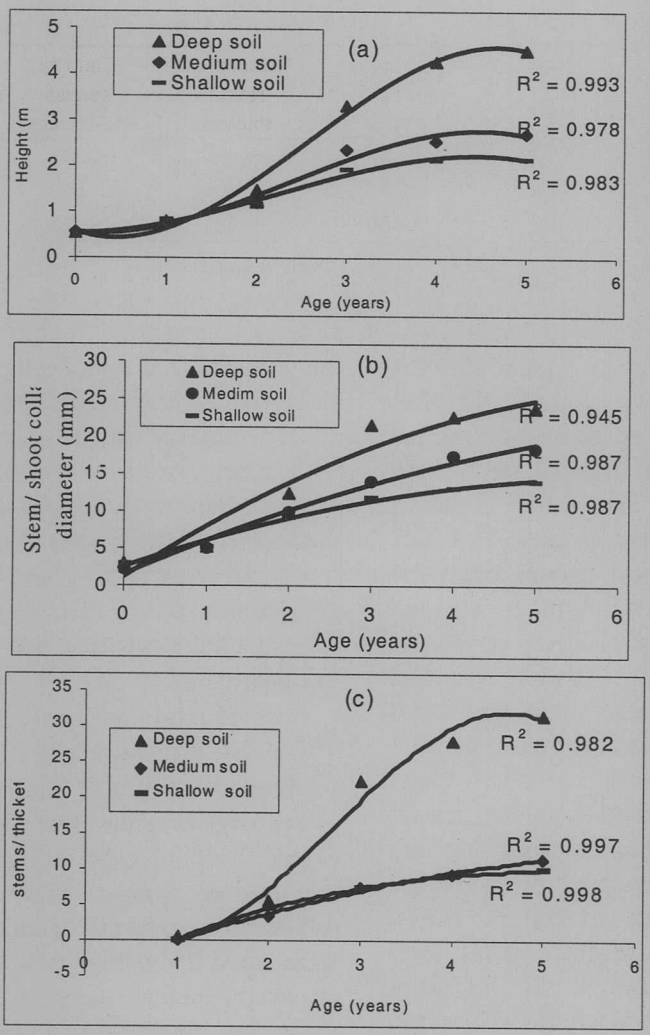

Fig. 1. Relationship between age and plant height (a), stem diameter (b), and stems/thicket (c) of A.jacquemontii.

deep soil followed by medium and shallow soils. However, foliage yield was at par in medium and shallow soils. Slight reduction in foliage allocation and corresponding increase in branch wood formation indicate that stem wood formation was at peak in deep soils resulting in maximum yield of small poles suitable for various purposes (Kunhamu *et al.*, 2005).

Considering the composition of small poles (taper ratio 0.65) in different height and diameter classes (Table 3), maximum poles suitable (height >3.0 m and diameter >40 mm) for making frame of the thatched houses and huts, house hold granaries (height 2-3 m and diameter 20-40 mm) and baskets (height <2.0 m and diameter <20 mm) were produced in deep soils.

Table 3. Yield of small poles (number/thicket) from five-year-old A. jacquemontii

Soil	Number of poles in height class			Number of poles in diameter class		
	<2.0 m	2.0-3.0 m	>3.0 m	<20 mm	20-40 mm	>40 mm
Deep (>100 cm)	17	6	10	14	10	10
Medium (50-100 cm)	8	3	0	6	5	0
Shallow (<50 cm)	14	0	0	14	0	0

Shallow soils yielded poles, which were suitable only for making baskets while; medium soils produced poles which could be used only for household granaries and baskets. Medium and shallow soils did not yield any pole which could be used for making frames of thatched houses and huts. Wide variation in height and thickness of small poles increases base for multiple uses in making frame of thatched houses/huts, granaries and baskets thus making it choice species for social forestry programs.

The results of the study indicated that *A. jacquemontii* had exhibited high potential of growth and biomass production in deep sandy soils of arid region. Its profuse growth habit and multi-stem character make it suitable for sand dune stabilization, as flank rows of shelterbelt plantation and social forestry programs.

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