Technical Bulletin No. 5

ACACIA TORTILIS (FORSK) - A PROMISING FAST GROWING TREE FOR INDIAN ARID ZONES

By

K.D. MUTHANA AND G.D. ARORA

CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR

Acacia tortilis (Forsk), A promising fast growing tree for indian arid zones

By

K.D. Muthana and G.D. Arora

Central Arid Zone Research Institute, Jodhpur - 342003

INTRODUCTION

The natural conditions prevailing in the arid zones of India often do not permit undertaking large scale tree plantations. Obviously, best alternative under such situations is to identify fastest growing tree species that are tolerant to water stress conditions. It is through the intensified research work carried out at the Central Arid Zone Research Institute, Jodhpur, that one fast growing tree species most suited for the arid zones in the country : *Acacia tortilis* (Forsk) Syn. *A. raddiana* (Savi), *A. spirocarpa* (Hochst. ex. A. Rech) has been identified, having excellent survivability, fast growth and very good coppicing behaviour. This species also has the best growth in terms of height, collar diameter and diameter at breast height when compared with other exotic and indigenous tree species.

GENERAL DESCRIPTION

Acacia tortilis is indigenous to Sudan, Ethiopia, Yemen, Somalia, Part of Kenya, Tenzania, Arabia and Southern Israel (Wadi Araba). In Israel, it was reported to attain about 4 metre height but in runnels, it was reported to be growing upto 8 to 10 metre. In Egyptian deserts, it grows to a height of 12-14 metre.

It is a medium size tree with an open parasol type of crown (Fig. 1). The flowers are white to cream coloured and capitate. Leaves are 1.25 to 3.5 cm long. The petioles are pubescent and the pinnae occur in 4 to 10 pairs. Leaflets are very small. Pods are yellowish, brown, spirally twisted and slightly constricted between the seeds (Fig. 2)

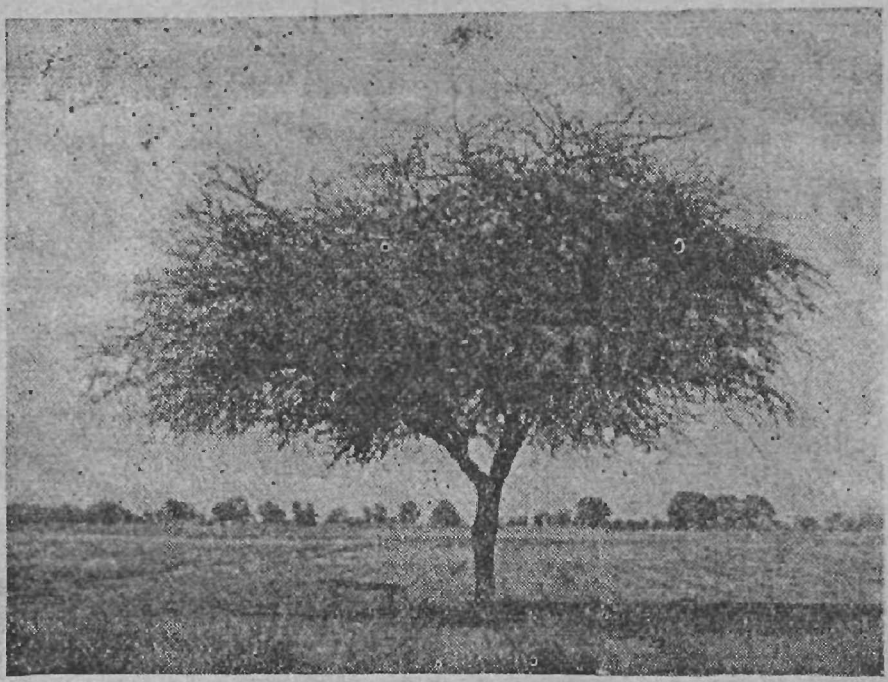

Fig. 1. *Acacia tortilis* with a flat parasol type of crown

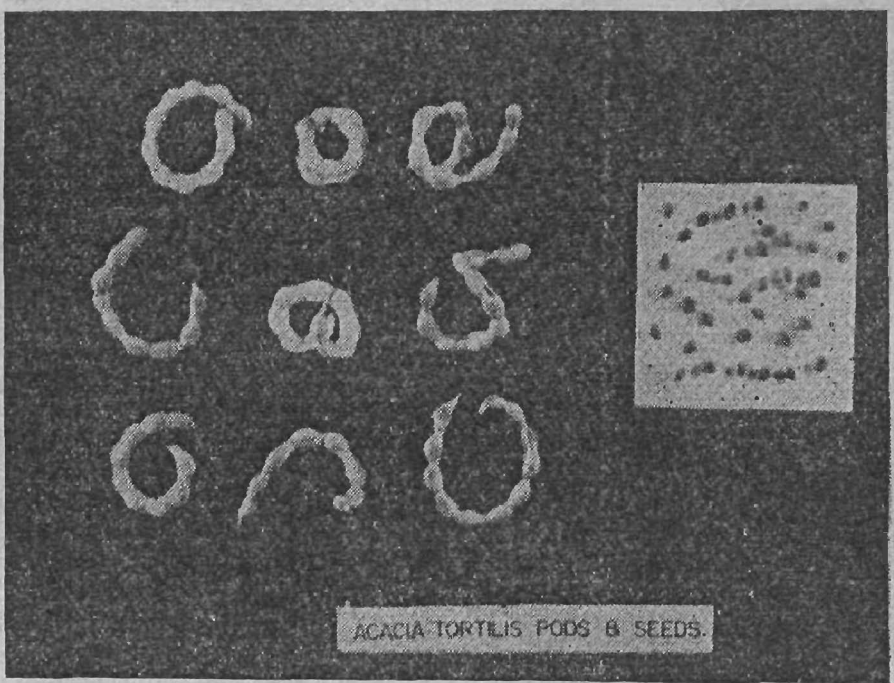

Fig. 2. *Acacia tortilis* pods and seeds

This species was first introduced from Israel in India in 1958 by the Central Arid Zone Research Institute, Jodhpur and is popularly known as *'Israeli babool'*. After careful and intensive studies in the laboratory, as well as in the nursery and field, the species was released for afforestation programmes, especially after being certain about a sustained seed supply, it is now being tried on large scale covering vast areas in the States of Rajasthan, Haryana, Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka and the arid districts of different other states.

The species is being grown in Indian arid zones in association with other *Acacias*, *Prosopis* and other indigenous tree species. It is thriving very well under extremely dry climates with less than 200 mm annual rainfall. It also withstands extreme temperatures ranging from 45°C to 3°C and sometimes even up to 0°C. Young plants however are liable to frost damage.

Flowering and Fruiting: Under Indian arid conditions, this species start flowering and fruiting after 3 years of transplanting. Flower buds appear in the first week of May and fruit setting commence from mid July. Fruits ripen from mid November to end of February. On an average, annually, a tree of 6 to 8 years old yields 5 to 6 kg. clean seeds. Air dried pods are threshed and winnowed. Seeds of this species which are light brown in colour *resemble* those of *Acacia nilotica* sub. sp. *indica* (babool) in size and the weight is approximately 85 gm/1000 seeds.

Seed Treatment: The seeds have very hard testa and take 40 to 60 days for germination and may even fail to germinate if not pretreated. To facilitate quick germination, the seeds are to be pretreated. There are two methods to treat the seeds.

1. Seeds are stirred in 50 per cent concentrated commercial sulphuric acid for 30 minutes in summer and 40 minutes in winter, washed in cold running tap water for about 30 minutes and dried at room temperature or under shade over-night. Pretreated seeds start germinating after 4th day of sowing and continue for about 20 days. Germination is 90 per cent from the treated seeds.

2. Seeds are also treated in boiling water (100°C). Seeds are put into boiling water and stirred for 3 minutes and the vessel placed under running water till it becomes cold. The seeds are then dried at room temperature. These seeds also start germinating after 4th day and

continue for about 30 days. This method is more appropriate and practical, while transferring technologies from 'Lab to Land' as the acid treatment has inhibitions about availability of acid, proper dilution and risks in handling. Such treated seeds can be stored for at least one year, in proper containers, without losing their viability.

Nursery Technique : Seedlings can be raised in G. I. containers, with a clasping arrangement which will enable them to be opened by side pressure. These may be 10.2 cm diam. x 30 cm long or 7 cm diam x 30 cm long or 7 cm diam x 22.5 cm long. Perforated polythene bags of 11 cm x 22.5 cm or sundried truncated pyramid shaped earthen bricks 30 cm long, 15 x 15 cm at bottom and 10 x 10 cm at top, with a hole at the top, 10 cm deep and 2 cm diam, for transplanting in the field during the onset of rains can also be used. Under favourable conditions, the development of seedlings is fairly fast. As the radicle establishes, the hypocotyl starts growing faster. Growth of apical bud leads to the development of a single pinnate leaf followed by bipinnate leaves with at least one pair of pinnules and then with 3 pinnules. Subsequent leaf growth consists in bipinnate leaves with pairs of pinnules. Early growth of stipular spines is conspicuous. Tap root development exceeds about six times that of the shoot (Kaul, 1963). Young plants have a tendency to develop long tap roots but with age many lateral roots develop depending on the type of soil.

Seed sowing is done either in September or in February months and seedlings from these sowings attain on an average 50 cm and 30 cm height growth respectively, by early July. Both these sizes of the seedlings are recommended for planting. Since young seedlings show signs of tenderness to frost, it is desirable to sow the seeds in the month of February to avoid the risk involved.

Planting Techniques : Seedlings of 10 to 6 months old raised in nurseries having the sizes specified above, are planted or treated seeds dibbled directly, in pits of 60^3 cm. Espacement of 5 m x 5 m and 5 m x 10 m for fuel and silvipastoral plantations respectively, give best results. Plantation programme should be commenced with the onset of rains. After planting the seedlings or dibbling seeds, saucer shaped depressions 1 m diameter may be made round the plants to harvest the rain water which would boost up the plant growth. Weeding and soil working is necessary for at least 3 times in the first year of plantation. In case rains fail after planting seedlings or dibbling seeds, watering should be given at 9

litres per pit fortnightly till end of March of the following year and increase the intensity of watering to weekly from early April till commenc-

Type of soil	Soil working technique	Cost of plantation in Rs. per ha. (Rs. 5/— per mandays)
1. Deep sandy soil	Pits of 60^3 cm are dug at required espacement and filled with weathered soil prior to the commencement of rains, Saucer shaped depressions (1 m diam,) are made round the plants to harvest rainwater. Normal planting distance for plantations is 5m x 5m.	800/-
2. Shallow sandy loam soils overlying hard calcareous pan	Pits of 90 cm deep and 60 cm diam. are dug at required espacement and filled in with a mixture of weathered soil and farm yard manure on equal proportion prior to the rains and planting done with the onset of rains.	1000/-
3. Rocky terrain with scattered soil pockets. 4. Semi rocky terrain with accumulation of transported soil.	Wherever soil pockets or accumulation of soil exist, pits of 45^3 cm or 60^3 cm are dug out and half filled with the dug out weathered soil and the remaining soil is made into crescent shaped ridge of 15 cm high across the local slope to harvest rain water.	800/-
5. Shifting sand dunes.	Pits of 60^3 cm are dug at 5m x 5m across the wind direction and planted with seedlings alongwith the earthen bricks or in the case of G. I. tubes or polythene bags, with the earth balls intact.	1000/-

ement of rains. If well distributed rains occur after planting, watering need not be done and if the plants show signs of wilting towards March-April, weekly watering may be adopted then onwards till the onset of rainy season.

Soil working techniques recommended for different soil types are detailed below.

COMPARATIVE GROWTH ATTRIBUTES

Acacia species from different isoclimatic regions of the world have been tried in the Research Farms of the Institute since 1962. Out of these *Acacia tortilis* (Forsk) has been adjudged as the best for arid zone afforestation. This species has established its superiority over other species when tried at different habitats viz., deep sandy soil, shifting sand dunes, rocky and semi rocky refractory sites, sandy loam shallow soils overlying hard calcareous pan beneath etc. Nursery raised seedlings of 10 to 6 months old when planted in different agroclimatic ragions of Western Rajasthan have proved their adaptability and suitability on seedling establishment and growth in height (Table I) (K. D. Muthana and G. D. Arora, 1973). Further this has been the only species which gave the maximum mean annual increment at the sites mentioned above viz., 61.0 c, 56.1 c, 44.0, 57.5 c and 55.5 cm respectively.

Ten to fourteen year growth studies done on sandy soils at Jodhpur with various other *Acacia* species revealed that *Acacia tortilis* exhibited 100 per cent survival and significantly increased growth in height (Ht.) collar diameter (CD) and diameter at breast height (DBH) as compared to the rest of the *Acacia* species (Table II).

Growth of *Acacia tortilis* was also compared with those of the most promising indigenous and exotic tree species and it has been established that *Acacia tortilis* plants exhibited significantly increased growth in height (Ht.), collar diameter (CD) and diameter at breast height (DBH) (Table III). From the data, it is evident that *Acacia tortilis* is the fast growing and much desired tree species over the slow growing indigenous tree species under desertic conditions where we are faced with shortage in supply of fuel and fodder in these arid regions.

A study was also conducted to determine the effect of weeding on seedling establishment and growth of *Acacia tortilis* on shallow sandy loam soils overlying hard calcareous pan, below 22 mm at Pali (Rajasthan).

The study revealed that frequency of weeding has definitely shown marked difference in all the growth attributes. Growth in control plots (no weeding) was the poorest. From the data, it was evident that even weeding twice round the plants is very beneficial and appreciably encourages the growth of the plants in such environmental conditions with shallow soil and low rainfall (Table IV).

Studies on fertilizer application for 3 consecutive years on the establishment and growth of *Acacia tortilis* at Jodhpur farm have shown no significant difference in height growth (Table V). It may be interesting to note that this species has grown more than five metres in height on an average in 8 years even in the control plots. In fact, growth in control plots gave better height growth than the fertilised plots indicating thereby that in such low rainfall regions with deep sandy soil fertilizer application may even have a depressing effect.

When introduced on rocky refractory sites (Kailana) to compare the performance of *Acacia tortilis* with that of *Acacia senegal*, the former attained three times increased growth in height under both direct seeding and transplanting as compared to the latter. In the case of direct sowing seeds, germination per cent of both these species was almost 100 but plant per cent declined in both the species i. e. *Acacia tortilis* recorded 87 per cent and *Acacia senegal* gave 60 per cent only. As regards transplanting done, the ultimate establishment in both these species was 100 per cent, which indicates superiority of planting over direct seeding. Transplanted seedlings of *Acacia tortilis* recorded 311.7 and *Acacia senegal* 118.8 cm as mean growth in height in 5 years duration, which was even less than *Acacia tortilis* plants (182.3 cm) established from sowing seeds in the same area (Table VI).

In Bikaner, Barmer, Jhunjhunu, Churu and other areas this Institute had done afforestation on barren shifting sand dunes in different years, to arrest their movement by planting *Acacia tortilis* seedlings. These seedlings have performed extremely well with 95 to 100 per cent establishment and their mean annual increment in height growth ranged from 50 to 75 cm on an average in these different agroclimatic regions (Table I).

Yield Studies : Studies on fuel yield cum coppicing behaviour revealed that this species is a very good and fast coppicer. Coppice shoots of 2 year old have recorded mean height of 384.0 cm. To attain this

mean height of 2 year old coppice shoots, seedlings initially transplanted took 4 years. Each stump has produced on an average 3 to 4 coppice shoots and 100 per cent shoot emergence was recorded from the felled trees of 12 years old plantation. Fuel yield recorded from the 12 years old trees from spacing trial has given very good indications that closer spacing yield more fuel wood than wider spacing. Fuel yield recorded in 1976 from 1964 plantation of *Acacia tortilis* is tabulated below.

Spacing	Yield in Tons/ha	
	Green wt.	Dry wt.
6 x 6 m	57.7	39.2
4.5 x 4.5m	61.0	44.4
3 x 3 m	76.4	53.6

A spacing of 3 x 3 m is advocated for fuel and for silvi-pastoral the spacing desired in 5 m to 6 m apart in lines and 10 m apart from row to row to provide ample scope and space for grasses to establish in between the tree rows. Grasses when introduced within the tree rows after felling the trees, yield annually on an average 2.0, 0.8 and 0.2 tonnes per hectare under 6 x 6 m, 4.5 x 4.5m and 3x3m spacing of trees respectively, for the first 2 years and the yield gradually declines as the tree canopy closes. If the objective is also for small timber for agricultural implements, cart wheels, etc. wider spacing say 6x6 m or 5 x 5 m is desirable to harvest stouter clear boles.

ROOT STUDIES

Recent study made on the root system of 5 years and 10 years old trees revealed that in places of deep sandy soils, overlying a Kankarpan, the tap root had not penetrated the Kanker pan (1.70 m) but had sent out lateral roots up to 20 metres away from the main stem (Fig. 3). In the case of shallow soils, the lateral roots have gone upto 18 m away from the main stem whereas the tap root has hardly gone beyond 1.20 m depth. On sand dunes, the tap root has gone beyond 4.5 m and the lateral roots have gone beyond 20 m. From such studies and observations made, it is evident that if this tree species is planted along the field boundary as live hedge or as shelterbelt, deep trenches of 0.50 m to 0.75 m depth and 0.30 m width should be dug out about 1 m away

from the row of plants to prevent root competition with the agricultural crops/fruit crops and isolate and arrest the lateral roots of these plantings.

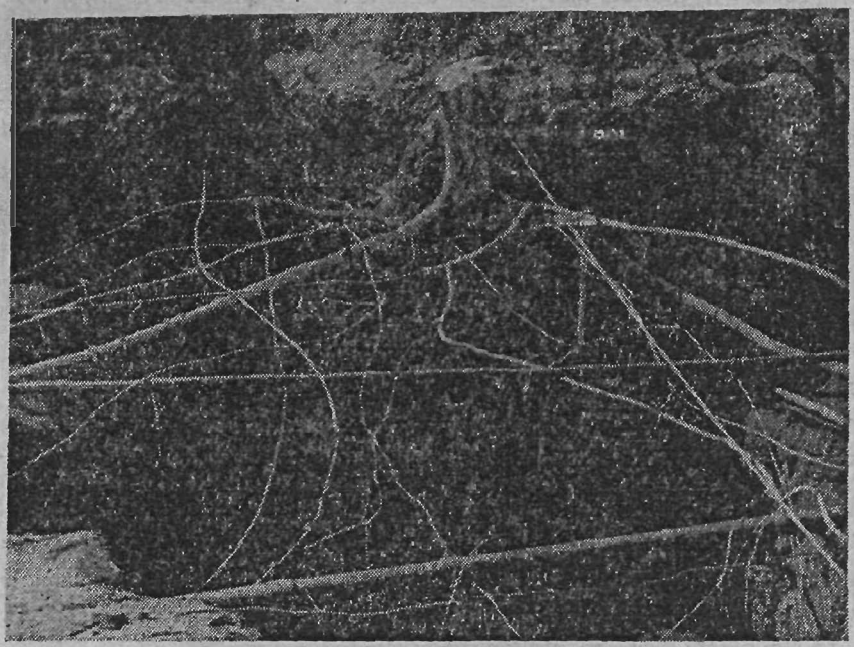

Fig. 3. Root Formation of *Acacia Tortilis* on Deep sandy soils.

ECONOMIC USES

Leaves and pods of this species have been .classified as good fodder (leaves having 19.00 CP and pods 15.4 CP). Yield of dry fodder and pods per tree has been on an average 4.0 to 6.0 kg and 10–12 kg respectively (Muthana *et al.* 1978).

Wood is hard and used as fuel. It has high calorific value (7800 Btu/pound) and compares equally with the other principal firewood tree species of Western Rajasthan. Wood is also used for charcoal making, small timber, agricultural implements, fence posts, construction of hutments, etc. Thorny branches are used for fencing the holdings, cattle sheds, sheep pens, etc. and tender green seeds are also used as vegetables in South Yemen (Arabia). Bark is reported to be rich in tannin. Tree also yields good quality gum. Wood if stored in open

yard is liable to be attacked by insects (borers), but if stored inside sheds remain free from insect damage. If sprayed with one per cent solution of DDT in oil or one per cent solution of Boric acid in water, prevents the fuel wood from borer attack. Economics worked out on an hectare basis (Table VII) indicate that cost benefit ratio is 1 : 2 (Muthana *et al.*, 1973).

In order to determine the optimum utilisation of a site, annual growth studies under each edaphic and climatic type may have to be done and the optimum rotation for each such site worked out when it is found that the peak rate of growth is obtained.

NEED FOR SELECTION AND IMPROVEMENT

From the studies, it is evident that *Acacia tortilis*, when compared with other tree species has given best performance under similar climatic conditions, soil types and uniform treatment as regards its growth in height, diameter and seed yield. There is a highly significant correlation between collar diameter of trees and their seed yield (Table VIII, Kaul, 1963).

In arid zones, priority should be given to improve the varieties of species which produce increased dry matter in terms of wood per tree. Considering all the good qualities of *Acacia tortilis*, a systematic selection and breeding is worthwhile to fulfill the enormous demand for plants and seeds.

Extension work : From all the above studies, it has been found that *Acacia tortilis* can be successfully established on different habitats under extreme conditions of rainfall and soils in the arid zones. The Institute has been supplying seeds of *Acacia tortilis* to various states since 1965. The supply had been more than 97.0 quintals of seed and 88,000 seedlings till the end of 1978. Tamil Nadu has extensively introduced this species on vast areas in Ramnad Dist. for stabilizing shifting sand dunes. Maharashtra State has successfully introduced it on black soils. Andhra Pradesh has raised plantations on all low rainfall regions to reclaim waste lands. Rajasthan has introduced it on shifting sand dunes and in all their afforestation programmes, on barren lands, roadside plantations, etc., in the desert districts in the west. Haryana State has covered vast areas with this species, especially along roadsides, canal banks and afforestation on shifting sand dunes. Gujarat state has also commenced raising this species on their low rainfall desertic regions in Kutch district.

ACKNOWLEDGEMENT

The authors take this opportunity to thank Shri C. P. Bhimaya, formerly Director and Sri R. N. Kaul, formerly Head, Division of Plant Studies respectively of this Institute for their guidance and initiating the studies on *Acacia tortilis*. We are also extremely grateful to Dr. H. S. Mann, Director and Dr. R. S. Paroda, Ex-Head, Division of Plant Studies of this Institute for their constant encouragement and guidance. Our thanks are also due to all the staff members of the Silviculture Section for their assistance rendered throughout.

REFERENCES

Kaul, R. N. (1963). A preliminary silvical study on *Acacia tortilis* (Forsk). *Indian Forester*, Vol. 89 : No. 1, 1963.

Kaul, R.N. and B.N. Ganguly (1963). Studies on the economics of raising nursery seedlings in the arid zones. *Annals of Arid Zone* 1 (2) : 1963.

Kaul, R.N. and B.N. Ganguly (1965). Trials on the introduction of Acacia in the arid zone of Rajasthan. *Indian Forester*, Vol. 91, No. 8, 1965.

Muthana, K.D. and Gyanchand (1973). Study on arid zone afforestation. Paper presented at winter School of Indian National Science Academy held at CAZRI, Jodhpur, 1973.

Muthana, K.D. and G.D. Arora, (1973). Study on *Acacia tortilis* (Forsk), a fast growing tree species for arid zones. Paper presented for Forestry conference held at Forest Research Institute, Dehra Dun, 1973.

Muthana, K.D. (1977). Improved techniques for tree plantation in the arid zone. Technical bulletin No. 2, CAZRI, Jodhpur, 1977.

Muthana, K.D. Gyanchand and G.D. Arora (1979). Silvical studies on Desert indigenous and exotic tree species. Paper presented at the International symposium on Arid Zone Research and Development held at CAZRI, Jodhpur, 1978.

Table I. Performance of *Acacia tortilis* under different agroclimatic regions (W. Rajasthan)

Location	Mean annual rainfall (mm)	Soil type	Age of plantation (years)	Mean growth (cm)		Survival (%)
				Ht.	DBH	
1. Jodhpur	320	Deep sandy soil	9	599.0	13.2	100
2. Pali	440	Shallow sandy loam overlying hard calcareous pan below 22 cm	9	547.0	10.8	98
3. Kailana (Jodhpur Distt.)	320	Rocky site with scattered soil pockets	6	304.0	7.5	100
4. Beriganga (Jodhpur Distt.)	320	Semi rocky site with accumilation of transported soil	5	328.0	8.0	100
5. Barmer	275	Shifting sand dunes	5	306.0	7.3	98
6. Jhunjhunu	445	Shifting sand dunes	6	460.0	7.6	100
7. Bikaner	265	Shifting sand dunes	9	480.0	8.0	90

Table II. Ten year and fourteen year growth data on survival and mean growth in Ht. CD and DBH of 7 Acacia species from different origin

S. No.	Species	Origin	Surviva l%		Mean Growth (cm) Height		CD		DBH	
			10 yr	14 yr	10 yr	14 yr	10 yr	14 yr	10 yr	14 yr
1.	Acacia tortilis	Israel	100	100	640.5	785.0	24.1	28.73	14.1	19.97
2.	Acacia gregii	Arizona	100	91	248.7	287.5	3.7	3.85	1.4	1.5
3.	Acacia salicina	Australia	100	82	615.5	649.4	12.2	14.6	7.6	9.94
4.	Acacia victoriae	Australia	100	82	183.5	245.0	3.9	4.45	2.9	3.65
5.	Acacia ligulata	Israel	36	10	594.2	610.0	18.5	20.8	8.9	13.0
6.	Acacia seyal	Kenya	73	64	284.4	361.4	5.0	6.8	3.3	4.85
7.	Acacia planifrons	Bellary (INDIA)	100	64	563.0	670.0	18.4	21.0	9.4	11.8

Table III. Comparitive performance of *Acacia tortilis* with exotic and indigenous promising tree species.

Species	Origin	Year of planting	Survival (%)	Mean ht. (cm)	Mean annual increment (cm)		
					Ht.	CD	DBH
Acacia tortilis	Israel	1962	100.0	703.30	50.27	1.49	1.17
Prosopis cineraria	Indigenous	1962	100.00	316.9	18.96	0.59	0.51
Tocomella undulata	,,	1962	92.31	431.60	27.86	0.73	0.66
Albizzia lebbek	,,	1962	84.61	442.1	14.00	0.82	0.69
Azadirachta indica	,,	1962	100.0	575.8	39.69	1.17	1.00
Holoptelia integrifolia	,,	1962	30.76	375.0	23.71	0.94	0.55
Acacia senegal	,,	1963	96.0	426.0	32.76	0.93	0.54
Acacia nilotica	,,	1963	100.0	596.6	45.80	1.26	0.82
Acacia catechu	,,	1963	84.0	560.2	43.00	1.22	0.70
Ailanthus excelsa	,,	1963	76.92	587.00	39.49	1.37	1.16
Tamarix articulata	,,	1963	61.53	247.80	12.75	0.83	0.30
Colophospermum mopane	South Rhodesia	1963	83.83	439.00	29.31	1.08	0.64
Dichrostachys glomerata	Israel	1963	91.66	347.27	21.53	0.64	0.44

Table IV. Type of soil working and frequency of weeding Pali 1963
Species : *Acacia tortilis*

Establishment and growth attributes	60 cm deep x 60 cm diameter pits with saucer depressions			90 cm deep x 60cm diam. pits with saucer depressions			60 cm deep x 60 cm diam. pits with ring trench			90 cm deep x 60 cm dian pits with ring trench		
	No weed-ing	Two weeding a year*	Weeding whole year	No weed-ing	Two weeding a year*	Weeding whole year	No weed-ing	To weeding a year	Weeding whole year	No weed-ing	Two weeding a year	Weeding whole year
Survival percent	100	97.91	95.85	97.91	95.83	100	100	93.75	95.83	93.75	95.83	100
Mean height (cm)	398.8	476.8	516.9	386.9	437.3	461.2	331.9	470.9	506.9	330.3	512.7	500.8
Mean collar diameter (cm)	6.86	11.28	12.50	7.40	11.28	11.81	6.28	11.06	12.04	7.34	10.99	12.05
Mean breast height diameter (cm)	4.86	8.05	8.88	6.14	6.53	5.70	3.69	7.76	8.87	4.17	8.24	8.97

*Two weeding a year i) a month after planting.
ii) by end of January, the following year.

Table. V. Effect of fertilizers on the establishment and growth of *Acacia tortilis*, Jodhpur (1970-1978)

Establishment and mean height	No Nitrogen				20 kg $(NH_4)_2SO_4$/ha				40 kg $(NH_4)_2SO_4$/ha				80 kg $(NH_4)_2SO_4$/ha			
	NO P_2O_5/	30 kg P_2O_5 ha	60 kg P_2O_5/ ha	120 kg P_2O_5/ ha	No P_2O_5	30 kg P_2O_5 /ha	60 kg P_2O_5 /ha	120 kg P_2O_5 /ha	No P_2O_5	30 kg P_2O_5 /ha	60 kg P_2O_5 /ha	120 kg P_2O_5 /ha	No P_2O_5	30 kg P_2O_5 /ha	60 kg P_2O_5 /ha	120 kg P_2O_5 /ha
Survival percent	100	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100
Mean height (cm)	636.7	641.1	638.6	658.5	575.0	582.9	548.0	571.4	540.0	562.9	514.0	536.7	583.8	631.3	578.6	490.0

Table VI : Height of plants (cm) at different sites under different treatments, Kailana (Jodhpur Distt.) (1965-70)

Treatments	Site			Mean (cm)
	I	II	III	
Acacia tortilis (Transplanting)	294.5	269.0	371.5	311.7
Acacia tortilis (Seed sowing)	156.5	191.0	199.5	182.3
Acacia senegal (Transplanting)	83.0	141.5	132.0	118.8
Acacia senegal (Seed sowing)	56.5	58.5	57.5	57.5
SEM ± (1)	13.4	16.0	13.7	6.1
F. Test	Sig.	Sig.	Sig.	Sig.
CD at 5%	37.3	62.9	53.9	17.7
C.D. at 1%	61.8	104.3	89.4	24.8

Reference to Sites :

I. Top of the slope with shallow soils

II. Middle of the slope with slightly less shallow soils

III. Bottom of the slope with more deeper soils

Table VII : Economics worked out on hectare basis (Spacing 5x 5m) species *Acacia tortilis*, Jodhpur.

Items	Cost Particulars	Amount (Rs.) Inputs	Items	Return Particulars	Returns (Amount(Rs.)
1.	Site preparation and layout	70.00	1.	Sale of seeds after 4 years	50.00
2.	Soil working i. e. digging and refilling pits	120.00	2.	Sale of top feed, twigs, thorns, etc. after 5 years	100.00
3.	Cost of seeds, sowing and transplanting	80.00			
4.	Cost of insecticides	40.00	3.	Sale of fuel wood (400 trees at 80 kg per tree) after 10 years rotation 300 quintals at 8/qt.	2400.00
5.	Replacement of casualities weeding and soil working in the first year	200.00			
6.	Weeding and soil working in second year	100.00			
7.	Maintenance for the rest of the perior	400.00			
8.	Cost of supervision, etc	40.00			
9.	Interest as fixed capital at 10%	89.00			
10.	Depreciation on fixed capital at 5%	45.00			
11.	Interest on variable capital at 5%	8.00			
	Total Rs.	1192.00		Cost benefit ratio = 1:2 Total Rs.	2550.00

Table VIII : Height, collar diameter and seed yield per tree (Jodhpur)

Tree No.	Height (cm) (a)	Collar diameter (cm) (b)	Seed yied (grams) (c)	Correlation coefficient
1.	505	12.6	910.74	
2.	450	17.8	628.60	
3.	540	14.0	953.90	
4.	550	9.7	511.30	
5.	528	8.4	62.00	rab = +.5277
6.	448	10.2	564.85	rac = +.7775**
7.	450	14.0	531.10	
8.	310	8.6	25.00	
9.	399	14.9	962.30	
10.	494	18.1	908.35	

**Significant at 1 percent level of significance