IPIL IPIL (*LEUCAENA LEUCOCEPHALA* LAM) - DE WIT IN PAKISTAN

M.I. Sheikh, K.M. Siddiqui & S. Rehman*

Leucaena leucocephala (Lam.) de Wit is a tropical legume with multipurpose characteristics. Some arboreal varieties of the species have done well under varying climatic and edaphic conditions of Pakistan. The present paper outlines the performance in Pakistan and compares it with a number of South Asian Countries.

1. Distribution and ecology

Leucaena is indigenous to Central America and originated in the midlands of southern Mexico about 2000 years ago (NAS 1977). Reached Philippines in 1565 and later on spread to Pacific Island, Indonesia, Malaysia, Papua New Guinea and South East Asia. During 1900 it spread to Hawaii, Fiji, Northern Australia, India, Africa and Caribbean Islands.

It is a member of the family leuguminosae and of subfamily mimmosidae and contains 10 species. Over 100 varieties are presently existing and these have been classified into three groups. These varieties have been assigned numbers with prefix "K". The growth characteristics of different varieties are often referred to as Hawaiian, Peruvian, Salvadorian, and "Hawaiian Giant" which are not varieties and the use of these names adds to confusion.

(i)	Rainfall:	600 – 2500 mm
(ii)	Temperature:	10 – 40°C
(iii)	Altitude:	0 – 500m depending on latitude
(iv)	Salt tolerance:	Partial tolerance; pH not below 5.5
(v)	Wind:	Withstands hurricanes when deep rooted.
(vi)	Rhizobial requirements	Does well in presence of Molybdenum, Boron and Zinc for good nodulation.
(vii)	Soils:	Prefers less acid soils and low lands; grows on rocky to heavy clay to coral type soils.

The species is a prolific seed producer with number of seeds varying between 18000 – 26000 per kg. As the seed is hard, it needs scarification. Seed may be kept for longer periods without loosing viability. It can be reproduced asexually with slight difficulty. Approximately 80% germination can be obtained by hot water (80°C) treatment for 2 to 3 minutes which can be further increased by then soaking for 2-3 days. It has been estimated that one kg seed would be sufficient for 9 hectares if germination is 100% and plants are spaced at 1 × 1 m. The species had been tested outside its range and done well in a number of countries as described below:

*Research Scientists, Pakistan Forest Institute, Peshawar

2. Review of the performance of the species in South Asian Countries

Man has deforested 1/3 of South America's native forests, 1/2 of Africa and 2/3 of South-east Asia in the recent past (NAS 1977). There is a need to protect the remaining forest cover from further damage and to reforest the new devastated areas. Most indigenous species take 50-70 years to mature and fast growing leguminous plants *e.g.* leucaena are seen as a first line of defence.

Leucaena had been planted outside its native range in a number of countries like; Australia, Malaysia, India, Thailand, Indonesia, Papua New Guinea, Philippines, Nepal, China, Taiwan and Pakistan. The performance of the species in these countries is described below:-

Benge (1980) reviewed the performance of different varieties of ipil ipil in a number of countries and reported that K-8, K-28 and K-67 had shown the most promise in terms of growth rate and forage production. K-8 variety is a sparse seed producer; K-28 produces more seed than K-8 but not as much as K-67. Therefore, he recommends that K-67 may be used in large scale afforestation programmes.

In the Philippines, dense leucaena plantations have yielded higher annual quantities of wood than any other species yet measured. Native fast growing hard woods *e.g. Albizia falcataria, Gmelina arborea, Eucalyptus deglupta* and *Anthocephalus chinensis* had grown with annual increments of 28-43 m3/ha while leucaena produced over 100 m3/ha per annum on best site. Hybridization studies on ipil ipil were also carried out among different varieties (K-8, K-28, K-67) for further improvement (FAO 1981).

Jones and Bray (1982) reportd that more than 100 introductions of various species were tested by CSIRO, Australia during 1955-1967. Two cultivar's were released to the grazing industry *viz* Peru (CPI—18614) and El Salvador (CPI–18623). Since 1977, the germ plasm collection increased and higher yielding lines like CPI–61227 (from Mexico) and CPI–58396 (from Barcelona) were developed in the continent.

Chee and Devendra (1982), Zulkifly and Ghani (1982) in Malaysia reported that a Peruvian variety, defoliated at 4 and 8 weeks interval, produced average annual yield of 3924 kg/ha and 5701 kg/ha respectively which are comparable with those reported from the dry tropics.

In Indonesia, Benge (1982) reported that varieties like K-8, K-28 and K-67 did well as firewood and poles. Extensive reforestation is being carried out using leucaena and more than 30,000 ha have been covered so far. It was also found that tea interplanted with leucaena has out-grown pure stands by almost 100% (NAS 1977). The species is also used as green manure, nurse tree and nurse crop.

Panday (1982) found that leucaena was not accepted by the farmers in Nepal. However, in Southern China, when tropical forests were cut or burned, nearly worthless coarse grass often takes over. Leucaena is one of the few plants that can also compete with vigorous grasses (NAS 1977). The species was introduced in China in about 1920 and it was found that Salvador type is well adapted to China (Houming 1982). During 1977 research in Papua New Guinea indicated that leucaena bushes markedly increased the soil nitrogen in only two years and bushes were easy to clear.

Benge (1982) reported that a leucaena cultivar (K-156) grew better in Mauritius and K-8 in Haiti.

In Taiwan, Wei and Kiang (1982) found that Salvadorian type leucaena (K-8, K-72 and SI) was found to grow 10 times better than local variety at 3 years after planting.

Pathak and Patil (1982) reported that leucaena was introduced as fodder crop on unproductive land in India mainly to support a dairy farming programme. Comparing the volume of different varieties of Ipil Ipil, it was observed by the authors that the total volume of Elsalvadorian type was greatest as compared with K-8 and K-28.

Dutta and Urmila (1987) have reported a field trial on the effect of coppicing at different heights for wood production in Ipil Ipil in 7m × 7m plot. Planting was done at 1m × 2m, in all 5 treatment replicated 4 times. The treatments were coppiced at ground level, 25 cm, 50 cm, 75 cm and 100 cm after 2 years growth. The results of the study revealed that:

— Significant increases in the number of sprouts produced per stump at 25 cm, 50 cm, 75 cm and 100 cm coppicing heights over coppicing at ground level.

– Significant increases in height, diameter and volume of the coppiced stems at 50 cm, 75 cm and 100 cm coppicing heights over coppicing at ground level and at 25 cm height.

— Differences between 50 cm, 75 cm, and 100 cm coppicing heights on the number of sprouts produced per stems were not significant.

— Differences between 50 cm, 75 cm and 100 cm in coppicing heights on height diameter and volume of coppiced stems were not significant, except in a few cases, where the increase was marginally significant. These results are presented in Table 1.

Table 1.

Effect of coppicing at different heights on the number of sprouts produced per stump and on height, diameter and volume of coppiced stems.

Coppicing heights	Sprouts / stump	Height			Dbh			Volume*		
		1 yr	2 yr	3 yr	1 yr	2 yr	3 yr	1 yr	2 yr	3 yr
			m			cm			m3 / ha	
Ground level	11.3	5.9	6.7	8.1	3.2	3.7	4.6	29.5	44.8	85.9
25 cm	15.2	5.9	7.0	8.4	3.4	3.9	4.8	34.0	53.3	96.6
50 cm	15.8	6.4	7.4	9.3	3.9	4.4	5.7	48.4	72.8	153.3
75 cm	17.2	6.4	7.6	9.1	4.0	4.8	5.8	50.7	88.5	155.4
100 cm	15.0	6.2	7.4	9.0	4.0	4.4	5.9	48.6	72.3	158.3

*Volume = 0.5 × Dbh2 × height (× population density)

For maximizing coppiced wood production, it appears that young plantations of leucaena should be coppiced at heights ranging between 50 cm to 100 cm.

Mohatkar and Relwani (1987) have reported the results of comparative growth of *Leucaena leucocephala* var. K-8 with 12 other species in India. Average growth of trees after 13 months indicated that K-8 had the best height of 4.3 and a satisfactory DBH (6.0 cm). *Gmelina arborea* showed the largest DBH (8.0 cm), followed by *Erythrina indica* (7.5 cm), but these species did not achieve the height of *Leucaena leucocephala*. The second best in height was *Cassia siamea* (4.0 m) and third one was *Erythrina indica* (3.0 m). Planting was done at 2 × 2 m spacing and plants were spot watered regularly until the establishment of the roots and shoots. Watering was discontinued after the rainy season began. The plantations were later spot watered with 3 or 4 litres of water per plant at an interval of 10 and 7 days in the winter and summer seasons respectively.

3. Work done in Pakistan

Based upon aforementioned observations of various workers and keeping into consideration the usefulness of Ipil Ipil, several studies were undertaken by the Pakistan Forest Institute, Peshawar.

3.1 *Varietal tests.*

To meet the ever increasing wood/forage demand in Pakistan, the PFI conducted studies on the performance of Ipil Ipil varieties in different regions. The varieties had been tested on 4 sites *viz* Peshawar (NWFP) Daphar and Chichawatni (Punjab) and Miani (Sind) and total of 6 acres area had been covered so far.

On few sites the species had been planted alongwith other broadleaf species for better comparison as growth and wood yield are a function of site, quality, age, spacing

and management. All of these have to be integrated into yield models for production purposes. Seed stands of the species have also been established for germplasm conservation. The total area on such sites is about 6 ha. The Provincial Forest Departments have started planting the species for firewood / forage / ornamental recently.

Although the species was introduced in early sixties in Pakistan but systematic work has been conducted since 1979 when seed of six varieties was procured from USA (Siddiqui and Khan 1983). The origin of these varieties is as under:

Table 2

Origin of Ipil Ipil varieties tested in Pakistan*

S.	Variety	Origin	Type	Comments
1.	K-8	Hawaii	Salvador	Nil
2.	K-8	Mexico	"	Uniform, low-seedy "giant"
3.	K-28	Salvador	"	Similar to K-8
4.	K-29	Honduras	"	Very low seediness and limbiness
5.	K-67	Salvador	"	More genetic variability
6.	K-132	Mexico	"	Very long pods
7.	P.F.I.	Philippines	"	Nil

*After Brewbaker and Hutton (1979)

Height-growth data were recorded for all sites except Chichawatni where only survival had been recorded so far. The average height/diameter values for three locations are as under:

Table 3

Comparison of different varieties of Ipil Ipil planted at 3 sites in Pakistan (unpublished data)

	1. PFI (NWFP) 4 years		2. MIANI (Sind) 3 years		3. Daphar (Punjab) 3 years	
	Ht. (m)	Dia (cm)	Ht. (m)	Dia (cm)	Ht. (m)	Dia (cm)
1. K-8 Hawaii	6.9	5.7	9.4	12.0	5.4	3.8
2. K-8 Mexico	7.0	5.7	-	-	-	-
3. K-28	7.8	6.3	9.7	12.6	5.0	3.5
4. K-29	8.8	7.0	8.9	10.3	4.6	3.2
5. K-67	9.3	7.8	9.3	12.3	4.0	3.7
6. K-132	2.8	1.9	9.1	10.5	5.3	3.8
7. Local (Pesh)	-	-	-	-	5.1	3.7
8. Philippines	8.0	6.7	-	-	4.2	3.0

The above table indicates that among these varieties, K-67 and K-8 seem to perform better under varying climatic conditions of Pakistan (Sheikh 1982).

3.2 *Effect of Frequency of irrigation and comparison with different species*

A study was planted in July 1982 (Sheikh 1985) to determine the effect of 5 watering frequencies namely weekly, 2-weekly, 3-weekly, 4-weekly and no watering on the survival and growth of 4 fodder species *viz. Leucaena leucocephala, Robinia pseudoacacia, Ceratonia siliqua* and *Tecoma undulata.* The data collected in May 1985 is reproduced below:

Table 4

Survival out of 28 plants of different species growing under different irrigation frequencies

Irrigation frequency	*Leucaena leucoce-phala*	*Robinia pseudo-acacia*	*Ceratonia siliqua*	*Tecoma undulata*	Average irrigation for frequency
1	2	3	4	5	6
Weekly	28	23	22	14	22
2-weekly	27	18	24	25	24
3-weekly	27	19	24	26	24
4-weekly	26	21	26	27	25
No irrigation	27	5	21	26	20
Average for the species	27	17	23	24	23

The above data show that there is no significant difference between survival of plants with different irrigations. However, the survival of *Robinia pseudoacacia* decreases with increase in the watering interval. This shows that *Robinia pseudoacacia* will not grow well without irrigation at Peshawar (Average annual rainfall 350 mm). There was no appreciable difference in the survival of *Leucaena leucocephala, Ceratonia siliqua* and *Tecoma undulata.*

The average height of the surviving plants of various fodder species under different irrigation frequencies are given below:

Table 5

Average height (cm) of different species under various irrigation frequencies, age 3 years

Irrigation frequencies	*Leucaena leucocephala*	*Robinia pseudo-acacia*	*Ceratonia siliqua*	*Tecoma undulata*	Average for irrigation frequencies
Weekly	621	530	545	461	544
2-weekly	202	430	547	327	376
3-weekly	222	411	541	324	374
4-weekly	211	403	452	331	349
No irrigation	211	410	483	238	432
Average for the species	293	437	519	336	416

The above data show that there is appreciable difference in the rate of growth among the species as well as irrigation frequencies.

3.3 Biomass production studies

3.3.1 *Biomass production from fast growing tree species.*

In order to find out the rate of growth and biomass production of different fast growing species, a study was conducted in the research garden of Pakistan Forest Institute, Peshawar (Sheikh 1985). Following species and clones were selected for the study.

Eucalyptus: *E. camaldulensis, E. citriodora, E. grandis*
Poplar 7 clones: 1-6351. S7C13, AY 48, China, S7C3, ST 67, I-18 / 62
Ipil Ipil (*Leucaena leucocephala*)

Planting was done in January 1982 at 2 × 2m spacing on trenches in 4 replications. There were seven trenches, 8 plants on each trench and 56 plants in each sub plot. Since Janter (*Sesbania* spp) plants died due to transplanting shock and frost, these were cut back to 3 cm from ground level. Also as a safeguard seed of Janter was sown which ultimately became the plants.

The experimental area was irrigated fortnightly giving about 10 cm depth of water in each irrigation. Diameter and height data recorded in 1985 are given in Table 6.

Table 6

Diameter and height of 4 species recorded at different sites

	Eucalyptus		*Poplars*		*Ipil Ipil*		*Sesbania*	
	Dia (cm)	Ht (m)	Dia (cm)	Ht (m)	Dia (cm)	Ht (m)	Dia (cm)	Ht (m)
January, 1985	5.9	7.2	5.8	7.2	4.2	6.5	4.0	4.7

Data on green and dry wet are summarized below:

Sl. No.	Species	Age year	Average weight / plant (kg) Green	Dry	
1.	*Leucaena leucocephala*	1	2.63	1.32	
		3	6.87	4.83	6.15
2.	*Sesbania aegyptiaca*	1	3.62	1.70	1.70
3.	*E. camaldulensis*	1	2.34	1.36	
		3	11.02	5.60	6.96
4.	*E. grandis*	1	1.68	0.31	
		3	1.09	0.58	0.89
5.	*E. citriodora*	1	1.68	0.92	
		3	3.70	1.82	2.74
6.	*Populus deltoides* clones	1	1.21	0.61	
		3	3.51	1.82	2.43

Results: Based on air dried weight of biomass:

- Among all the species *Eucalyptus camaldulensis* is the best in biomass production followed by Iple Iple at age three years.
- *Sesbania* is the best in biomass production at age one year followed by *Eucalyptus camaldulensis* and Iple Iple.
- *Eucalyptus grandis* is the poorest of all the species in biomass production.

3.3.2 **Biomass from different spacings.**

In order to find out suitable spacing for optimum production of biomass from Ipil Ipil, Sheikh (1987) has reported results of a study laid out in Research Garden, PFI, in May 1985 using six spacings in four replications. The number of plants for different spacings in each replication are:

Spacing	*No. of plants*
A = 0.50 × 0.50 m	560
B = 0.75 × 0.75 m	234
C = 1.00 × 1.00 m	140
D = 1.25 × 1.25 m	88
E = 1.50 × 1.50 m	54
F = 1.75 × 1.75 m	40

During January, 1987 one year old coppice shoots were harvested from half of the plot of each spacing. The biomass data collected are given below:-

Spacing (m)	Average No. of coppice per stool	Average dia (cm)	Average Ht. (m)	Average green weight coppice per stool (kg)	Average production per ha. (tonnes)
0.50 × 0.50	1.98	1.5	3.63	1.45	58.0
0.75 × 0.75	3.08	1.8	4.02	2.82	50.1
1.00 × 1.00	3.31	2.0	4.16	3.99	39.9
1.25 × 1.25	3.75	2.1	4.35	5.23	33.5
1.50 × 1.50	5.42	2.2	4.35	9.72	43.2
1.75 × 1.75	5.20	2.3	4.27	10.30	33.6

Maximum yield was obtained from the closest spacing

4. Rotation

Generally the tropical timber species have rotations of 50-80 years which is considered too long for conventional economic planning and investment. Leucaena, on the other hand, could be managed comparatively on shorter rotation.

Leucaena plants grazed rotationally are usually long lived with good stands persisting for more than 20 years without the need from regeneration from seed. Many reports indicate that optimum forage yield is obtained when the plant is cut after it is 100-150 cm height (Pound and Cairo 1983).

It has been reported that 40,000 stems per hectare may be harvested before the first year. If household firewood is to be obtained, close spacing (20,000-40,000 per hectare) would be suitable producing uniform stems about 3-4 cm in diameter and 46 cm in height which may be cut at two years age.The optimum plant density for poles would be 10,000-20,000 per hectare over a 3-4 year rotation. For pulpwood production, wider spacing 5000-10000 per hectare or less on 4-5 year rotation would be superior. Where labour is cheap the stand could be established at a closer spacing and thinned back to the desired stocking density by 2-3 years.

It has been also observed that Hawaiian-type cultivars could profitably be managed at six years rotation. It has been recommended that 10-20 cm cutting height should be left when clear felling trees. About 1-4 good shoots should be left for coppice regrowth which should start 2-3 year after cutting. The Salvadorian varieties are comparatively newly discovered and so far no firm recommendations on the rotation have been made.

Under Pakistani conditions it is recommended to have closer spacings (40,000-60,000 plants per hectare) to get highest short term biomass yield and then to thin progressively to final stand 4-5 years using thinning as fuel or forage.

5. Pests and diseases

5.1 *Leucaena psyllid (Heteropsylla cubana)*

An insect pest called leucaena psyllid (jumping plant lice) has spread rapidly to Asia and the Pacific in the past few years. The psyllid are tiny usually 1-2 mm insects of the family psyllydae, often causing serious damage to *Leucaena leucocephala.*

Psyllids have long been known to feed on Leucaenas in the Caribbean islands. In late 1983, they were discovered defoliating leucaena in Florida. In April 1984, psyllids were found in Hawaii and caused serious defoliation there since then. In 1985 and 1986 the insects arrived in the South Pacific, Australia and Southeast Asia and are expected to become pantropical.

A regional research plan is being developed through a series of national and regional meetings by F / FRED (Forestry / Fuelwood Research and Development Project) coordinating unit in Bangkok.

6. Uses

As a multipurpose tree species, Ipil Ipil has been called "Tree of Life", and sometimes "Miracle Tree". The species possesses following desirable characteristics:-

6.1 *Fuelwood*: Leucaena wood makes excellent firewood and charcoal. New varieties are so productive that they are already being planted to provide fuel for electric generators and allied factories / industries. The species is fast growing and readily coppices. The calorific value is 4200-4600 k calories/kg. Charcoal has a heating value of 7000 k calories/ kg (NAS 1977).

6.2 *Forage*: Cattle feeding on leucaena foliage in Queensland, Australia has shown some of the highest weight gains ever measured in the tropics. The leaf meal is suited mainly to cattle, water buffalo and goats. Leucaena foliage is highly palatable, digestable and nutritious. The plants are drought tolerant making it promising candidate for increasing meat and milk supplies throughout the dry tropics.

6.3 *Timber*: The newly discovered arboreal leucaena varieties grow rapidly, yielding wood of useful size for lumber and timber. Its wood has the potential to become a major source of pulp and paper, round wood and construction material.

6.4 *Soil Improvement*: Leucaena is a nitrogen fixing legume that helps to enrich soil and aids neighbouring plants. Its aggressive root system also breaks up the impervious sub-soil layers, improves soil moisture penetration nand decreases surface runoff.

6.5 *Reforestation*: Th species thrives on steep slopes, marginal soils and in areas with extended dry season, which makes it a prime candidate for restoring forest cover to watersheds, slopes and grass lands that have been denuded through wood cutting and fire.

6.6 *Miscellaneous*: It can be used as an intercrop. Helps controlling erosion and can be used in landscaping, shading, windbreaks and fire breaks. Seems resistant to insects and pests. Can also be used to suppress grasses like: *Imperata cylinotrica* and *Saccharrum spontaneum* which are the notorious weeds in Pakistan.

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