Early survival and growth of three fodder trees in the mid-hill farmlands of Nepal

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A participatory study on survival percentage and growth rate of *Artocarpus lakoocha*, *Morus alba* and *Leucaena diversifolia* was carried out in farmlands at Dhading, Kabhrepalanchok and Sindhupalchok districts. Soil samples collected from each experimental plots were tested for pH, texture, organic carbon, nitrogen, phosphorus and potassium. Similarly, survival percentage and height growth of the seedlings were recorded in every two months. Soil properties were found to be significantly different (p=0.00-0.05) across the plots. Of the three species, *L. diversifolia* displayed significant variation in survival and growth rate (p=0.008) among the villages and correlated strongly with pH (r=0.87; p=0.05). In contrast, *Morus alba* (p=0.07) (p=0.06) and *Artocarpus lakoocha* (p=0.07) (p=0.23) variation in survival and growth rate was less significant between the plots. Performance of the three species were in the order of *L. divesifolia* > *M. alba* > *A. lakoocha*.

Keywords: Survival, growth, fodder trees *Artocarpus lakoocha*, *Morus alba*, *Leucaena diversifolia*, farmlands

Farm trees constitute an integral component of the traditional farming system in the mid-hills of Nepal. They provide range of tree products that are essential to sustain farmers' livelihood, agricultural productivity and animal husbandry (Mahat, 1987; Singh and Sharma, 1990). Farm trees support livestock by supplying fodder, which is extensively used particularly in dry period as a valuable nutritive diet. It is estimated that private trees supply fodder ranging from 5% to 60% of the total annual tree fodder requirements of the animal in the country (Heuch, 1986). In Dhading, Kabhrepalanchok and Sindhupalchok districts farm trees fulfill nearly half of the total yearly fodder demand (Hada *et al.* 1997).

In the recent past the number of trees along the terraces, risers and gullies of the farmland has grown quite considerably (Das and Oli, 2001; Gilmour, 1995; Thapa, 1994; Shrestha, 1997). As a result the supply of fodder has improved to some extent in fulfilling the demand posed by rapidly growing human and livestock population together with deficit caused by sizeable loss of national forest (DFRS/FRISP, 1999, 1989). Early initiatives made in this regard consist of plantation of various tree species such as *Artocarpus lakoocha, Morus alba, Leucaena diversifolia* and several others that can give fodder in dry period (Warner *et al.*, 1999; Karki and Gold, 1992; Harrison, 1988; Veldhuis, 1988; van der Dool, 1987). The majority of planted trees displayed significant variation in their survival and growth between the species, which in many cases were linked with miss-match of the site (van der Dool, 1987; Karki and Gold, 1992; Demanski and Bashyal, 1990).

Site requirements of many tree species have long been established and documented (Webb *et al.*, 1984; Singh, 1984; MPTS, 1990), however, similar information based on local site conditions, which, in the hills, varies tremendously even in shorter distance, are very limited (Howell, 1989; Jackson, 1994). The present investigation describes the performance of *A. lakoocha, M. alba,* and *L. diversifolia* in different soil conditions of the mid-hill farmlands and attempts to establish relation between inter-site variation of soil properties and early survival and growth of these species.

Material and Methods

Site and species selection

All the sites and tree species used in the study were chosen with the participation of the local farmers. A committee consisting of 50 keen and enthusiastic local farmers 10 from each village and project staff was involved in this process (Hada *et al.*, 1997). The study sites were basically a *bariland* (rainfed land) located at Gajurichhap, Gauthale in Dhading District, Tawari and Chankhubesi in Kavrepalanchock District

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and Ange in Sindhupalchok District. Similarly, the selected species were all fodder such as *A. lakoocha*, *L. diversifolia* and *M. alba*.

Site description

Gajurichhap (27° 49'; 84° 52') and Gauthale (27° 49'; 84° 50'), at an altitude ranging between 650-790 m above sea level (masl) lie in Kumpur and Salang Village Development Committees (VDCs), ward no. 3 and 9 respectively of Dhading District. The climate in both the VDCs is sub-tropical and annual rainfall is about 1213 mm. Annual temperature ranges from 8.9° C to 30.4° C. Soils are loamy soil at Gajurichhap while clay loam at Gauthale.

Tawari (27° 31'; 85° 33') is located near Khopasi, the nearest town on the Dhulikhel road, at an elevation of 1750 m a.s.l in ward no 5 of Mahankalchour VDC. It has a cool temperate climate. Chankhu besi (Naya Gaun) (27° 34'; 85° 27') is situated at an altitude of 1200 m a. s. l. in ward no. 6, Dhulikhel Municipality, which is 30 minutes walk from Arniko highway. It has also temperate climate. Annual precipitation is 1213 mm and temperature varies from 4.6° C to 32°.7 C. Soils at Tawari and Chankhu Bensi are silt loam and loam respectively.

Ange (27° 41'; 85° 55') lies near Tipeni, ward no. 9, Langarehe VDC at an altitude of 1500 m. The climate is warm temperate with fairly high annual rainfall of about 1475 mm. In winter temperature goes down to 4° C while in summer temperature reaches to 38° C. It has sandy loam texture.

Experimental layout

Ten experimental plots were laid out in each village with every plot having twenty meters long terrace and about two meters deep riser. Six tree species and 5 grass species were planted in each riser. Tree and grass species planted in the experimental plots within a village was same, however, they differed from other village (Kiff *et al.*, 1999). Species like *A. lakoocha*, *L. diversifolia* and *M. alba* were common to all the villages and therefore they have only been taken in account in this paper.

Plantation

Plantation was done in early July 1999. Altogether five different species of trees and six grass were planted on surface and riser of the study plots. Although, trees and grass species planted in each village was different, *L. diversifolia*, *A. lakoocha* and *M. alba* were common in all. *L. diversifolia* was planted in the surface layer and the spacing at 50 cm, while *A. lakoocha* and *M alba* were planted in the bottom layer and their spacing varied with site. In the middle part of the riser, which was planted with stylo and molasses grass the spacing was retained at 25 cm. Height growth and survival percentage of the seedlings were recorded every two months after plantation.

Soil sample collection and analysis

A composite soil sample was taken from each at 0-20 cm, 20-40 cm, 40-100 cm and 100-200 cm depth of the riser. All the samples were analyzed for pH, texture, total organic carbon (C), total nitrogen (N), available phosphorus (P) and exchangeable potassium (K), following the methods given in the manual by Anderson and Ingram (1993).

Results

Physico-chemical properties of the soil samples collected from the study plots are given in Table 1. All the soils displayed marked variation ($p<0.001$) across the plots in their physical and chemical properties, except for exchangeable potassium. Similar difference was observed within a village down the profile in total nitrogen and carbon contents (not show in the Table 1).

Soil texture ranged from coarse to fine soil with Ange having sandy loam soil, whereas Gauthale had clay loam. Gajurichhap, Chankhubensi and Tawari had medium textured loam and silt loam soils respectively. Soil pH in the entire experimental plots was acidic with highest soil reaction (6.11) at Gajurichhap, whilst the lowest (4.65) at Chankhubensi. Soil nutrient contents were generally high in the surface layer and it gradually decreased down the layers. Total nitrogen, organic carbon and exchangeable potassium contents were highest at Tawari, whereas available phosphorus was highest at Chankhubensi.

Table 2 shows the survival and growth rate of three fodder seedlings. Overall survival rate of the seedlings ranged from 45.1% at Chankhubesi to 84.8% at Gajurichhap. *L. diversifolia* displayed both the highest and the lowest survival rate among the three species. The highest survival rate of *L. diversifolia* was at Gajurichhap (84%) followed by Gauthale, Tawari, Ange and Chankhubesi. The second highest survival rate was observed in *M. alba* (82.4%) at Tawari and was followed by *A. lakoocha* (78.1%) at Gauthale and *L. diversifolia* (45.8%) at Ange respectively. On an individual species basis, survival percent of *A.*

Table 1. Analytical results of soil samples collected from the experimental plots

Soil Test	Depth (Cm)	Experimental Sites (VDC)					F-test Sig. level
		Gajurichhap	Gauthale	Tawari	Chankhubensi	Ange	
pH	0-20	6.11	5.95	5.54	4.65	5.27	0.000
	20-40	6.08	5.94	5.50	5.19	5.31	
	40-100	6.10	5.89	5.53	5.24	5.41	
	100-200	6.08	5.84	5.46	5.34	5.48	
Sand	0-20	40	26	25	43	68	0.000
(%)	20-40	38	26	25	38	67	
	40-100	37	24	24	40	67	
	100-200	36	26	25	43	61	
Silt	0-20	43	47	57	42	22	0.000
(%)	20-40	43	47	57	43	23	
	40-100	44	47	56	42	21	
	100-200	43	43	53	39	24	
Clay	0-20	17	27	18	15	10	0.000
(%)	20-40	19	27	18	19	10	
	40-100	19	29	20	18	12	
	100-200	21	31	22	18	15	
Texture	0-20	L	CL	STL	L	SL	-
	20-40	L	CL	STL	L	SL	-
	40-100	L	CL	STL	L	SL	-
	100-200	L	CL	STL	L	SL	-
Exch. K+	0-20	0.15	0.27	0.33	0.32	0.28	0.052
(me)	20-40	0.16	0.21	0.14	0.26	0.23	
	40-100	0.18	0.22	0.12	0.20	0.25	
	100-200	0.18	0.28	0.11	0.22	0.29	
Avail P	0-20	6.51	12.31	10.01	83.65	56.52	0.000
(ppm)	20-40	4.04	10.44	5.74	74.71	46.71	
	40-100	3.34	9.70	5.18	38.45	47.06	
	100-200	3.17	13.08	3.42	43.89	50.88	
Org. C	0-20	1.10	1.21	1.84	1.16	0.87	0.005
(%)	20-40	0.91	1.04	1.25	0.92	0.67	
	40-100	0.71	1.04	0.94	0.78	0.63	
	100-200	0.77	0.94	0.75	0.63	0.55	
Total N	0-20	0.12	0.13	0.16	0.10	0.08	0.000
(%)	20-40	0.10	0.11	0.12	0.08	0.09	
	40-100	0.08	0.11	0.09	0.07	0.05	
	100-200	0.09	0.11	0.07	0.05	0.04	

SL = Sandy Loam; CL = Clay Loam; L = Loam; STL = Silty Loam

lakoocha was in the order of Gauthale (78.1%) > Gajurichhap (73.7%) > Chankhubesi (56.2%) > Ange (50 %), whereas in the case of *M. alba* it was in the sequence of Tawari (82%) > Gauthale (77.3%) > Ange (64%) > Gajurichhap (56.2%) > Chankhubesi.

Growth rate of tree seedling had a trend similar to that of survival rate with *L. diversifolia* having the highest growth followed by *M. alba* and *A. lakoocha*. It ranged from 2.3 cm in case of *A. lakoocha* at Gauthale to 55.2 cm in *L. diversifolia* at Gajurichhap.

Of the three species *L. diversifolia* exhibited noticeable differences in survival ($p = 0.008$) and growth ($p = 0.016$) between the plots, whilst *M. alba* ($p = 0.07$) ($p = 0.06$) and *A. lakoocha* ($p = 0.07$) ($p = 0.27$) were comparatively less variable.

Correlation matrix between soil characteristics and survival/growth rate is presented in Table 3. Of the three species *L. diversifolia* displayed strong correlation between soil pH and survival percent ($r = 0.96$; $p = 0.01$) and a little less with growth rate ($r = 0.79$; $p =$

Table 2: Average survival and growth rate of the seedlings planted in the study sites (9 months data)

Parameter	Species	Experimental Sites					F-test Sig. level
		Gajurichaap	Gauthale	Tawari	Chankhu	Ange	
Survival	*A. lakoocha*	73.7	78.1	-	56.2	50.0	0.073
(%)	*L. diversifolia*	84.8	71.7	50.4	45.1	45.8	0.008
	M. alba	56.2	77.3	82.4	54.8	64.0	0.070
Growth	*A. lakoocha*	7.3	2.3	-	16.1	9.8	0.276
(cm)	*L. diversifolia*	55.2	29.1	24.0	23.7	22.2	0.016
	M. alba	28.5	10.1	17.5	41.7	27.9	0.060

Table 3: Correlation matrix for survival percentage and growth of fodder sp. versus soil properties

Test	Plant Survival (%)						Plant Growth (cm)					
	A. lakoocha		*L. diversifolia*		*M. alba*		*A. lakoocha*		*L. diversifolia*		*M. alba*	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
pH	0.88	0.12	0.96	0.01	-0.06	0.93	-0.74	0.25	0.79	0.11	-0.37	0.53
Exch. K	-0.34	0.66	-0.49	0.40	-0.24	0.69	-0.30	0.70	-0.60	0.28	-0.00	1.00
Total N	0.98	0.02	0.60	0.27	-0.37	0.53	-0.82	0.18	0.36	0.54	-0.69	0.20
Organic C	0.93	0.07	0.14	0.82	0.53	0.36	-0.79	0.21	-0.08	0.89	-0.74	0.15
Avail P	-0.97	0.02	-0.72	0.16	-0.48	0.41	0.68	0.31	-0.55	0.33	0.59	0.29
Sand	0.86	0.13	-0.39	0.51	0.52	0.37	0.55	0.45	-0.17	0.77	0.59	0.29
Silt	0.86	0.13	0.28	0.65	0.52	0.37	-0.33	0.67	0.16	0.80	-0.40	0.50
Clay	0.83	0.17	0.55	0.34	0.57	0.31	-0.75	0.25	0.17	0.77	-0.75	0.14

0.11). In case of *A. lakoocha* positive correlation was observed between survival percentage and nitrogen ($r = 0.98$; $p = .02$), organic carbon contents ($r = 0.93$; $p = 0.07$) and available P ($r = -0.97$; $p = 0.02$). Whilst, *M. alba* did not show any such correlation with any soil characteristics except for clay content with growth rate ($r = -0.75$; $p = 0.14$).

Discussion

Tree seedlings raised in the study plots in the field condition without any external inputs appear to have survived quite well. Height growth of these seedlings, however, were relatively inferior compared to other studies having additional nutritional input and water.

Of the three species, *L. diversifolia* has displayed significant variation in survival percentage and growth rate, and strong positive correlation with soil pH. The higher growth rate at Gajurichhap, which differs from the value reported by (Sunil Puri *et al.,* 1992; Bertalot and Guerrini, 1998; Shakya, 1990), can be attributed to their higher pH level (6.11 and 5.95). Similarly the higher survival percentage at Gajurichhap (84.8%) and Gauthale (71.7%), which is similar to the findings of Puri *et al.,* (1992); Shakya (1990); Khajuria and Singh (1991) and Harrison (1988), is also related with higher pH. While lower growth and survival rate at Tawari (50.4%), Chankhubesi (45.1%) and Ange (45.8%) that agrees with Veldhuis (1988), Pradhan (1988) and van der Dool (1987) seems to be due to lower soil pH (4.6 to 5.5). This indicates that *L. diversifolia* is susceptible to soil pH. Several sites in Asia with low pH have shown poor survival of *Leucaena* species (Khoa *et al.*, 1997; Castillo *et al.,* 1997). Kadita and Mulongoy, (1991). Cheng and Pan (1988) in a separate study also found that growth of *L. diversifolia* was retarded in soil pH 4.35. It, however, differs from the results of Hutton (1990, 1995); Oakes and Foy (1984) and Sorenson and Brewbaker, (1986), which show that *L. diversifolia* tolerate some acidic soil.

Although *L. diversifolia* is a nutrient demanding species (Baggayan, 1990), it has failed to show any such relation with soil nutrient contents in this study. Possibly this is due to the low pH as a result even the higher nutrients were not be taken up. The other reason could be the moisture stress during the dry period and lack of adequate care, to which this species is susceptible to (Van Den Belt, 1984), may also have contributed in restricting its height growth. Moreover, the higher survival and growth rate at Tawari, which is located at relatively higher altitude than at Chankhubesi and Ange suggest that this species is cold tolerant, which agrees with the findings of Khajurai and Singh (1991) and Gutteridge and Sorrenson (1992).

Morus alba has demonstrated some differences in survival ($p = 0.06$) and growth rate ($p = 0.07$) among the plot, but these parameters do not show any correlation with soil characteristics. Previous studies indicate that this species responds to fertilizer application (Potdar *et al.,* 1997; Sriharsha and Shankar, 1998), however, in the present case the survival rate appears to be linked with the moisture availability, as it is drought sensitive (MPTS, 1990). This explains why Tawari, which is relatively moist because of its cool temperate climate, has the highest survival percent. While Gajurichhap, Ange and Chankhubensi, which fall in subtropical climate, has more or less similar lower survival rate. In case of Gauthale, although it also lies in the subtropical climate, it differs with others in its heavy soil texture, which may provide moisture during dry period. Unlike survival percentage the height growth seems to be related with medium soil texture as this species prefer loamy soil (Jackson, 1994). Chankhubesi and Gaujurichhap having loamy soil texture, have the highest height growth, whereas Gauthale having clay loam soil has the lowest height growth. Survival percentage of 54.8-82.4% and growth rate of 10.1 cm-41.7 cm in nine months seems to quite comparable to the findings

of van der Dool (1987) (83% and 2.3 m in 32 months at 900 m) and Karki and Gold (1992)(1.05 m at 900 m after two years).

Artocarpus lakoocha, although has done well in its survival rate, but has performed poorly in its height growth. There is no marked difference in survival and growth rate across the plots, which is possibly due to its slow early growth rate and also because nutrient content and altitude contradicts. The survival rate tends to show positive correlation with nutrient contents such as total nitrogen and organic carbon and inverse relation with available P (Table 3) and altitude of the site. Positive correlation of survival rate with nitrogen and organic carbon is perhaps because *A. lakoocha* is nutrient demanding species. While inverse relation of survival rate with altitude can attributed to susceptibility of *A. lakoocha* to cold and frost (Jackson, 1994, MPTS, 1990). The growth rate (2.3 cm – 16.1 cm months) of *A. lakoocha,* unlike its survival rate, is comparatively slower than values reported by Jackson (1994) (30-60cm at 1500 m in two years) and Kari and Gold (1992) (1.36-2.22m in three years). It did not show any relations with soil reaction and nutrient contents (Table 3). This may partly due to the study plot that has higher nutrient content and pH and is located at higher altitude, which is unfavorable for its growth. Partly it may also be due to its slow growth rate in early years (Jackson, 1994) and small pit size used during plantation (Neville, 1987). The survival percentage (50-78%), however, is found to be higher than the value (28.57%) obtained in separate study by van der Dool (1987) and Campbell and Bhattarai (1983) of the IHDP area. But it agrees with the value (60%) obtained in the Community Forest Development Project (Campbell and Bhattarai, 1983).

Conclusion

Based on the present survival and growth rate of seedlings, *L. diversifolia* was found to be the most promising fodder species among others. It was followed *M. alba* and *A. lakoocha* respectively. *L. diversifolia* appears to be suitable in the sites with weakly to neutral level of soil pH and high nutrient content, while *M. alba* can grow well in deep loamy soils having fair amount nutrients. Likewise *A. lakoocha* may perform better at lower altitude with well-drained deep soil having sufficient nutrient content.

Further investigation on-station with some additional fertilizer and irrigation inputs in relatively controlled condition would be highly useful in making recommendations for enriched productive plantation work.

References

Anderson, J. M. and Ingrain, J. S. I. 1993. **Tropical Soil Biology and Fertility: A Handbook of Methods** Second Edition, C.A.B. International.

Baggayan, R. L. Jr. 1990. Fertilization of *Leucaena diversifolia* (Schlecht.) Benth. In Carranglan grassland. *Sylvatrop* **12(3-4):** 93-107.

Bertalot, M. J. A., Guerrini, I. A. and Mendoza, E. 1998. Performance of four nitrogen fixing tree species in cerrado soil condition. *Forest Farm and Community Tree Research Report* **3:** 1-3.

Campbell, J. G. and Bhattarai, T. N. 1983. Plantation survival, private planting, improved stove use and knowledge increase in community forestry, Miscellaneous Document No. 14, Community Forestry Development Project, HMG/UNDP/ FAO, Kathmandu.

Carter, A. S. and Gilmour, D. A. 1989. Increase in tree cover on private farmland in Central Nepal. *Mountain Research and Development* **9:** 381-391.

Castillo, A. C., Acasio, R. N., Vicorio, E. E, Moog, F. A. and Palis, R. 1997. Leucaena productivity on the highly acidic soil of Tanay, Rizal, Philippines. LEUCNET News **4:** 20-22.

Cheng, W. E. and Pan, F. G. 1988. Effect of pH on the growth and nutrient levels of seedling of *Leucaena diversifolia. Bulletin Taiwan Forest Research Institute New Series* **3(3):** 133-146

Das, A. N. and Oli, B. N. 2001. Tree growing practices on farmland: an option for sustaining rural livelihoods. *Banko Janakari* **11(2):** 8-12

Demanski, S. S. and Bashyal, H. P. 1990. **Reports on the private planting survival survey in Dang and Salayan Districts of the Rapti Zone.** Rapti Development Project, Dang, Nepal

DFRS/FRISP, 1999. **Forest Resources of Nepal** (1987-1998). Publication No. 74, Department of Forest Research and Survey, MFSC, HMGN, Forest Resource Information System Project, the Government of Finland

Gilmour, D. A. 1995. Rearranging trees in the landscape in the Middle Hills of Nepal. *In Tree Management in Farmer Strategies: Responses to agricultural Intensification* (eds.) Arnold, J. E. M. and Dewees, P. A., Oxford Press. UK.

Gutteridge, R. C. and Sorensson, C. T. 1992. Frost tolerance of a *Leucaena diversifolia* x *Leucaena leucocephala* hybrid in Queensland, Australia. *Leucaena Research Report* **13:** 3-5.

Hada. M., Nakarmi, G. and Pandit, B. H. 1997. **Strategies for Improved Fodder Production in the Dry Season in the Mid-hills of Nepal, using participatory research techniques: Initial Research Site Selection Field Visit Conducted by NAF in November and December 1997.** Project code: R6994 A0721, Report 1, Forest Research & Survey Centre/ Natural Resource Institute/ Nepal Agroforestry Foundation, Kathmandu, Nepal

Harrison, A. 1988. Miscellanea: *Leucaena diversifolia. Banko Janakari* **2(1):** 63-64.

Heuch, J. H. R. 1986. **Fodder for Forester: An Introduction to Tree Fodder Use in Nepal.** LAC Technical Paper No.86/13, Lumle Agricultural Centre, Kaski, Nepal.

Howell, J. 1989. **Choice of Species for Planting in Nepal: A Summary List of Uses and Site Requirements.** FRIC, Occasional Paper 2/89

Hutton, E. M. 1990. Field selection of acid-soil tolerant *Leucaena* from *L. leucocephala* x *L. diversifolia* crosses in a tropical oxisol. *Tropical Agriculture* **67:** 2-8

Hutton, E. M. 1995. Very acid soil constraints for tree legumes like *Leucaena* and selection and breeding to overcome them. *In Nitrogen-Fixing Trees for Acid Soils* (eds.) Evans, D.O. and Szott, L. T. Turriablba, Costa Rica, 258-264

Jackson, J. K. 1994. **Manual of Afforestation in Nepal.** Forest Research and Survey Centre, Kathmandu, Nepal

Kadiata, B. D. and Mulongoy, K. 1991. Soil effect on early growth and nodulation of three Leucaena species. *Leucaena Research Reports* **12:** 80-82

Karki, M. B. and Gold, M. A. 1992. Evaluation of growth performance of ten commonly grown fodder tree species in central and western Nepal. *Banko Janakari* **3(4):** 21-26

Khajuria, H. N. and Singh, A. 1991. *Leucaena diversifolia*- a potential species for subtropics. *Leucaena Research Reports* **12:** 45-46

Khoa, L. V., Xuan Co, H. Quoc Viet, N. 1997. Acid tolerance of *Leucaena* germplasm in Vietnam. LEUCNET News **4:** 18-20

Kiff, E., Hendy, C., Regmi, B. N., Vickers, B. and Chhetri, R. 1998. **Strategies for improved fodder production in the dry season in the mid-hills of Nepal, using participatory research techniques. Project Code: R6994 A0721** Third Joint field work and data analyses to cross-check bimonthly survey findings, discuss species performance with farmers and follow-up activities and reporting with local NGOs 15th March to 2nd April 1999 VS6177, Report 4, NAF/ NRI /DFRS, Kathmandu, Nepal.

Mahat, T. B. S. 1987. **Forest Farming Linkages in the Mountains.** ICIMOD Occasional Paper No. 7, Kathmandu, Nepal.

MPTS, 1990. **Multipurpose Tree and Shrub and Database.** ICRAF

Neville, G. A. 1987. Site amelioration for the establishment of fodder trees. *Banko Janakari* **1(3):** 32-33.

Oakes, A. J. and Foy, C.D. 1984. Acid soil tolerance of *Leucaena* species in greenhouse trials. *Journal of Plant Nutrition* **7:** 1759-1774

Potdar, M. P., Patil, B. C. and Patil, R. R. 1997. Response of mulberry (*Morus alba* L.) variety S-54 to nitrogen levels under irrigation. *Karnatak Journal of Agricultural Sciences* **10(4):** 1171-1173.

Pradhan, D. R. 1988. Study of the productivity of different species of *Leucaena* in Pokhara. *In Fodder Trees, Forest Fodder and Leaf Litter* (ed.) Robinson, P. J., Occasional Paper No. 2/88, Forest Research and Information Centre, Forest Survey and Research Office, Babarmahal, Kathmandu 13-13.

Shakya, R. 1990. *Leucaena leucocephala* variety trial in Nepal. *Leucaena Research Reports* **11:** 84-85.

Shrestha, R. K. 1997. Existing indigenous agroforestry practices in the mid-hills of Nepal and their impact on soil conservation. Ph. D. Thesis, Vienna, Austria

Singh, R. V. 1982. **Fodder Trees of India.** Oxford & IBH Publishing, New Delhi, India.

Singh, V. and Sharma, R. J. 1990. Forest-livestock-crop human relationship and development of sustainable system. **Advances in Forestry Research in India Vol.V,** 211-245.

Sorensson, C. T. and Brewbaker, J. L., 1986. Resistance of Leucaena species and hybrids. *Leucaena Research Reports* **7:** 13-15.

Sriharsha, S. A., Shankar, M. A. and Dev, G., 1998. Response of mulberry to potassium nutrition and its economics. *Crop Research Hisar* **16(2):** 186-191.

Sunil Puri, Shamet, G. S. and Puri, S., 1992. Root and shoot growth of *Leucaena leucocepala* and *Leucaena diverisifolia* in the Shivalik Hills of India. *Leucaena Research Reports* **13:** 43-45.

Thapa, B., 1994. **Farmers' Ecological Knowledge About the Use of Farmland Tree Fodder Resources in the Mid-Hills of Eastern Nepal.** Ecological Knowledge Research Group, School of Agricultural and Forest Sciences, University of Wales, Bangor.

Van Den Beltd, R. J. 1984. Effect of irrigation on growth of Leucaena stands. *Leucaena Research Reports* **5:**99-100.

van der Dool, M., 1987. Survival and growth of nine fodder tree species at RDC farm, Pokhara. *Banko Janakari* **1(2):** 29-30.

Veldhuis, M. 1988. Short notes: comparison of different kinds of ipil-ipil at Lampatan, Pokhara. *Banko Janakari* **2(1):** 49-51.

Warner, M., Bezkorowajnyj, P. G., Rana, R. B. and Witcombe, J. R., 1999. Matching livelihood needs to tree selection in high potential farming system: lesson from participatory research in Nepal and India. *Network Paper Agricultural Administration Research and Extention Network* No. 89,12 pp.

Webb, D. K., Wood, P. J., Smith, J. P. and Henman, G. S., 1984. **A Guide to Species Selection for Tropical and Sub-Tropical Plantations.** Tropical Forestry Papers No. 15, Second Edition, Commonwealth Forestry Institute, University of Oxford.