Study of fodder production, leaf: twig ratio and palatability of *Artocarpus lakoocha* in Nepal

Krishna C. Paudel[1]

The fodder of *Artocarpus lakoocha* is preferred by farmers as it is considered to increase the fat content of buffalo milk. It is fed during winter as a supplement to crop residues. The relationship between the tree size and fodder biomass production for *A. lakoocha* was investigated in a lopping trial using farmers practice at Kaski District, Nepal during the winters of 1991 and 1992. Diameter at breast height (DBH) gave the best prediction of fodder biomass. A fodder biomass table, based on DBH as a single predictor variable is presented for this species. The regression equation, derived on the basis of two years data from 50 trees of 3 - 50 cm DBH is Ln Biomass = -2.799+2.16 Ln DBH (R^2=95%). Of the total fodder, 65% is leaves and 35% is twigs. Feeding trials have shown that approximately 85% of the fresh fodder lopped is palatable to livestock.

Keywords: *Artocarpus lakoocha*, fodder biomass, palatability, DBH, Nepal

Artocarpus lakoocha Wall.ex Roxb., locally called Badahar, is a deciduous tree commonly used as fodder in Nepal. This species is also found in India, Sri Lanka, Burma and Malaysia. It grows well from 400 to 1300 m. The leaves contain about 14-16% crude protein (Wood *et al.*, 1994; Jackson 1987). The fruits are edible and are marketed. Farmers believe that *A. lakoocha* leaves when fed to buffaloes produces more milk with a higher fat content. The fodder is more nutritious than some common grasses and that of many other Nepali fodder trees (Panday 1982; Shrestha and Tiwari 1991). The species is generally grown by farmers on field boundaries and corners of farms as a single tree and managed in a traditional way. Fodder is lopped mostly between November and February and fed to milking animals (usually buffalo) as a dietary supplement to crop residues. Although information on silvicultural characteristics, nursery and plantation establishment and nutritive value is available (Jackson, 1987; Shrestha and Tiwari, 1991), statistics on fodder biomass production and its utilisation are limited.

The present paper therefore, attempts to determine the relationship between the size of trees and fodder biomass and to help prepare a fodder biomass table for the species. The additional objectives of the study were to estimate leaf : twig ratio and palatability percentage of *A. lakoocha*

Methods

The study was conducted, at Jhobang village of Kaski District (1050 m) in western Nepal. The study area is a typical middle-hill valley floor that receives monsoon rainfall of approximately 3500 mm; soils are inceptisols and mostly well drained.

An informal survey was carried out to assess the size distribution of *A. lakoocha* in the Jhobang village area. Most trees were less than 50 cm diameter at breast height (DBH). This range of DBH was divided into 10 groups of five cm interval (1-5 cm, 6-10 cm, 11-15 cm, to 45-50 cm). Deformed trees and those with other abnormalities such as top broken, severely

[1] Forest Officer, Lumle Agricultural Research Centre, Lumle.

debranched and left uncut for several years, were not selected for the experiment.

Five trees each were selected randomly from the healthy population for each DBH interval in a way to avoid bias and to provide equal representation of trees of all sizes. Data were collected from a total of 50 trees. Sample trees were completely lopped by cutting green branches, as is practised by the local farmers, once between November to February in 1991 and 1992.

Measurements such as diameter at breast height (cm), tree height (m), crown height (m), crown diameter (m), fodder biomass, leaf biomass (kg), twig biomass (kg), and percentage palatability of the sample trees were carried out.

Tree height and crown height, and DBH were measured with a clinometer and tape respectively. Maximum crown diameter was measured in two directions (E/W and N/S) to calculate mean crown diameter. The crown volume was estimated using Huber's formula considering the crown of *A. lakoocha* a frustum of a paraboloid. Sample trees were lopped completely followed by making bundles and weighing to find fresh fodder biomass. Data were then used for preparing the biomass table.

Fodder biomass refers here, to the amount of fresh fodder (including green branches, petioles and leaves) cut from trees, bundled, carried and fed to animals without processing or long storage, which is the common farmer's practice in Nepal. Leaf biomass refers to the amount of leaves (including the petiole) separated from the green branches.

Every portion of the foliage is not eaten by animals as it also contains branch wood; an investigation to find out leaf : twig ratio and the amount palatable to livestock was essential. In order to estimate the leaf : twig ratio, the leaf biomass and twig biomass were calculated by separating leaves (with petioles) from the lopped branches (twigs). For this purpose, 44 samples of known weight (10-15kg each) from the sample trees of various diameter classes were chosen. To calculate palatability percentage, another 45 samples of known weight (20-25 kg each) were fed to 5 milking buffaloes every evening. While sampling, fodder branches from each diameter class were evaluated and the farmers' usual practices were adopted for lopping and feeding. Leaf content and palatability percentages were calculated using the following equations respectively:

$$\text{leaf content (\%)} = \frac{(\text{fresh fodderweight} - \text{twig weight})}{\text{sample fresh foliage weight}} \times 100$$

$$\text{palatability (\%)} = \frac{(\text{sample fed to animal} - \text{amount left uneaten})}{\text{sample fed to animal}} \times 100$$

These data were collected for two successive winters (November 1990—February 1991 and November 1991—February 1992) to take some account of variation in annual fodder production and were pooled to form one single set of data whilst preparing the biomass table.

Table 1: Adjusted R² values and Residual Mean Square (RMS) obtained from regression analysis of log biomass on predictor variables for *A. lakoocha*

Predictor variables	Adj. R	RMS	Predictor variables	Adj.R2	RMS
DBH	78%	2009	Ln DBH	95%	0.147
Ht.	63%	3470	Ln Ht.	85%	0.422
Crown Vol.	79%	1965	Ln Crown Vol.	94%	0.177
DBHxHt	79%	1896	Ln DBH + Ln Cr.vol	96%	0.120
Ht x DBH2	80%	1831	Ln DBH+ Ln Ht.+Ln Cr.Vol.	96%	0.132

Analysis

The statistical package INSTAT was used for simple linear and multiple regression analysis using the method of least squares. The criteria for selecting the biomass equation were adjusted R^2, the residual mean square, the probability value of F-ratios and residual analysis. Logarithmic transformation of both measured biomass and predictor variables were used to achieve homogeneity of variance [Sprugel, 1983]. The equation thus obtained was in the form of Ln Biomass = a + b LnX, where a and b are y-intercept and slope respectively and X is the predictor variable. The arithmetic biomass table was prepared using predicted biomass = exp (a+b LnX).

Results

The results of regression analysis are presented in Table 1. Regression of log biomass on log DBH gave a higher adjusted R^2 value (95%) than did either log height (85%) or log crown volume (94%) as a single predictor of fodder biomass. The combination of height multiplied by DBH (Ht x DBH) did not provide additional precision for the regression neither did DBH squared multiplied by height (DBH^2 Ht.). Although the multiple regressions of log biomass on log DBH and log crown volume (adj R^2=96%), and log biomass on log DBH, log height and log crown volume (adj R^2=96%) gave slightly higher precision, the improvement was very small and did not justify the increase in the complexity of the model. Therefore, the single variable, DBH was used to prepare the biomass table.

Fodder biomass production

The regression equation derived on the basis of DBH for fodder biomass estimation of *A. lakoocha* is Ln biomass = - 2.799 + 2.16 Ln DBH (Fig 1).

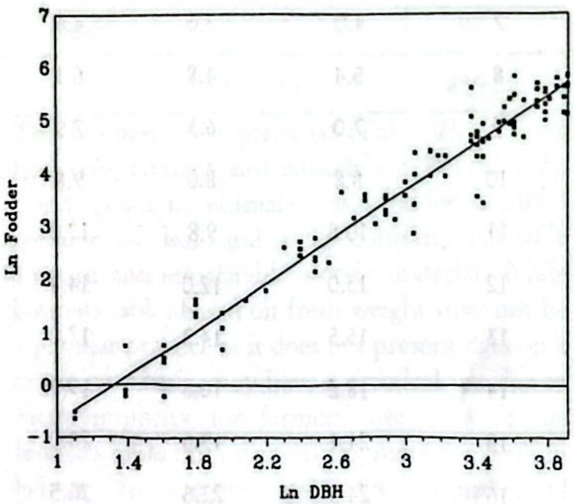

Figure 1 Regression of log biomass on log DBH for Badahar (*A. lakoocha*)

The predicted biomass on the basis of this equation is prepared in arithmetic form and presented in Table 2. The overall fodder biomass production increased with increase in DBH. The relationship between the DBH and biomass production were the same in both years but that mean production per tree was about 20% lower in the second year.

DBH (cm)	Predicted Fodder Biomass (kg)	95% Confidence limit		DBH (cm)	Predicted Fodder biomass (kg)	95% Confidence limit	
		lower (kg)	upper (kg)			lower (kg)	upper (kg)
5	1.9	1.7	2.3	28	81.3	75.7	88.9v
6	2.9	2.5	3.3	29	87.7	81.5	96.0
7	4.0	3.6	4.6	30	94.4	87.6	103.5
8	5.4	4.8	6.1	31	101.3	94.0	111.2
9	7.0	6.3	7.9	32	108.5	100.4	119.3
10	8.8	8.0	9.8	33	116.0	107.2	127.7
11	10.8	9.8	12.0	34	123.7	114.1	136.5
12	13.0	12.0	14.4	35	131.7	121.3	145.5
13	15.5	14.3	17.0	36	140.0	128.7	154.9
14	18.2	16.8	19.9	37	148.5	136.3	164.6
15	21.1	19.6	23.0	38	157.3	144.2	174.7
16	24.3	22.6	26.5	39	166.8	152.3	185.0
17	27.7	25.8	30.1	40	175.7	160.6	195.8
18	31.3	29.2	34.0	41	185.3	169.1	206.8
19	35.2	32.9	38.2	42	195.2	177.8	218.2
20	39.3	36.8	42.7	43	205.4	186.8	230.0
21	43.7	40.9	47.5	44	215.9	196.0	242.1
22	48.3	45.2	52.5	45	226.6	205.4	254.5
23	53.1	49.7	57.8	46	237.6	215.1	267.3
24	58.3	54.5	63.4	47	249.0	225.0	280.5
25	63.6	59.4	69.3	48	260.5	235.0	294.0
26	69.3	64.6	75.0	49	272.4	245.4	307.8
27	75.2	70.0	82.1	50	284.5	266	322.0

Note: The predicted values are based on the equation Ln Biomass = -2.799 +2.16 Ln DBH (adjusted R^2=95 %, SEE = 0.38).

Leaf : twig ratio and palatability percentage

For trees with DBH greater than 10 cm, of the total fresh fodder, 65% are leaves and 35% are twigs (Table 3). The feeding trial found that 85% of the fresh fodder is palatable when about 20-25kg a day is fed to milking buffalo and 15% is unpalatable woody branch. This means, beside leaves, about 20% of the green branches are also palatable to livestock. There is an almost constant proportion of leaf content and amount of palatable material in the trees with DBH greater than 20 cm (Table 3) whereas the talatable proportion was higher in smaller trees (< 10cm DBH).

Table 3 : Average leaf content and palatability % of *A. Lakoocha* as lopped and fed by farmers

DBH class (cm)	leaf content %	palatability %	DBH class (cm)	leaf content %	palatability %
3-5	100	100	26-30	63	74
6-10	80	92	31-35	64	81
11-15	65	91	36-40	65	84
16-20	65	86	41-45	64	85
21-25	63	89	56-50	62	87
Average of 6-50 cm DBH class				65%	85%

Discussion

Because of variations in environmental factors such as soil, competition and lopping practices, and the possible genetic variability of the species, fodder production varies greatly among trees of similar height or DBH. Lack of information on age and origin of the plant material in the farmers' fields and no previous yield records prevented consideration of these effects on biomass and comparison with past yields. There is very little readily available published work on predictive equations for foliage biomass estimation in multipurpose trees. Although Otieno *et al.* [1991] have studied the relation between leaf biomass and DBH in *Sesbania sesban*, it is difficult to compare this with *A. lakoocha* which has a completely different architecture. However, in both species, DBH proved to be a reliable and practical parameter for the estimation of fodder biomass. The relationship demonstrated between DBH and fodder biomass in *A. lakoocha* is similar to that found in a study on biomass in Sahelian browse species [Cisse, 1980]. In both the cases,DBH was selected as a reliable predictor of fodder biomass.

The increasing trend in fodder biomass production up to 50 cm DBH indicates a need to incorporate larger trees in future studies. The lower fodder yields in the second year may have been caused in part by a hailstorm in November 1992. Some of the trees in the study had not been lopped in 1990 and so the fodder yield was enhanced in the first year (1991) but stabilised in the second year (1992).

The biomass table prepared (Table 2), and the leaf: twig content and palatability % (Table 3), can be used to estimate fresh fodder, separate amount of leaf and twig content, palatable amount and unpalatable woody material. While biomass tables based on fresh weight may not be a popular practice as it does not present data on a dry matter basis, they have a practical use due to their simplicity for farmers' use. Use of the biomass table can assist development workers in helping farmers to plan the number of productive fodder trees needed for the livestock on their farms. For example, a tree of 40 cm DBH can produce about 176 kg of green fodder annually. If about 10-15kg of Badahar fodder per day is supplemented with crop residues, a Badahar tree of this size can support a milking buffalo for about two weeks in the dry winter period. This means about 6-8 mature trees are required to support a milking buffalo in the fodder scarcity period under prevailing farmers' conditions in Nepal.

This study attempts, for the first time, to produce a fodder biomass table for *A. lakoocha* in Nepal. Verification is needed over wider areas and revisions can be made as more information becomes available. Production and supply of sufficient planting materials from superior sources of *A. lakoocha* and maintenance of their growth records in different agroclimatic zones is an immediate concern in Nepal. *A. lakoocha,* as a suitable agroforestry species, needs more research attention from the farmers' perspective. Studies on the effect of this fodder on different livestock and in different physiological stages (lactating and non- lactating) would be another area for future research.

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