Altitudinal variation in nutritive value of adult-juvenile foliage of *Celtis australis* L.: A promising fodder tree species of Central Himalaya, India

Bhupendra Singh [1], Bhagwati Prasad Bhatt [2] and Pratti Prasad [3]

[1] Department of Forestry, H.N.B. Garhwal University, Srinagar Garhwal- 246 174, Uttarakhand, India
[2] ICAR Research Complex for NEH region, Nagaland Centre, Medziphema- 797 106, Nagaland, India
[3] H.N.B. Garhwal University, Srinagar Garhwal- 246 174, Uttarakhand, India
butola_bs@yahoo.co.in

Abstract: The aim of the study was to compare the nutrient composition of adult and juvenile foliages of *Celtis australis*, collected from different altitudes. Adult foliages were collected from four different altitudes for nutritional analysis and compared with the nutritive value of juvenile foliage (seedlings of different provenances raised under the similar climatic conditions in the experimental garden for one year and the foliage has been referred herein as juvenile). The data revealed that nutritive value of *Celtis* foliage was strongly influenced by altitudinal gradient. The dry matter content in adult and juvenile foliage exhibited significant inverse correlation ($P < 0.05$) with altitude whereas, phosphorus, potassium and calcium contents showed strong positive correlation ($P < 0.01$) with elevational range of foliage. Crude protein in adult foliage also showed strong positive correlation with altitude ($P < 0.01$). A significantly higher ($P < 0.01$) dry matter, ash, crude protein and starch was recorded in adult compared to juvenile foliage of *C. australis*. On average, high altitudinal populations exhibited comparatively higher nutritive values than those from low altitude. High altitudinal trees, therefore, should be selected for multiplication of *Celtis* for quality fodder production. [Journal of American Science 2010;6(2):108-112]. (ISSN: 1545-1003).

Key words: *Celtis australis*, altitude, nutritive value, adult- juvenile foliage

1. Introduction

The fodder trees provide nutritious feed to the livestock population of hill farmers. Even the landless labourers, keeping small herds of sheep and goats mostly depend on the top feed resources from trees growing near habitats. *Celtis australis* L. of family Ulmaceae is an indigenous multipurpose agroforestry tree-crop of Central Himalaya, India and grown mainly in agrisilviculture and silvipastoral agroforestry systems throughout the hills. It is the only agroforestry species that has wide range of ecological amplitude (extending from 500 to 2000 m asl) and provides an excellent feed during dry season when protein and nutrient deficiencies are likely to occur to the livestock population (Bhatt and Verma, 2002; Singh, 1982; Singh, 2004).

Thus, this broad–leaved genus play a vital role in socio-economic structure of hill people by supplying highly palatable, nutritious and tannin free green fodder particularly during peak periods (Makkar et al., 1993; Subba et al., 1994). However, season of harvesting (Bhandari et al., 1979; Pal et al., 1979) and source of collection, i.e., altitude (Morecroft et al., 1992b; Woodward, 1986) influence the nutritive values of tree foliage significantly. Keeping in view the importance of this potential agroforestry tree–crop in the rural economy, present study was designed to know the effect of altitude on nutrient composition of adult and juvenile foliages so as to screen the suitable provenances for mass afforestation in Central Himalaya, India.

2. Material and Methods

The study was conducted at H.N.B. Garhwal University Srinagar (Garhwal), Uttarakhand, India for assessing the nutritive value of Celtis foliage. Tree foliage was harvested from four different sites, ranging 550 to 1980 m altitude, 30^0 06' to 30^0 25'N latitude and 78^0 38' to $78^0$48'E longitude (Table 1).

Table 1. Geographical description of foliage collection sites of *Celtis australis*, Central Himalaya, India

Provenance	Altitude (m asl)	Latitude (N)	Longitude (E)
Srinagar	550	$30^0$13'	$78^0$48'
Agroda	1180	$30^0$06'	$78^0$47'
Kandikhal	1550	$30^0$20'40"	$78^0$38'05"
Badiyargaon	1980	$30^0$25'	$78^0$48'

From each selected site, more than half kg of fresh leaves of *C. australis* was collected from adult trees in the month of December from single branch of selected trees. To collect the juvenile foliage, seeds from four different altitudes were collected and sown in nursery beds in the experimental garden of Forestry Department (situated at $30^0$13' N latitude, 78^0 48' E longitude and 550m asl altitude). The juvenile foliage was harvested from one year old grown seedlings of *C. australis* and compared with nutritive value of adult foliage. Initially 2 kg of leaf sample was harvested from each of the population representing all the seedlings. Bulk sample was mixed thoroughly and only half kg was finally collected for drying and further investigation.

The dried samples were grounded and sieved through a 1 mm mesh sieve for nutritional analysis. The dry matter (DM), crude protein (CP), crude fibre (CF) and Ash was estimated following the procedure of AOAC (1995). CF was estimated in defatted samples. The total phenolic (TP) was estimated using the method of Makkar et al. (1993). Calcium (Ca) was estimated as per the procedure of Underwood (1977) and the estimation of phosphorus (P) and potassium (K) was carried out as per the methods described by Okaebo et al. (1993). Similarly, soluble sugars (SS) and starch were determined by the method of Mc-Cready et al. (1950). Each parameter of nutrient composition (mean ± S.D.) was analyzed with four replicated samples of juvenile and adult foliages.

All the statistical analyses were performed using SPSS software package, version 10.0.1 (SPSS Inc., Chicago, USA). Variation in nutrient composition of the foliages was analyzed by ANOVA. The model included adult, juvenile and altitude as source of variation. Pearson's correlation analysis was performed to study the association between different experimental parameters.

3. Results

This study describes the effect of different provenances on nutrient composition of adult and juvenile foliage of *C. australis*. The results indicated significant variations in nutrient composition of adult and juvenile foliages. Further, altitude significantly influenced the nutrient composition of *Celtis* foliage. DM content of the adults and juvenile foliage has been given in Table 2. Foliage collected from the area with an altitude of 550 m asl exhibited significantly ($P < 0.05$) higher DM than those from higher altitude areas (1550 m asl). Significant ($P < 0.05$) inverse correlation between foliage DM content and altitude was recorded, which indicates that with increasing altitude, DM content declined in adult and juvenile foliages (Table 3).

Table 2. Altitudinal variations in nutritive value (Mean ± S.D.; n = 4) of adult and juvenile foliage of *C. australis*

Altitude (m asl)	Foliage	Dry matter (mg/g)	Crude protein (mg/g)	Crude fibre (mg/g)	Ash (mg/g)	Phosphorus (mg/g)	Potassium (mg/g)	Calcium (mg/g)	Soluble sugars (mg/g)	Starch (mg/g)	Phenolic (mg/g)
550	Adult	414.80 ±8.79	126.60 ±5.38	163.60 ±7.18	414.80 ±7.74	1.10 ±0.08	4.39 ±0.15	28.74 ±0.10	16.65 ±1.83	49.30 ±2.58	5.21 ±0.09
	Juvenile	288.05 ±7.39	96.90 ±3.71	141.00 ±4.08	134.00 ±6.06	0.94 ±0.06	4.62 ±0.14	21.99 ±0.11	20.74 ±2.94	65.17 ±5.50	3.18 ±0.05
1180	Adult	412.50 ±11.80	126.90 ±4.83	134.20 ±5.74	412.50 ±4.76	1.14 ±0.07	4.29 ±0.16	30.87 ±0.08	16.27 ±1.82	47.08 ±1.83	7.79 ±0.14
	Juvenile	272.00 ±5.59	105.80 ±6.06	145.00 ±6.06	126.00 ±4.08	1.06 ±0.05	5.27 ±0.10	24.27 ±0.07	17.70 ±0.97	52.95 ±3.16	6.58 ±0.08
1550	Adult	368.10 ±10.08	133.40 ±5.08	171.20 ±3.65	368.10 ±5.48	1.04 ±0.06	4.23 ±0.12	30.62 ±0.06	14.85 ±1.75	63.11 ±4.24	7.26 ±0.06
	Juvenile	266.00 ±11.13	96.90 ±4.08	154.50 ±4.43	124.00 ±3.58	1.03 ±0.04	5.75 ±0.11	25.12 ±0.09	18.83 ±1.12	53.81 ±2.58	3.23 ±0.06
1980	Adult	370.00 ±9.45	140.02 ±3.18	160.80 ±2.94	370.00 ±5.59	1.05 ±0.03	5.01 ±0.15	32.64 ±0.08	14.45 ±1.83	61.17 ±2.16	5.21 ±0.04
	Juvenile	276.00 ±10.03	91.10 ±1.41	157.50 ±6.78	138.00 ±4.94	1.12 ±0.10	5.12 ±0.14	25.87 ±0.11	16.87 ±1.14	75.45 ±5.59	4.20 ±0.05
"t" value (adult vs juvenile foliage)		13.74**	8.89**	4.37*	10.74**	0.14NS	0.64NS	2.36NS	1.98NS	13.63**	1.16NS
"r" value (adult vs juvenile foliage)		0.16NS	-0.76**	0.12NS	-0.98**	-0.66**	-0.26NS	0.95**	0.65**	0.29NS	0.84**

*Significant at $P < 0.05$, **significant at $P < 0.01$ and NS = Non-significant

Table 3. Correlation coefficient 'r' between altitude and nutritive values of adults and juvenile foliage of *C. australis*

Parameters	Adults foliage	Juvenile foliage
Dry matter	- 0.64*	-0.65*
Ash content	0.11^{NS}	0.12^{NS}
Phosphorus	0.74**	0.66**
Potassium	0.57*	0.59*
Calcium	0.90**	0.93**
Crude protein	0.91**	0.46^{NS}
Soluble sugars	- 0.94**	-0.85**
Starch	0.80**	0.30^{NS}
Crude fibre	$- 0.01^{NS}$	0.96**
Phenolics	0.37^{NS}	0.24^{NS}

* Significant at P < 0.05, ** Significant at P < 0.01 and NS- Non-significant

However, ash content did not exhibit any established trend with an altitude either in case of adult or juvenile foliages. On average, ash content in foliages of higher altitude population (1980 m asl) was significantly (P < 0.05) higher compared to foliages from other provenances. Similarly, CP content of foliages of 1980 m asl provenance was significantly (P < 0.05) higher than those of 550, 1180 and 1980 m altitudinal populations. There was significant (P < 0.01) positive correlation between CP content and altitude of the adult foliage. However, CP content of juvenile foliages did not exhibit significant relationship with altitude (Table 3). Data on CF also exhibited significant (P < 0.05) altitudinal variations and the foliages collected from 1980 m altitude showed significantly (P < 0.05) higher CF content compared to other altitudinal populations. There was significant (P < 0.01) positive correlation between CF and altitude of juvenile foliage, indicating increasing trend of CF with an increasing altitude (Table 3).

4. Discussion

The nutritive value of adult foliage of *Celtis* observed in the present study was well within the range as reported by Singh (1982), Verma et al. (1992), Negi and Todaria (1994) and Subba et al. (1994). Significant provenance variation in chemical contents of *Albizia lebbek* foliage has also been reported, which supports to the present findings (Kumar and Toky, 1994). In the present study, significant positive correlation between CP and altitude was recorded. Morecroft et al. (1992a) also reported that nitrogen concentration in plants increased with altitudinal gradient which supports the present findings and the variations in nitrogen content may partly be attributed to re-translocation of leaf nitrogen into branches before leaf fall and partly due to a dilution factor with expansion and maturity of the leaves (Khosla et al., 1992).

In general, CP content has been reported to be the most important nutrient (Negi, 1986). Higher level of crude protein in young leaves of *Celtis* was recorded which decreased with leaf maturation. A similar pattern of variation in protein content with the season was also reported by earlier workers in the foliage of *C. australis* (Wood et al., 1995; Subba et al., 1994) and *Grewia optiva* (Khosla et al., 1980). A detailed study on six fodder trees of the Central Himalaya, India also suggested that early successional fast growing tree species like *Celtis* has much greater content of protein in leaves (16.97%) than late successional slow growing species (Khosla et al., 1992).

Significant (P < 0.05) provenance variations have been noticed for P content among the foliages. There was significant (P < 0.01) positive correlation between P content and altitude of foliage. Likewise K in the foliage showed significant (P < 0.05) altitudinal variations. Therefore, significant (P < 0.05) positive correlation between K content and altitude of foliage. Ca contents in the foliage of high altitude populations was also significantly (P < 0.05) higher than those of low altitude provenances. Significant (P < 0.01) positive correlation between Ca content and altitude of adult and juvenile foliages was recorded (Table 3).

Very few studies are available on concentration of P, K and Ca of foliages along an altitudinal gradient. However, the high altitude species of *Alps* showed higher concentration of P (Korner, 1989), which supports to the present findings. Butola (2004) also reported significant seasonal variations in the concentration of minerals in the *Celtis* foliage.

Data on SS exhibited significant (P < 0.05) altitudinal variations. There was significant (P < 0.01) inverse correlation between SS content and elevational range of foliage, indicating decreasing trend of sugars with increasing altitude. Significant altitudinal variations for the starch content of adult and juvenile foliages were also recorded. There was significant (P < 0.05) positive correlation between starch content and altitude of foliage. TP contents also showed significant (P < 0.05) altitudinal variation between adult and juvenile foliages of different provenances. However, there was insignificant association between phenolic content and altitude of provenances among the adult and juvenile foliages (Table 2).

These variations in TP contents of adult and juvenile foliages of different provenances suggested that the level of secondary metabolites change with change in the altitude of plant origin. These findings are in conformity with earlier report of Khanduri and

Purohit (1981) in case of Himalayan *Berberis* spp. Mooney and Billings (1961) and Pekka et al. (2000) also reported that TP in foliage decreases with increasing altitude. Besides altitudinal variation, significant seasonal variations in chemical composition of *Celtis* foliage have been recorded and peak values of SS and TP have been observed during October-December (Butola, 2004).

So far no attempts have been made to compare the nutritive value of juvenile and adult foliage of *C. australis*. However, agronomic, biochemical and morphological parameters have been widely used in the evaluation of various promising agroforestry tree species including *Celtis* (Negi, 1986). From the present investigation, it is well understood that there is strong correlation between altitude and nutritive value of *Celtis*.

The present study suggests that altitude influenced significantly the chemical composition of *Celtis* foliage. Strong correlation was also recorded for chemical composition of adult and juvenile foliage. On average, high altitude foliage (Badiyargaon population-1980 m asl) exhibited comparatively higher values for CP, Ca and K whereas, the foliages of low altitude (550 m asl) revealed higher value for P, SS and DM content. Based on the present findings, we recommend that the high altitudinal populations could be selected for multiplication of *Celtis* for obtaining the nutritionally superior fodder.

Corresponding Author:

Dr. Bhupendra Singh
Department of Forestry,
H.N.B. Garhwal University,
Srinagar Garhwal- 246 174,
Uttarakhand, India
E mail: butola_bs@yahoo.co.in

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