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VARIATION STUDIES IN TREE MORPHOLOGICAL PARAMETERS IN ANOGEISSUS LATIFOLIA WALL IN HIMACHAL PRADESH

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ABSTRACT

Variation studies in tree morphological parameters of *Anogeissus latifolia* Wall in Himachal Pradesh was undertaken in four district, viz., Solan, Sirmour, Kangra and Una considering three different diameter classes (10-20 cm, 20-30 cm and 30-40 cm) in eight sites with three replication. Site S7 (Jaach-Kangra) followed by Site 1 (Jaach-Solan) and S2 (Majru-Solan) were found best over other all sites. Diameter class 30-40 cm excelled over other classes in major tree morphological parameters in determining growth and development of trees as well as direct indicator of productivity and fodder quality value. Plus tree are recommended from the sites having 30-40 cm dbh class.

Keywords: *Anogeissus latifolia*, Variation, Morphological, Sites, Diameter class.

INTRODUCTION

Himachal Pradesh is a hilly state and of the total geographical area of the state, i.e., 55673 km², about 2400 km² constitute the pastures, which have become highly unproductive on account of heavy grazing (Chauhan 1989). To augment the fodder resources for the large domestic animal population of the state, plantation of fodder trees are the right choice. Owing to the scarcity of green fodder in the hills, the farmers throughout the year commonly feed trees leaves to the livestock. Joshi and Talapatra (1960) and Momin and Kehar (1947) recorded the nutritive value of the leaves of some trees and suggested their use as a fodder during the lean winter months. Some major forest trees on which farmers depends heavily during the lean period of winters include Maggar (*Dendrocalamus hamiltonii*), Beul (*Grewia optiva*), Banj (*Dendrocalamus strictus*), Kachnar (*Bauhinia variegata*) Shahtoot (*Morus alba*), Ban oak (*Quercus leucotrichophora*), Kharsu oak (*Quercus semicarpifolia*), Black locust (*Robinia psudocacia*), etc.

Anogeissus latifolia Wall. Ex. Bedome is one of the multipurpose fast growing, lean season and nutritive fodder species belonging to family Combretaceae and is commonly known as Axel wood, Dhav, Dhavra, Chall, etc. The genus has 8 species, 5 of which belong to South Asia, 2 from South Arabia and one is native to Africa. In India, two species of *Anogeissus*, i.e., *A. latifolia* and *A. pendula* are found growing. *Anogeissus latifolia* is a small to medium-sized tree up to 20 to 36 m tall. Bole straight and cylindrical or sometimes more poorly shaped, branchless for 8 to 10 m, up to 80 to 100 cm in diameter, occasionally with small buttresses; bark surface smooth or with scales, pale to dark gray in colour with drooping branches. Leaves are opposite or sub-opposite, variably distichous, simple, entire, exstipulate, with grayish-yellow or whitish hairs on adaxial surface.

The species is common in deciduous or semi-evergreen forest also it is common element of teak forest and can also occur as the understory of dipterocarpus forests, in Bamboo forests and even in vegetation under semi-arid conditions like Savannah woodland and dry rocky hills. It is usually associated with *Albizia lebbeck*, *Dalbergia* spp., *Grewia tilaefolia*, *Albizia amara*, *Gyrocarpus jacquini* and *Mesua ferrea*. The species grow till an altitude of 1200m with mean annual temperature being 44⁰C. Mean annual rainfall required is between usually 625-225mm.

The species is found in variety of soils but the species prefer deep alluvial soils and also it does not tolerate water logging.

In Himachal Pradesh, it is naturally growing in lower belts falling in the jurisdictions of district Kangra, Una, Sirmour and Solan. It is also found in few patches in Mandi district too. This tree is found between the elevations of 300 to 1200 m in Himachal Pradesh.

Anogeissus latifolia is used mainly as fodder during the dearth period, particularly in the month of January, when there is no other option left with the farmers to feed the livestock. So farmers lop this tree to feed their cattle and buffaloes. Very little scientific and systematic information is available on this species with reference to its morphological characteristics, nutritive value and its productivity potential etc. Hence, present study was an attempt to accomplish variation studies in tree morphological parameters, within sites, between tree and sites and also in different diameter classes.

MATERIALS AND MEYHODS

The experimental study was conducted in the jurisdiction of four districts of Himachal Pradesh viz., Solan, Sirmour, Una and Kangra. From each district, two sites were selected where species occurred almost in abundance. These sites were Jadli and Majru (Solan); Majra and Chaoban (Sirmour); Banghar and Psali in district Una and Jach and Sakari in district Kangra. The main aim of the experiment was to study the variation among the trees, within trees, between trees and the site and in also diameter classes in the view of mentioned aspects. From each site, nine trees were selected three each from diameter class 10 to 20 cm, 20 to 30 cm and 30 to 40 cm, respectively.

Study areas		
Sr No	District	Sites
1	Solan	Jadli(945m above mean sea level)
		Majru (372 m above mean sea level)
2	Sirmour	Majra (559 m above mean sea level)
		Chaoban (654m above mean sea level)
3	Una	Bangarh (362m above mean sea level)
		Pasali (365m above mean sea level)
4	Kangra	Jachh (453m above mean sea level)
		Sakari (444m above mean sea level)

Variation in three diameter classes (small, medium and large), viz., 10 to 20 cm, 20 to 30 cm and 30 to 40 cm each having uniform population, were grouped in the sampling plots of eight selected sites. The morphological characters recorded were height of the tree (m), diameter at breast height (cm), number of main branches, clean bole height (m), crown length (m), crown width (m) and volume of wood (m³). Tree height was measured with the help of Rabi's

Multimeter; diameter at breast height (cm) was measured with the help of calliper; number of primary/first branches were counted in each tree separately; clean bole height (m) was measured with the help of tape; crown length (m), crown width and crown were measured with the help of tape; while volume of wood (m^3) was calculated with the help of quarter girth formula as mentioned below.

$$V = (G/4)^2 \times L$$

Where

G = Girth at breast height.

L = Height of the tree.

V = Volume of wood.

RESULTS AND DISCUSSIONS

Analysis of variance revealed that some morphological traits exhibited variation between the sites but not among the tree, viz., crown length, crown width. However, number of main branches per tree, diameter at breast height and volume showed non-significant variations among the sites also.

Analysis of overall mean of diameter classes showed maximum value for number of main branches per tree, crown width, in diameter class 10 to 20 cm. maximum values for clean bole and crown length were shown by diameter class 21 to 30 cm and maximum values for height, volume were shown by diameter class 31 to 40 cm.

Data presented in Table 1 reveals that maximum mean height was shown by T7 (16.36 m) and minimum mean height was shown by T1 (8.20 m) when analyzed within tree variation and T6 (14.78 m) and T9 (15.00 m) were found significantly at par. The variations among sites revealed that maximum height was shown by site S7 (17.11 m) and minimum value was shown by S5 (9.69 m) while S3 (15.89 m), S4 (15.74 m) and S8 (15.39 m) were found statistically at par. When trees among site interaction was analyzed so it resulted into maximum mean height shown by S7T2 (24.76 m) and minimum height was recorded of the tree S5T1 (5.00 m) and non-significant interaction was found between tree height and different sites. From the mean of diameter class, it is clear that diameter class 30 to 40 cm showed excellence (15.05 m) over other diameter classes.

Table 1. Tree to tree variation in height (m) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			33-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	7.00	6.45	6.45	13.75	12.25	9.70	10.50	11.50	13.00	10.07
S2	5.52	8.75	11.50	17.70	9.20	17.10	11.75	14.60	8.00	11.57
S3	12.50	15.50	11.00	20.50	9.50	8.75	29.50	11.60	24.20	15.89
S4	6.50	23.20	12.50	8.00	15.50	23.50	20.00	17.50	15.00	15.74
S5	5.00	5.29	7.90	9.50	11.50	11.50	12.50	11.60	12.45	9.69
S6	5.53	5.36	5.50	10.00	12.99	9.50	11.35	12.50	15.59	9.81
S7	13.30	24.76	19.93	12.20	23.53	16.75	15.00	14.50	14.00	17.11
S8	10.27	5.50	16.25	15.21	15.5	21.50	20.00	16.50	17.79	15.39
Mean	8.20	11.85	11.38	13.36	13.75	14.79	16.36	13.79	15.00	
Mean of the Diameter class	10.47			13.96			15.05			
CD _{0.05} Tree = 2.00 Sites = 3.46 Tree x Site = NS										

Perusal of the data in Table 2 revealed that maximum value of diameter at breast height within trees was recorded for T9 (34.23 cm) and minimum value for diameter within trees was recorded for T1 (13.50 cm). Analysis for variation among the sites accounted for maximum mean diameter for the site S1 (25.29 cm) and minimum mean diameter was recorded for site S2 (22.05 cm). When the interaction between trees and sites recorded then it was found that maximum mean diameter was of the tree S1T9 (37.10 cm) and minimum mean diameter was recorded for the tree S8T2 (10.50 cm). Variation in trees, sites and tree and site interaction was found non significant. Mean of the diameter class showed maximum value for class 30 to 40 cm (31.06 cm).

Table 2. Tree to tree variation in diameter at breast height (cm) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			31-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	17.11	16.00	17.90	21.00	22.00	28.50	35.00	33.00	37.10	25.29
S2	10.50	10.75	15.23	22.20	23.56	21.45	30.50	31.50	32.76	22.05
S3	16.00	15.50	17.08	22.55	27.72	21.00	30.33	36.97	31.05	24.24
S4	14.50	13.00	17.50	20.00	21.00	23.00	30.90	34.89	35.40	23.35
S5	11.50	13.00	11.75	20.34	22.50	27.50	30.78	36.97	37.56	23.54
S6	12.00	16.00	14.46	24.50	26.60	22.78	33.50	30.30	31.00	23.46
S7	11.50	15.00	19.90	21.50	29.50	28.00	30.00	31.00	34.50	24.54
S8	13.00	10.50	19.00	21.00	21.67	26.60	30.30	32.20	34.50	23.20
Mean	13.50	13.61	16.60	21.64	24.32	24.85	31.41	32.55	34.23	23.64
Mean of the Diameter Class	14.37			23.60			32.06			
$CD_{0.05}$ Tree = NS Sites = NS Tree x Site = NS										

Data appended in Table 3 showed maximum number of main branches for variation within trees were recorded for T3 (11.00) which was non significant only with T2 (9.00) and T4 (8.50) and minimum number of main branches in trees were recorded for T4 (8.50). When analyzed among sites the difference was found non significant and the maximum number of main branches were shown by site S7 (11.67) and minimum number of main branches were shown by site S1 (7.67). For tree and site interaction the maximum branching was shown by S7T2 (19.00) and minimum branching (5.00) was shown by S1T4, S3T2 and S3T6, respectively, which differ non significantly. Diameter class 10 to 20 cm has shown the maximum number of branches per tree (9.91).

Table 3. Tree to tree variation in number of main branches per tree of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			30-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	8.00	4.00	8.00	5.00	6.00	13.00	8.00	7.00	10.00	7.67
S2	14.00	7.00	11.00	6.00	15.00	12.00	6.00	9.00	8.00	9.78
S3	12.00	5.00	10.00	10.00	7.00	5.00	11.00	7.00	12.00	8.78
S4	6.00	12.00	14.00	15.00	10.00	12.00	10.00	13.00	9.00	11.22
S5	12.00	8.00	8.00	10.00	9.00	7.00	9.00	7.00	9.00	8.78
S6	7.00	8.00	12.00	7.00	9.00	11.00	11.00	12.00	9.00	9.56
S7	10.00	19.00	17.00	7.00	15.00	11.00	7.00	9.00	10.00	11.67

S8	9.00	9.00	8.00	8.00	12.00	13.00	12.00	11.00	10.00	10.22
Mean	9.75	9.00	11.00	8.50	10.38	10.50	9.25	10.25	9.63	9.81
Mean of Diameter Class	9.91			9.79			9.71			
$CD_{0.05}$ Tree = NS Sites = NS Tree x Site = NS										

Table 4 illustrates the highest mean clean bole height within trees was recorded for T9 (4.24 m), which was significantly at par with T4 (3.51 m), T5 (4.00 m), T6 (3.59 m) and T7 (3.83 m) and the minimum value for the same was recorded for T1 (2.18 m). For among site variation, the maximum value was recorded for S2 (9.05 m) and minimum value was recorded for S7 (1.25 m). Interaction of tree and site showed maximum value of clear bole height (17.10 m) for S2T9 and minimum (0.50 m) recorded for S1T6, S1T1, S7T1 and S7T5. Diameter class 30 to 40 cm showed maximum value (3.72 m) for clean bole height.

Table 4. Tree to tree variation in clean bole height (m) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			30-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	0.50	1.20	4.12	1.00	1.20	0.50	2.50	2.15	2.20	1.71
S2	4.43	5.79	1.50	5.52	8.75	11.50	17.70	9.20	17.10	9.05
S3	2.50	0.75	3.95	8.58	9.55	5.79	4.12	2.53	3.11	4.54
S4	5.00	1.50	5.79	1.50	3.20	1.50	1.50	0.52	2.50	2.56
S5	2.50	0.75	1.50	2.30	3.95	1.54	1.00	5.00	2.50	2.34
S6	1.50	0.69	2.73	2.35	2.73	4.43	1.50	2.50	2.50	2.33
S7	0.50	0.69	1.75	4.33	0.50	0.69	0.57	1.50	0.75	1.25
S8	0.52	2.53	1.50	2.50	2.15	2.76	1.75	1.50	3.24	2.05
Mean	2.18	2.84	2.86	3.51	4.00	3.59	3.83	3.11	4.24	3.35
Mean of Diameter class	2.63			3.70			3.72			
$CD_{0.05}$ Tree = 0.84 Sites = 1.45 Tree x Site = 2.51										

Critical analysis of Table 5 revealed that maximum crown length within the trees was shown by T3 (4.38 m) and T1 (3.51 m) shows the minimum value for the same. While analyzing

variation among sites, maximum value was recorded for site S7 (5.21 m), which was significantly at par with S1 (5.10 m), S2 (4.72 m) and S6 (4.26 m) and minimum value was recorded for S4 (2.24 m). Tree and site interaction showed maximum value (6.50 m) for S1T3, S2T4 and S2T5 and minimum value (1.52 m) for S4T5. Diameter class 20 to 30 cm has shown the maximum value (4.04 m) for crown length.

Table 5. Tree to tree variation in crown length (m) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			30-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	5.40	5.00	6.50	4.50	4.50	4.50	5.50	4.75	5.25	5.10
S2	6.00	2.50	6.30	6.50	6.50	3.20	3.20	4.00	4.25	4.72
S3	2.50	1.50	2.50	4.00	2.30	1.50	2.00	3.30	2.75	2.48
S4	1.50	3.20	1.50	1.50	1.52	2.50	3.90	3.00	2.50	2.24
S5	3.30	2.10	5.50	4.47	2.50	3.20	4.50	3.30	2.50	3.49
S6	4.40	4.50	1.50	5.80	5.00	5.80	5.50	2.50	3.30	4.26
S7	2.50	6.39	7.23	4.33	5.00	6.00	6.25	4.00	5.20	5.21
S8	2.50	3.00	4.00	3.25	4.52	5.20	3.00	4.24	3.00	3.63
Mean	3.51	3.52	4.38	4.29	3.86	3.99	4.23	3.54	3.59	3.88
Mean of Diameter Class	3.80			4.04			3.79			
CD _{0.05} Tree = NS Sites = 1.16 Tree x Site = NS										

An appraisal of Table 6 elucidated that the maximum value for crown width was recorded for T3 (4.84 m) and minimum value was T6 (3.14 m). For among site variation, maximum value recorded was for site S2 (5.36 m) and minimum value was recorded for site S3 (2.97 m). Analysis of trees within site interaction revealed that the maximum value (8.80 m) for S7T3 and minimum value (1.39 m) was recorded for S6T3. Diameter class 10 to 20 cm has shown maximum mean value (4.31 m) for crown width over other diameter classes.

Table 6. Tree to tree variation in crown width (m) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			30-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	6.30	6.00	7.50	3.75	2.50	6.10	3.00	4.92	2.88	4.77
S2	6.75	3.20	6.30	6.50	6.50	3.20	4.50	2.50	8.80	5.36
S3	4.20	1.50	2.50	4.00	2.30	1.50	5.50	1.05	4.20	2.97
S4	2.50	5.50	3.50	2.50	1.50	2.50	3.25	4.00	1.50	2.97
S5	2.50	3.35	4.23	4.50	1.50	4.31	6.50	1.05	2.00	3.33
S6	3.50	2.20	1.39	2.50	2.50	4.50	6.30	2.50	4.00	3.27
S7	2.20	7.50	8.80	3.50	3.50	1.50	1.50	2.20	6.30	4.11
S8	5.30	2.35	4.50	5.29	6.21	1.50	2.50	3.75	2.50	3.77
Mean	4.16	3.95	4.84	4.07	3.31	3.14	4.13	3.02	4.02	3.85
Mean of Diameter Class	4.31			3.50			3.72			
$CD_{0.05}$ Tree = NS Sites = 1.66 Tree x Site = NS										

Examination of data in Table 7 elucidated that highest mean volume within the trees was shown by T9 (1.08 m^3) and minimum being T1 (0.09 m^3). Among the sites, the site with highest mean volume were sites S3 and S7 (0.67 m^3) and site with minimum mean volume was recorded site S2 (0.41 m^3). In case of tree and site interaction the tree with highest volume was recorded as tree S4T7 (1.18 m^3) and tree with minimum volume were S2T1, S5T1 and S8T2 (0.04 m^3). On the basis of mean diameter of diameter classes, diameter class 30 to 40 cm (0.99 m^3) has excelled in this parameter.

Table 7. Tree to tree variation in volume (m^3) of *Anogeissus latifolia* at different sites in different diameter classes

Trees Sites	Diameter class									Mean
	10-20 cm (Small)			20-30 cm (Medium)			30-40 cm (Large)			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
S1	0.13	0.10	0.13	0.37	0.37	0.49	0.79	0.77	1.10	0.47
S2	0.04	0.06	0.16	0.54	0.31	0.48	0.67	0.89	0.53	0.41
S3	0.20	0.23	0.20	0.64	0.45	0.24	1.67	0.98	1.44	0.67
S4	0.08	0.24	0.24	0.20	0.42	0.77	1.18	1.31	1.16	0.62

S5	0.04	0.06	0.07	0.24	0.36	0.54	0.73	0.98	1.08	0.45
S6	0.05	0.08	0.07	0.37	0.57	0.30	0.78	0.71	0.92	0.43
S7	0.11	0.34	0.49	0.35	1.26	0.81	0.83	0.86	1.03	0.67
S8	0.11	0.04	0.36	0.41	0.45	0.94	1.13	1.05	1.30	0.64
Mean	0.09	0.14	0.19	0.39	0.50	0.56	0.99	0.90	1.08	0.54
Mean of Diameter Class	0.14			0.48			0.99			
CD _{0.05} Tree = NS Sites = NS Tree x Site = NS										

The data obtained directly from the field regarding the morphological traits revealed that a significant difference was found among the sites for traits, viz., height, clean bole height, crown length. Maximum mean value for the characters such as Height, number of main branches, crown length and volume was shown by site S7 (Jach, Kangra) whereas, site S1 (Jadli, Solan) excelled in diameter at breast height. Clean bole height and crown width were recorded maximum at site S2 (Majru, Solan).

Within the trees, variations showed non-significant difference for morphological parameters other than for height and clear bole height. When data was analyzed on the basis of overall diameter class basis by taking further average of the tree mean in different diameter classes, it was revealed that diameter class 30 to 40 cm excelled in the characters, viz., height, and volume while diameter class 20 to 30 cm (medium) has shown maximum values for traits, i.e., clean bole height. Diameter class 10 to 20 cm has shown maximum values for remaining traits.

One present finding lend in the support to the results obtained by various workers on different species for height, diameter and number of branches in *Cedrela* species (Whitmore, 1971); Jaswal (1992) in *Grewia optiva*, Chiang (1982) in *Schima superba*, Helliwall and Harrison (1978) in *Acer pseudoplatanus* and *Betula verrcosa*, Wani (2005) in *Bauhinia variegata* and Pant *et al.* (2003) in *Grewia optiva*. Similar variations were reported with respect to leaf dimensions and leaf area in *Juglans nigra* (Dixon, 1988). Studies on tree morphological parameters by Boeger (2004) showed similar variations. Morphometric variation studied by Danquah *et al.* (2011) in *Khaya* spp. and Bayramzadeh (2011) in *Fagus orientalis* exhibited same pattern. Site S7 (Jaach-Kangra) followed by Site 1 (Jaach-Solan) and S2 (Majru-Solan)

were found best over other all sites. Diameter class 30-40 cm excelled over other classes in major tree morphological parameters in determining growth and development of trees as well as direct indicator of productivity and fodder quality value. Plus tree are recommended from the sites having 30-40 cm dbh class.

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