Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; SP1: 1085-1087

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Multivariate Analysis of Biomass characteristics of *Acacia catechu* under Mid hill sub – humid Conditions of Himachal Pradesh

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Abstract
The paper deals with the usefulness of multivariate techniques (Principal Component and Factor analyses) for determination of relative contribution of morphological characters in the biomass production of *Acacia catechu.*

Keywords: *Acacia catechu*, *biomass*, principal component analysis, factor analysis

Introduction
There may be many characteristics which affect the biomass of the tree but the researchers are always interested in identifying those sets of attributes (variables) which most significantly affect the biomass of the tree. Multivariate statistical techniques are advanced techniques that deal with the analysis of two or more than two variables simultaneously. This assumes great importance in applied research problems in biological sciences, which involves many variables. The multivariate techniques allow simultaneous analysis of multiple measurements of individuals being investigated (Hair *et al* 1987). Principal component analysis is one of the data reduction techniques, where in the variables are correlated such that they convey the same things. It is a multivariate statistical technique to reduce the data with large number of correlated variables into substantially smaller sets of new variables through linear combination of variables which account for most of the variation present in the original variables (Hotelling, 1933). Using principle component analysis we can gauge about the relative contribution of various variables. The essential purpose of factor analysis is to describe, if possible, the covariance relationship among many variables in terms of a few underlined but unobservable variables called factors. The technique of factor analysis was primarily developed by seeking better understanding of human intelligence.

Acacia catechu, commonly known as khair, belongs to the family fabaceae and sub family mimosae which includes about 800 species of trees, shrubs and climbers (Tewari, 1995). It is found in abundance in Australia, Africa and Central Asia. It occurs in Tropical Moist Deciduous, Tropical Dry Deciduous and Tropical Thorn Forest types of India. There are about 22 indigenous species of *Acacia catechu* which are well distributed in the states of Uttar Pradesh, Bihar, Orissa, Jammu, Punjab, Uttarakhand, Himachal Pradesh, Tamil Nadu, Karnataka, Assam and Madhya Pradesh. In Himachal Pradesh, *Acacia catechu* is widely distributed in Mandi, Hamirpur, Kangra, Sirmaur, Una, Chamba, Shimla, Solan and Bilaspur districts below 1300 m amsl (Chowdhery *et al* 1984). This species is mainly exploited for katha and cutch. The most common use of katha is in pen making and the treatment of sore throat (Hashmat and Hussain, 2013). Cutch is chiefly used in dying and tanning industry. It yields good quality gum and also contains polyphenolic components, tannins, alkaloids, carbohydrates and flavonoids. Moreover, the seeds of this plant is a good source of protein. Keeping in view the economic importance of species, an attempt has also been made to assess the relative contribution of morphological characters in the biomass production.

Materials & Methods
The present study was carried out at two sites i.e plantation (Site-I) and natural forest (Site-II) at the main campus of Dr. Y S Parmar University of Horticulture and Forestry, Nauni (Solan), Himachal Pradesh located in the mid hill of Himachal Pradesh at 30050 30" to 30052 0" N latitude and 77008 30" to 77011 30" E longitude (Survey of India Toposheet No. 53F/1) with an elevation between 900-1300m. The data on various growth characteristics *viz.* diameter at breast height (cm), tree height (m), crown height (m), crown length (m), bole height (m) and

crown width (m) were collected. The above ground biomass was estimated separately for stem, branches and leaves + twigs of *Acacia catechu* at two sites. An optimum sample size of 105 trees was selected randomly by following a two-step approach as suggested by Stein (1945) and Cox (1958). Principal Component and Factor Analyses were carried out to find out the basic components associated with the above referred morphological characters of *Acacia catechu*.

Results and Discussions

Growth behaviour: To meet the previously stated objectives the trees were classified into four diameter classes with class interval of 5 centimetres i.e. 10-15 cm, 15-20 cm, 20-25 cm and >25 cm, respectively. The statistical constants for stem growth characteristics were worked out. The mean diameter at breast height (DBH), tree height and bole height along with standard error of mean and coefficient of variation for plantation and natural forest are given in Table 1. In a manner similar to the stem growth characteristics, statistical constants for crown characteristics were also worked out which have been presented in Table 2. The DBH, tree height and bole height exhibited increasing trend with respect to diameter class.

Table 1: Statistical constants for diameter at breast height, tree height and bole height of *Acacia catechu* at two sites

Diameter Class (cm)	DBH (cm)		Tree height (m)		bole height (m)	
	Site - I	Site – II	Site – I	Site – II	Site - I	Site - II
10-15	12.25	12.80	5.85	5.59	3.49	2.38
15-20	17.17	16.52	6.70	6.80	3.32	3.43
20-25	22.52	22.47	8.02	7.75	3.47	3.47
>25	26.72	26.1	9.88	8.33	4.58	2.89
Mean	17.54	16.93	6.95	6.66	3.49	3.03
SE	0.57	0.671	0.23	0.21	0.10	0.14
CV (%)	25.24	26.31	25.27	20.9	22.01	30.12

Table 2: Statistical constants for crown height, crown length and crown width of *Acacia catechu* at two sites

Diameter Class (cm)	Crown height (m)		Crown length (m)		Crown width (m)	
	Site – I	Site – II	Site - I	Site - II	Site - I	Site - II
5-10	3.77	4.00	3.74	5.99	3.39	4.78
10-15	3.35	3.46	7.44	8.78	4.02	4.50
15-20	3.82	4.18	9.68	9.04	5.12	5.71
20-25	4.73	6.26	13.12	11.42	5.21	6.81
Mean	3.92	4.47	8.49	8.81	4.44	5.45
SE	0.29	0.61	1.97	1.11	0.44	0.52
CV (%)	14.85	27.40	46.35	25.21	19.83	19.12

Variability analysis and evaluation of factors responsible for biomass production

F-test suggested that there was no significant variation among the characteristics of trees observed at two sites. The highest average values of all the characters such as tree height (13.42 m), crown height (4.29 m), crown width (5.33 m) and bole height (5.09 m) were observed at site-I, except dbh (15.93 cm) and crown length (9.17 m), which was maximum at site-II.

Table 3: Variability analysis for different growth characteristics

Tree characteristics	Variances		
	Site – I	Site – II	F−statistic
DBH (cm)	19.59	19.84	1.01
Tree height (m)	3.09	1.94	1.59
Crown height (m)	0.720	0.68	1.05
Crown length (m)	1.49	1.26	1.18
Crown width (m)	1.05	0.66	1.59
Bole height (m)	0.59	0.83	1.14
Total green biomass (kg)	2064.37	1304.47	1.58
Total dry biomass (kg)	710.34	506.04	1.40
Proportion of dry biomass	0.0039	0.0056	1.42

*****significant at 5% level of significance

Principal Component Analysis

The results pertaining to principal component analysis have been presented in Table 4. Study of Table revealed that two of the six principal components (PCs) have eigen values greater than unity and therefore these two principal components are playing main role in the analysis. Thus, two principal components have been retained in the analysis which explained 73.939 per cent of the total variation. The first principal component was a linear combination of three characters *viz.* diameter at breast height (cm), tree height (m) and bole height (m). This component may be interpreted as stem growth. The second principle component was a linear combination of crown height (m), crown length (m) and crown width (m) which represents crown characteristics.

Table 4: Eigenvectors of the PC analysis

Variables	PC_1	PC_2
DBH (cm)	0.427	−0.265
Tree Height (m)	0.527	−0.114
Crown height (m)	0.424	0.481
Crown length (m)	−0.482	0.424
Crown width (m)	0.239	−0.360
bole height (m)	0.638	0.352
Eigen values	3.313	1.123
% of variance	55.224	18.715
Com. % of variance	55.224	73.939

Factor analysis: One factor, F_1 has been retained in the analysis by virtue of mineigen criteria (i.e., factors having eigen value greater than one). The variation explained by factor F_1 was 51.912 per cent.

Ignoring the non-significant correlations, the orthogonal factor can be expressed as:

$F_1 = 0.682\ D + 0.991\ H + 0.566\ BH + 0.780\ CH + 0.791\ CL$

The factor F_1 was a combination of DBH (D), tree height (H), bole height (BH), crown height (CH) and crown length (CL). The communalities of the variates viz, DBH (D), tree height (H), bole height (BH), crown height (CH) and crown length (CL) were observed to be 0.494, 0.990, 0.525, 0.941 and 0.946, respectively. Thus, Factor Analysis has brought out some of the basic factor associated with morphological characters of *Acacia catechu* tree and as such it can be considered as an important tool for optimizing biomass production.

Conclusion

The tree growth and crown characteristics showed an

increasing trend with increase in diameter at the two sites. The value for diameter at breast height (17.54 cm), tree height (6.95 m), crown length (4.52 m) and bole height (3.49 m) were registered to be higher in plantation (site-I). Likewise, greater value of total green biomass (124.25 kg) and total dry biomass (74.93 kg) were recorded in plantation (site-I) as compared to the natural forest (Site-II). Non-significant variation the between two sites has been observed for all the tree characteristics in *Acacia catechu*. Significant mean difference was observed for bole height (m), total green biomass (kg) and total dry biomass (kg), whereas non-significant mean difference was recorded for the rest of the characteristics for the two sites.Two principal components were retained which together accounted for 73.93 per cent of the total variation. In factor analysis, one factor related to the combination of diameter at breast height (cm), tree height (m), crown length (m), crown length (m) and bole height (m) was retained. The variation explained by this factor was 51.912 per cent of the total variation.

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