Original Research Article

PRINCIPAL COMPONENT ANALYSIS IN BIOMETRIC, PULP QUALITY AND ANATOMICAL PROPERTIES OF THRONLESS BAMBOO (*Bambusa balcooa*)

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ABSTRACT

Aims: To estimate the impact, connection and association among the biometric attributes, pulping qualities and anatomical characters in *Bambusa balcooa*

Place and Duration of Study: The study was conducted across the agro climatic regions viz., North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone of Tamil Nadu, India during 2017-2018.

Methodology: The Principal Components Analysis (PCA) was examined to establish the numbers of clusters using Statistical Package for Social Studies (SPSS) version 16.0.1 software in order to identify the patterns of variation (PCA). The principal component analysis was computed using the equation PCA = Σ*a jXj*

Results: The PCA separated into three cluster principal components among the nineteen parameters studied. Out of nineteen principal components generated, twelve principal components had contributed positively on pulp yield. Among these twelve traits, maximum contribution to the pulp yield was observed by the traits *viz.,* numbers of culms, hollocellulose, kappa number, tear index, burst index, fibre wall thickness and vessel diameter with respect to *Bambusabalcooa*.

Conclusion: The results showed some relationships between the biometric attributes, pulping qualities and anatomical characters in *Bambusa balcooa.* PCA was shown to be a useful tool for assessing the impact and connection for further research.

Keywords: Thornless bamboos, PCA, Impact & Connection, biometric attributes, pulping qualities, anatomical characters, *Bambusa balcooa*

1. INTRODUCTION

India is the second richest country in bamboo genetic resources after China.These two countries together have more than half the total bamboo resources globally. Bamboos are aptly called the poor man’s timber and are found in great abundance. Their strength, straightness and lightness combined with extraordinary hardness, range in sizes, abundance, easy propagation and the short period in which they attain maturity make them suitable for a variety of purposes[1]. Deo Kumar Tamang *et al.,*[2] reported 136 species of bamboos occurring in India. Fifty-eight species of bamboo belonging to 10 genera are distributed in the north eastern states alone. The forest area, over which bamboos occur in India is approximately 9.57 million hectares, which constitutes about 12.8% of the total area under forests[3]. The general consumption pattern of bamboo in India indicates that 8.4% of bamboo is being consumed by pulp and paper industries while, cottage, furniture and implements industries consume 65% bamboo[4]. In earlier days, more than 70% bamboo was used for paper and paperboard production. In Bamboo, pulp yield is an important trait. This trait is more complex as it depends on the action and interaction of various component traits *viz.,* growth attributes, pulp quality and anatomical characters. In the integrated structure of Bamboo, most of the traits are inter-related with one another. Understanding of such association between traits is very essential for any genetic improvement program. Moreover, the Principal Component Analysis enables easier understanding of impacts and connections among the different traits by finding and explaining them[5]. Such studies are in infant stage in *Bambusabalcooa.* Keeping the above perspectives, the investigation on the impact and connection of different traits on *Bambusa balcooa* has been determined and presented hereunder.

2. MATERIAL AND METHODS

2.1 Materials

The thorn less bamboos species *Bambusa balcooa* grown in five agro climatic viz., Western Zone, Northern Zone, North Eastern Zone, Cauvery Delta Zone and Southern Zone were chosen as the experimental material for the present study. From the each agro climatic regions, five year old plantations of *Bambusa balcooa* were selected. From each plantation, 25 clumps in three replications were selected for recording the biometric observations. In order to carry out pulp quality analysis of, selected single culm were felled from a clump and billets of 1 m length were extracted and chipped for pulp quality analysis. Five culm samples each of dimension 2 x 2 x 2 cm^3 were sliced out separately to study the anatomical properties in this species. The growth attributes, pulp quality and anatomical characters viz., Height, Diameter, Number of culms, Internodal length, Bulk density, Basic density, Acid insoluble lignin, Holocellulose, Kappa number, Pulp yield, Tensile index, Tear index, Burst index, fiber wall thickness, fiber diameter, fiber length, Lumen diameter, Vessel length and Vessel diameter recorded at five years old *Bambusa balcooa* were subject to Principal Component Analysis.

2.2 Principal Component Analysis

A large number of variables are often measured by breeders, some of which may not be of sufficient discriminatory power for evaluation, characterization, and management. In such case, Principal Component Analysis (PCA) may be used to reveal patterns and eliminate redundancy in data sets[6] [7] as any variations routinely occur in any species. Analysis of variance using descriptive statistics such as mean, standard deviation and coefficient of variation and correlation coefficient for each of the studied traits were calculated. Clustering of genotypes into similar groups was performed using Ward's hierarchical algorithm based on squared Euclidean distances. For the three groups of traits *viz.,* biometric attributes (height, diameter, number of culms and internodal length), pulping qualities (bulk density, basic density, acid insoluble lignin, holocellulose, kappa number, pulp yield, tensile index, tear index and burst index) and anatomical characters (Fiber wall thickness, Fiber diameter, and Fiber length, Lumen diameter, Vessel length and Vessel diameter), the data were standardized to have a mean of zero and a variance of one prior to squared Euclidean distance calculation. The pseudo F statistic and the pseudo T2 statistic[8] were examined to establish the numbers of clusters using Statistical Package for Social Studies (SPSS) version 16.0.1 software[9].In order to identify the patterns of variation, (PCA) was conducted.

Those Principal Components with Eigen values greater than one were selected as proposed by Jeffers [10]. Correlations between the original traits and the respective Principal Components were calculated. Data were processed using statistical program Statistical Package for Social Studies (SPSS) version 16.0.1 software [9]. The principal component analysis was computed using the following equation:

$$PC = \Sigma a_{j} X_{j}$$

Where: PC = Principal component,

a_{ij} = Linear coefficient

X_j= Eigen vectors

3. RESULTS AND DISCUSSION

The Principal Component Analysis, is one the multivariate analysis method and provides easier understanding of impacts and connections among different traits [11]. There is a certain number of criteria for selecting the number of principal components (PC) to be included in the future analysis, and mostly these are based on the height of Eigenvalues Principal Components or needed Summary communality in percentage [11]. In most cases the number of principal components rotated depends on the number principal components chosen for the next analysis [12].

The present investigation was carried out in five agro climatic regions of Tamil Nadu *viz*., North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone with thorn less bamboo species *viz*,. *Bambusa balcooa* across different age gradations in order to elucidate the suitability of thorn less bamboos based on their growth performance, pulping qualities as well as wood anatomy. The results of Principal Component Analysis are presented here under. Number of Principal Components calculated from correlation matrix was 19. It is similar to the number of observed traits *viz.,* biometric attributes, pulp quality traits and anatomical characters of *Bambusa balcooa*. Principal Component Analysis concentrated variability in first principal components. Total variance explained with the first Principal Component was 38.99 per cent followed by second principal component (32.578 %), third principal component (18.159 %) and fourth principal component (10.273 %). With these four principal components hundred per cent of total variability had been accounted. Variances explained by the rest of fifteen principal components were irrelevant (Table 1).

The first four principal components explained were based on rotated values. Among the three groups of traits *viz.,* biometric traits, pulping qualities and anatomical characters, Significant correlation was exhibited by vessel diameter (0.997) followed by number of culms (0.987), holocellulose (0.815), burst index (0.612), tear index (-0.695), fiber wall thickness (0.805) and kappa number (0.936) in the first principal component. In the highest significant correlation with second principal component were lumen diameter (0.950) followed by fiber diameter (0.891), acid insoluble lignin (0.845) and basic density (0.865). These first and second principal components comprised of quality parameters that relates to pulp yield and paper and hence these principal components could be named as pulp and paper quality (Table 2).

TABLE 1 Eigenvalues and variability of rotated values of Principal components in *Bambusabalcooa*

Principal components	***Initial Eigenvalues***		
	Total	**% of Variance**	**Cumulative %**
Height	7.408	38.990	38.990
Diameter	6.190	32.578	71.568
Number of culms	3.450	18.159	89.727
Internodal length	1.952	10.273	100.000
Bulk density	4.910	2.584	100.000
Basic density	4.244	2.234	100.000

Acid insoluble lignin	3.331	1.753	100.000
Holocellulose	2.848	1.499	100.000
Kappa number	1.969	1.036	100.000
Pulp yield	1.061	5.584	100.000
Tensile index	6.289	3.310	100.000
Tear index	1.662	8.750	100.000
Burst index	-1.585	-8.343	100.000
Fiber wall thickness	-8.391	-4.416	100.000
Fiber diameter	-1.240	-6.525	100.000
Fiber length	-2.065	-1.087	100.000
Lumen diameter	-2.812	-1.480	100.000
Vessel length	-3.916	-2.061	100.000
Vessel diameter	-6.598	-3.473	100.000

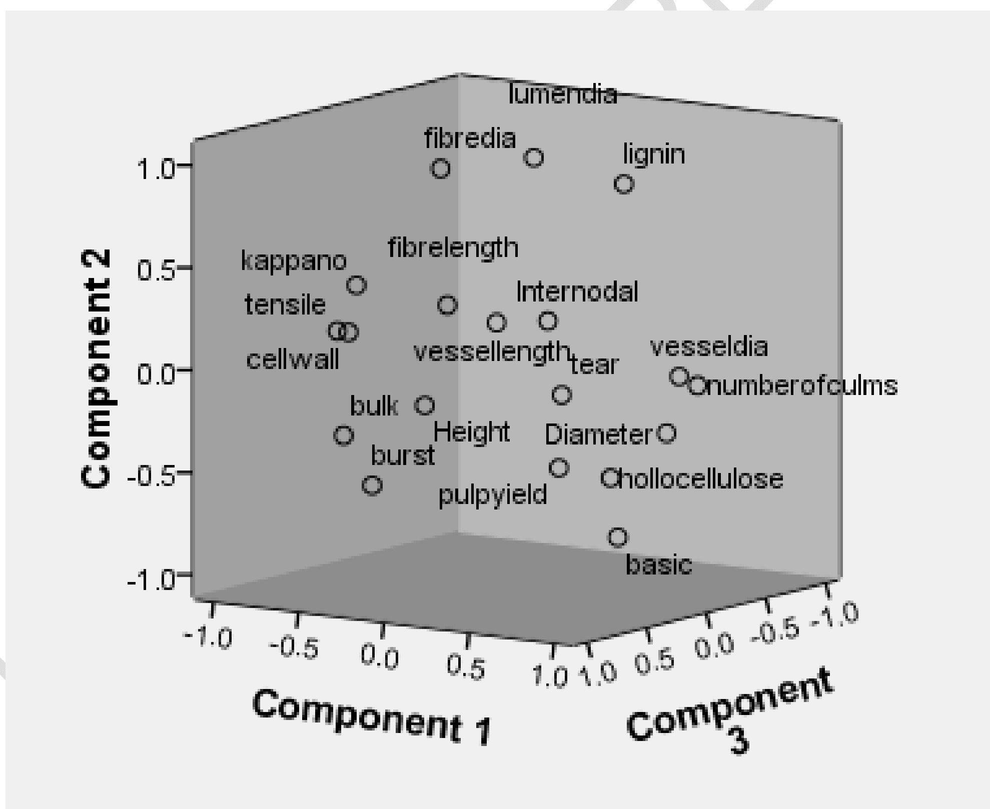
TABLE 2. Principal Component analysis of *Bambusabalcooa*–rotated values

Traits	***Principal components***			
	Component 1	**Component 2**	**Component 3**	**Components 4**
Height	0.151	-0.064	**0.986**	-0.002
Diameter	0.487	-0.389	**-0.563**	0.542
Number of culms	**0.987**	-0.040	-0.110	-0.110
Internodal length	-0.043	0.141	-0.324	**0.935**
Bulk density	-0.487	-0.309	**0.754**	-0.315
Basic density	0.405	**-0.865**	-0.272	0.120
Acid insoluble lignin	0.375	**0.846**	-0.365	0.104
Hollocellulose	**0.815**	-0.439	0.376	0.045
Kappa number	**-0.936**	0.072	0.167	0.303
Pulp yield	**0.625**	-0.033	0.514	-0.586
Tensile index	-0.306	-0.532	**0.773**	-0.159
Tear index	**-0.695**	0.347	0.350	0.524
Burst index	**0.612**	-0.390	0.518	-0.453
Fibre wall thickness	**-0.805**	0.092	0.260	-0.525
Fibre diameter	-0.442	**0.891**	0.005	0.101
Fibre length	0.083	0.378	**0.698**	-0.602
Lumen diameter	-0.058	**0.950**	-0.228	0.205
Vessel length	-0.100	0.176	0.024	**0.979**
Vessel diameter	**0.997**	0.030	0.059	0.045

The third principal component explained 18.15 percentage of total variance recorded maximum significant correlation with the pulp yield in the order of height (0.986), tensile index (0.773), bulk density (0.754), fibre length (0.698) and diameter (-0.563). Vessel length (0.979) and internodal length (0.935) recorded the maximum significant correlation with pulp yield in fourth principal component which explained 10.273 per cent of total variance. Hence the third and fourth principal components could be named as components productivity (Table 2).

In the present investigation, with respect to *Bambusa balcooa*, out of nineteen principal components generated, twelve principal components *viz.,* height, diameter, number of culms, internodal length, bulk density, basic density, acid insoluble lignin, holocellulose, kappa number, tensile index and tear index had contributed positively on pulp yield. Among these twelve traits, maximum contribution to the pulp yield was observed by the traits *viz.,* numbers of culms, holocellulose, kappa number, tear index, burst index, fibre wall thickness and vessel diameter. (Figure 1).

FIGURE 1. Principal Component analysis for *Bambusa balcooa* – rotated values



Similar to the present study PCA had also been used as an effective tool to confirm the impacts and connections among different traits in Eucalyptus [13], *Casuarina equisetifolia*[14][15] and *Azadirachta indica*[16] which fall in line with the findings of the current investigation.

4. CONCLUSIONS

Holistically, out of nineteen principal components generated, twelve principal components *viz.,* height, diameter, number of culms, internodal length, bulk density, basic density, acid insoluble lignin, holocellulose, kappa number, tensile index and tear index had contributed positively on pulp yield. Among these twelve traits, maximum contribution to the pulp yield was observed by the traits *viz.,* numbers of culms, holocellulose, kappa number, tear index, burst index, fibre wall thickness and vessel diameter with respect to *Bambusa balcooa*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Deo Kumar Tamang, Dinesh Dhakal, Sambhawana Gurung, Sharma NP, Shrestha DG. Bamboo diversity, distribution pattern and its uses in Sikkim (India) Himalaya. International Journal of Scientific and Research Publications. 2013; 3 (2).
2. Gokul R. Genetic analysis and hybridization in *Eucalyptus* species. M.Sc. (For) Thesis.Tamil Nadu Agricultural University, Coimbatore. 1997.
3. Kovacic. A factor analysis of plant variables associated with architecture and seed size in dry bean. Euphytica. 1994; 60:171-177.
4. Krishnakumar N, Kanna SU, Parthiban KT, Shree MP. Growth performance of thorn less bamboos (*Bambusa balcooa* Roxb. and *Bambusa vulgaris* Schrader ex JC Wendland). Int. J Cur. Microbiol. App. Sci. 2017; 6(4):32-39.
5. Kundu SK, Tigerstedt PMA. Geographic variation in seed and seedling traits of neem (*Azadirachta indica*) among 10 populations studied in growth chamber. Silvae Genet. 1997;46 (2-3): 129-137.
6. Paramathma M. Studies on genetic inheritance and interspecific crosses of *Eucalyptus*. Ph.D. Thesis. Tamil Nadu Agricultural University, Coimbatore. 1992.
7. Pinyopusarerk K, Williams ER, Luangviriyasaeng V, Puriyakorn B. Geographic variation in growth and morphological traits of *Casuarinaequisettifolia*. Recent Casuarina Research and Development. (In. Proceedings of Third International Casuarina Workshop Da Nang,Vietnam 4-7 March. 1996**:**143-151.
8. Tewari DN. A monograph of Bamboo. International Book Distributors. Dehradun, India. 1996: 495p.
9. Vasic Mirjana, Jelica Gvozdanovic- Varge, Janko Cervenski. Divergence in the dry bean collection by PCA. Genitika. 2008: 23-29.

10. Adams MJ. The principles of multivariate data analysis. *Analytical methods of food authentication.* 1998: 308.
11. Amy EL, Pritts MP. Application of principal component analysis to horticultural research. *Hort science*. 1991; 26(4): 334-338.
12. Jeffers JNR. “Two Case Studies in theApplication of Principal ComponentAnalysis,” *Applied Statistics.* 1967;16: 225–236.
13. Jobson JD. *Applied Multivariate Data Analysis, Volume II: Categorical and Multivariate Methods*. Springer-Verlag. New York. NY. USA.1992: 731.
14. Katwal RPS, Srivastva RK, Kumar S, Jeeva V. State of forest genetic resources conservation and management in India. Forestry Department. 2003.
15. Seal Hilary. "Multivariate statistical analysis for biologists." *Multivariate statistical analysis for biologists.* 1964.
16. SPSS INC. "SPSS version 16.0." *Chicago, IL: SPSS Incorporated*. 2007.