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RESEARCH ARTICLE

Association of biometric attributes and feed stock quality on ligno cellulosic ethanol yield

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ABSTRACT

Investigations were carried on the eight identified lingo cellulosic ethanol feed stock *viz., Acrocarpus fraxinifolius*, Casuarina MTP 2, *Chukrasia tabularis*, Eucalyptus MTP 1, *Melia dubia*, *Populus deltoids*, *Leucaena leucocephala* and *Thespesia populnea* on order to identify the association of biometric attributes (height, basal diameter and volume index), physical and proximate characters (bulk density, basic density, acid insoluble lignin, moisture, holo- cellulose, fibre wall thickness, fibre diameter, fibre length and lumen diameter) of feed stock on ethanol yield. The study has revealed that holocellulose (0.416), volume index (0.325) and basic density (0.199) had exhibited signifi- cant positive correlation with ethanol yield. Whereas, moisture (-0.413) and bulk density (0.010) recorded negative and significant correlation and lignin (-0.343) showed negative and non-significant correlation with ethanol yield. Thirteen principal components were generated and five principal components *viz.,* holocellulose (0.416), bulk den- sity (0.010), basic density (0.199), fibre length (0.594) and fibre diameter (0.144) had contributed maximum to ethanol yield and the other traits *viz.,* lignin (-0.343), moisture (-0.413) and height (0.266) had exerted minimum contribution to ethanol yield.

Key Words : Association Studies - Ligno Cellulosic Ethanol - Feed Stock Quality

Introduction

Nation's prosperity and development demands energy resources mainly relying on oil consumption. Considering that world-wide geopolitical, economi- cal and market forces control oil availability, its prices and demand, governments have encouraged renew- able energy development. Issues like environmental pollution and climate change, in combination with well-documented drawbacks of fossil fuels, are driv- ing the search for clean carbon-neutral fuels. Hence, the necessity for alternative and renewable energy sources became a priority. Biofuels, derived from re- newable plant biomass may both reduce our depen- dence on oil and other fossil fuels as well as restrain mankind's activities that contribute to environmental instability. Biomass, as a versatile renewable energy source with high potential, could contribute to the energy needs of modern society in short to medium term. Even though, other renewable sources can be used for the production of heat and electricity, bio- mass is unique in terms of conversion into a transpor- tation fuel that is compatible with the current existing infrastructure (Theoni Margaritopoulou, 2016).

India has 0.5 per cent of the oil and gas resourc- es of the world but support 16 per cent of the world's population with the result that the country depends heavily on oil imports to meet the domestic demand (Sukumaran and Pandey, 2009). The demand for mo- tor gasoline has been growing at an average annual rate of approximately 7 per cent during the last de- cade and it shows an increasing trend (MPNG, 2009). With the ever increasing demand for energy and the fast depleting petroleum resources, globally there is an increased interest in alternative fuels, especially in ligno cellulosic ethanol (ICRIER, 2011) since it mitigate greenhouse gas emissions for a sustainable environment (Bishnu Joshi *et al.,* 2011). In the year 2003, the Plan- ning Commission, Government of India brought out an extensive report on the development of biofuels (Planning Commission, 2003) and bio-ethanol and biodiesel were identified as the principal biofuels to be developed for the nation. Elaborate policies for promoting ligno cellulosic ethanol were formulated and the time frames for implementation of policies were defined. The blending targets for ethanol in gas- oline and petroleum diesel were also proposed as 10 per cent and 20 per cent by 2016 and 2017 respec- tively (Planning Commission, 2003) and currently 5 per cent ethanol blend in gasoline was made manda- tory. Bio-ethanol from ligno cellulosic biomass is one of the important alternatives being considered due to its cleaner fuel with higher octane rating than gaso- line (Wheals *et al.,* 1999; Grad, 2006). It is estimated that consumption of petrol for transportation needs during 2016 - 2017 was 2078.5 billion litres and the demand for bioethanol at 5 per cent blending level itself will be 103.9 billion litres against the mandatory level of 20 per cent blending (415.7 billion litres) as per the National Biofuel Policy 2009. A comparison between the available ligno cellulosic feed stocks with current use shows that about two-fifths of the exist- ing ligno cellulosic feed stock potential is used and the current biomass use is clearly below the available potential. Therefore, an increased biomass use is pos- sible for production of bioethanol.

Opportunities to match feed stock physical and chemical properties to ethanol conversion efficien- cy are manifold and have long been recognized. At- tempts to capitalize on such opportunities however have been limited by several concerns. According to Dinus (2001), the wood physical and chemical prop- erties *viz.,* moisture content, specific gravity, fibre morphology, ash, lignin, cellulose and extractives of the ligno cellulosic biomass feed stock are the im- portant attributes which had contributed significant impact on bioethanol conversion efficiency. Howev- er information pertaining to the influence of specif- ic traits to ethanol yield and the cumulative effect of various traits are not available for many ligno cellu- losic species. Besides this the Principal Component Analysis enables easier understanding of impacts and association among the different traits by finding and explaining them (Vasic *et al.,* 2008). Earlier the use of Principal Component Analysis was very well docu- mented in many tree species to understand the level of association among the investigated parameters and their contribution to the character of interest. Hence it is essential to determine the association among the physical and chemical properties of the ligno cel- lulosic feed stock as well as their contribution to the bioethanol yield through a systematic investigation.

Methods

The experimental materials for the current study consisted of fifteen lingo cellulosic ethanol feed stock plantation trial comprising of various potential species *viz., Acacia auriculiformis, Albizzia falcataria, Anthocephalus cadamba, Acrocarpus fraxinifolius, Cassia siamea,* Casuariana MTP2*, Chukrasia tabularis, Dalbergia sissoo,* Eucalyptus MTP1, *Gmelina arborea, Leucaena leucocephala, Melia dubia, Populus deltoi- des, Swetinia macrophylla* and *Thespesia populnea* established at Seshasayee Paper and Boards Limited, trial field, Erode. After preliminary screening for Holo cellulose content, eight species *viz., Acrocarpus frax- inifolius*, Casuarina MTP 2, *Chukrasia tabularis*, Euca- lyptus MTP 1, *Melia dubia*, *Populus deltoids*, *Leucaena leucocephala* and Thespesia *populnea* were deployed for growth assessment, ethanol recovery and further association studies. Association between Biometric attributes of lingo cellulosic feed stocks (Height, Basal Diameter, Volume Index), chemical composition (Holo cellulose, Lignin, Moisture, Bulk Density, Basic Densi- ty) and fiber characters (Fibre Length, Fibre Diameter, Fibre Wall Thickness, Fibre Lumen Width) on ethanol yield were studied through correlation based on the method suggested by Dhillon *et al* (1992). Clustering of genotypes into similar groups was performed us- ing Ward's hierarchical algorithm based on squared Euclidean distances. For the three groups of traits *viz.,* biometric attributes, chemical composition and fiber characters of lingo cellulosic feed stocks 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 T^2 statistic were examined to establish the numbers of clusters using Statistical Package for Social Studies (SPSS) version 16.0.1 software (SPSS, 2007). In order to identify the patterns of variation, Principle Compo- nent Analysis was also conducted.

Results and Discussion

Ethanol yield is a complex entity associated with many parameters, which are themselves *inter*-relat- ed. Such *inter* relationship of various biometric, phys- ical and proximate parameters are highly essential to understand the relative importance of each character involved. If correlations are high, attempts to obtain a response in one character by selecting for the associ- ated traits may be worthwhile.

In the present investigation, the association of biometric, physical and proximate characters on ethanol yield revealed that holocellulose (0.416), volume index (0.325) and basic density (0.199) had exhibited significant positive correlation with etha- nol yield. Whereas, non-significant but positive cor- relation was observed with fibre length (0.594), fibre diameter (0.144), fibre wall thickness (0.058), fibre lumen width (0.390), height (0.266), basal diameter (0.206) as ethanol yield. All the other characters *viz.,* moisture and bulk density recorded negative and sig- nificant correlation with ethanol yield but the lignin content exhibited negative and non-significant cor relation with ethanol yield (Table 1). Based on the current investigations, the significant and positively correlated parameters *viz*., holocellulose, volume in- dex and basic density could be used as selection in- dices for the selection of high yielding short rotation ligno cellulosic species for ethanol production. Similar indices were also reported by a plethora of workers *viz.,* Krishnakumar (2013) in *Bambusa balcooa* and *Bambusa vulgaris*, Bamboo species (Thiruniraiselvan, 2012), *Melia dubia* (Saravanan, 2012), Eucalyptus clones (Vennila, 2009), *Leucaena leucocephala.* The positive correlation between cellulose and ethanol and negative correlation between lignin and ethanol yield could be used as an ideal indicator for screening ligno cellulosic species for ethanol production.

The Principal Component Analysis, is one the multivariate analysis method and provides easier understanding of impacts and connections among different traits (Kovacic, 1994). In the present inves- tigation, with respect to ligno cellulosic species, out of thirteen principal components generated, nine princi-

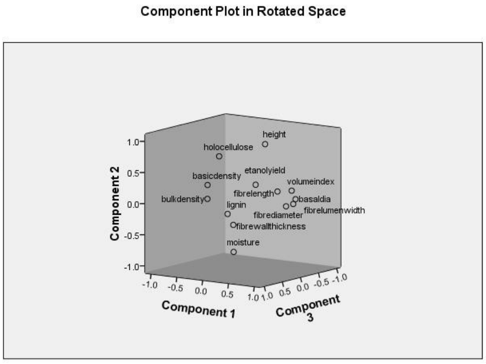

Fig 1. Principal Component analysis of biometric, physical and proximate characters on Ethanol yield – rotated values

pal components *viz.,* holocellulose (41.04), bulk densi- ty (62.62), basic density (78.91), fibre length (90.36), fibre diameter (95.94), fibre wall thickness (99.37), fibre lumen width (100), basal diameter (100) and vol- ume index (100) had contributed maximum to ethanol yield (data not shown). The other three principal com- ponents *viz.,* lignin, moisture and height had exerted minimum contribution to the ethanol yield (Fig 1).

Thus, it is concluded from the current investiga- tion that even though nine principal components had contributed maximum to ethanol yield, the cumula- tive effect principal components viz., holocellulose, bulk density, basic density, fibre length, fibre diameter accounted more than 95.947 per cent correlation to- wards ethanol yield. Hence, these parameters could be most influential or associated traits for the ethanol yield. The principal component analysis had also been used as an effective tool to confirm the impacts and association among the different traits in *Bambusa vul- garis, Bambusa balcooa* (Krishnakumar, 2013), which lend support to the current study.

Conclusion

The association studies of biometric, physical and proximate characters on ethanol yield revealed that holocellulose, volume index and basic density had exhibited significant positive correlation with ethanol yield. Whereas, moisture and bulk density re- corded negative and significant correlation and lignin showed negative and non-significant correlation with ethanol yield.Thirteen principal components generat- ed and five principal components viz., holocellulose, bulk density, basic density, fibre length and fibre di- ameter had contributed maximum to ethanol yield. Other traits *viz.*, lignin, moisture and height had exert- ed minimum contribution to ethanol yield.

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Table 1. Correlation co-efficients of biometric, physical and proximate parameters on ethanol yield

	Holo cellulose	Lignin	Moisture	Bulk Density	Basic Density	Fibre Length	Fibre Diameter	Fibre Wall Thickness	Fibre Lumen Width	Height	Basal Diameter	Vo e In
Holo cellulose	1.000	-0.083	-0.679	0.364	0.576	0.158	-0.075	0.275	-0.131	0.594	-0.125	0.08
Lignin		1.000	0.479	-0.262	-0.075	-0.108	-0.684	-0.237	-0.479	-0.333	-0.364	-0.33
Moisture			1.000	-0.373	-0.471	-0.560	-0.381	-0.002	-0.388	-0.845**	-0.357	-0.51
Bulk Density				1.000	.906**	0.236	0.083	0.435	-0.045	-0.062	-0.098	0.04
Basic Density					1.000	0.304	-0.035	0.297	-0.092	0.130	-0.085	0.01
Fibre Length						1.000	0.657	0.241	0.765*	0.446	0.823*	0.92**

Fibre Diameter							1.000	0.447	0.938**	0.267	0.843**	0.88*
Fibre Wall Thickness								1.000	0.246	-0.202	0.196	0.19
Fibre Lumen Width									1.000	0.282	0.866**	0.84**
Height										1.000	0.444	0.50
Basal Diameter											1.000	0.97**
Volume Index												1.00
Ethanol Yield												