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Suitability of invasive species for briquette production: *Lantana camara* and *Prosopis juliflora*

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Abstract
Study on production of briquettes from two invasive forest weeds, i.e., *Lantana camara* and *Prosopis juliflora* was carried out. The experiments were carried out using a 70 mm industrial briquetting unit. The optimum moisture content for briquetting was found around 10–12%. *Lantana camara* and *Prosopis juliflora* biomass briquettes were found to have high density (1.1 g cm-3). In this study, fuel properties (proximate and ultimate analysis), combustion characteristics and ash elemental composition of *Lantana camara and Prosopis juliflora* biomass were investigated. Both the species are found to have less ash content. The emphasis was given to these species because of the huge biomass they produce. These species are widely present in different agro-climatic zones of India and can play a major role in future bioenergy schemes.

Keywords: Biomass, briquettes, *Lantana camara*, *Prosopis juliflora*, invasive weeds

Introduction
Historically, wood is oldest form of energy feedstock used by mankind. Wood is either burned directly as firewood or indirectly as charcoal (Matti 2004). In many developing countries, charcoal is used as a domestic fuel for cooking and heating. The demand of charcoal has increased greatly in recent past due to multiple uses of charcoal. However, due to strict environmental regulations and forest protection policies there is hardly any supply of wood as feedstock from the forest, and therefore, the utilization of alternative available biomass resources (such as weeds) as feedstock for charcoal production is necessitated. In this study, we have focused on utilization of lantana stem biomass for production of charcoal. Lantana camara is an invasive weed species, which grows wild throughout the India. It is regarded as one of the worst weeds in almost 50 countries because of its invasiveness, potential for spread, and economic and environmental impacts. Lantana forms dense, impenetrable thickets that take over native vegetations. It is a dominating weed species which is reported as threat to biodiversity and ecology (Cronk and Fuller 1995; Rawat and Bhainsora 1999). However, they produce huge woody biomass which can be utilized for energy purposes. Some efforts in the past have been made to make use of these available biomass sources as feed stock for energy (Senelwa and Sims, 1999; Prasad *et al.*, 2001).
Lantana camara is a noxious forest weed. It is termed as an invasive weed in many countries throughout the world. *Lantana camara* is fiercely competitive plant. It covers an open ground very quickly. It causes serious damage to ecology and local biodiversity. It is an ecologically tolerant species; however, more than its widespread distribution, it is the density of infestation which is recognized as a future threat to ecosystems (Sharma *et al.*, 2005) [8].
Prosopis juliflora is another invasive species. It has covered millions of hectares of cropland and forest areas throughout the country (Kumar and Mathur 2014) [17]. In Tamil Nadu alone spread over the area of more than 35,000 ha. Spread of *Prosopis juliflora* has several ecological implications. Its presence is correlated with decrease in crop production, shrinking water bodies and displacement of native flora and fauna (Shiferawa *et al.*, 2004). There are several uses reported from *Prosopis juliflora*. The pods are used as food and medicinal supplement for both man and animal. The alkaloids obtained from leaves have antifungal properties. Its wood is used for production of charcoal and activated carbon (Kailappan *et al.*, 2000) [4]. *Prosopis juliflora* wood has high calorific value (Kumar *et al*., 2020) [23] and it is widely distributed in different agro-climatic zones of India and is expected to play a major role in future bioenergy schemes (Kumar *et al.*, 2009). These two invasive species are deteremental to the wildlife habitat. The government also started to eradicate these invasive species to be mitigate man animal conflict.

Briquetting of biomass presents a possible avenue for a large scale and sustainable utilization biomass resources for energy production. *Lantana camara* and *Prosopis juliflora* biomass in their original form are difficult to use as energy feedstock because of their high moisture content, irregular shape and sizes, low bulk density, etc. Densification of biomass materials, known as briquetting, helps in overcoming such problems and facilitates easy transportation, handling and storage. The quality of briquettes depends upon basic fuel characteristics of raw material, particle size, moisture content, etc. (Chen *et al.*, 2009). Fuel value of briquette is a function of chemical and elemental composition of raw material (McKendry 2002). Calorific value, ash content and moisture content are important fuel parameters which directly affect the quality of fuel. Grover and Mishra (1996) [2] reported the importance of particle size and shape for densification. It was recommended to use 80% material of 5–6 mm size and to add around 20% powdery component (<1 mm mesh) for best results. If the size of the particle is bigger (C 20 mm), it is difficult to make good quality briquettes (Emerhi 2011; Saptoadi 2008).

In this study, briquettes were produced from *Lantana camara* and *Prosopis juliflora* biomass. The effect of moisture content on quality of briquettes was investigated. Fuel properties (calorific value, ash content, volatile and fixed carbon content) of *Lantana camara* and *Prosopis juliflora* biomass were determined. Study on chemical and elemental properties has been carried out. The ash elemental analysis and combustion characteristics were also determined.

Materials and Methods

Samples of *Lantana camara* and *Prosopis juliflora* were obtained from Sathyamangalam Forest Division, Tamil nadu, India. After harvesting, the biomass samples were left in the field for a few days for drying. Only woody parts of *Lantana camara*, i.e., stem and twigs samples, were collected and used for experiments. *Prosopis juliflora* trees were procured from erode, district of Tamil nadu, India. The trees were obtained from similar soil and climatic condition.

Ash content and volatile matter content were determined according to ASTM D5142, by using proximate analyzer (LECO TGA-701). The fixed carbon content (FCC) was estimated using the following equation:

FCC (%) = 100 – (% Moisture content + % Ash content + % Volatile matter)

The combustion characteristic of *Lantana camara* and *Prosopis juliflora* was studied under the air atmosphere (21% oxygen and 79% nitrogen). Thermogravimetric analysis (TGA) was carried out using TGA Q500 V20.2. A known quantity of powdered sample (10 mg) was placed in a platinum crucible and heated from ambient to 800 °C at a heating rate of 10 °C min^{-1}. The airflow rate (60 ml min^{-1}) was kept uniform during the experiment. General guidelines of ASTM D 3850 were followed. The burning profiles of the samples were derived by applying the derivative thermogravimetry technique (Kumar and Chandrashekar 2014) [17].

The biomass briquettes were prepared using a 70 mm industrial briquetting unit which has production capacity of 700 – 800 ton per hours. The unit functions on ram and piston technology, involving injecting biomass material into a tapering die by reciprocating ram. The two load wheels (flywheels) reciprocally rotate and thrust the piston into die. This generates sufficient amounts of heat within the die, resulting in softening of lignin. The soft lignin once cools down, results in binding of fibers (Grover and Mishra 1996) [2]. *Lantana camara* and *Prosopis juliflora* biomasses were converted into two different size particles, i.e., ≤ 1 mm and 5 – 6 mm. The small and large size particles were used in the ratio of 1:4. The amount of moisture present in the feedstock plays a very critical role in determining the quality of briquettes (Mani et al. 2006) [9]. The moisture content (MC) was measured by oven dry method. The effect of moisture content on the quality of briquette and machines performance was investigated. The green biomass samples were sundried for 6–7 days in the field after harvesting. These air-dried samples (≈20% MC) were further chipped and converted into smaller size particles. The powdered samples were spread under the shed for a few more days. After sun drying and air-drying, the MC was recorded to be around 10–15%. Part of this raw material was oven dried to < 5% MC. Finally, the samples were packed in airtight bags and transported to industry for experiments. For each set of Moisture content, four experiments were performed and their average value is reported. The moisture content (MC) of the sample was calculated using the following formula,

$$MC = \frac{(W_2 - W_1)}{W_2} * 100$$

Where

W1 = Initial mass, g; W2 = Oven dry mass of sample, g

As soon as the briquettes were ejected, the density was determined. Density (g cm^{-3}) of the samples (D) was determined using equation,

$$D = W_B - W_g$$

Where W_B is the oven dry mass of briquettes and Vg is the volume of cylindrical briquettes. Stereometric methods were used for determination of briquette density, wherein, mass of briquette was measured using digital weighing balance, and its volume was estimated by obtaining its radius and height using caliper (Demirbas and Sahin 1998) [3].

Result and Discussion

The quality of fuel depends on the basic properties of raw material. The results on proximate analysis are summarized in Table 1. The presence of less ash content in *Lantana camara* (3.8%) and *Prosopis juliflora* biomass (2.3%) gives added advantage to briquettes made from these species. The fixed carbon content is another important parameter for comparing fuel properties of different feedstocks. High fixed carbon content corresponds to high-energy value of a fuel. As shown in Table 1, *Lantana camara* biomass is found to have more fixed carbon content (16.6%) than *Prosopis juliflora* biomass (14.9%). The values of volatile matter content were found to be 70% and 72% in *Lantana camara and Prosopis juliflora* samples, respectively.

Table 1: Physical properties of biomass

Wood species	Basic density (g cm^{-1})	Proximate analysis (wt% dry basis)			
		MC	Ash	VMC	FCC
L. camara	0.11	5.70	3.8%	70%	16.6%
P. juliflora	0.09	4.25	2.3%	72%	14.9%

In this study, the effect of moisture content (≤ 5% and between 10–12%) on quality of briquette was investigated. The raw material with 10–12% MC resulted in stronger, denser and more stable briquettes. The process of briquetting was trouble-free with minimum blockages and cracks. The performance of the machine was also flawless with less power consumption. On the other hand, a large number of cracks and breakages appear, when dry biomass (<5% MC) is used. Further, more pressure was exerted on load wheels (flywheels), and a decline in mechanical thrust by piston was observed. An increase in load on flywheels resulted in increases in power consumption. Li and Liu (2000) noted that if the moisture is ≤ 4%, briquettes tend to become fragile in a few days and absorb moisture from the atmosphere. Presence of moisture in the biomass helps in the densification process. The available moisture facilitates the bonding via van der Waal's forces by increasing the contact area between the particles (Grover and Mishra 1996) [2]. The heat generated due to friction and piston moment results in steam formation which softens or relaxes the fibers and thereby helps in producing compact and smooth briquettes (Colley *et al.*, 2006).

In this study, TGA technique has been used for understanding the thermal degradation behaviour of different biomass under oxidizing atmosphere (Obernberger and Thek 2004). The burning profiles of *Lantana camara and Prosopis juliflora* biomass are given in Table 2 and Fig 1. Three major steps of decomposition/weight loss have been observed for both biomasses. Between the temperatures 50–90 °C, DTG curves show a weight loss which is mainly due to the removal of moisture from the biomass Fig 1. The second weight loss between temperatures (180–360 °C) is due to oxidative decomposition of biomass. The third major weight loss observed in the temperature range of 350–550 °C is due to the combustion process of char (Table 2). The extent of weight loss in these two combustion steps differs with the species. The difference in the profile can be attributed to difference in the physical and chemical properties of biomass. The ignition temperature and peak temperature are two important characteristic temperatures of a burning profile (Haykiri-Acma 2003). The ignition temperature corresponds to the point at which the burning profile underwent a rapid rise.

However, the temperature where the rate of weight loss due to combustion remains high is called peak temperature (Munir *et al.*, 2009) [10]. The understanding of peak temperature has significance in the designing of thermochemical conversion processes. This point is considered as an indicator of the reactivity of the sample. The rate of weight loss at the burning profile peak temperature is called maximum combustion rate. The rate of combustion for *Lantana camara and Prosopis juliflora* biomass was found to be 1.4 and 1.8 mg min^{-1}, respectively. The weight loss percentages of *Lantana camara and Prosopis juliflora* at 700 °C were found to be 99% and 98%, respectively.

Table 2: Characteristics of thermo gravimetric experiment under oxidizing (air) conditions

Biomass feed stock	Oxidative degradation zone				Char combustion zone			
	Ignition temperature (°C)	Peak temperature (°C)	Maximum combustion rate (Mg min^{-1})	Temperature range (°C)	Ignition Temperature (°C)	Peak Temperature (°C)	Maximum combustion rate (Mg min^{-1})	Temperature Range (°C)
L. camara	245	323	1.444	240-350	425	436	1.013	410-490
P. juliflora	239	309	1.796	230-350	400	425	1.405	380-490

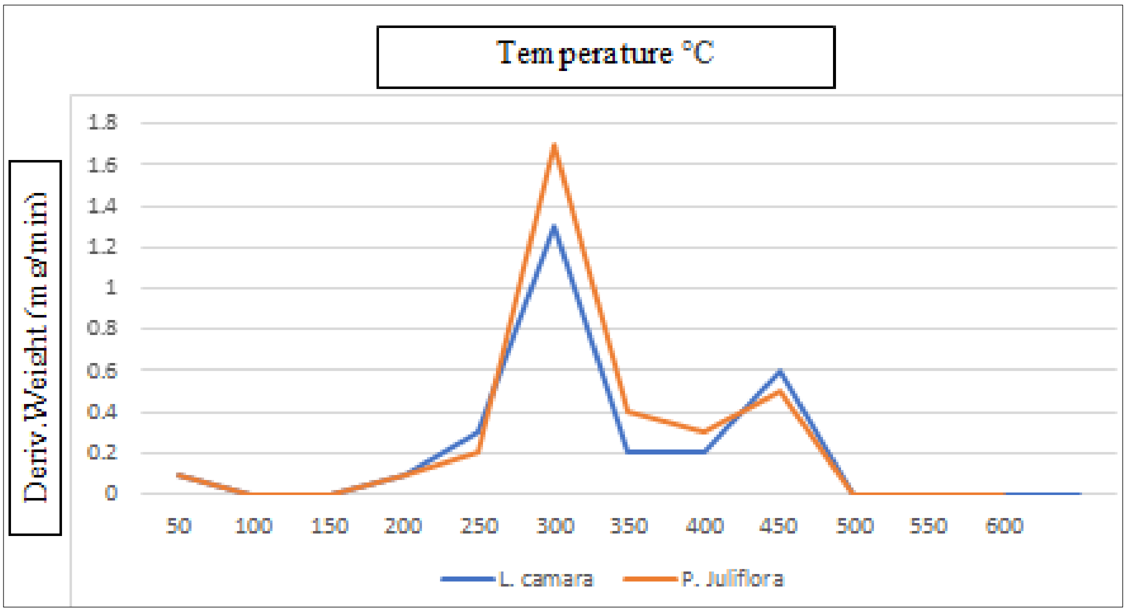

Fig 1: Burning Profiles of *Lantana camara and Prosopis juliflora*

Conclusions

The briquettes produced from *Lantana camara and Prosopis juliflora* found to have optimum moisture content in biomass briquetting. Presence of less ash content (≤ 5%) in *Lantana camara and Prosopis juliflora* enhances the quality of briquettes and appropriate and absolute mixing proportion of saw dust with *Lantana camara* and *Prosopis juliflora* material will be finalized for efficient production of briquettes.

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References

1. Lindley JA, Vossoughi M. Physical properties of biomass briquets. Transactions of the ASAE. 1989;32(2):361-0366.
2. Grover PD, Mishra SK. *Biomass briquetting: technology and practices*. Bangkok, Thailand: Food and Agriculture Organization of the United Nations. 1996, 46.
3. Demirbaş A, Şahin A. Evaluation of biomass residue: 1. Briquetting waste paper and wheat straw mixtures. Fuel processing technology. 1998;55(2):175-183.
4. Kailappan R, Gothandapani L, Viswanathan R. Production of activated carbon from prosopis (Prosopis juliflora). Bioresource Technology. 2000;75(3):241-243.
5. Bhattacharya SC, Leon MA, Rahman MM. A study on improved biomass briquetting. Energy for sustainable development. 2002;6(2):67-71.
6. Haykırı-Açma H. Combustion characteristics of different biomass materials. Energy Conversion and Management. 2003;44(1):155-162.
7. Obernberger I, Thek G. Physical characterisation and chemical composition of densified biomass fuels with regard to their combustion behaviour. Biomass and bioenergy. 2004;27(6):653-669.
8. Sharma GP, Raghubanshi AS, Singh JS. Lantana invasion: an overview. Weed Biology and Management. 2005;5(4):157-165.
9. Mani S, Tabil LG, Sokhansanj S. Specific energy requirement for compacting corn stover. Bioresource Technology. 2006;97(12):1420-1426.
10. Munir S, Daood SS, Nimmo W, Cunliffe AM, Gibbs BM. Thermal analysis and devolatilization kinetics of cotton stalk, sugar cane bagasse and shea meal under nitrogen and air atmospheres. Bioresource technology. 2009;100(3):1413-1418.
11. Furtado TS, Valin M, Brand MA, Bellote AFJ. Variables of briquetting process and quality of forestry biomass briquettes. Pesquisa Florestal Brasileira. 2010;30(62):101-106.
12. Patel B, Gami B, Bhimani H. Improved fuel characteristics of cotton stalk, prosopis and sugarcane bagasse through torrefaction. Energy for Sustainable Development. 2011;15(4):372-375.
13. Yin CY. Prediction of higher heating values of biomass from proximate and ultimate analyses. Fuel. 2011;90(3):1128-1132.
14. Nhuchhen DR, Salam PA. Estimation of higher heating value of biomass from proximate analysis: A new approach. Fuel. 2012;99:55-63.
15. Mandal S, Singh RK, Kumar A, Verma BC, Ngachan SV. Characteristics of weed biomass-derived biochar and their effect on properties of beehive briquettes. Indian J. Hill Farming. 2013;26:8-12.
16. Kumar R, Chandrashekar N. Study on chemical, elemental and combustion characteristics of Lantana camara wood charcoal. Journal of the Indian Academy of Wood Science. 2013;10(2):134-139.
17. Kumar S, Mathur M. Impact of invasion by Prosopis juliflora on plant communities in arid grazing lands. Tropical Ecology. 2014;55(1):33-46.
18. Shinde VB, Singarvelu M. Thermo gravimetric analysis of biomass stalks for briquetting. Journal of Environmental Research and Development. 2014;9(1):151-160.
19. Tokan A, Sambo AS, Jatau JS, Kyauta EE. Effects of particle size on the thermal properties of sawdust, corncobs and Prosopis Africana charcoal briquettes. American Journal of Engineering Research (AJER). 2014;3(8):369-374.
20. Abebe S, Leta S, Soromessa T, MM K. Fuel briquette potential of Lantana camara L. weed species and its implication for weed management and recovery of renewable energy source. Ethiopia (Addis Ababa University). 2015.
21. Raj SK, Syriac EK. Invasive alien weeds as bio-resource: A review. Agricultural Reviews. 2016, 37(3).
22. Abebe FB. Invasive Lantana camara L. shrub in Ethiopia: ecology, threat, and suggested management strategies. J Agric Sci. 2018:10(7):184-195.
23. Kumar R, Chandrashekar N. Production and characterization of briquettes from invasive forest weeds: Lantana camara and Prosopis juliflora. Journal of the Indian Academy of Wood Science. 2020;17(2):158-164.
24. Bisen KS, Sharma P, Gupta B, Baredar P. Development and experimental characterization of energy efficient poultry litter & plant weeds-based briquettes (PLPWBB) by comparing with rice husk briquettes. Materials Today: Proceedings. 2021;46:5428-5432.
25. Nunes LJ, Rodrigue AM, Loureiro LM, Sá LC, Matias JC. Energy recovery from invasive species: Creation of value chains to promote control and eradication. Recycling. 2021;6(1):21.
26. Pasiecznik N, Livingstone J, Shibeshi A, Ahmed S, Fre Z. Utilization of *Prosopis juliflora* in the Horn of Africa: Recent developments. Prosopis as a Heat Tolerant Nitrogen Fixing Desert Food Legume. 2022, 169-185.