Ambient Science, 2018: Vol. 05(Sp2); Online
DOI:10.21276/ambi.2018.05.sp2.ra03

ambient
SCIENCE
Vol. 5(Sp2):Online
Year 2018

Published by: National Cave Research and Protection Organization, India

RESEARCH ARTICLE

Energy Potentiality from Surplus Crop Residues of Cotton Stalk in Tribal Areas of Southern Rajasthan, India

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Study Areas & their respective Coordinates: 6 districts of Rajasthan, India= Chittorgarh (24.88°N; 74.63°E), Pratapgarh (24.03°N; 74.78°E), Udaipur (24.58°N; 73.68°E), Rajsamand (25.07°N; 73.88°E), Banswara (23.55°N; 74.45°E) Dungarpur (23.84°N; 73.72°E).

Key words: Biomass fuel, Renewable energy

Abbreviations: Ha- Hectares; GJ- GigaJoules; Cv- Calorific values; Kcal/Kg- Kilo calorie/Kilogram; MT- Metric tonne; CR- Crop residue

Abstract

Energy is considered as the basic need of development for the wealth of nation and societies. All around the world, the surplus agricultural biomass is being utilized as a fuel for power generation. Largely in India, the biomass utilized as a valued source of energy and contributing around 70% in the rural areas. In the present study, the assessment was done for cotton stalk as crop residue biomass in six districts of southern Rajasthan of India. The bio-energy potential study was done by using crop statistics, collection of secondary data from Government Authorities and followed by standard procedures to estimate heating value. In Rajasthan, the total area under cotton cultivation in six targetted districts was 167126 Ha. Correspondingly, the gross crop residues estimated was around 1.39 million metric tonnes during the year 2009-2010 to 2013-2014. The surplus crop residues of the cotton stalk were estimated around 34% (0.184 million metric tonnes) during the study period. Subsequently, the gross and surplus bio-energy potential was estimated around 2422 and 823 GJ respectively. The study revealed that a huge amount of agricultural residue of the cotton stalk was available in the region having a broader scope for bio-energy generation.

Introduction:

In India, crop residues utilize as biomass fuel mostly in the villages due to its vital availability and consideration as a cheap alternative energy source. Biomass energy still is the main energy source in many developing countries and regions because it provides roughly around 35% of energy demand in developing countries. Biomass energy accounts for about 15% of the world's primary energy consumption and about 38% of the primary energy consumption in developing countries (Hall & House, 1993). Furthermore, biomass often accounts for more than 90% of the total rural energy supplies in developing countries (Demirbas & Demirbas, 2007).

If biomass grows in a sustainable manner, utilization of this energy does not add "new" carbon dioxide to the atmosphere, because the carbon dioxide released during combustion is offset by the carbon dioxide biochemically fixed by photosynthesis (Hall & House, 1993). A tonne of crop residues is used to replace 0.5 tonnes of coal that can prevents additional 1.5 tonnes of CO_2 without going to release into atmosphere. Proper use of 150 MT of anticipated biomass could reduce CO_2 emission by over 250 MT each year (Dubey *et al.*, 2013). A similar study by Panwar & Rathore (2009), to assess surplus biomass potential in Rajasthan to 1656 tonnes of crop residues consideration surplus was conducted which has 1 MW electricity generation potential further, it was also mention that from 1 MW of power generation plant about 1656 tonnes of CO_2 can be show on annual basis.

India has fifteen different agro climatic zones with a variety of both tropical and temperate crops grown in highly diverse regions. A number of studies have estimated that in India huge potential of surplus agro residues is available and the same can be significantly exploited as a fuel for power generation. The agricultural residues are an authentic, efficient, and promptly accessible resource of renewable energy, which can be used as a fuel for power generation. The use of biomass as a source of energy is of interest worldwide because of its environmental welfare. During recent decades, biomass use for energy production has been proposed increasingly as a substitute for fossil fuels. Biomass can also offer an immediate solution for the reduction of the Co_2 content in the atmosphere (Gemtos &

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DOI:10.21276/ambi.2018.05.sp2.ra03

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Tsiricoglou, 1999). It has two other main advantages; firstly it is renewable and secondly, the fact that it can be used without essential damage to the environment (Nendel *et al.*, 1998). In addition to its positive output, while comparing with other sources of energy, it has no risk (Ghislain, 1994).

As per Chauhan (2010), in India over 370 million tonnes of biomass generated every year. In the Haryana State, only from the agricultural sector, a total 24.697 MT/Year of residue is generated, of which 71% is consumed in various domestic and commercial activities within the state. While in agro-based industrial sector, a total of 646 KT/Year of sawdust is generated, of which only 6.65% is consumed in the state. Of the total generated biomass in the state, 45.51% is calculated as basic surplus, 37.48% as productive surplus and 34.10% as a net surplus. The power generation potential from all these three categories of surplus biomass reported 1.499 GW, 1.227 GW, and 1.120 GW respectively. Singh & Gu (2010), studied biomass conversion to energy in India and concluded that a large potential exists for the biomass feedstocks from the various kinds of crop residues. The gasification, as well as anaerobic digestion process, seems to be most attractive in the Indian scenario. A detailed assessment was done on biomass resources for decentralized power generation in Punjab by Singh (2015). The study concluded that utilization of biomass as an energy source not only provide waste disposal solution but could also overcome the problems of the energy deficit in the state and global warming in overall.

The aim of present study is to assess the surplus crop residue in southern part of Rajasthan. The present study will be helpful is formulated of the power generation policy in the tribal areas of southern Rajasthan. It also help in manage the crop waste in effective way.

Methodology:

Study area: we narrowed down to the six districts of southern Rajasthan. The districts mainly covered in the present study were, Chittorgarh, Pratapgarh, Udaipur, Rajsamand, Banswara, and Dungarpur.

In the present study, biomass crop residues were categorized in two classes -

- Gross agriculture crop residues *i.e.* the total amount of residues.
- Surplus agriculture crop residues i.e. the residue potential left after any competitive uses (such as cattle feed, animal bedding, grazing, cooking fuel, thatching, and organic fertilizers). The surplus crop residues can be used as bio-energy generation.

Energy properties: the content related to crop production was acquired by consulting agricultural statistics and corresponding governing authorities (Ministry of Agriculture, Government of Rajasthan). The annual gross potential of agricultural biomass was determined by using residue-to-product-ratio (RPR) by using given below equation (Singh *et al.*, 2003).

$$(CR)i = (RPR)i \times (PrC)i$$

Where, (CR)i is the amount of agricultural biomass of i^{th} crop in ton, (RPR)i the RPR of the i^{th} crop on dry mass basis and (PrC)i the amount of crop production in ton.

Next, energy potential from recoverable crop residues was determined by multiplying the net supply potential of recoverable crop residue (RPR) by the heating value (HV).

$$Qi = (CRi * HVi)$$

Where, Qi is the energy potential (GJ/h/year) of i^{th} crop and HVi the HV of i^{th} crop (GJ/t).

To estimate the calorific value (Cv) or heating value method IS: 1350(PART-II)-1970 (method of test for coal and coke, part-II, determination of calorific value) was followed.

Proximate and Ultimate analysis: for cotton stalk samples this analysis was done following the ASTM (American Society for Testing and Materials).

Results and Discussion:

The bio-energy potential study was done by using crop statistics, a collection of secondary data from Government Authorities and estimation of energy generation potential from cotton crop residues are presented in Tables-1 (a,b,c,d,e) for the period 2009-10 to 2013-14.

Table -1a: Estimated energy generation potential (cotton stalks)

Rajasthan District	Year 2009-10; Heating Value-4468 Kcal/kg AUC (Ha)*	CCP (MT)*	AB (CR)(MT)*	EPA (GJ)
Chittorgarh	8590	2967	25770	115.14
Rajsamand	6525	2254	19575	87.46
Pratapgarh	2260	589	6780	30.3
Banswara	11021	3304	33063	147.73
Dungarpur	423	201	1269	5.67
Udaipur	756	261	2268	10.13
Total	29575	9576	88725	396.42

AUC-Area under cultivation; CCP-Cotton Crop Production; AB- Agriculture Biomass; EPA- Energy Potential Available
* Source (Table 1 a,b,c,d,e): Directorate of Eco. & Stats., Rajasthan

Table -1b: Estimated energy generation potential (cotton stalks)

Rajasthan District	Year 2010-11; Heating Value-4468 Kcal/kg AUC (Ha)*	CCP (MT)*	AB (CR)(MT)*	EPA (GJ)
Chittorgarh	5948	3742	17844	79.73
Rajsamand	2871	1835	8613	38.48
Pratapgarh	2163	446	6489	28.99
Banswara	11308	4318	33924	151.57
Dungarpur	463	201	1389	6.21
Udaipur	973	422	2919	13.04
Total	23726	10964	71178	318.02

Table -1c: Estimated energy generation potential (cotton stalks)

Rajasthan District	Year 2011-12; Heating Value-4468 Kcal/kg AUC (Ha)*	CCP (MT)*	AB (CR)(MT)*	EPA (GJ)
Chittorgarh	21051	12915	63153	282.17
Rajsamand	6583	5501	19749	88.28
Pratapgarh	1377	435	4131	18.46
Banswara	11954	4243	35682	159.43
Dungarpur	1033	535	3099	13.85

Udaipur	2896	1501	8688	38.82
Total	44894	25130	134502	600.95

Table -1d: Estimated energy generation potential (cotton stalks)

Rajasthan District	Year 2012-13; Heating Value-4468 Kcal/kg AUC (Ha)*	CCP (MT)*	AB (CR)(MT)*	EPA (GJ)
Chittorgarh	17855	10625	53565	239.33
Rajsamand	7032	3492	21096	94.26
Pratapgarh	1841	233	5523	24.68
Banswara	15429	4074	46287	206.29
Dungarpur	1356	673	4068	18.18
Udaipur	3155	1567	9465	42.29
Total	46668	20664	140004	625.54942

Table -1e: Estimated energy generation potential (cotton stalks)

Rajasthan District	Year 2013-14; Heating Value-4468 Kcal/kg AUC (Ha)*	CCP (MT)*	AB (CR)(MT)*	EPA (GJ)
Chittorgarh	13076	9050	39228	175.27
Rajsamand	6551	3646	19653	87.81
Pratapgarh	818	346	2454	10.96
Banswara	11863	4968	35049	156.6
Dungarpur	1174	653	3522	15.74
Udaipur	2636	1205	7908	35.33
Total	22263	13901	107814	481.71

From the above tables, the total area under cotton cultivation in six districts was estimated as 167126 hectares. Accordingly, the gross crop residues estimated around 0.54 million metric tonnes during the year 2009-2010 to 2013-2014. The study about the surplus crop residues for cotton stalk was estimated around 0.184 million metric tonnes (as assumed 34% according to study done by Hilloidhari et al., 2014). The gross and surplus bio-energy generation potential was estimated around 2422 and 823 GJ respectively (Fig.-1).

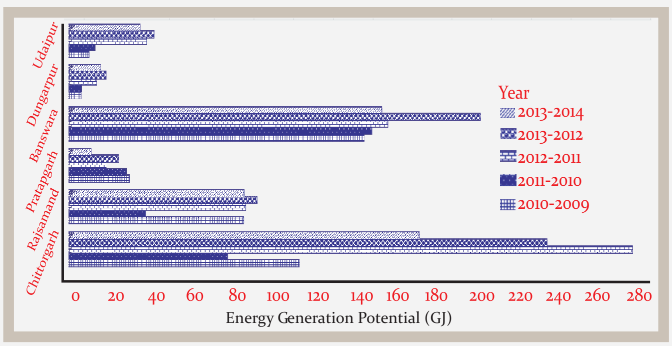

Figure-1: Year-wise gross energy generation potential (GJ)

Similarly, characteristics of agriculture crop (cotton stalks) residues were analysed (ultimate and proximate analysis) and results are presented in Table-2.

Table-2: Characteristics of crop residue (cotton stalks)

Ultimate analysis		Proximate analysis	
Carbon, %	47.07±1.22	Ash content, %	5.10±028
Hydrogen, %	4.58±0.21	Cal. value, Kcal/kg	4468±18.72
Nitrogen, %	1.15±0.11	Volatile matter, %	76.1±2.56
Sulphur, %	0.13±0.04	Moisture content, %	12.10 ± 0.04
Oxygen, %	42.10±1.20	Fixed carbon, %	18.80±0.06

From the experimental results (Table-2) it was found that cotton stalk had good energetic properties (calorific value obtained, 4468±18.72 Kcal/kg) and can be utilized as cleaner fuel, without harm to environment.

Finally, we concluded that considerable bio-energy potential is available in tribal areas of southern Rajasthan and crop residues of cotton stalk could be utilized as a sustainable source of energy. The results are promising under the criteria for utilization as clean fuel which leads to the solution of the local waste management problem and beneficial in terms of environment and resource conservation.

Acknowledgements:

Authors are thankful to Dr. A. Ramesh, ICAR-Indian Institute of Soybean Research, Indore, Madhya Pradesh, for their necessary help and support during analysis of samples.

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