Cash the Trash

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Sugarcane crop produces a huge quantity of residue (green leaves, dry leaves, and green top) after harvesting of cane. The common practice of farmers is either burning or removal of the crop residues from the field. The removal of trash from the field is a labor and time-intensive process. Rampant burning of trash to clean the field is the only solution in front of farmers. There is a need to convert waste into wealth to provide an alternative to residue burning. Sugarcane trash can produce series of value-added chemicals besides its field application. Field application of trash in the form of mulching enriches the soil organic carbon pool besides conserving essential elements. Trash mulching improves soil's organic carbon content and ultimately, after recycling, add nutrient into the soil. Efficient utilization of trash reduces environmental pollution, sustains soil health, and provides economic gain to the farmers.

Keywords: Bioenergy, Crop residues, ICAR-IISR, Sugarcane, Trash

Introduction

Sugarcane is the second most important commercial crop cultivated in India after cotton. It plays a vital role in the Indian economy in addition to providing employment opportunities. Sugar industries in India remain regulated and are a source of livelihood for 6 million farmers and their families, along with workers and entrepreneurs of over 550 sugar mills, apart from a host of wholesalers and distribution spread across the country. It provides direct employment to over 5 lakh for skilled labourers and semi-skilled labourers in sugar mills and allied industries across the Nation. It has high biomass, sucrose, and efficiency in accumulating solar energy. Sugarcane trash represents dry leaves, green leaves, and the top of the cane (Fig. 1). Sugarcane residues (tops and leaves) account for 12 million tonnes (about 2% of C.R.s in India). The highest residue is generated from Uttar Pradesh (60 million tonnes), followed by Punjab (51 million tonnes) and West Bengal (36 million tonnes). Maharashtra stood first in sugarcane residue generation. Crop residue management improves soil organic carbon and soil quality. Recycling of cane trash is an important renewable source of plant nutrients, which can supplement crop need, besides conserving the soil moisture and controlling the weeds.

The rapid growth of bio-energy production from bio-fuel is an example of agricultural crop diversification in recent years, especially those crops with a high content of starch and cellulose. Agricultural wastes have an important potential to produce

Table 1. Sugarcane trash composition

Cellulose	40.4%
Hemicelluloses	33.2%
Lignin	17.4%
Ash content	6.45%
Silica	2.76%

Fig. 1. (a) Trash available in the sugarcane field after harvesting of crop (b) Trash burning

sustainable energy from renewable fuels. The chemical composition of trash (Table 1) represents its potential to convert it into cash with appropriate use.

The problem of Trash management

About 100 tonnes cane produces 10-12 tonnes dry leaves per ha per year. After harvesting of sugarcane crop, trash creates hindrance during planting/sowing of succeeding crop (Fig. 1). Removal of trash from the field is labour-intensive, and farmers use the easiest solution, i.e., trash burning. The burning of trash results in the potential loss of useful plant nutrients and creates environmental pollution.

Fig. 2. Trash mulching in ratoon recycling nutrients and biomass to the soil

Waste to wealth

Worldwide aversion to pollution caused by sugarcane trash burning has prompted a number of countries to set targets for reducing the amount of sugarcane trash that is burnt. This pressure to reduce sugarcane trash burning, together with concerns regarding existing energy usage, has also encouraged interest in alternative uses for sugarcane trash. There are different alternative ways for effective utilization of sugarcane trash:

Trash mulching in ratoon

Sugarcane is a nutrient exhaustive crop and removes large amounts of nutrients from the soil. Trash mulching in ratoon crop is a better option for recycling nutrients and biomass to the soil (Fig. 2). The importance of recycling the trash in ratoon crop is associated with improvement in soil organic matter, soil structure, soil nutrient supply capacity to plant, and ultimate monetary return in terms of yield. Trash mulch acts as a source of energy for the multiplication of microorganisms and gives the appropriate ecological shelter for plant-microbe interaction. Trash treated with cellulolytic/ligninolytic microorganisms like *Trichoderma*, *Trichurus*, and *Aspergillus* spp. Accelerate the decomposition process and nutrients available to crops. The increased yield of ratoon crop and improved soil quality can be obtained with proper cane trash in the ratoon crop. Trash mulching with *Trichoderma* inoculation increased soil organic carbon (SOC) and phosphorus (P) content by 5.08 Mg ha^{-1} and 11.7 kg ha^{-1} over their initial contents of 15.75 Mg ha^{-1} SOC and 12.5 kg $ha^{"1}$ P. Therefore, residue mulching facilitates soil security by enhancing moisture retention, adding nutrients to the soil, reducing evapo-transpiration, curbing weed problems etc. Mechanical harvest with residue mulching, referred to as green-trashing, provides a suitable solution for sequestering atmospheric carbon to soil organic carbon pool. More significant organic matter content, microbial activity, and aggregate stability in the inter-row mean the soil is less prone to compaction and/or erosion as well as being protected by the surface mulch.

Organic matter in the soil maintains the porous structure of the soil, improves its water holding capacity (important, as most of the sugarcane in India is grown on partially-irrigated areas), and improves its permeability to oxygen, which is needed by the soil organisms that break down manure, crop residues, and other organic matter. Therefore, to sustain sugarcane production under multiple ratooning systems where the soil gets compacted by the movement of farm implements such as harvesters, the soil's organic matter content must be maintained either by recycling organic farm wastes by trash mulching. Results of an experiment conducted at ICAR-IISR, Lucknow, presented in Table 2.

Sugarcane trash and bioenergy

Agriculture is one of the largest biological sectors with the highest biomass production, which becomes an essential input for the bio-economy. This represents a great opportunity, not only because its use and exploitation favors the reduction of fossil fuel use and greenhouse gas

Table 2. Effects of different trash mulching treatments on soil organic carbon content (%) after successive harvests in a multiple ratoon system

Treatment	Plant crop	Ratoon I	Ratoon II	Ratoon III
Trash burnt	0.55	0.56	0.54	0.53
Trash removed	0.55	0.57	0.56	0.55
Trash retained	0.55	0.61	0.65	0.68
Mean	0.55	0.58	0.58	0.59
C.D. 5%	-	0.03	0.05	0.06

Source: Recycling sugarcane trash to conserve soil organic carbon for sustaining yields of successive ratoon crops in sugarcane. Yadav *et al.,* 1994. Yadav R. L., Prasad, S. R., Singh R. and Srivastava V. K.1994. *Bioresource Technology.* 49:231-235.

emissions, but also because it contributes to the development of new green markets and jobs by promoting the conversion of vegetable waste into value-added products (by-products), such as food, feed, bioproducts and bioenergy.

Stopping the pre-harvest burning makes it possible to use the trash to produce steam and electricity by the sugar mills and distilleries, improving the amount of this kind of energy in the country's energy matrix. There is a high potential for the generation of renewable energy from various sources wind, solar, biomass, small hydro, and cogeneration bagasse. Biomass power of 17,536 MW (1.60%), 5000 MW (0.46%) is generated from bagasse-based cogeneration in sugar mills, and 2554 MW (0.23%) from waste to energy (Energy statistics, 2019). India is very ambitious in its targets for promoting renewable energy. Sugarcane trash is an important source of lignocellulose conversion to biofuels and biochemicals such as ethanol, lactic acid, furfural, butanol, methanol, with the consecutive production of electricity. The biomass feedstock obtained as a result of crop harvest showed a high potential for energy production through conversion technologies. The energy obtained from the recoverable dry leaf is equivalent to 10 tonnes of coal per ha, which is one-third of the total energy available. Sugarcane mills possess a significant contribution in the production of exportable energy from the cane trash with the reduced release of carbon dioxide compared to conventional fossil fuel systems. The energy produced from sugarcane is significantly higher than the energy obtained from coal. The cost of production is also cheaper for sugarcane sources when compared to crude oil/coal with carbon capture. Dry cane trash has the potential to replace the natural energy deficit by 50%, as it generates high potential energy for the cogeneration process. Supplementing bagasse with trash is reported to enhance electricity generation by 500% (UNDP, 2007).

Table 3. Energy content on sugarcane bagasse, trash and juice

Entity	Mass (Kg)	Energy content (M.J.)
Bagasse	135	2,500
Trash	140	2,400
Juice	150	2,500

Source: The potential of sugar cane as an energy source.

Thus an effective collection mechanism is required if trash is to be employed in the sugar factory for cogeneration. The use of sugarcane trash for bioelectricity and second-generation ethanol production has motivated its total or partial removal from the field. Number of people that could be served each year by this biomass, if the energy is converted as electricity.

Composting of sugarcane trash

Biodegradation of lignocellulosic wastes through an integrated composting system converts waste into organic manure rich in plant nutrients and humus. Enrichment of organic (humus) nitrogen in the soil after application of biowaste compost has been observed.

Sewage sludge management

The mixing of sugarcane trash as an amendment material, in vermicomposting of some non-traditional waste materials such as sewage sludge, can enhance the nutritive value of end product but, at the same time also suppresses the toxicity by metals through supplying a considerable amount of organic matter. The use of sludge as a raw material in the vermicomposting systems can potentially help to convert this waste into value-added products, i.e., vermicompost. Sugarcane trash in sewage sludge not only supports earthworm growth but at the same time also lowers the risk of earthworm mortality during the process of vermicomposting. Utilization of sugarcane trash during vermicomposting can potentially convert the noxious community waste into value-added materials, i.e., vermicompost and earthworm biomass. The recycling of roots/trash directly in the soil through vermiculture can return multi-nutrients to the soil from the sugarcane crop itself.

Charcoal

Sugarcane trash can be converted into charcoal powder, biochar, and briquette. Biochar is normally associated with plant biomass or biowaste-derived materials within the black carbon (B.C.) continuum. Biochar application to the nutrient-poor soils is increasingly being recognized as an attractive option, given the potential agronomical and environmental benefits. Biochars are their high specific surface area (S.S.A.). Adopting a stabilized C product such as biochar as a vehicle for nutrient delivery might address two ends of a problem: to increase nutrient use efficiency by plants while creating a viable and efficient strategy to increase stable C in soil.

Animal feed material

Sugarcane trash can be used as animal fodder for a few days before the leaves start rotting.

Other use

The lignin component of sugarcane trash can be utilized as a phenol source for resin and pesticide production and for making nanostructured films for heavy metal adsorption. Conversion of trash into nanomaterial also provides a solution to its burning.

The burning of crop residue aggravates the problem of environmental pollution. Farmers need the easiest and cheapest solution as like burning for residue utilization. Crop residue recycling either through field application or converting it into value-added products may solve rampant burning and give economic gain to the farmers.

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