



In-situ trash management induced sustainability of soil health to produce the qualitative products

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ARTICLE INFO	ABSTRACT
<p>Original Research Article Received on May 28, 2020 Revised on June 06, 2020 Accepted on June 13, 2020 Published on June 18, 2020</p> <p>Article Authors Rajendra Bairwa, Mamta, Devi Lal Dhaker, Neeraj Bagoria</p> <p>Corresponding Author Email rkchironjsoil@gmail.com</p>	<p>In-situ trash management is necessary to cut the atmosphere pollution as well as replenishment of plant nutrient. Burning of crop residues leads to release of soot particles and smoke causing human and animal health problems. It also leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P, K and S. Soils of the world's agro ecosystems (<i>i.e.</i>, croplands, grazing lands, rangelands) are depleted of their soil organic carbon (SOC) stock by 25-75% depending on climate, soil type, historic management and the magnitude of this loss may be 10 to 50 Mg C ha⁻¹. Integrated sugarcane trash management (ISTM), microbial enriched (<i>Trichoderma viridae</i>) and farm yard manure is effective in enhancing the soil health and sugarcane yield. Soil organic carbon is the most important attribute and chosen as the most important indicator of soil and environment quality and agricultural sustainability.</p>
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Crop residue management is a big challenge for the agriculture production, soil health as well as human health also because burning of crop residue is causes atmospheric pollution. As per Ministry of New and Renewal Energy (MNRE, 2009) about 500 Mt of crop residues are generated annually in India, used as animal feeding, soil mulching, bio-manure making, thatching for rural homes and fuel for domestic and industrial uses. As such, crop residues have tremendous value, however, a large portion of the residues (about 93 Mt) is burnt on-farm. A sugarcane residue consisting of tops and leaves generate 12 Mt, *i.e.*, 2 % of the crop residues in India.

Study of state-wise data on crop residue generated, residue surplus and burnt annually indicates that about 140.84 Mt. of crop residue are surplus and about 92.81 Mt. of crop residues are being burnt across the India annually (Pandey, 2018). In the burnt system, >70 % of the organic matter and nutrients in the trash are lost to the atmosphere (Mitchell *et al.*, 2000). Conversely, with retention of trash, nutrients and organic matter may be accumulating in the soil. Increases in total soil N, organic carbon (C) and N mineralization have been reported under a GCTB system in northern Australia (Wood, 1991, Sutton *et al.*, 1996).

Soils of the world's agro ecosystems (*i.e.*, croplands, grazing lands, rangelands) are depleted of their soil organic carbon (SOC) stock by 25-75% depending on climate, soil type, and historic management, and the magnitude of this loss may be 10 to 50 Mg C ha⁻¹ (Lal, 2011). Suma and Savitha (2015) are reported that ISTM (integrated sugarcane trash management), microbial enriched (*Trichoderma viridae*) and farm yard manure is effective in enhancing the soil health and sugarcane yield. Ram (2018) was studied that the soil organic carbon is the most important attribute and chosen as the most important indicator of soil and environment quality and agricultural sustainability.

Organic carbon performs additional functions of increasing soil organic matter content, and CEC, enhance biological activity, improve soil structure (Uwah and Iwo, 2011). Retention of crop residues has been shown to increase soil organic matter and soil nutrient contents in other cropping systems (Larson *et al.*, 1972, Barber, 1979). A trash blanket of 10 t DM/ha will contain about 4500 kg C and 55 kg N/ha, with a C: N ratio of 82 typical values from these experiments, (Robertson and Thorburn, 2007). Soil macrobiotic play a central role in decomposition of organic residue in soils, and the rate of this turnover can be increased by microbial enhancement using microbially enhanced compost extracts (Ingham, 2005, Ryan, 2003). Some of the fungal species known to aid in degradation of organic matter, and prevalent in most soils, are *Trichoderma* spp. and cellulose digesting brown rot fungi, such as *Coniophora prasinoides*, *C. puteana* (Highley, 1980) and *Cellulomonas* spp. (Lines-Kelly, 2004).

Increased evolution of CO₂ is indicative of the presence of higher populations of active microorganisms in the immature compost (*e.g.* IMC) as compared to the mature composts. Respiration decreases during the maturation or stabilization processes (Wu *et al.*, 2000). Mulching generally increases microbial load and respiration in soil as indicated by the release of CO₂-C (measured with fumigation extraction) and by the stimulation of substrate induced respiration (SIR), respectively (Wardle *et al.*, 1999). Bell *et al.*, (2007) were documented that the soil microbial activity was comparatively higher, although not at significant level, when sugarcane stubble was retained compared to the bare soil.

A reason for lower soil biological activity without trash is generally linked to the decline in dissolved organic C (labile C). In the current experiment, however, sugarcane trash treated with compost extracts did show visual signs of degradation, such as discoloration, compared to those treated with water only. Visual discoloration of in-situ composted sugarcane residue, due to the acceleration of indigenous microbes, was also noted by (Boopathy, 2003) when treated with one time application of molasses. This could be due to leaching of nutrients caused by the mineralization of organic matter of trash or due to degradation caused by microbial attack or cellulose utilization by the microbes (Parsons and Congdon, 2008). Synergistic or antagonistic effects of microbial diversity in litter decomposition of the terrestrial ecosystems have been reviewed by (Hattenschwiler *et al.*, 2005).

Synergistic interaction, in general, enhances the rate of decomposition unlike the antagonistic interaction, in which microorganisms compete for the similar resources, thereby slowing the rate of litter decay. The retention of green trash resulted in an increase in C_L but a decrease in C_T, compared to the burning of trash. This indicates that the green trash was releasing more active labile C from the crop residue than the burnt treatments. Sugarcane trash is one of the most commonly available farm wastes in sugarcane growing areas and about 8-10 tonnes of trash can be obtained from one ha of sugarcane and contains about 5.4 kg N, 1.3 kg P₂O₅, 3.1 kg K₂O / ton of sugarcane trash and small quantities of micronutrients. Sugarcane (*Saccharum* spp. complex hybrid) is an important cash crop of India.

The crop is long duration and nutrient exhaustive. It is cultivated in an area of 5.08 million hectare with an average productivity of 68.0 t ha⁻¹. Continuous sugarcane cropping with imbalance use of fertilizers and the lack of organic matter application had led to depletion of soil fertility and posing threat to the long-term productivity. The deterioration in soil health and ecology has been reported in recent years mainly due to erratic and imbalance use of chemical fertilizer. The yield of sugarcane has reached a plateau due to decline in factor productivity. The loss in organic matter is the root cause for decline in factor productivity.

Restoration of soil organic matter is thus, needed for improving productivity through correction of essential macro and micronutrients deficiencies and improvement in soil health.

Cane Trash

It refers to the material collected from the ground after mechanical harvesting, where a greater concentration of a mixture of leaves and tops of sugarcane can be found. A large amount of lignocellulosic residues are left on the ground during mechanical harvesting. These residues, composed of a varied number of residual components after harvest is known as trash basically green and dry leaves, sheath and leaves' tip, including physical impurities.

Cane Green Leaves

They refer to the green leaves located at the top of the plant, varying from 30 to 35 leaves on each tip.

Cane Straw

Sugarcane straw refers to the dry leaves and sheaths removed from stems or stalks during the cleaning process to help the plant grow healthier.

Problems Generated due to On-Farm Burning of Crop Residues

Burning of crop residues leads to release of soot particles and smoke causing human and animal health problems. It also leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P, K and S. The burning of crop residues is wastage of valuable resources which could be a source of carbon, bio-active compounds, feed and energy for rural households and small industries. One option of disposal is burning despite the large losses (up to 80%) of N (Raison, 1979), 25% of P and 21% of K (Ponnamperuma, 1984), 4-60% of S (Lefroy *et al.*, 1994), significant air pollution, killing of beneficial soil insects and microorganisms, and depletion of soil organic matter. Heat generated from the burning of crop residues elevates soil temperature causing death of active beneficial microbial population, though the effect is temporary, as the microbes regenerate after

a few days. Repeated burnings in a field, however, diminishes the microbial population permanently. The burning of crop residues immediately increases the exchangeable $\text{NH}_4^+\text{-N}$ and bicarbonate-extractable P content, but there is no build up of nutrients in the profile. Long-term burning reduces total N and C, and potentially mineralizable N in the upper soil layer. The burning of agricultural residues leads to significant emissions of chemically and radiatively important trace gases such as methane (CH_4), carbon monoxide (CO), nitrous oxide (N_2O), oxides of nitrogen (NO_x) and sulphur (SO_x) and other hydrocarbons to the atmosphere. About 70%, 7% and 0.7% of C present in rice straw is emitted as carbon dioxide, carbon monoxide and methane, respectively, while 2% of N in straw is emitted as nitrous oxide upon burning. It also emits a large amount of particulates that are composed of a wide variety of organic and inorganic species.

Trash and its Importance in Sustaining the Soil and Products Quality

Trash production from the sugarcane crop is common, farmers are burned that producing trash and losing plant nutrients which taken-up from the sugarcane crop field. The burning of sugarcane trash is contaminant to air and induced pollution which causes various types of disease in human as well as animals also. According to current demands and pollution issues, farmers have to go for trash management in the field or in-situ trash management. In-situ management of trash may be very valuable for soil health, cut the air pollution as well as produce qualitative product also. Chen *et al.* (2015) were reported that bulk density of soil at more than 10 cm significantly higher within no-tillage with residue retention on the surface of soil (NT) and rotary tillage with residue retention (RT) as compared to plough tillage with residue retention (PT) and plough tillage without residue (PT_0).

In-situ trash decomposition enhances the soil carbon stock and maintains the soil health through improving of biological, chemical and physical conditions of soil. Compared with PT_0 , soil organic carbon (SOC) concentration within RT and PT were significantly higher at 5-10 and 10-20 cm depth of soil (Chen *et al.*, 2015). Another option is incorporation into the soil, but its decomposition is slow and soil nitrate is immobilized (Bacon, 1987), reducing the N uptake and yield of succeeding

wheat crops by about 40% (Bacon, 1987, Sidhu and Beri, 1989). The combined use of rice or wheat straw and inorganic fertilizer can, however, increase the yield of rice and wheat in rice-wheat system (Mahapatra *et al.*, 1991). The crop residues left on the soil surface limit water evaporation, soil sealing and crusting and thereby, increase infiltration and limit soil erosion. Residue incorporation into the soil by ploughing or chiseling is preferred to burning, because of legal restriction on direct CO₂ emission in Europe (Cannell and Hawes, 1994). In the rice-wheat region, because of the agro-ecological variations within the region, the time of wheat seeding varies considerably from West to East.

Decomposition of trash in same field which induces the intrinsic capacity of soil to supply the plant nutrition for growth. Mulching generally increases microbial load and respiration in soil as indicated by the release of CO₂-C and by the stimulation of substrate induced respiration (SIR), respectively (Wardle *et al.*, 1999). For microbial biomass C, there was only one major difference between treatments. Microbial biomass C was significantly increased in 10SCE (compost extract produced from nine month old compost amended with equal volume of sugarcane trash and further composted for a month) applied to bare soil as compared to the water control treatment with sugarcane stubble. Organic carbon (OC) content in soil is a key factor for its health and fertility. The ISTM resulted in increased OC content of soil from 0.42 to 0.58 per cent over the three years, which amounts to an average increase of 11.2 per cent. Further, intervention of application of N and lignolytic microbial culture (*Trichoderma viridae*) might have enhanced the faster decomposition of trash resulting build-up of organic carbon in ISTM plots. Trash burning decreased the organic carbon content, such that at the end of third year the organic carbon content was to 0.40 per cent compared to 0.44 percentages in the initial period.

This may be due to loss of dry matter and carbon during the burning processes of trash. According to (Mitchell, *et al.*, 2000) depending on the severity of the fire, 77-97 per cent of the dry matter and carbon may be lost by burning sugarcane trash. On contrary, the retention of trash in the field will increase the organic carbon through decomposition process in the long term. The available nitrogen in the soil depends mainly on the sources of nitrogen supply, crop removal and

organic carbon content of the soil. The increase in the available nitrogen in ISTM soil was low (3%), while, the trash burnt soil showed decreased N content over the years even after excess N application through fertilizers (350 kg/ha). This may be due to loss of N during burning of trash. The inorganic N supplied through fertilizer is prone to more loss than retention. Sugarcane trash is produced commonly from sugarcane crop which can enhance soil quality or health through in-situ application. Organic products are current trend of market demand which can fulfill with in-situ crop residue management. It may be attributed to wider C: N ratio in trash and might have resulted in immobilization by microbes. The immobilization was higher during the initial year and in the later years the N builds up was comparatively higher. Robertson and Torburn (2000) reported similar results of slow N buildup in wider C: N crop residue management.

The impacts of ISTM are available phosphorus (P) content of soil. The results revealed that there was a trend of increased available P content in soil in ISTM plot, while, the check plot recorded decreasing trend. This increased available P may be attributed to inoculation of *Trichoderma viridae*, which mobilizes the unavailable P content in the soil through production of organic acids reported by (Allison and Killham, 1998) and also P from sugarcane trash. Even though trash ash had higher P content and farmers usually applied more P than the recommendation (125 kg/ha), there was decrease in the P content in check plot. This might be due to alkaline soil which turns P into unavailable form. The available potassium (K) also recorded the similar trend as that of the P. The effective management of trash results in increased potassium content as the trash is a rich source of K. The results are in line with findings of (Graham *et al.*, 2000). Though the trash ash contained more potassium, the volume of ash generated through burning was not sufficient to meet the potassium requirement of the sugarcane crop.

Conclusions

Investigation of state-wise data on crop residue generated, residue surplus and burnt annually indicates that about 140.84 Mt. of crop residue are surplus and about 92.81 Mt. of crop residues are being burnt across the India annually.

In the burnt system, >70 % of the organic matter and nutrients in the trash are lost to the atmosphere. In-situ trash decomposition enhances the soil carbon and maintains the soil health through improving of biological, chemical and physical conditions of soil. Compared with PT₀, soil organic carbon (SOC) concentration within RT and PT were significantly higher at 5-10 and 10-20 cm depth of soil.

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