AATCC Review

26 October 2022: Received
30 November 2022: Revised
21 January 2023: Accepted
28 January 2023: Available Online

http://aatcc.peerjournals.net/

Review article Open Access

Harmful effect of Sugarcane Trash Burning and Significant Benefit on Utilization of Sugarcane Trashes - A Review

V. Dhanushkodi[1], A. Krishnaveni2, R. Nageswari[3], K. Senthil[1] , K. R. Ramesh1, S. Sangeetha[4] and R.Anitha[1]

[1]Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India
[2]Agricultural College and Research Institute, Thiruvannamalai, Tamil Nadu, India
[3]Tamil Nadu Rice Research Institute, Aduthurai, Tanjore district, Tamil Nadu
[4]Horticultural College and Research Institute for women, Tiruchirappalli, Tamil Nadu,

Abstract

Sugarcane is one of the important commercial crops. Burning of sugarcane trash inside the field in India is a common practice among farmers due to a lack of labor availability and less time available for the sowing of the next crop. This is a hazardous practice that has affected soil health, air, human health, etc. leading to massive as well as monetary losses Therefore, new eco-friendly agricultural practices for sustainable food production are needed. Intensive agricultural production is necessary to satisfy food requirements for the increasing population. Microbes are important in degrading environmental solid waste and restoring the ratio of degraded ecosystems. Conversion of crop residue like sugarcane trash into a beneficial nurtinet resource is the best alternative method to landfilling and insulation in developed countries. Insitu composting or Mulching could potentially serve the purpose of reducing soil evaporation, conserving moisture, controlling soil temperature, reducing weed growth, and improving microbial activities. Mulches combat different stress conditions in agricultural lands. This review paper focuses on multiple significant impacts of mulches or in situ composting for the production and establishment of different crops in nature. Mulches conserve soil moisture, enhance the nutrient status of soil, control erosion losses, suppress the weeds in crop plants, and reduce pesticide and fertilizer usage. The selection of mulching material is important with respect to crop type, management practices, and climatic conditions. Therefore, the impacts of low-cost, eco-friendly, and biodegradable mulching materials on soil microbes, nutrient balance, plant growth, and soil erosion should be explored in the future. Therefore, in-situ composting can be a good alternative to mitigate these problems.

Keywords: *Sugarcane trash, impact of burning, techniques for in-situ composting,mulching, befits on soil health, fertilizer saving, pest and disease management, crop yield, Government initiatives*

Introduction

Sugarcane (*Saccharum officinarum* L.) is an important industrial crop, which has a high saccharin concentration and low fiber content. Sugarcane originated in Asia, it can thrive in the tropical and subtropical regions. Sugarcane grows best in soil rich in organic matter, wet, and has a pH of 7.5 to 8.5 [21]. The recycling of sugarcane wastes is both an ecological necessity and an economic compulsion. Bioconversion of the residues to good-quality compost or manure through the microbial process is an eco-friendly and viable proposition [2]. India is one of the largest producers of sugar and is in close competition with Brazil for the top position. In India, sugarcane is cultivated over an area of 4 million hectares and the production is estimated to be about 325 million tonnes with a productivity of 70 tonnes per hectare. In Tamil Nadu, India, sugarcane is cultivated in an area of 3.22 lakh hectares with average productivity of 101.8 tonnes. India needs to produce more than 320 million tonnes of sugarcane to cater to the crushing requirement of sugar factories operating in the country. Hence, greater attention is given only

*Corresponding Author: Dhanushkodi V
E-mail Address: - dhanushselgi@yahoo.com.au
DOI:https://doi.org/10.58321/AATCCReview.2023.11.01.03

in improving the sugar cane yield and not much to managing the cane trash. In India, approximately 6.5 million tonnes of sugar cane trashes are produced every year and most of the residues are usually burnt in the field due to a lack of proper composing techniques [20]. On the other hand, farmers apply a huge quantity of fertilizers to meet the nutrient requirement of the crop [32]. Intensive use of chemical fertilizers and pesticides further deteriorates soil fertility. To restore the productivity of soil, recycling crop biomass like sugarcane trashes and crop restudies, and compost application in the field is a good alternative [8].

Availability of sugarcane trash in India

Sugarcane is cultivated on about 26.9 million hectares (M ha), in more than 109 countries, with a worldwide harvest of 1.91 billion tonnes. India is the second largest agriculture-based economy with year-round crop cultivation and therefore generates a huge amount of agricultural waste including crop residues. In the absence of appropriate sustainable management practices, approximately 92 metric tonnes of crop waste is burned every year in India, causing excessive gaseous and particulate matter emissions and air pollution. About 7-12 tonnes of trash can be obtained from 1 ha of sugarcane [25]. Every ton of sugarcane trash contains about 5.4 kg N, 1.3 kg P_2O_5, 3.1 kg K_2O, and small quantities of micronutrients. In this context, sustainable solutions that involve methods to incorporate the nutrients in the crop residue back into the same croplands have better promise to be successful.

Practices adoption in disposal of trashes and impact of burning

The practice of stubble burning actively contributes to draining the richness of the soil and destroying all the useful bacteria which are otherwise quite useful for the soil. Burning of straw and greenhouse gas (GHG) emissions cause severe air pollution (Table 1). Above all, burning of crop residues will cause major pollution to the farmland ecosystem (Soil and Air) and also health problems for the farming community. The burning of crop residue causes phenomenal pollution problems in the atmosphere and huge nutritional loss and physical health deterioration in the soil. Burning of agricultural waste leads to the release of soot particles and smoke causing human and animal health problems (Table 2.).

Table 1. Reasons for burning of sugarcane trashes

S. No.	Reason for burning	References
1	Time available between the crop harvesting and crop sowing is very narrow	[13] [20]
2	Transportation of crop residues is laborious and cost involving	[13] [20]
3	Transportation of crop residues from field to other area for composting is cost involving	[13]
4	The natural decomposition of crop residues will take long time	[13] [20]
5	Insufficient or unavailability of effective decomposing microorganism in the soil.	[13]]20]

Table 2. Impact of sugarcane trashes burning in soil and environment

S No.	Impact of burning	References
1	Damage to the atmosphere resulting in global warming and respiratory diseases	[1]
2	Emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)	[14] [26]
3	Carbon inside the stubble is converted to carbon dioxide, 7% to carbon monoxide and 6.6% to methane	[29]
4	Affects the soil quality and useful microorganisms	[34]
5	Air pollutants like nitrous and sulphur oxides, People die prematurely due to exposure to such noxious gases, skin, eyes and respiratory functioning in humans, even leading to cancer and permanent lung diseases,	[9]
6	Stubble burning also causes depletion of fungi in the soil, which is harmful to the environment	[2] [19]
7	Burning of one tone of crop residues releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2.	[20]
8	Soil properties like soil temperature, pH, moisture, available nitrogen, phosphorus, potassium soil organic matter, enzymes and beneficial microorganism has been greatly affected.	[13]
9	Gases released during burning affect human health and air quality resulting in aggravation of eye and skin diseases.	[9] [13]
10	Repeated burnings diminishes the microbial population permanently resulting in soil hardening & erosion of soil.	[24]

Nutrient content of sugarcane trashes

Being a C4 crop sugarcane had a high potential of accumulating higher biomass of up to 381 t/ha and sugar content of up to 14.5 %. It also produces 10 to 12 t of dry leaves/ha during the 5th and 7th months manually to carry out varied intercultural operations [5]. The nutrient content of sugarcane trashes are more and presented in figure 1.

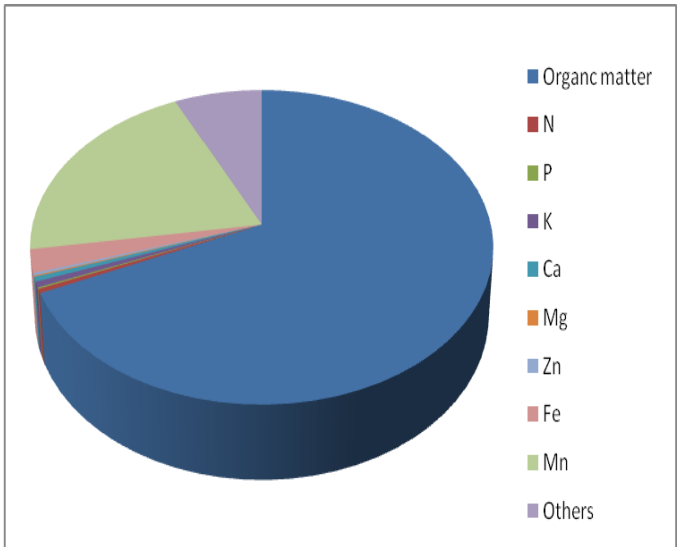

Figure 1. Nutrient content of sugarcane trash

Beneficial effect of insitu composting

The presence or absence of trash has many effects, such as on soil water, returns of nutrients to the soil, weed control, etc. The carbon and nitrogen contents were always higher in the former case after three months of soil incorporation. The high nitrogen content of this composted straw, adding to the slow-release character of nitrogen and phosphorous components in its residues may represent a good bio-fertilizer for plant growth and will reduce the use of chemical fertilizers as a nitrogen source. Sugarcane trash is the main source of potassium (K) and silica (Si) so the re-application of this material can slow down the decrease of K and Si in the soil [10]. To anticipate fertilizer expensive prices and reduce energy for fertilizer production, now is the time to utilize abundant local resources such as crop straw, green manure, and household waste as plant fertilizers with the right process [10]. Additional benefits of the green trash blanketing system, that attracted growers to adopt this system, include better weed control, and reduced labor requirements [28] [30].

Effect on soil physical and chemical properties

Improvement in physical soil properties by application of sugarcane compost may also be contributed to observed better plant growth (Table 3). Incorporating the crop residue that remained after harvest is one of the feasible and beneficial alternatives with a limitation of immobilization of nutrients like nitrogen at initial stages due to the high C: N ratio which could be mitigated by inoculation of fast decomposing microorganisms. The major portion of the residue generated i.e., paddy, wheat straw, and sugarcane trash could be transformed into valuable organic compost at insitu level, thus could enhance the physical, chemical, and biological properties [29].

Table 3. Soil physical and chemical Properties as improved by sugarcane trash insitu composting

S.No.	Properties improved by insitu composting	References
Physical properties		
1	Reduce soil compaction and improve physical properties of soil	[10] [25]
2	The organic matter in the compost plays a crucial role in maintaining soil functions and is a parameter for soil fertility and resistance to erosion.	[13]
3	Sugarcane trash contains, the valuable organic matter in the available crop residues will improve the soil structure and texture.	[13]
4	This approach provides mulch, resulting in water holding capacity in soil	[25] [33]
5	Utilization of Sugarcane trash improve soil structure Chemical properties	[25]
6	Sugarcane trash contains, valuable organic matter in the available crop residues will improve macronutrients (N, P, and K) and micronutrients and also the activity of soil enzymes and beneficial microorganisms of the soil.	[13] [32] [5]
7	Compost provides macronutrients, like N, P, and K which are immediately plant-available, but also micronutrients. The compost has a wide range of micronutrients that may be added, including iron (Fe), copper (Cu), zinc (Zn), and B.	[7] [12] [32]
8	Cation exchange capacity and soil pH: CEC refers to the total exchangeable cations in the soil. Clay minerals and humic substances are negatively charged and adsorb cations, avoiding them to leach. Cations may only enter the soil solution through the exchange for other cations. Generally, soils with large quantities of negatively charged sites are more fertile, because they retain more cations.	[10] [12] [5]
9	During the degradation period, the pH was slightly reduced and subsequently increased to neutral; a reduction in EC, organic carbon, Carbon: Nitrogen ratio, and an increase in nitrogen content was also noted.	[7] [12] [13]

Effect on soil biological properties

Added nutrients due to in-situ composting of crop residues in the soil will improve the soil's biological value, which has a positive impact on the growth and development of the subsequent crop without adding any additional organic manure and it reduces the cost of the cultivation of the subsequent crop. The increase in temperature during the composting process was caused by the heat generated from the respiration and decomposition of sugar, starch, and protein by the population of microorganisms. The increment in temperature is a good indicator that there is a microbial activity in the compost pile, as a higher temperature denotes greater microbial activity. Almost the entire C is absorbed by the microorganisms and transformed into CO2 during the metabolism process of the cells. The leftover C will be changed into membrane and protoplasm form. Throughout the composting process, this organic matter is decomposed by microorganisms through which the organic carbon will be oxidized in aerobic conditions to CO2 gas to the atmosphere and thus lower the C/N ratio. The increase in total N may be due to the dry mass net loss as the loss of organic C as CO2 during composting. In addition, the N values might also increase due to the nitrogen-fixing bacteria activity that commonly occurs at the end of composting. Although a decrease of N can occur due to the leaching of NO_3-N and ammonia volatilization, in this experiment, both piles were covered with plastic to retain the moisture and avoid moisture from outside, which could lead to the result obtained. Moreover, in high-technology composting, where they can control the leaching problem, the resultant compost achieves an increment in total N. The increase in the N value at the end of the composting period might occur due to the usage of N by microorganisms to build up cells, thus reducing the N, and some of the organisms will eventually die, which will be recycled as N and thus contribute to the increase. The increased amount of N at the end of composting is due to this stored source of N [19].

Effect on water saving

Mulching materials have the ability to reduce evaporation losses and hence conserve soil moisture, thus reducing irrigation water requirements. The increasing greenhouse gas emission and global warming during climate change result in increased frequency and intensity of extreme weather events. Climate change is expected to have important consequences for sugarcane production, as much as 20% reduction in sugarcane productivity is predicted for every degree rise in temperature, irrespective of the region where sugarcane is grown. Recently, several states of central and south India, including Maharashtra, faced severe droughts between 2012 and 2015, leading to severe stress on the economy. By and large, there was deficit rainfall of 12 and 15% during 2014–2015 and 2015–2016 cropping seasons that brought a multi-year drought over the entirety of India which significantly reduced the sugarcane area from 5.0 to 4.5 m ha and cane productivity from 70 to 68 t/ha. With context to tropical sugarcane regions, i.e. Maharashtra, Telangana, Karnataka, Kerala, and Puducherry, the rainfall deficit was exceedingly higher (20–27% deficit rainfall) which was not sufficient to recharge water reservoirs. The escalating deficit rainfall scenario delineates that drought is a recurrent phenomenon associated with tropical sugarcane farming, and in the coming years, the availability of irrigation water for sugarcane cultivation will be very less. However, on the contrary, sufficient soil moisture availability during the crop growth period is of paramount importance to get a good yield. Sugarcane requires about 125 L of irrigation water to produce 1 kg of sugarcane. There is a linear relationship between cane yield and actual evapotranspiration. Water deficit can lead to productivity losses of up to 60%. For this reason, sugarcane is mostly grown as an irrigated crop, and the water requirement of sugarcane varies widely with climate, soil conditions, and the duration of the crop. Cane grown in the tropical region has a crop growth cycle of 15–20 months, and as many as 30–36 irrigations are given, therefore water requirement in the tropics (2000–3000 mm) is higher. To meet the high water requirement of sugarcane, about 15 and 60% of the water used for irrigation in Tamil Nadu and Maharashtra is diverted for sugarcane. In the future, it may not be possible to allot more water for irrigating sugarcane. In fact, the future water allocation and new lands to cultivate sugarcane should be reduced; hence for satisfying the demand for 50% more sugar by 2030, efficient use of irrigation water in conjugation with soil moisture conservation measures by using composted coir pith and chopped trash is of paramount importance for sustainable sugarcane production.

The application of chopped sugarcane trash was also found beneficial in soil moisture conservation and retained 2.16–3.56 and 1.6–3.12% higher soil moisture content than control plots under 100 and

75% irrigation levels [6]. Higher soil moisture content in trash-applied plots was due to the fact that trash application reduces soil temperature by 3–4^{0}C due to shading during summer and reduces evaporation losses which help the crop evade heat stress. Sugarcane trash application conserved soil moisture from 0.70 to 5.92% and buffered soil temperature in the top 5-cm soil layer under tropical Indian conditions.

Effect on Weed management

Mulching is a favorable tool for controlling the weed populations in the nursery as well as field conditions. There was 92% reduction in weed population as compared to non-mulched treatment. When mulch is spread on the soil surface, they act as a barrier in the passing of light resulting in reduced germination of small-seeded weed species. A significant difference exists in the reduction of weeds with bare soil treatment. Mulches act as physical obstacles in the emergence of weeds; however, when the organic mulches decompose, they quickly come out of the soil surface. Some organic mulch also acts as the allelopathic and releases some toxic chemicals which are helpful for the reduction of weeds. The number of mulches should be limited in field conditions, and if living mulches are used too much, then they compete for the basic resources of light, moisture, oxygen, and nutrients. Plastic mulches such as those of white and green color allow photosynthetic active radiations (PAR) to pass through them, and in this way, weeds grow beneath these mulches, and at the same time, the dark-colored mulches do not allow these radiations to pass, and reduction of weed population occurs. Organic mulches have various capabilities for controlling weed colonization. Mulch material that is used in a thin layer will sufficiently enhance the germination of weed seeds; otherwise, if it will be used in a thick layer, it will reduce the seed germination. Mulching reduces the light penetration below the surface and acts as a barrier so there is no process of photosynthesis in weeds, and in this way, weeds cannot survive without glucose formation. It is the best strategy for controlling weeds of annual nature. Intercultural practices in crop plants grown with mulches can be minimized due to a smaller number of weeds as mulch restricts weed growth. Reduction in weed density with increasing the amount of mulch was observed [3].

Effect on Pest management

If trashes is left in the field without proper management, it can cause the spreading of disease, which originates from the trash, such as stem disease, and can also encourage the breeding of pests, especially rats. Burning is not the best way to deal with such waste, as it is harmful to the environment. Mulches can act as barriers against irrigation water or beating the action of raindrops which carry spores of different diseases. These spores attach themselves to foliage and shoots of vulnerable plants. Mulches help in the nutrition of many beneficial organisms which compete with the incoming pathogenic spores or sometimes release chemicals for the inhibition of pathogens; in this way, they reduce the chances of disease occurrence. There are many ways of disease reduction in plants through mulches. Mulches have a direct or indirect mechanism to lessen the disease. The root rot disease through short- and long-term mulching effects.

The indirect effects of mulches are helpful for the prevention of plant diseases such as improvement in the nutrition of plants, better drainage, moderation of soil temperature, improved soil aggregation, and conservation of soil moisture. Consequently, mulch materials provide a healthy atmosphere for crop plants which optimizes the vigorous growth and development of plants that may remain safe from pathogenic organisms. Organic mulches also restrain many soil microbes which directly compete with or degrade the pathogenic organisms with the help of many enzymatic reactions. The pathogens of fungi mostly contain cellulose in their cell wall which is degraded by the cellulose enzyme which is produced by most of the soil microbes which live inside the mulch. Mulching with the aim of maximum colonization of microbes will also be helpful for the biological control of many harmful pathogens. This is the main reason for reducing diseases using organic mulches such as straw in relation to polyethylene and fabric mulches. Mulches are an important part of integrated pest management. Therefore, the selection of the mulch material is imperative because mulches are a part of IPM plan. Mulch materials can decrease the stress level on plants and deal with different pathogens. Plants get resistance to weed attacks and other harmful pests, and in this way, there will be no use of any type of fungicides, insecticides, and herbicides. A decline in the use of such chemicals will be in favor of farmers in the sense that no money is used for such chemicals and also the non-use of chemicals will be in favor of beneficial soil organisms' population and the environment [23].

Effect on crop growth and yield

Soil texture (sand, silt, and clay) and structure determine the soil water-holding capacity. For instance, silt-loam and clay soils hold more plant-available water than sandy soils. Bulk density (grams of soil per cm^3) is related to the mechanical impedance of soil to root growth and the movement of O_2 to roots. There are many research studies that showed the positive impacts of mulches on germination, survival of newly grown plants, transplantation of seedlings, and overall performance of crop plants in relation to un-mulched treatments. In this way, mulching is favorable for maximum yield with very low input resources [11]. Mulching can increase agricultural yield from 7 to 47% based on the results obtained in past studies [15] [5]. Mulch depth and seedling age are necessary for the proper establishment and survival of transplanted seedlings. Deeper mulches can better control the weed population, but these are not as effective in areas that are grown with smaller seeds. When the mulch material is used after the broadcasting of seeds, a thin layer is most effective as compared to heavy mulch application before the seeding of smaller seeds. Mulch materials reduce evaporation losses, in this way enhancing the water retention in soil and helping in the reduction of weed species. This is also achieved by mulches via increasing root establishment, growth, and development. Organic mulches are better than any other mulch materials because they provide nutrients and water to newly grown plant roots. If the plants' roots grow successfully, then the survival of the plant is certain. The best mulch which is mostly used in field conditions is organic mulch, and it can increase the overall performance of crop plants and also brings improvement in soil conditions [6] [7] [32].

Fertilizer saving

Sugarcane is one of the world's largest crops. Sugarcane is a long-duration cash crop categorized under exhaustive crop. It requires larger amounts of macro- as well as micro-plant nutrients. It has been measured that sugarcane of 100 t produced from 1 ha of land removes 140, 34, and 332 kg NPK ha^{-1}, respectively, from the soil. High requirements for plant nutrient limits crop yield due to the scarcity of fertilizers. More than 45 million sugarcane growers in India and about 65 % of the rural population depend on this agro-based industry. These industries are struggling for energy with the high cost of production. It needs lower cost input and use of by-products as a fertilizer[7]. Keeping crop residues over the soil will increase soil N stock and N recovery by sugarcane, reaching equilibrium after 40 years with the recovery of approximately 40 kg ha^{-1} $year^{-1}$ of N. Of the total nutrients in the trash, 75 % of the K_2O (81 kg ha^{-1} $year^{-1}$) and 50 % of the N (31 kg ha^{-1} $year^{-1}$) are at the top, indicating the importance of maintaining tops in the soil to sustain soil fertility. A cane crop producing a cane yield of 100 t/ha removes about 208kg.N, 53 kg of P, 280 kg K, 3.4 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from the soil. For getting those nutrients to return to the soil insitu composting is essential.

Government initiatives in recycling of trash

National policy for management of crop residue (NPMCR) recently formulated by the Central Government, has laid out policies and regulations to be undertaken by the local agencies to curb crop burning and initiatives towards sustainable management practices. Central Pollution Control board (CPCB) now monitors crop burning through aerial surveillance and penalizes farmers who burn crops. Indian Government introduced numerous laws to alleviate the hazards caused due to open field burning of crops like Section 144 of the Civil Procedure Code (CPC) to ban the burning of rice crops; The Air Prevention and Control of Pollution Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995; and The National Environment Appellate Authority Act, 1997. The states of Rajasthan, Uttar Pradesh, Haryana, and Punjab have implied the National Green Tribunal (NGT) to limit crop residue burning as mentioned by. Other stringent measures taken by the Government are installing biogas plants in remote villages and popularizing bio-compost methods. Several schemes and policies proposed by the Government also played a beneficiary role in reducing crop-burning practices in India. Schemes like The Rashtriya Krishi Vikas Yojana (RKVY), and State Plan Scheme of Additional Central Assistance. A program called the National Policy for Management of Crop Residue (NPMCR) has recently been established by the Ministry of Agriculture of India. It aims to encourage crop residue management technology, avoid soil nutrient losses, produce new equipment and provide discounts and incentives for the procurement of happy seeders, turbo seeders, shredders, and bailing machines. NPMCR also intends to track crop residues using the National Remote Sensing Agency (NRSA). Similarly, another initiative by The National Green Tribunal Act aims to spread awareness among the farmers

to curb crop burning. The implementation of such systems and ventures has effectively reduced the open combustion of crop stubble.

Techniques for rapid decomposition

One promising alternative is straw incorporation into the soil, where the actions of microbial enzymes transform the lingo cellulose component of the straw into compost. Actinomycetes are able to degrade cellulose and solubilize lignin extensively as their primary metabolic activity, thus they are important agents of lignocellulose decomposition in soil, adding to their documented role in bio-control of plant diseases. The rate of decomposition can be enhanced by treating the wastes initially with certain efficient microflora. *Pleurotus sajorcaju, Trichoderma viride,* and *Aspergillus niger* are known to degrade hemicellulose and cellulose [29]. Inoculation with phosphate-solubilizing *Pseudomonas striata* may help solubilize phosphorus and increase its availability to plants [22]. Bacteria having specific activities, such as ligninolytic and cellulolytic microbes, can enhance agricultural waste quality. The process of mineralization is the final phase in the breakdown process when plant minerals N, P, K, Ca, Mg, S, and microelements as organic matter components are released by plants to produce organic compounds in body tissues [21] [29].

Composting was the first concept for using effective microorganisms (EM) in environmental management. Recently, Indian Agricultural Research Institute New Delhi, scientists have developed the bio decomposing product, namely Pusa decomposers, to convert stubble of crops into compost. The PUSA bio decomposer is a low-cost microbial bio-agent that can decompose crop residues in a bid to prevent farmers from setting them on fire. Another advantage of the capsule containing crop-friendly fungi is that it does not have any side effects [2] [27].

Microbial inoculation of compostable material could allow the inoculated microorganisms like (*Streptomyces aurefaciens, Trichoderma viride, Trichoderma harzianum, Thermomyces lanuginosus, Aspergillus niger, Bacillus subtilis, Bacillus sphaericus,* and *B. licheniformis, Bacillus stearothermophilus*) to dominated over the indigenous micro-biota and successfully develop appropriate degradation[18]. Additional benefits of composting as the mechanism for waste management are the production of valuable soil amendments, low operation costs, ease to be application in most developing countries, and encouragement of environmentally friendly practices such as reduction of the emission of greenhouse gases, promoting the efficiency of fertilizer application.

Future scope of the study

Inorganic fertilizers make nutrient availability easy for plants, but their disadvantages outweigh their advantages. Becuase, inorganic fertilizer contributes to environmental pollution, greenhouse effects, death of soil organisms and depletion of the ozone layer, marine inhabitants, and human diseases etc.,. Recycling of farm residue is a more efficient method that can be implemented in trash management in India for sustainable soil health and also for agriculture. Composting with microbial inoculants technology will make sure to improve environmental conditions, to save external nutrient resources and healthy quality food for the future population.

Conclusion

It is the right time to make them aware of the technologies for utilization of sugarcane trash and produce compost, which not only helps in protecting the environment but also provide economic gain. Sugarcane trashes can potentially conserve soil moisture, reduce evaporation losses, and suppress the weed population. The contradictions about the performance of mulching exist as adverse effects of mulching have been reported by different scientists. However, it can be concluded from the literature that mulches are a cheap source to reduce weed populations and conserve soil moisture contents to a substantial level. Therefore, properly managed mulching strategies could compensate for the water requirement of crops in water deficit/drought conditions. It was evident from the various studies that the major constraints like traditional norms, lack of awareness of technology, and high cost of machinery were faced by the farmers. Thus there is a need to organize a training program, and proper demonstration of improved technology to encourage the farmers to the utilization of sugarcane trash so that the farmers become aware of the technology for the utilization of sugarcane trash. It was evident that in-situ sugarcane trash composting had a positive influence on soil fertility, the yield of cane, and the income of the farmers. Insitu composting and mulching exhibited significant impacts on the growth, yield, and quality of crops. Moreover, integrating the mulching system could serve as an efficient technique to enhance overall crop growth, development, and

yield.

Acknowledgement

It is a genuine pleasure to express my deep sense of thanks and gratitude to all the authors for the deep knowledge and support towards inscribing this dissertation. I also felt elated to express my bountiful thanks to those who directly or indirectly helped me in the successful completion of this study. A special thanks goes out to the editorial team for finding interest in the present study and publishing the work. This project study was supported by all researchers and funding from ICAR through ATARI, Hyderabad, India.

Conflict of interest: Nil

References

[1.] Abdurrahman, M.I., Chaki, S., Saini, G. Stubble burning. (2020). Effects on health and environment, regulations and management practices. India, Elseveir.

[2.] Abhishek Tiwari and Ravindra Sachan. (2022). Pusa Decomposers: An alternative approach of crop residue burning. Time of India. 25 123-124

[3.] Ahmad, S., Raza M.A.S., Saleem, M.F., Zaheer, M.S., Iqbal, R., Haider, I., Aslam, M.U., Ali. M and Khan, I.H. (2020). Significance of partial root zone drying and mulches for water saving and weed suppression in wheat. J.Anim.Plant.Sci. 30 154–162

[4.] Bisen, N., and Rahangdale, C.P. (2017). Crop residues management option for sustainable soil health in rice-wheat system: A review. *Int. J.Comput. Syst*. 5 1038-1042

[5.] Christy P. Nirmala Mary and R. Anitha. *(2019.)* Effect of Sugarcane Trash Biochar on Enhancement of Soil Health and Sugarcane Productivity. *International Journal of Current Microbiology and Applied Sciences. ISSN: 2319-7706* 8(11)

[6.] Dhanapal R., Tayade, A. S., Bhaskaran, A. and Geetha, P. (2018). Efficient Water Management in Sugarcane with Composted Coir Pith and Sugarcane Trash Under Tropical Indian Conditions. Sugar Tech · February,

[7.] Dotaniya1 M. L. S. C. Datta, D. R. Biswas, C. K. Dotaniya, B. L. Meena, S. Rajendiran1, K. L. Regar. Manju Lata. (2016). Use of sugarcane industrial by-products for improving sugarcane productivity and soil health, . Int. J. Recycl. Org .Waste Agricult. 5 185–194

[8.] Gaind, S. and Nain, L. (2007) Chemical and biological properties of wheat soil in response to paddy straw incorporation and its biodegradation by fungal inoculants. Biodegradation. 4 495–503

[9.] Ghosh, P., Sharma,S., Khanna, I., Datta, A.,Suresh, R., Kundu, S., Goel, A., and Ddatt, D., (2019). Scoping study for South Asia Air Pollution.

[10.] *Ismon* Lenin, *Widia* Siska, and *Eka* Mirnia. (2021). The effect of straw compost on nutrient uptake and yield of rice in newly opened and intensive lowland. E3S Web of Conferences. 306 01032

[11.] Kader, M.A, Singha, A, Begum, M.A, Jewel, A, Khan, F.H, and Khan, N.I. (2021). Mulching as water-saving technique in dry land agriculture. Bulletin of the National Research Centre., 43,1–6

[12.] Kannan, J. (2020). Impact of In-situ Composting of Sugarcane Trashes on Soil Nutrients and Fertility. Agricultural Science Digest.. 40 4 400-403

[13.] Krishnaveni, A., Pandian, M., ,Sivakumar, C, and Anbumani, S. (2018). Status on in situ sugarcane trash management to avoid burning for uplifting the farmers wealth, soil and environmental health. International Journal of Development Extension. 9 2 16 -24

[14.] Kumar, S., Sharma, D.K., Singh, D., Biswas, H., Kumar, P., and Sharma, V. (2019). Estimating loss of ecosystem services due to paddy straw burning in north- west India.

[15.] Masaka, J., Dera, J., and Muringaniza, K. (2019). Dry land grain Sorghum (Sorghum bicolor) yield and yield component responses to tillage and mulch practices under subtropical African conditions. Agric. Res. 1-9

[16.] Mitchell, R.D.J., Thorburn, P.J., and Larsen, P. (2000). Quantifying the loss of nutrients from the immediate area when sugarcane residues are burnt. Proceedings of the Australian Society of Sugar Cane Technologists., 22 206-211

[17.] Mitchell, Ross D.J., Peter J. Thorburn and Peter Larsen. (2000). Quantifying the loss of nutrients from the immediate area when sugarcane residues are burnt. In Proceedings of the 2000 Conference of the Australian Society of Sugar Cane Technologists Held at Bundaberg, Queensland, Australia. 206–211

[18.] Mohammad Hafeez, Pramila Gupta and Yash Pal Gupta. (2018). Rapid Composting of Different Wastes with Yash Activator Plus. Int. J. Life Sci. Scienti. Res. 1670-1674

[19.] Mohd Lokman Che Jusoh, Latifah Abd Manaf and Puziah Abdul Latiff. (2013). Composting of rice straw with effective microorganisms (EM) and its influence on compost quality . Iranian Journal of Environmental Health Sciences & Engineering. 10 17 1-9

[20.] Prasanthrajan Mohan and Duraisamy Ponnusamy. (2011). Addressing the challenges of sugarcane trash decomposting through effective microbes. International conference on food engineering and biotechnology. IPCBEE. 9 229-233

[21.] Rahayu, F., Nugraheni, S. D., Diana, N.E., Santoso, B., Wijanarko, A, and Hariyono, B. (2022). The potential of new bio-decomposers for composting sugarcane waste. IOP Conf. Series: Earth and Environmental Science. 974 012060.

[22.] Rahul Kumar, Deepshikha Verma, Bhanu L. Singh, Umesh Kumar, Shweta. (2010). Composting of sugar-cane waste by-products through treatment with microorganisms and subsequent Vermicomposting . Bioresource Technology. 101 6707–6711

[23.] Rashid Iqbal , Muhammad Aown Sammar Raza, Mohammad Valipour, Muhammad Farrukh Saleem, Muhammad Saqlain Zaheer, Salman Ahmad, Monika Toleikiene, Imran Haider, Muhamm ad Usman Aslam1 and Muhammad Adnan Nazar1. (2020). Potential agricultural and environmental benefits of mulches—a review. Iqbal et al. Bulletin of the National Research Centre., 44 75

[24.] Ravi G., Savitha, B., Sreenivasulu, M., and Vidyasagar, Ch.G.E. (2021). A Study on Extent of Adoption of Agri Waste Management Practices by the Farmers of Medak District of Telangana, India. *Asian Journal of Agricultural Extension, Economics & Sociology.*, *39 4 125-133*

[25.] Robertson, F.A., and Thorburn, P.J. (2007). Decomposition of sug-arcane harvest residue in different climatic zones. *Australian Journal of Soil Research*. 45 1-11

[26.] Saggu, G.S., Mittal, S.K., Agarwal, R., and Beig, G. (2018). Epidemiological study on respiratory health of school children of rural sites of Malwa region (India) during post harvest stubble burning events. M.A.P.A.N.

[27.] Sayed Tatheer Zaidi. (2021). Rice Crop Residue burning and alternative measures by India: A Review.Journal of Scientific Research., 65 1 132-137

[28.] Shabnam and Rimpika. (*2021*). Pusa Decomposer: An Effective Curb to Crop Residue Problem . Just *agriculture.in .,* 1 11

[29.] Siva Devika, O., Subhadip Paul, Deepranjan Sarkar, Rahul Singh Rajput, Sonam Singh , Manoj Parihar, Parewa, H.P., Sumita Pal, Singh, H.B., Amitava Rakshit. (*2019*), *Trichoderma*: A part of possible answer towards crop residue disposal. Journal of Applied and Natural Science. 11 2 516 – 523

[30.] Small, F.G. (2000). Quantifying the socio-economic impacts ofharvesting residue retention systems - Growers' surveyon burnt and green cane trash blanket farming systems inthe Burdekin and Proserpine districts. Sugar Researchand Development Corporation. BSS173.

[31.] Souri, M. K., and M. Bakhtiarizade. (2019). Biostimulation effects of rosemary essential oil on growth and nutrient uptake of tomato seedlings. Scientia Horticulturae. 243:472–476

[32.] Suma, R., and Savitha, C.M. (2015). Integrated Sugarcane Trash Management. A Novel Technology for Sustaining Soil Health and Sugarcane Yield. Adv Crop Sci Tech. 3 1 http://dx.doi.org/10.4172/2329-8863.1000160

[33.] Wenjing Cai, Xiaobo, G.u , Yadan, D.u, Tian Chang, Shiyu, L.u, Xiaobo Zheng, Dongping Bai, Hui Song, Shikun Sun, Huanjie Cai. (2022). Effects of mulching on water saving, yield increase and emission reduction for maize in China . Agricultural Water Management. 274 107954

[34.] Yadav, R.S. (2019). Stubble Burning. A problem for the environment, agriculture and humans. Blog https://www.downtoearth.org.in/