Sustainable Sugarcane Trash Management in Tropical Soil

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ABSTRACT:
The treatment of sugarcane waste is becoming a common practice in sugarcane farming systems. Returning sugarcane bagasse to the land is one method of managing sugarcane waste. This procedure would hasten the degradation of the bagasse in a tropical area with hot, humid temperatures. This further has the effect of making organic materials in soil nutrients available. However, soil-borne fungi like Sclerotium rolfsii, Rhizoctonia salami, and Xylaria Warburg can also thrive well in bagasse. Diseases including root rot, ribbon midrib blight, and leaf midrib dry rot are all brought on by this pathogenic fungus. The death of plants brought on by a severe infection brought on by these pathogenic fungi reduced sugarcane production.

KEYWORDS:

Bagasse Tropical Area, Managing Sugarcane Waste, Organic Matter Soil, Soil Bone Diseases, Sugarcane Waste Soil.

I. INTRODUCTION

About 75% of the sugar produced globally for human use is produced by the sugarcane (*Saccharin officinarum L.*), one of the world's primary food-producing crops. 120 nations produced more than 1.90 billion tons of food in total in 2019 on more than 26.27 million hectares of land in subtropical and tropical regions. Continuously rising global consumption demands have resulted in crop yields that are centered on agriculture operations and overlook the sustainability of agro-ecosystems, or biological and ecological processes. Due to the degradation of soil organic matter caused by agricultural intensification over a long period of time, soil fertility has decreased and the emergence of soil-borne illnesses has been encouraged. Sugarcane is a perennial crop grown for 9 to 13 months from vegetative cuttings. The shoots that sprout back from the stump after harvesting are referred to as ration cane. The lifespan of ration cane varies between seven and twelve years in several developing nations, including Indonesia (7–12 ration crops). Traditional practices include burning mature sugarcane crops on some sugarcane plantations prior to harvest in order to streamline the process and perhaps lower manpower costs, or burning the leftover sugarcane after harvesting before ration. The sugarcane garbage was assessed to be 10.7 t/ha or even 8 to 30 t/ha and was made up of 54% dry leaves and 46% tops.

Burning waste made of sugar cane is not safe for the environment since it releases smoke and other poisonous substances that are bad for human health, kills helpful insects like parasitoids and predators, and diminishes insect variety. Additionally, soil microbes, small flower species, and fauna are eliminated by rubbish burning. According to Sagged et al., the effect of burning sugarcane waste reduced the populations of ants, spiders, ladybird beetles, and sow bugs by 96%, 95%, 85%, and 61%, respectively. In addition, silica in the ash created by burning damaged the environment and could lead to respiratory conditions. Negative soil conditions were caused by the depletion of organic matter and nutrients. Because fire is used to clear and maintain sugarcane plantations, this practice has detrimental impacts on the land. As a result, several sugar enterprises have established a waste management system to enhance the physical conditions of the soil and boost soil productivity. This technique enables mulching or soil incorporation of sugarcane waste. However, some areas where sugarcane is grown, such as those in tropical countries, have hot, humid weather that is ideal for soil-borne fungal diseases, which can live saprophytic ally and spread disease to newly planted crops. In order to maintain the health of the soil and lower the danger of soil-borne diseases, particularly in tropical settings, we suggest managing sugarcane waste in this study [1], [2].

Techniques for Managing Garbage from Sugarcane

It has been widely stated that garbage management research will increase soil fertility, improve sugarcane productivity, and lead to sustainability. Implemented waste management practices included keeping the trashes and adding compost to them. These techniques enhanced the physical, chemical, and biological properties of the soil, boosted sugarcane sett germination, increased yield, reduced evapotranspiration, promoted microbial and tiny fauna activity, and controlled soil erosion. Lists reports on the benefits of sugarcane garbage control techniques. When the garbage was ploughed under and enriched with Trichoderma viridian, the setts' germination jumped to 82% from 68% when they were planted in soil where the leftovers had been burned. The average cane yield also increased by 12.8%. According to Munoz-Arboreta and Quinter-Duran (2009), eighth ration cane (RC) yield increased as a result of garbage retention on the soil, but plant cane (PC) yield did not. In the PC, the sugarcane yield was about 150 t/ha. When the trash was removed from the ninth RC without the addition of fertilizers, 80 t/ha were produced. However, the cane yield improved by 30 t/ha when the crops were fertilized or the leftovers were mulched on the soil. When mulching was done in addition to fertilizer treatment, the output increased even more, reaching 160 t/ha.

Sugarcane waste should be mulched in between rows to prevent weed growth and retain moisture. The first two months of tailoring should be clear of weeds. According to Hansini, weeds could be managed by mulching between rows using bagasse and/or sugarcane waste applied at 3-5 t/ha. Improved soil characteristics as a result of reintroducing organic matter to the soil are the additional advantages of integrating or mulching sugarcane waste. Enhancing the function of organic matter and nutrient levels in the treated soils is part of this. According to Haynes et al., Johnston et al, organic matter would stabilize soil aggregates, reducing soil erosion and water runoff, enhancing infiltration, water retention, and acting as a chelating agent. When used as a mulch, the residual sugarcane waste could provide as a long-term supply of nitrogen and carbon and increase carbon buildup in the soil surface to a depth of 30 cm. According to Singh and Solomon and Siva Raman a tone of sugarcane garbage contains roughly 5.4 kilograms N, 1.3 kg P2O5, 3.1 kg K2O, and trace amounts of micronutrients, or 0.35 percent N, 0.13% P2O5, and 0.65 percent K2O. To give agronomic and environmental benefits, Carvalho et al. suggested that a minimum mass of sugarcane garbage, at least 7 t/ha, should be maintained on the soil surface. Reintroducing sugarcane waste into the soil also boosted microbial and micro faunal populations, especially those of fungal decomposers. According to Rashid et al. the bacterial community was less impacted by the rubbish than the fungal community [3], [4].

II. DISCUSSION

The diversity of soil-dwelling collembolan, including species of Brachystomella, Folsom ides, Mesaphorura, Alloscopus, and Dicranocentrus, was also boosted by sugarcane dry leaf mulch, but not the population due to a high predator population (Rahardjo et al., 2019). The population of soil micro arthropods, such as mesostigmata, orbited mites, and collembolans, was found to be greatly increased when sugarcane fresh leaf was mulched, according to Mainwaring et al. (2018). Incorporating sugarcane trash for 23 weeks increased carbon, microbial biomass, microbial activity, numbers of free-living nematodes, and unknown predatory fungus. It also suppressed plant-parasitic nematodes like Pratylenchus zee and Tylenchorhynchus annulets by 85% and 71%, respectively, and reduced root infection in sugarcane by 95%. The microclimate around and in the soil offers opportunities for soil-borne pathogens to thrive, especially those that inhabited in trash as saprophytes and acted as a disease inoculate for the next season's crop, even though trash management practices have benefits for improving soil characteristics, including improving the performance of soil micro inhabitants. The soil-borne pathogens that could infect the plant as a result of retaining and mulching sugarcane waste into the soil are discussed in the chapter that follows. Incorporating sugarcane waste and mulch with soil-borne illnesses.

High humidity is a defining characteristic of the tropics practically all year round. Numerous pathogens have been documented to infect sugarcane with illnesses or to mutate into more virulent inoculate that cause crop diseases in agro ecosystems with high humidity. The residual sugarcane waste could be a source of inoculate that will seriously afflict the following sugarcane plantation under ideal conditions of high humidity. According to numerous reports, debris borne inoculum contributes to the survival of fungal propagates. For instance, Sclerotium rolfsii Sac, an important disease-causing pathogen in several plant species, including sugarcane, requires high humidity for optimal growth; isolates of Rhizoctonia salami, the pathogen causing soybean seedling disease, became more virulent at high soil moisture and Xylaria sp., which typically survive as saprophytes on sugar We talk explicitly about these three soil-borne diseases connected to mulch and sugarcane waste in the soil.

(Anthelia rolfsii) Sclerotium rolfsii Sac:

In sugarcane plantations, Sclerotium rolfsii Sac. (Anthelia rolfsii) has not been regarded as a significant fungal pathogen. Typically, the fungus affects the leaf sheath and results in red rot or dry rot of the leaf sheath. Recently, however, we discovered that the fungus was responsible for the failure of sugarcane setts to germinate in Malang, East Java, Indonesia as well as in a new sugarcane plantation site in Serum Island, Maluku, Indonesia. The new location was formerly cleared forest area with some wood and leaf debris still on the ground. Additionally, the fungus decreased sugarcane sett germination by more than 70%, according to Bunyan et al. In contrast, DaVita and Suma showed that plough sugarcane residue and enriched with T. viridian improved the germination of the set-in subtropical Karnataka. We propose that the relevance of S. rolfsii as a soil-borne sugarcane disease would be influenced by the microclimates of tropical and subtropical locations. Necrotrophic soil-borne pathogen S. rolfsii can persist on plant remains and, in the soil, as sclerotic. The lower part of stems at or at the soil surface of a wide variety of host agricultural plants, including vegetables, fruits, herbaceous, and woody plants, are typically infected by sclerotic. When sugarcane-waste management is used, especially in humid areas, it should take into account the fungus' capacity to thrive in plant detritus, including trash from sugarcane plants [5], [6].

Kuhn's Rhizoctonia Salami

Thanatephorus cucumbers Dunk, also known as Rhizoctonia salami Kuhn, is a soil-borne neurotropic pathogen with a wide range of host plants. This fungus was regarded by Sharma et aland Safi Uddin and Sheikh as a significant fungal pathogen of sugarcane in India. R. salami typically starts out in sugarcane's lower leaf sheath or leaf blade, close to the soil surface, and subsequently spreads to the top section. The ideal humidity conditions would allow R. salami to flourish and spread illness. On lower leaf sheaths or blades in some sugarcane plantations in Indonesia we saw some oval, water-soaked, yellow-green patches. This can be the first sign of R. salami infection. When the atmosphere in the sugarcane plantation was extremely humid and there was shade from the plantation's dense canopy of 4-6-month sugarcane plants, the symptoms were more pronounced. Sheath blight, which primarily affects older leaves, is the name for the spots' later development as irregular lesions with greyish white centers and tan-brown edges. Banded leaf blight is an area on the leaf blade that is light brown and is surrounded by dry, dark brown bars. Mycelia could be seen sprouting and developing like spider webs on the leaf surface and generating sclerotic on the dead, dried tissue.

Mycelia ranged in color from white to pale brown. The stem may be affected by the severe infection, leading to dried rot and fractured stems. Safi Uddin and Sheikh discovered various symptoms in sugarcane plants infected with R. salami, though. R. salami killed sugarcane seedlings in various parts of Uttar Pradesh and caused stunting in older infected plants. The fungus created brown to dark brown dry rot leaves when it attacked sugarcane leaves. The huge losses, however, have not been disclosed. Salami can live for a very long time in plant debris and soil, making infected dried plant materials left on the pitch a potential source of inoculum for the following season. The fungus persisted as pigmented hyphae or sclerotic. R. Solana’s saprophytic growth was accelerated by plant wastes like sawdust, peat, coconut fibers, cellulose, glucose, and biochar as well as by compost pam and maize litter. When planted, the seedlings suffered serious damage as a result of the fungal sclerotic that fared better on rice straws than in soil. Additionally, the soil-applied green manure of Brassica species encouraged R. Solana’s saprophytic activity to produce damping-off in canola. R. Solana’s survival was said to be impacted by the humidity and temperature levels. R. salami sclerotic that are present on the soil's surface or in close proximity to plant detritus are pathogenic structures that, when the right environmental factors, particularly temperature and humidity, are present for their growth, can develop into primary inoculate that cause illness.

The ideal temperature and humidity for this fungus to develop and infect plants are present in tropical microclimates. When incubated at 4°C, the fungus could survive in infected rice straw for 16 months but, at 25°C and 36°C, it could only survive for 50% and 35% of that time, respectively. When the sick rice straws were mixed with wet or flooded paddy soils (100%) as opposed to dry soil (75%), the fungus also thrived for up to 10 months. There is little information about R. Solana’s ability to survive in sugarcane waste in sugarcane plantations. The impact of managing sugarcane waste residues produced a variety of consequences. For instance, Papavizas reported that the addition of organic residues with a high C/N ratio led to nitrogen competition among microorganisms, which could reduce the saprophytic activity of R. salami and its potential pathogenicity over the long run. Contrarily, Bonanomi et al. discovered that the short-term cellulolytic activity of organic materials with a high C/N ratio could boost R. salami inoculum. However, over time, these organic materials can encourage the activity of rival bacteria and reduce R. Solana’s saprophytic activity. Therefore, more research on the R. salami population dynamics and its activities in sugarcane waste residue is required [7], [8].

A soil-borne pathogen called Xylaria cf. warburgii causes sugarcane root and basal stem rots, mainly in Palembang of South Sumatera and Lampung Provinces in Indonesia. It was most likely discovered for the first time in 1993 and resulted in yield reductions of 12.3–15.4%. Taiwan, Puerto Rico, and the United States have reported cases of the illness. This virus infected more than 700 ha of sugarcane farms in Taiwan, resulting in losses of up to 30% on ration cane and 5% on plant cane. The symptoms of yellowing leaves are brought on by X. warburgii infection of the root system, which inhibits the movement of nutrients. Infected plants typically develop slowly, are thin, stunted, and have fewer tillers. A severe infection can even because plant mortality while reducing sugar yield and quality. Infected stumps continue to harbor the fungus, which then infects ration crops the next season (Figure 1). Planting patches that were yellow and dried out were the signs in endemic areas. According to Akhtar et al. (2015), the genus Xylaria is a white soft-rot fungus that has infected numerous woody plants. According to Soon et al. (2011), it is a saprotrophic fungus that lives in the soil and is capable of digesting lignocellulose.

Figure 1: X. warbugii-induced sugarcane basal stem rot [Research Gate].

If the conditions are right, X. warburgii, a decomposer, can, like the two infections before it, cause serious illnesses in sugarcane. The ideal temperature and humidity levels are the best environmental conditions for the fungus to grow into a disease. The sugarcane basal-stem rot control technology has undergone extensive research. Although in laboratory studies using PDA media, these fungicides suppressed the growth of pathogens, control employing fungicides with the active components of benzoyl and carbendazim proved ineffective against X. warburgii infection. Hexaconazole 6 mL/L was also found to limit the fungus' in vitro development, according to Win Arno. In Indonesia, only the PS 881, PS 864, PS 882, PSJT 941 and PSJK 922 cultivars, which were created by an Indonesian sugarcane firm in South Sumatra, have limited resistance to X. warburgii. According to a study by Jami et al. using the antagonistic fungus Trichoderma spp., isolate T10 from the collection of the Indonesian Sugar Research Institute (ISRI) had the potential to be used as a biological control agent for X. warburgii in sugarcane due to its high chitin lytic index value of 1.15.

The development of a strategy to control X. warburgii in sugarcane should not only concentrate on slowing the spread of pathogens and diseases, but also take into account how to balance the soil's micro ecosystem by using techniques like polarization, minimum tillage, silicon fertilizers, and organic manure enriched with the antagonist. When crop residues are returned to the soil as part of a trash management programmer, the biomass present could help the previously mentioned neurotropic saprophytic pathogens survive and grow when the microclimate is favorable for the pathogen to grow and infect humans. In order to speed up decomposition and lower the survivability of germs, efficient garbage management should be used. We suggest a number of methods that can be applied to the sugarcane management system. The methods for accelerating decomposition include adding favorable substrates, flooding the area with primary decomposers, and introducing microbial decomposers. All of the treatments would thereby lessen infection while enhancing sugarcane development.

Process of Sugarcane Trash Decomposition

Although returning nutrients and organic matter to the soil by integrating or mulching sugarcane waste takes a long time or years to get the desired results. By this time, particular neurotropic saprophytic infections linked to such media can take advantage of the chance to persist in the biomass. Therefore, when choosing a garbage management solution, it is important to consider a safe, acceptable, and quick process of sugarcane trash breakdown. The chemical makeup of the waste, the kind of soil, the climate, the presence of water, and the availability of oxygen all affect how quickly sugarcane waste decomposes. According to Robertson and Thornburg and Ferreira et al., the majority of sugarcane garbage was made up of dry sheets and leaves with a C: N ratio of 70–100:1. This led the nitrogen to become immobilized and less readily available for the crop the following season. Only 15% of nitrogen was added during the first six months after spreading 10 t/ha of crushed sugarcane garbage on two types of soil, and it gradually decreased over the course of 18 months. This meant that less than 10% of the demand for sugarcane was met by the available N from the waste.

Furthermore, Fortes et al. noted that after adding residues to the field for three years, the ration-cane plant only used 20% of the nitrogen from the garbage. Even Robertson and Thornburg asserted that after six years of integration, the nitrogen from the trash remained in the soil at a level of about 80%. As a result, nitrogen fertilizer was still necessary for the first six years following incorporation because it was necessary to break down the trash's cellulose, hemicellulose, and lignin. This is because soil microbes took a longer time to degrade the trash's content than they did other soil components. Microbial consortiums that produced enzymes for primary degradation and subsequent processes are required for the cellulose, hemicellulose, and lignin degradation process in sugarcane waste. Numerous species of bacteria, fungi, and actinomycetes, as well as cellulolytic, hemi cellulolytic, and lignin lytic microorganisms, have been found as decomposers linked to sugarcane waste. It is well known that cellulolytic microbes produce the enzyme cellulose, which is crucial to the breakdown of cellulose.

Intestinal bacteria from sugarcane-fed Diarrhea saccharalis moth larvae were found to contain bacteria from the genera Klebsiella, Stenotrophomonas, Micro bacterium, Bacillus, and Enterococcus. According to Denture et al. (2015), these bacteria had good cellulolytic activity and high extracellular protein concentrations. While Pinero et al. claimed that several bacteria from the genus Cellulosimicrobium, Micro bacterium, and Agromyces, which were discovered in the digestive tract of the snail Achaia folic, produced cellulosic enzymes capable of breaking down the cellulose in sugarcane bagasse. Hemicelluloses like glycan, xylem, Arabian, galactic, and manna must be broken down using a number of enzymes produced by microbes such fungi, bacteria, and actinomycetes as well as microscopic animals. For instance, Aspergillums -endo-mannanases and -mannosidases can break down manna.

To further hydrolyze xylenes and manna's, xylem esterase, frolic and p-comedic esterase's, -l-arabinofuranosidases, and - 4-O-methyl glucuronidase were required. While the hydrolysis of polysaccharide cellulose required the enzymes endoglucanase, exoglucanase or cellobiohydrolase, and -glycosidase, which are mostly produced by fungi, bacteria, and protozoans. According to Ballerina and Valáková, endoglucanases (EGs) are typically produced by basidiomycetes, brown rot, white rot, and the plant pathogen S. rolfsii. According to Algoid et al, T. harzianum, T. longibrachiatum, and A. fumigates all produced -glycosidase enzymes as well as cellulose and endoglucanase enzymes. According to Akhtar et al., Bacillus subtitles from composting materials can break down cellulose. In addition, Singh et al. (2008) discovered three bacteria B. macrons, Cellulomonas cartage, and C. due that could convert cellulose and lignin into fermentable sugar. Finding new and powerful strains that produce lignocellulose enzymes is one of the key concerns surrounding the application of enzymes to enhance the biomass utilization in Brazil Valencia and Chamber go, 2013 [1], [9].

III. CONCLUSION

Systems for growing sugarcane today frequently include sugarcane-trash management. Sugarcane bagasse being returned to the earth is one method of managing sugarcane waste. This practice would speed up microbial activity to decompose the bagasse in a tropical area with humid and hot circumstances. The availability of organic matter in soil nutrients is further a result of this. Bagasse is a suitable growing medium for fungi that are found in soil, including Sclerotium rolfsii, Rhizoctonia salami, and Xylaria warburgii. The diseases ribbon midrib blight, root rot, and leaf midrib dry rot are all brought on by this pathogenic fungus. This pathogenic fungus might kill plants if there was a severe infestation, which would reduce sugarcane yield. The management of sugarcane waste must be improved in order to hasten its decomposition and prevent the emergence of diseases transmitted through the soil. It should be thought about combining the methods to speed up the breakdown rate with sugarcane waste management.

REFERENCES

[1] R. Wijayanti and B. Prasetya, “Pengaruh Pemberian Urea Terhadap Laju Dekomposisi Serasah Tebu di Pusat Penelitian gula Jengkol, Kabupaten Kediri,” J. Tanah dan Sumberd. Lahan, 2018.

[2] V. K. Snekapriya and M. Jayachandran, “Effect of Sugarcane Trash Biochar on Growth and Yield of Sugarcane Seed Crop,” Madras Agric. J., 2018, doi: 10.29321/maj.2018.000119.

[3] S. A. Assunção, A. P. P. Oliveira, L. H. C. dos Anjos, M. G. Pereira, and E. Lima, “Soil organic matter fractions affected by n-fertilizer in a green cane management in Brazilian Coastal tableland,” Bragantia, 2018, doi: 10.1590/1678-4499.2017296.

[4] C. A. Corsiga, R. Badayos, P. Sanchez, E. Paterno, and P. Sta. Cruz, “Socio-Economic Assessment of Sugarcane-Based Cropping System in Negros Occidental, Philippines,” Philipp. J. Agric. Econ., 2018, doi: 10.7719/pjae.v2i1.546.

[5] J. Z. Zhu, H. J. Zhu, B. Da Gao, Q. Zhou, and J. Zhong, “Diverse, novel mycoviruses from the virome of a hypovirulent sclerotium rolfsii strain,” Front. Plant Sci., 2018, doi: 10.3389/fpls.2018.01738.

[6] J. F. Díaz Nájera et al., “Diagnosis and integrated management of fruit rot in Cucurbita argyrosperma, caused by Sclerotium rolfsii,” Plant Pathol. J., 2018, doi: 10.5423/PPJ.OA.08.2017.0185.

[7] A. Tarafdar, T. S. Rani, U. S. S. Chandran, R. Ghosh, D. R. Chobe, and M. Sharma, “Exploring combined effect of abiotic (soil moisture) and biotic (sclerotium rolfsii sacc.) stress on collar rot development in chickpea,” Front. Plant Sci., 2018, doi: 10.3389/fpls.2018.01154.

[8] S. Jacob, R. R. Sajjalaguddam, and H. K. Sudini, “Streptomyces sp. RP1A-12 mediated control of peanut stem rot caused by Sclerotium rolfsii,” J. Integr. Agric., 2018, doi: 10.1016/S2095-3119(17)61816-1.

[9] S. Dhapate, S. Dilpak, and R. Pawar, “Studies on effect of cellulolytic fungi on decomposition of sugarcane trash,” ~ 2975 ~ J. Pharmacogn. Phytochem., 2018.