E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(9): 779-784
Received: 13-07-2025
Accepted: 17-08-2025

Pradhan JA
Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Nalawade SV
Assistant Professor, Plant Pathology, Central Sugarcane Research Station, Padegaon, Satara, Maharashtra, India

Jadhav AC
Jr. Mycologist, AICRP on Mushroom, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Phalke DH
Associate Professor, Division of Soil Science, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Lohate SR
Junior Pathologist, AICRP on Floriculture, ZARS, Ganeshkhind, Pune, MPKV, Rahuri, Maharashtra, India

Vasave MS
Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Anjali M
Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Corresponding Author:
Pradhan JA
Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune, MPKV, Rahuri, Maharashtra, India

Impact of liquid bioinoculants, organic and chemical additives application on nutrient status of sugarcane trash

JA Pradhan, SV Nalawade, AC Jadhav, DH Phalke, SR Lohate, MS Vasave and Anjali M

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9k.3856

Abstract
Burning of sugarcane trash inside the field in India is a common practice among farmers due to a lack of proper composting techniques, labour availability and less time available for the sowing of the next crop. This burning not only results in the loss of organic matter and plant nutrients but also causes atmospheric pollution by emitting toxic gases. Composting is a method of utilizing these plant residues, whether composted can serve as a cost-effective alternative to inorganic fertilizers. Enriching compost with mineral additives can effectively boost the growth and efficacy of indigenous fungi, accelerating the decomposition process of sugarcane trash. The present investigation was undertaken during 2024–25 at the Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune with main objective to evaluate the impact of liquid bioinoculants (*Trichoderma* spp. including *T. asperellum, T. harzianum, and T. hamatum*), organic additives such as cow dung slurry and chemical fertilizers (Urea, DAP, MAP, SSP) on the rate of decomposition and overall compost quality of sugarcane trash. The experiment was laid out in a completely randomized design with seven treatments and three replications by pot method. Different chemical parameters such as pH, electrical conductivity (EC), organic carbon content, total NPK, and micronutrients (Fe, Zn, Mn, Cu) were also assessed at initial and final stage. Among the treatments, spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5 lit. + liquid bioinoculant *Trichoderma* spp. (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. per ton of sugarcane trash, emerged as the most effective treatment and exhibited superior compost quality with pH ranging toward neutrality, reduced total carbon (22.2%) higher nutrient content (N: 1.25%, P_2O_5: 0.63%, K_2O: 0.88%) and enhanced micronutrient availability (Fe: 937 mg kg^{-1}, Zn: 96 mg kg^{-1}, Mn: 244 mg kg^{-1}).This approach not only reduces environmental pollution but also offering a sustainable solution for trash management and recycles nutrients back into the soil, improving soil fertility and reducing the need for synthetic fertilizers.

Keywords: Composting, bioinoculants, organic carbon, macro and micronutrients

Introduction
In India, approximately 6.5 million tons of sugarcane trash are produced annually, with most residues typically burned in the field due to a lack of proper composting techniques (Mohan and Ponnusamy 2011) [30]. About 7-12 tons of trash can be obtained from 1 ha of sugarcane (Robertson and Thorburn, 2000) [35]. 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 (Singh and Solomon, 1995) [37]. Burning of sugarcane trash inside the field in India is a common practice among farmers due to a lack of labour 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. This burning not only results in the loss of organic matter and plant nutrients but also causes atmospheric pollution by emitting toxic gases such as methane and carbon dioxide, which pose threats to both human health and the ecosystem (Mohan and Ponnusamy, 2011) [30]. Further, these elements get converted to various environmental pollutants like CH_4, N_2O, CO, CO_2, particulate matter, volatile hydrocarbons, heavy metals, etc. on burning, affecting air quality and human health and immensely contribute to climate change

(Lal, 2008) [28]. It destroys beneficial insects, such as parasitoids and predators and reduces insect diversity. Also, the trash burning causes the negative impacts on soil temperature, soil microorganisms, florals and fauna (Gupta *et al.*, 2005; Bhuvaneshwari *et al.*, 2019) [17, 6]. On the other hand, farmers use a significant amount of fertilizers to fulfil the nutritional needs of the crops (Suma and Savitha, 2015) [38]. Intensive use of chemical fertilizers and pesticides further deteriorates soil fertility. To rejuvenate soil productivity, adopting practices such as recycling crop biomass such as sugarcane residues and left over crop material, presents a promising alternative (Gaind and Nain 2007) [12]. Utilizing these plant residues, whether composted or otherwise, can serve as a cost-effective alternative to inorganic fertilizers, able it they may yield early compost with limited nutrient content. Enriching compost with mineral additives can effectively boost the growth and efficacy of indigenous fungi, accelerating the decomposition process of sugarcane trash. For decomposition of 1 ton sugarcane crop residues added 8 kg Urea + 10 kg SSP + 1 kg decomposing culture. (Ghodke *et al.*, 2020) [14] The cellulose-decomposing microbes play a vital role in preserving the carbon equilibrium in nature, particularly evident in the decomposition of sugarcane trash, which ultimately fosters humus formation and enhances soil fertility. It significantly enhances the levels of nitrogen, phosphorus, potassium, and micronutrients (Vogtmann *et al.*, 1993) [39].

Incorporation of cow dung slurry into trash during composting significantly accelerates decomposition and enhances compost quality. Being rich in diverse microbes and nutrients, particularly nitrogen and carbon, cow dung stimulates microbial activity and promotes faster breakdown of organic matter. Cow dung slurry contains essential nutrients like 0.7% nitrogen, 0.285% phosphorus (P_2O_5), and 0.231% potassium (K_2O), which contribute to soil fertility and microbial proliferation (Devakumar *et al.*, 2014) [10]. Additionally, composting cow dung reduces harmful ammonia emissions and weed seeds, while enhancing moisture retention and aeration in soil (Jagdish, 2020) [26]. Overall, cow dung slurry acts as a natural bio-augmenting agent, intensifying microbial oxidation reactions and enriching the compost with beneficial humic acids, making it more suitable for soil application and crop productivity.

Trichoderma spp., common rhizosphere inhabitants, not only accelerate decomposition of organic residues but also act as biocontrol agents against soilborne pathogens (Chet, 1987; Chet *et al.*, 1997; Harman and Lumsden, 1990; Harman, 2000) [8, 9, 21, 22]. They can suppress diseases and promote plant growth under both greenhouse and field conditions (Harman and Bjorkman, 1998; Ousley *et al.*, 1994) [20, 31].

The use of chemical additives facilitates the decomposition process as they decrease the C:N ratio of the biomass which favor microbial growth. Generally, urea and SSP or rock phosphate are used as chemical additives. This are generally broadcasted in field in solid form which dissolves as if the water is available, this may require some time. Therefore, to address this problem and to develop an alternative method for decomposing sugarcane trash, research to study the effect of spray of chemical, organic additives and liquid bioinoculants i.e. *Trichoderma* spp. (*T. asperellum, T. harzianum and T. hamatum*) has been proposed.

Materials and Methods

The experiment was conducted from September-2024 to January-2025 at Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune. The experiment was laid out in completely randomize design with three replications and 7 treatments in pot method. The plastic pots were fixed by digging small pit at experimental site. In each treatment of pot, 10-15 layers of chopped sugarcane trash was filled with chemical additives *viz.*, Mono ammonium phosphate (MAP) @ 5 kg, Diammonium phosphate (DAP) @ 5 kg and Urea @ 10 kg urea mixed in 100 lit. water for per ton of sugarcane trash. These layers are then moistened with filtered 5 litres of slurry made up of cow dung (i.e., 50 g soil + 50 g cow dung for every 1 litre of water). Liquid bioinoculant of *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash was applied in each layer of sugarcane trash. Over the final trash layer, a layer of soil will be spread to a thickness of 15cm and the head is covered. The heap will be moistened once in a week from above and allowed to decompose up to 4 months. The compost material was turned once at 30 days after composting to allow more aeration inside the material. Allowing bottom layer to top and top layer at bottom for uniform composting. The initial characterization of sugarcane trash and cow dung slurry along with following methods were used for estimation of different chemical properties *viz.*, pH, Electrical Conductivity (EC), Organic Carbon (%), available Nitrogen (N), Phosphorus (P), Potassium (K) and Total micronutrient (Fe, Mn, Zn, Cu) content of sugarcane trash during decomposition of compost.

Table 1: Methods used for chemical analysis of sugarcane trash during decomposition

Sr. No.	Parameter	Method	Reference
1.	pH	Potentiometric	Richard (1954)
2.	EC	Conductometric	Richard (1954)
3.	Organic carbon	Muffle furnace	Gorsuch (1970) [15]
4.	Total N	Micro-Kjeldahl's method	Jackson (1973) [24]
5.	Total P	Vanadomolybdate method	Jackson (1973) [24]
6.	Total K	Flame photometeric	Chapman and Pratt, (1961) [7]
7.	Total Micronutrient (Fe, Mn, Zn, Cu)	Atomic Absorption Spectrophotometer	Lindsay and Norvell (1978) [29]
8.	CO2 evolution method	Alkali trap method	Anderson *et al.*, (1989) [2]
9.	Moisture content	Oven dry	Hati (2021) [23]

Fig 1: Field view of studies on effect of liquid bio-inoculants, organic and chemical additives on decomposition of sugarcane trash

Results and Discussion

Characterization of sugarcane trash and cow dung slurry

The data pertaining to the initial composition of sugarcane trash were analysed at the time of composting are presented in Table 1. The study revealed that sugarcane trash contained 44.3% total organic carbon, 0.37% total nitrogen, 0.12% total phosphorus and 0.54% total potassium. The pH and EC of sugarcane trash were recorded to be 6.85 and 0.85 ds m^{-1}, respectively. Micronutrient content of sugarcane trash was found to be Fe (326 mg kg^{-1}), Zn (70 mg kg^{-1}), Mn (202 mg kg^{-1}) and Cu (9 mg kg^{-1}). The C:N ratio was 119.7, indicating a high lignocellulosic composition. The cow dung slurry, used as a microbial activator contain lower C:N ratio of 22.5, pH and EC of cow dung slurry were found to be 7.52 and 1.45 ds m^{-1}, respectively. Nutrient analysis showed total nitrogen, total phosphorus and potassium contents of 0.68%, 0.112% and 0.25%, respectively. The micronutrient content was observed as Fe (58.9 mg l^{-1}), Zn (7.54 mg l^{-1}), Mn (17.42 mg l^{-1}) and Cu (4.98 mg l^{-1}). Goyal *et al.*, (2005) [16], Hagar *et al.*, (2015) and Shinde *et al.*, (2024) [36] concluded that co-composting crop residues with dung enhances microbial activity and nutrient balance, resulting in improved compost quality.

Table 2: Characterization of sugarcane trash and cow dung slurry

Sr. No.	Composition	Sugarcane trash	Cow dung slurry
1.	Total Organic Carbon (%)	44.3	15.3
2.	C:N Ratio	119.7	22.5
3.	pH	6.85	7.52
4.	EC (dSm^{-1})	0.85	1.45
5.	Total Nitrogen (%)	0.37	0.68
6.	Total Phosphorus (%)	0.12	0.112
7.	Total Potassium (%)	0.54	0.25
8.	Total Fe (mg kg^{-1} or mg l $^{-1}$)	326.0	58.9
9.	Total Mn (mg kg^{-1} or mg l $^{-1}$)	202.0	17.42
10.	Total Zn (mg kg^{-1} or mg l $^{-1}$)	70.0	7.54
11.	Total Cu (mg kg^{-1} or mg l $^{-1}$)	9.00	4.98

Chemical properties of matured sugarcane trash compost

Chemical properties *viz.*, pH, electrical conductivity (EC), total carbon content, macro (N, P, K) and micro nutrients (Fe, Zn, Mn and Cu) of matured sugarcane trash compost after 120 days of composting produced by the decomposition of sugarcane trash using various combinations of chemical fertilizers, organic additives and microbial inoculants are enumerated in Table 3 and depicted graphically in Figures 2 and 3.

pH

The pH value of matured compost produced after decomposition was found in the range of 7.11 to 7.60. Highest pH 7.60 was recorded in T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture and it was statistically at par with treatment T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane and T_4- Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.*(*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash reaching pH value 7.53 and 7.42, respectively. While lowest pH was found in both treatments T_1 (Urea + MAP) and T_7 (Absolute control)**.** These results are supported by Shinde *et al.*, (2024) [36] and Jagadabhi *et al.*, (2018) [25] who reported pH ranged from 7.1 to 7.8 that during composting of sugarcane trash using a microbial consortium, as maturity was achieved. Similarly, Pan and Sen (2013) [32] observed that during aerobic composting, the initial pH of 5.0 stabilized around pH 7.0 indicating compost maturity.

Electrical conductivity (EC) (dS m^{-1})

The electrical conductivity (EC) of matured compost, as shown in Table 4, varied significantly among the treatments ranged in 0.68 to 1.66. The significantly highest EC 1.66 dS m^{-1}**,** was observed in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane indicating a higher release of soluble salts due to enhanced mineralization. This was closely followed by 1.54 dS m^{-1} in both T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture and T_2-Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) per ton of sugarcane trash. Comparatively lower EC values were noted in the absolute control T_7 which showed 0.68 dS m^{-1}. **S**imilar observations were made by Haggar *et al.*, (2015) [19] and Asava *et al.*, (2025) [3], who found that electrical conductivity increased as a result of elevated nutrient ion concentrations generated during the microbial breakdown and mineralization of organic materials.

Total Carbon Content (%)

The total carbon content of compost at maturity indicated that there significantly decreased in total carbon content 22.20% in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash. This was statistically at par with T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture, T_4- Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.*(*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash and T_2-Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) per ton of sugarcane trash recorded 22.30%, 24.08% and 25.81%, respectively. Higher carbon levels were recorded in the T_7 (absolute control) at 32.71%, reflecting poor composting. The results obtained were similar to Gupta (2018) [18] reported that organic carbon content decreases during composting due to microbial degradation. The loss occurs as carbon is released in the form of CO_2 through microbial respiration. Patil (1994) [33] who made compost from wheat straw and recorded that organic carbon per cent was 17.0. Ayed *et al.*, (2021) [4] found that the values for total organic carbon decreased from initial and stabilized at 23.33- 25.23 per cent at the end of maturation phase.

Total Nitrogen (N) Content

Maximum total nitrogen content of different treatments of matured compost across different treatments was observed 1.25% in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash and was statistically at par with T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture and T_4-Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.*(*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash recorded 1.23% and 1.16%, respectively**.** Absolute control (T_7) recorded significantly lower nitrogen contents of 0.56%. Dhapate *et al.*, (2018) [11] observed that nitrogen content increased progressively with the advancement of decomposition, likely due to the combined effects of carbon reduction, biomass loss and accumulation of microbial proteins. Goyal *et al.*, (2005) [16] reported a rise in total nitrogen content during composting of sugarcane trash mixed with cattle dung, with values increasing from 0.93% to 1.46% over time.

Total Phosphorus (P_2O_5) Content (%)

An overall increase in phosphorus content was observed with the application of chemical fertilizers, especially in combination with microbial inoculants. The highest phosphorus content 0.63% was recorded in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash. This was statistically at par with T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture and T_4- Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash recorded 0.63% and 0.61% respectively**.** The lowest values was observed in T_7 (Absolute control) at 0.27%**.** Similar results were found by Asava *et al.*, (2025) [3] indicating rise in total phosphorous content at maturity of compost due to microbial break down of organic phosphorus compounds into inorganic forms.

Total Potassium (K_2O) Content (%)

A considerable increase in potassium content was also observed across all treatments as. The highest potassium content 0.88% was recorded in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash. This was statistically at par with T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture and T_4-Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash at 0.84% and 0.74%**,** respectively, highlighting the synergistic effect of bioinoculants and potash-supplying chemical inputs. T_7 (0.23%) showed minimal potassium content, reflecting poor nutrient mobilization in the absence of synthetic inputs. These findings are in consistent with Haggar *et al.*, (2015) [19] who reported that total phosphorus and potassium content in compost generally increased with decomposition.

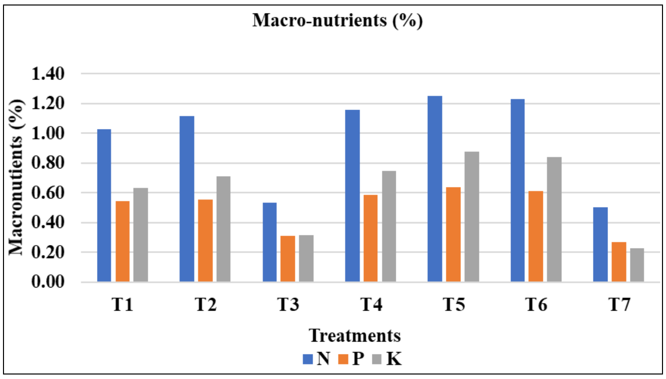

Fig 2: Effect of liquid bio-inoculants, organic and chemical additives on nutrient content of compost (NPK) from sugarcane trash at maturity

Total Fe

The data in Table 3 indicated notable variation in iron content among the different composting treatments. The highest Fe concentration (937 mg kg^{-1}) was recorded in T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash. This was statistically at par with **T_2**-Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) per ton of sugarcane trash and T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture recorded (905 mg kg^{-1}) and (860 mg kg^{-1})**,** highlighting the positive impact of nutrient supplementation and microbial inoculation on Fe mineralization. The absolute control T_7 (394 mg kg^{-1}) exhibited the lowest values.

Total Mn

Manganese levels remained fairly uniform across treatments but still showed statistical significance. The highest Mn concentration (245 mg kg^{-1}) was recorded in T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture, this was statistically at par with T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash, T_4- Spray of 10 kg Urea + 5 kg Monoammonium Phosphate (MAP) (12:61:0) + Spray of filtered cow dung slurry @ 5lit + liquid bioinoculant *Trichoderma spp.*(*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton sugarcane trash and T_2-Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) per ton of sugarcane trash recorded **(**244 mg kg^{-1})**,** (241 mg kg^{-1}) and (240 mg kg^{-1}), respectively. The lowest observed in T_7 (211 mg kg^{-1}), indicating marginal influence of treatments on Mn availability.

Total Zn

The highest Zn concentration (108 mg kg^{-1}**)** was recorded in T_6-Application of 8 kg Urea + 10 kg SSP and 1 kg decomposing culture, indicating the benefit of combining Urea, SSP, and decomposing cultures. This was statistically at par with T_5 - Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) + Spray of filtered cow dung slurry @ 5lit. + liquid bioinoculant *Trichoderma spp.* (*T. asperellum, T. harzianum and T. hamatum*) @ 1 lit. each per ton of sugarcane trash and T_2-Spray of 10 kg Urea + 5 kg Di-ammonium Phosphate (DAP) (18:46:0) per ton of sugarcane trash recorded (96 mg kg^{-1}) and

(89 mg kg^{-1}), respectively. Absolute control T_7 (77 mg kg^{-1}) had the lowest Zn concentrations.

Total Cu

Cu content in matured compost was found relatively stable across treatments, ranging between 9–10 mg kg^{-1} Treatments T_2 to T_6 maintained a consistent Cu level of 10 mg kg^{-1}, whereas T_1 and T_7 recorded a slightly lower value of 9 mg kg^{-1}. As there were no statistically significant differences (NS), it may be inferred that copper content is less influenced by the type of nutrient or microbial input under the given composting conditions.

This interpretation highlights that integrated use of chemical inputs and microbial inoculants (especially in T_5 and T_6) effectively enhances micronutrient (Fe, Zn, Mn) enrichment in compost. These improvements may be linked to microbial solubilization of mineral elements through acidification and enzymatic activity, as also observed by Gawad and El-Howeity (2019) [13] and Akbari *et al.*, (2010) [1].

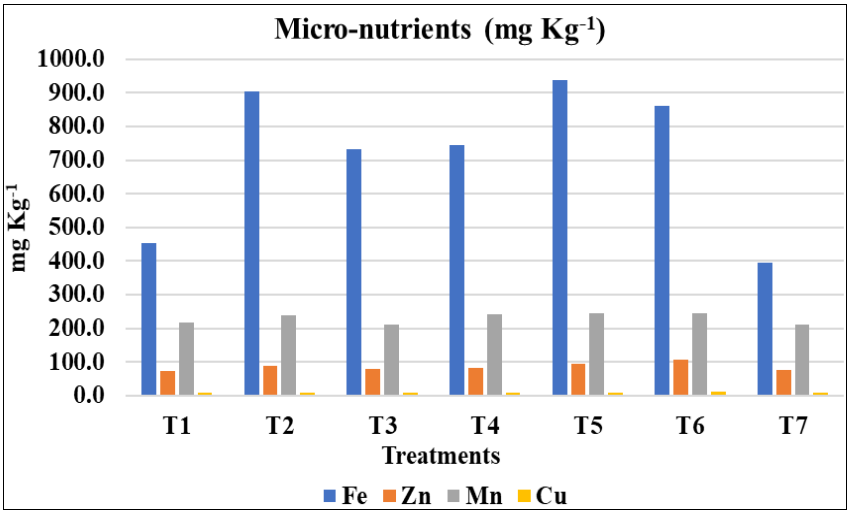

Fig 3: Effect of liquid bio-inoculants, organic and chemical additives on micro-nutrient content of compost from sugarcane trash at maturity

Table 3: Chemical properties of matured sugarcane trash compost after 120 days of composting as influenced by liquid bio-inoculants, organic and chemical additives.

Treatment	pH	EC (dS m^{-1})	Total Carbon content (%)	Macro-nutrients (%)			Micro-nutrients (mg Kg^{-1})			
				Total N	Total P_2O_5	Total K_2O	Fe	Mn	Zn	Cu
T_1	7.12	1.33	25.81	1.03	0.55	0.63	453	217	73	09
T_2	7.28	1.54	24.22	1.12	0.56	0.71	905	240	89	10
T_3	7.26	0.75	30.24	0.63	0.31	0.32	731	212	78	10
T_4	7.42	1.49	24.08	1.16	0.58	0.74	744	241	83	10
T_5	7.53	1.66	22.20	1.25	0.63	0.88	937	244	96	10
T_6	7.60	1.54	22.3	1.23	0.61	0.84	860	245	108	10
T_7	7.11	0.68	32.71	0.56	0.27	0.23	394	211	77	09
S.E. (m) ±	0.09	0.03	0.77	0.03	0.01	0.01	0.51	0.03	0.03	0.006
CD 5%	0.28	0.09	2.34	0.10	0.02	0.04	1.54	0.09	0.09	NS

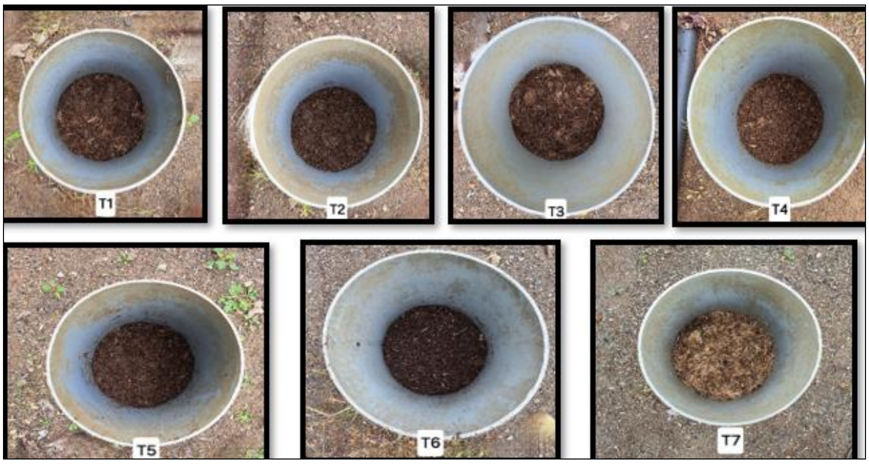

Fig 4: Field view of decomposed sugarcane trash in the composting pots due to effect of liquid bio-inoculants, organic and chemical additives

References

1. Akbari KN, Vora VD, Sutaria GS, Hirpara DS, Padmani DR. Enrichment of compost by bio inoculants and natural mineral amendments. Asian J Soil Sci. 2010;5(1):100-2.
2. Anderson JM, Flanagan PW, Caswell E, Coleman DC, Cuevas E, Freckman D, *et al.* Biological processes

regulating organic matter dynamics in tropical soils. In: Dynamics of soil organic matter in tropical ecosystems. 1989;4:97-125.
3. Asava S, Sharma D, Parab C, Nema A, Donzo OL, Kumar A, *et al*. Exploring sustainable waste solutions: evaluating mixing ratios in agitated pile composting with sugarcane agro-industrial waste. Pollution. 2025;11(1):117-33.
4. Ayed F, Boussadia O, Grissa H, Abdallah R, Hayfa JK, Mejda DR. Assessment of physico-chemical, microbial and phytotoxic changes of various organic wastes during their composting process. J Environ Agric Stud. 2021;2710-40.
5. Bhardwaj KK, Gaur AC. The effect of humic and fulvic acid on the growth, efficiency of nitrogen fixation by *Azotobacter chroococcum*. Folia Microbiol. 1970;15:364-8.
6. Bhuvaneshwari S, Hettiarachchi H, Meegoda JN. Crop residue burning in India: policy challenges and potential solutions. Int J Environ Res Public Health. 2019;16(5):832.
7. Chapman HD, Pratt FP. Methods of analysis for soils, plants and waters. Riverside (CA): Univ. of California, Division of Agricultural Science; 1961. p.309.
8. Chet I. *Trichoderma*: application, mode of action, and potential as biocontrol agent of soilborne plant pathogenic fungi. In: Innovative approaches to plant disease control. 1987. p.137-60.
9. Chet I, Inbar J, Hadar Y. Fungal antagonists and mycoparasites. 1997. p.165-84.
10. Devakumar N, Shubha S, Gowder SB, Rao G. Microbial analytical studies of traditional organic preparations beejamrutha and jeevamrutha. In: Building organic bridges. 2014;2:639-42.
11. Dhapate SS, Dilpak SA, Pawar RK. Studies on effect of cellulolytic fungi on decomposition of sugarcane trash. J Pharmacogn Phytochem. 2018;7(15):2975-7.
12. Gaind S, Nain L. Chemical and biological properties of wheat soil in response to paddy straw incorporation and its biodegradation by fungal inoculants. Biodegradation. 2007;18(4):495-503.
13. Gawad AS, El-Howeity MA. Effect of microbial inoculation and mineral amendments on improving compost quality. Environ Biodivers Soil Secur. 2019;3:97-107.
14. Ghodke SK, Gavit UA, Patil KB, Raskar BS. Effect of in-situ recycling of sugarcane crop residue and its industrial wastes on yield and quality of sugarcane and soil sustainability in Inceptisol. Int J Chem Stud. 2020;8(4):3177-82.
15. Gorsuch TT. The destruction of organic matter. International series of monographs in analytical chemistry. Vol. 39. New York: Pergamon Press; 1970.
16. Goyal S, Dhull SK, Kapoor KK. Chemical and biological changes during composting of different organic wastes and assessment of compost maturity. Bioresour Technol. 2005;96(14):1584-91.
17. Gupta PK, Sahai S. Residue open burning in rice wheat cropping systems in India: an agenda for conservation of environment and agricultural resources. In: Conservation agriculture. 2005;50.
18. Gupta S, Verma R. Role of cow dung slurry in enhancing decomposition rates of agricultural residues. Soil Biol Biochem. 2018;50(1):112-9.
19. Haggar EL, Mahmoud SE, Nakhla DA. Chemical and microbiological evaluation of compost from sugarcane wastes. Middle East J Appl Sci. 2015;5(4):879-92.
20. Harman G, Bjorkman T. Potential and existing uses of *Trichoderma* and *Gliocladium*. In: Enzymes, biological control and commercial applications. 1998;2:229-43.
21. Harman GE, Lumsden RD. Biological disease control. The rhizosphere. 1990. p.259-80.
22. Harman GE. Myths and dogmas of biocontrol changes in perceptions derived from research on *Trichoderma harzinum* T-22. Plant Dis. 2000;84(4):377-93.
23. Hati KM, Somasundaram J, Chaudhary RS. Determination of soil moisture retention field capacity and permanent wilting point. In: Soil analysis. Ch. 3.3. Indian Soc Soil Sci. 2021. p.277-9.
24. Jackson M. Soil chemical analysis. New Delhi: Prentice Hall (India) Pvt. Ltd.; 1973.
25. Jagadabhi PS, Wani SP, Kaushal M, Patil M, Vemula AK, Rathore A. Physico-chemical, microbial and phytotoxicity evaluation of composts from sorghum, finger millet and soybean straws. Int J Recycl Org Waste Agric. 2018;8:279-93.
26. Jagdish. Making compost with cow dung – a full guide. Agri Farming. 2020. https://www.agrifarming.in/making-compost-with-cow-dung-a-full-guide.
27. Laharia GS, Navale VD, Rathod PH, Jadhao SD, Aage AB. Changes in biochemical properties during decomposition of various crop residues. Int J Chem Stud. 2019;7(5):3383-6.
28. Lal MM. An overview to agricultural waste burning. Indian J Air Pollut Control. 2008;8(1):48-50.
29. Lindsay WL, Norvell W. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci Soc Am J. 1978;42(3):421-8.
30. Mohan P, Ponnusamy D. Addressing the challenges of sugarcane trash decomposition through effective microbes. In: Proc Int Conf Food Eng Biotechnol. 2011;9:229-33.
31. Ousley MA, Lynch JM, Whipps JM. Potential of *Trichoderma* spp. as consistent plant growth stimulators. Biol Fertil Soils. 1994;17:85-91.
32. Pan I, Sen SK. Microbial and physico-chemical analysis of composting process of wheat straw. Indian J Biotechnol. 2013;12:120-8.
33. Patil VS. Studies on use of wheat straw, PMC and FYM on preparation of vermicompost with *Eisenia foetida* and its effect on yield and nutrient uptake of wheat [MSc thesis]. Rahuri: MPKV; 1994.
34. Richards LA, editor. Diagnosis and improvement of saline and alkali soils. Washington, DC: US Government Printing Office; 1954. (No. 60).
35. Robertson FA, Thorburn PJ. Trash management: consequences for soil carbon and nitrogen. In: Proc Conf Aust Soc Sugar Cane Technol. Bundaberg, Queensland, Australia. 2000 May 2-5. p.225-9.
36. Shinde TB, Borate VA, Chavan SD, Pol VB. Composting of sugarcane trash by using a microbial consortium. Int J Res Agron. 2024;7(4):641-4.
37. Singh GB, Solomon S. Sugarcane: agro-industrial alternatives. 1995;556.
38. Suma R, Savitha CM. Integrated sugarcane trash management: a novel technology for sustaining soil health and sugarcane yield. Adv Crop Sci Technol. 2015;3:1.
39. Vogtmann H, Fricke K, Turk T. Quality, physical characteristics, nutrient content, heavy metals and organic chemicals in biogenic waste compost. Compost Sci Util. 1993;1(4):69-87.
40. Zhengyu J, Liyun Z, Yuanwang L, Xiaqing L, Zhaojun L. Evaluation of composting parameters, technologies and maturity indexes for aerobic manure composting: a meta-analysis. Sci Total Environ. 2023;886:164-78.