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Influence of *in situ* Sugarcane Trash Burning on Physico-chemical and Biological Properties of Soil

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ABSTRACT

The present investigation was undertaken to characterize sugarcane trash and its ash generated after *in situ* trash burning and changes in soil properties as influenced by *in situ* trash burning. The sugarcane trash and its ash samples were collected from 15 selected sites of recently harvested sugarcane plots (var. CoM 0265 at village Padegaon, Dist. Satara, Maharashtra, India. The samples quantified and analyzed for nutrient composition. Similarly, pre and post burning of sugarcane trash soil samples were also collected and analyzed in laboratory for soil physico-chemical and biological properties. The percentage of ash received from sugarcane trash after burning was ranged from 7.30 to 10.8 per cent. The sugarcane trash composed of mean value of total carbon 41.66 per cent, total N 0.51 per cent, total P 0.34 per cent, total K 0.85 per cent and total S 0.16 per cent, while the total micronutrient contents were Fe 8.68 mg kg^{-1}, Mn 1.47 mg kg^{-1}, Zn 1.32 mg kg^{-1} and Cu 32 mg kg^{-1}. However, the sugarcane trash ash resulted in complete loss of TOC and total N, while total P up to 71 per cent, total K up to 79 per cent, total S up to 80 per cent, total Fe up to 21 per cent, Zn up to 93 per cent, Mn up to 41 per cent and Cu up to 11 per cent was observed. The soil temperature at surface and at 5 cm depth were significantly increased almost 2.5 times (59.78^{o}C) and by 2.4 times (42.92^{o}C) while, the soil moisture at 5 cm soil depth significantly reduced from 26.89 per cent to 19.95 per cent due to *in situ* trash burning. There was no significant effect of *in situ* sugarcane trash burning on soil physical properties *viz.,* soil bulk density and soil porosity at 0 to 10 cm soil depth. The soil chemical properties as influenced by *in situ* sugarcane trash burning showed non significant effect on soil pH, EC, TOC, $CaCO_3$, available P, available K and available micronutrients however, the available nitrogen was reduced significantly due to *in situ* sugarcane trash burning. The practice of sugarcane trash burning in Maharashtra state causes monitory loss of nutrients estimated about Rs. 990.67cr yr^{-1}.

Keywords: Sugarcane, *in situ* sugarcane trash burning, physico-chemical properties, monitory

INTRODUCTION

Sugarcane industry in Maharashtra is the second largest agro based industry next to cotton in which the higher improvement is made and brought about desirable changes in social, economical, educational and political sectors in the rural areas. This development in sugar industry might be due to developments in production technology and introduction of high yielding varieties. This leads to increase in substantial quantities of sugarcane trash and stubbles including root mass production. Currently, sugarcane growers are facing problems such as decline in productivity, soil health deterioration, improper management of farm crop residues, increasing cost of production particularly due to increasing cost of inputs *viz.,* organic manures, chemical fertilizers, labour charges, intercultivation

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etc. and fluctuating sugarcane prices. Sugarcane after harvest leaves behind 8 to 13 t ha^{-1} of sugarcane trash, 4 to 5 t ha^{-1} of stubbles and adequate amount of root mass. (Phalke et al. 2014, 2015).

Sugarcane being a C_4 grass is capable of producing large quantities of biomass. Out of total biomass, about 75- 80 per cent is cane stalk which is source to sugar, power, alcohol and other allied products. The remaining biomass (about 25 per cent) is left out in the field after green cane harvest. The biomass comprising tops, dried and green leaves is called as trash. Sugarcane crop is harvested for milliable cane, while tops are fed to the cattle and trash remains in the field which is burnt. The plant nutrients contained in cane trash are lost because of trash burning. After harvest of cane crop, the quantity of trash left over in the field is from 10 per cent to 13 per cent of the weight of cane produced. India being the world's second largest producer of sugarcane has 30-36 million tones of trash left over in the fields. In jaggery areas, trash supplements bagasse as fuel for manufacturing of jaggery but in white sugar factory zones trash is generally burnt in the fields. Burning of sugarcane trash before and after harvesting is a common practice followed by almost all the cane growers.

As sugarcane trash is a real potential source of organic matter in sugarcane cultivation and still it is not used properly. Trash is usually burnt results in potential loss of useful organic matter and plant nutrients. In Maharashtra alone, more than 105 lakh tons of sugarcane trash is produced and excluding some portion for conventional use, rest of the part of sugarcane trash burnt every year. As the compost making from sugarcane trash has not become yet popular, because it decomposes at a very slow rate due to wider C:N ratio and it is not economically viable as it requires land, labors and time for handling. There are different schools of thoughts in trash burning. In some cases trash is burnt to hurry up the ratoon operations, to clear fields for next crop, to destroy weeds and to overcome problems like snakes and rats. Trash burning ensures partial sterilization of soil and breaking the chain of carryover of insect, pests and diseases. Burning also kills the upper buds of the stubble and allows sprouting the deeper ones. After harvest of sugarcane, farmers used to burn trash, sometimes it is utilized by people for covering huts and house roofs for shelter in rural areas and recently it is utilized as a fuel for jaggery and other allied industries situated in adjoining sugarcane areas and for cogeneration in power plants (Natrajan, 2009).

Burning of sugarcane trash, as a huge quantity of organic matter and nutrients results in potential loss of 40 to 50 kg N, 20 to 30 kg P_2O_5 and 3 to 4 t of organic carbon per ha, while only 75 to 100 kg K_2O and mineral elements are left behind in the form of ash (Phalke et al. 2014, 2015). Burning of sugarcane trash leads to the loss of 0.84 Mt nutrients yr^{-1} (Meena et al. 2015). Under the climate where sugarcane is grown in the country, soil needs large application of organic matter. Organic matter contents in a soil primarily determines its sustainability for harvesting optimum yields over a long time. Currently the cane trash in most of the developing countries where green cane harvesting is prescribed as burnt, polluting the atmosphere. Under the present conditions, trash, a residue of cane from the field is considered as liability. Organic manures act as slow release fertilizers and release only a portion of nutrients contained in them during a growing season. The use of organic materials will reduce the dependence on commercial fertilizers to an appreciable extent. Sugarcane trash is important renewable organic resource, scattered all over the country and this is available to every farmer at his door step. Every year about 30-36 million tones of sugarcane trash is produced.

As far as soil health is concerned the biological health, physical health and chemical health is to be maintained. The addition of adequate quantity of organic matter is highly essential for maintaining soil fertility. Sugarcane trash is an important component of soil fertility management. The sugarcane trash can be converted to high value manure of quality better than FYM. Its use along with chemical fertilizers not only sustains present level of crop yields but also increase it. The recycling of crop residues is essential for supplementing plant nutrients and returning at least a part of the nutrients drawn from the mother earth. In sugarcane *in situ* recycling of sugarcane trash in relation to soil fertility can be carried out in different ways such as *in situ* mulching in ratoon and plant cane and *in situ* incorporation after harvest of ratoon cane. An investigation was undertaken to assess the changes in soil properties as influenced by *in situ* sugarcane trash burning.

MATERIALS AND METHOD

The experimental field survey was conducted during December, 2021 to February, 2022 in village Padegoan, Tal. Phaltan, Dist. Satara, Maharashtra in the periphery of Meteorological observatory of the Central Sugarcane Research Station, Padegaon, Dist. Satara (Maharashtra). Geographically, it is located at 180012' (N) latitude and 74014' (E) longitude and at an elevation of 556 m above MSL. The total 30 representative air samples were collected from selected sites during the period of 23 to 25 February, 2022.

The soil samples of the selected experimental sites were medium deep Inceptisol (Vertic Haplustert). The soil was a black in colour. Representative soil samples were collected from 15 selected sites with the depth from 0 to 5 cm and 0 to 10 cm before and after burning of *in situ* sugarcane trash for assessment of physico-chemical and biological properties during the period of 23 to 25 February, 2022. These collected composite and representative soil samples were analyzed for physical, chemical and biological properties before and after *in situ* burning of sugarcane trash.

Soil Sampling and Analysis

At pre and post sugarcane trash burning, the representative surface soil samples from the study sites were collected at 0-10 cm depth from each location. The obtained soil samples were air dried in the shade, thoroughly mixed sieved through a 2 mm mesh, used for analysis of physical, chemical and biological properties and before being analyzed for soil chemical properties using standard analytical techniques.

The representative soil sample was also analyzed for pH, EC, ESP and SAR (Jackson, 1973), organic carbon (Nelson and Sommer, 1982), calcium carbonate (Allison and Moodie, 1965). The available nitrogen was analyzed by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus as per method Watanabe and Olsen (1965) and available potassium determined by flame photometrically as described by Jackson (1973). The exchangeable calcium and magnesium determined as per the method described by Black (1965) and sodium by Jackson (1973). The DTPA extractable micronutrients (Fe, Mn, Zn and Cu) were analyzed as per the standard method given by Lindsay and Norvell (1978). Physical properties were assessed at 0 to 5 cm and 0 to 10 cm layer of soil. Soil temperature is measured by Thermocouple method as described by Taylor and Jackson (1986). Soil moisture is measured gravimetrically as per the method described by Prihar and Sandhu (1979). Bulk density is determined by Clod coating method described by Blake and Hartage (1986). Biological properties *viz.*, bacterial count, actinomycetes count and fungi count were assessed at 0 to 5 cm layer of soil by using Serial dilution plating technique (Halvorsun and Zeiglar 1933).

The soil data recorded in an investigation was statistically analyzed by using standard methods described as by Panse and Sukhatm, 1985.

RESULTS AND DISCUSSION

The present investigation was undertaken from December, 2021 to February, 2022 on 15 locations of farmers fields at village Padegaon, Tal. Phaltan, Dist. Satara, Maharashtra to study the influence of *in situ* sugarcane trash burning on soil properties.

Influence of in situ Burning of Sugarcane Trash on Soil Physical Properties

The data pertaining to changes in soil physical properties *viz.*, soil temperature, soil moisture, bulk density and soil porosity as influenced by *in situ* sugarcane trash burning are presented in Table 1.

Table 1 : Effect of *in situ* sugarcane trash burning on soil physical properties

Location	Soil temp. at surface (^oC)		Soil temp. at 0 to 5 cm soil depth (^oC)		Soil moisture at 0 to 5 cm soil depth (%)		Bulk Density at 0 to 10 cm soil depth ($Mg\ m^{-3}$)		Soil porosity at 0 to 10 cm soil depth (%)	
	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning
L_1	22.75	59.95	19.05	40.2	31.17	11.19	1.05	1.05	60.38	60.38
L_2	22.85	57.5	19.9	41.63	27.41	19.17	1.04	1.04	60.75	60.75
L_3	23.2	57.26	19.7	42.9	25.8	15.47	1.04	1.05	60.75	60.38
L_4	22.8	59.7	19.1	42.3	24.53	13.32	1.06	1.06	60.00	60.00
L_5	23.23	62.06	18.6	43.4	23.82	11.72	1.07	1.08	59.62	59.25
L_6	22.9	54.8	19.8	40.6	26.39	12.41	1.06	1.07	60.00	59.62
L_7	25.26	60.6	20.9	40.36	24.67	12.17	1.07	1.07	59.62	59.62
L_8	23.31	61. 63	18.72	43.7	25.49	13.39	1.06	1.06	60.00	60.00
L_9	23.14	62.12	18.55	44.26	23.48	13.16	1.07	1.07	59.62	59.62
L_{10}	23.67	59.58	19.43	43.62	27.16	12.28	1.06	1.06	60.00	60.00
L_{11}	24.22	61.02	20.18	42.74	28.12	14.16	1.06	1.07	60.00	59.62
L_{12}	23.7	60.34	18.8	44.22	31.28	13.63	1.06	1.06	60.00	60.00
L_{13}	23.47	60.33	17.92	45.41	23.82	11.42	1.05	1.07	60.38	59.62
L_{14}	24.4	59.57	18.45	43.77	32.16	13.62	1.04	1.06	60.75	60.00
L_{15}	23.9	60.17	[illegible]	44.64	28.06	11.09	1.04	1.06	60.75	60.00
Mean	**23.52**	**59.78**	**19.17**	**42.9 2**	**26.89**	**13.21**	**1.06**	**1.06**	**60.18**	**59.92**
SE (±)	0.18	0.50	0.21	0.41	0.73	0.53	0.00	0.00	0.11	0.10
Max	25.26	62.12	20.90	45.41	32.16	19.17	1.07	1.08	60.75	60.75
Min	22.75	54.80	17.92	40.20	23.48	11.09	1.04	1.04	59.62	59.25
Range	2.51	7.32	2.98	5.21	8.68	8.08	0.03	0.04	1.13	1.51
SEm (±)	0.38		0.33		0.64		0.00		1.90	
CD at 5%	1.10		0.95		1.85		NS		NS	

Before and after *in situ* sugarcane trash burning the soil temperature at surface and 5 cm depth was recorded from various locations. The soil temperature at surface was significantly increased due to *in situ* trash burning. There was almost 2.5 times increase in soil temperature after *in situ* burning of sugarcane trash (59.78°C) over pre burning of trash (23.52°C). The minimum increase in soil surface temperature after burning was 54.80°C over 22.75°C at pre burning of trash, while there was maximum increase up to 62.12°C due to *in situ* sugarcane trash burning over before burning of trash (25.26°C). When soil temperature at 5 cm depth was measured, there was 2.24 fold significant increase due to *in situ* trash burning (42.92°C) over pre burning (19.17°C) of sugarcane trash. There was rise in soil temperature at 5 cm depth ranged from 40.20 to maximum rise up to 45.41°C, from minimum 17.92°C to 20.90°C, respectively. This increase in soil temperature at soil surface and at 5 cm soil depth are alarming as far as soil properties are concerned. The observations on soil moisture clearly indicated that there was significant reduction in soil moisture from 26.89 per cent to 13.21 per cent due to *in situ* burning of trash. The minimum soil moisture was registered 11.09 due to burning of trash which was 23.48 per cent before *in situ* burning of trash. These post burning observations were immediately recorded after complete burning of *in situ* sugarcane trash.

Study reported that the soil surface exposed to the temperature of more than 100°C for the period of more than 5 minutes which drastically reduced soil moisture and increased soil temperature at 0 to 5 cm soil depth. As the calorific value of sugarcane trash found highest among all agricultural crop residues (Awulu, 2023).

As far as the bulk density and soil porosity were concerned, the changes were not significant. These results are also in accordance with the findings reported by Letey (2001) who observed that high surface temperatures 'burn' off organic materials create vapours that move downward in response to a temperature gradient and then condense on soil particles causing them to become water repellent.

The burning of crop residue declines the organic matter content of the soil which in turn broken down soil aggregates, destroyed soil structure, increased soil temperature coupled with rapid loss of moisture, soil get exposed to harmful solar radiations and becomes sensitive to wind and water erosion reported by Turmel, 2014. Hesammi et al. (2014) also reported that the heat generated from burning of crop residues rises soil temperature to 33.8 to 42.2°C from 1 cm soil depth leads to kill bacterial and fungal population. Wheat straw burning can kill about 50 per cent of bacterial population in up to 2.5 cm of soil depth also considerable reduction in amount and activity of soil enzymes involved in nutrient cycling.

The burning of crop residue greatly affects soil health and due to slow and steady reduction in soil health that eventually results in reduced productivity that cannot be overcome with increased additions of mineral fertilizers. Further, reduced soil organic matter, poor aggregation, reduced water holding capacity, damage to soil bio-diversity, susceptibility to erosion are some of the many adversities arising due to the burning of crop residue documented by Yadav et al. (2020).

Influence of in situ Burning of Sugarcane Trash on Soil Chemical Properties

The soil chemical properties *viz.*, pH, electrical conductivity (EC), total organic carbon (TOC), CaCO3, available nitrogen, available phosphorous, available potassium and DTPA extractable micronutrients as influenced by *in situ* burning of sugarcane trash were assessed from experimental soils at 0 to 10 cm soil depth and presented in Table 2.

Table 2 : Effect of *in situ* sugarcane trash burning on soil chemical properties (at 0 to 10 cm soil depth)

Location	pH		EC (dSm^{-1})		TOC (%)		$CaCO_3$ (%)		Available N ($kg\ ha^{-1}$)		Available P ($kg\ ha^{-1}$)		Available K ($kg\ ha^{-1}$)	
	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning
L_1	8.83	8.70	0.38	0.31	0.64	0.57	13.25	13.50	112.89	100.35	10.75	9.63	522.59	484.84
L_2	8.70	8.61	0.39	0.29	0.73	0.67	18.25	18.25	112.89	98.44	12.99	12.32	552.83	535.92
L_3	8.82	8.82	0.32	0.27	0.82	0.49	15.5	13.50	137.98	112.89	13.44	12.99	578.81	546.78
L_4	8.10	8.12	0.51	0.28	0.94	0.87	13.75	12.50	150.52	112.89	21.95	21.05	538.94	513.07
L_5	8.02	8.10	0.45	0.55	0.88	0.90	9.25	10.75	137.98	125.44	14.33	13.66	494.14	463.9
L_6	8.52	8.49	0.34	0.58	0.84	0.75	13.25	12.00	137.98	100.35	15.45	15.00	499.74	490.67
L_7	8.58	8.63	0.62	0.32	0.55	0.68	10.25	9.75	137.98	125.44	18.14	15.23	505.12	495.26
L_8	8.61	8.61	0.28	0.41	0.3	0.51	12.75	11.50	125.44	106.68	16.12	15.23	557.2	539.84
L_9	8.32	8.34	0.36	0.32	0.79	0.67	13.75	12.25	112.89	102.89	16.8	12.88	580.38	555.85
L_{10}	8.58	8.56	0.28	0.26	0.82	0.79	14.00	11.75	125.44	112.89	13.88	11.28	534.35	505.12
L_{11}	8.21	8.28	0.33	0.28	0.68	0.67	13.5	11.50	112.89	100.35	12.32	11.42	519.45	513.74
L_{12}	8.10	8.41	0.36	0.33	0.72	0.69	12.75	12.75	137.98	125.44	16.12	15.90	527.74	510.94
L_{13}	8.33	8.17	0.29	0.27	0.81	0.79	13.25	13.00	137.98	108.25	15.9	14.78	456.4	435.45
L_{14}	8.38	8.24	0.31	0.31	0.84	0.81	13.5	12.50	125.44	112.89	15.68	15.00	480.48	438.14
L_{15}	8.32	8.38	0.34	0.37	0.78	0.73	13.25	11.75	150.52	112.89	17.47	16.12	528.97	491.68
Mean	**8.43**	**8.43**	**0.37**	**0.34**	**0.74**	**0.71**	**13.35**	**12.48**	**130.45**	**110.54**	**15.42**	**14.17**	**525.14**	**501.41**
SE (±)	0.07	0.06	0.02	0.03	0.04	0.03	0.52	0.49	3.42	2.42	0.70	0.69	8.94	9.35
Max	8.83	8.82	0.62	0.58	0.94	0.90	18.25	18.25	150.52	125.44	21.95	21.05	580.38	555.85
Min	8.02	8.10	0.28	0.26	0.30	0.50	9.25	9.75	112.89	98.44	10.75	9.63	456.40	435.45
Range	0.81	0.72	0.34	0.32	0.64	0.41	9.00	8.50	37.63	27.00	11.20	11.42	123.98	120.40
SEm (±)	0.06		0.02		0.04		0.50		2.96		0.70		9.15	
CD at 5%	NS		NS		NS		NS		8.58		NS		NS	

There was no significant effect on soil pH due to burning of sugarcane trash. Soil pH was remained 8.43 after burning of sugarcane trash. The non significant change in soil pH might be due to very short period of collection of soil samples after burning of trash. As the soil samples were collected immediately after completion of *in situ* trash burning i.e. within 15 minutes. That might have not given sufficient time for any reaction in soil due to burning of *in situ* sugarcane trash. The electrical conductivity of soil was slightly decreased from 0.37 dSm^{-1} to 0.34 dSm^{-1}. However, this decrease was found to be non significant. The results obtained from present investigation were corroborated with the findings of Dengia and Lantinga, 2018. The data on Total Soil Organic Carbon (TOC) as influenced by *in situ* burning of sugarcane trash showed non significant due to *in situ* burning of sugarcane trash but there was numerical decrease in TOC concentration from 0.74 to 0.71 per cent at 0 to 10 cm soil depth. Similar results were reported by Chan and Heena, 2006 who stated that the burning of crop residues decreased organic matter content rises soil pH and alkalinity and reduces level of N, C and cation exchange capacity in the top 0 to15 cm soil profile. The observed temperature causing the death of bacterial and fungal populations. Repeated burning in the field, however, permanently diminishes the microbial population. Long-term burning reduces total N and C and potentially mineralizable N in the 0-15 cm soil layer (Meena et al. 2015). Further Hemwong et al. 2009 who reported that trash burning resulted in loss of organic carbon, plant nutrients and soil biota. The results of calcium carbonate ($CaCO_3$) as influenced by *in situ* burning of sugarcane trash showed that the $CaCO_3$ was slightly decreased due to *in situ* burning of sugarcane trash. The decrease in $CaCO_3$ was from 13.35 to 12.48 per cent. This decrease in $CaCO_3$ content was found to be non significant. The data pertaining to soil available nitrogen as influenced by *in situ* burning of sugarcane trash showed that there was significantly decreased due to *in situ* burning of sugarcane trash. The available N content was decreased from 130.45 to 110.54 kg ha^{-1}. The present results obtained are in close agreement with reports of Hemwong et al. 2009 and Meena, et. al. 2015 who reported that trash burning resulted in loss of organic carbon, plant nutrients such as N, S and soil biota. The results of soil available phosphorus as influenced by *in situ* burning of sugarcane trash showed that there was decrease in available phosphorus from 15.42 to 14.71 Kg ha^{-1} which was found to be non significant.

The data pertaining to soil available potassium as influenced by *in situ* burning of sugarcane trash revealed that the *in situ* burning of sugarcane trash affected available potassium in soil and found to be non significant. There was numerical decrease in available potassium from 525.14 to 501.41 Kg ha^{-1}.

The data regarding effect of *in situ* sugarcane burning of sugarcane trash on soil available micronutrients from experimental soils at 0 to 10 cm soil depth are presented in Table 3. Soil available micronutrients *viz.*, Fe, Mn, Zn and Cu were estimated before and after *in situ* burning of trash. The Fe content was decreased from 1.62 to 1.49 mg kg^{-1}, Mn from 1.60 to 1.53 mg kg^{-1}, Zn from 3.63 to 3.20 mg kg^{-1} and Cu from 4.78 to 4.65 mg kg^{-1}. The available micronutrients were numerically decreased, however the difference was found to be non significant. The non significant decrease in nutrient status observed might be due to collection of soil samples immediately after *in situ* sugarcane trash burning which might have not given sufficient time for different soil reactions. Similar results are reported by Azmal et al. (1997).

Table 3 : Effect of *in situ* sugarcane trash burning on soil micro nutrients (at 0 to 10 cm soil depth)

Location	DTPA extract micro nutrients (mg kg^{-1})							
	Fe		Mn		Zn		Cu	
	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning	Pre burning	Post burning
L_1	1.61	1.55	1.84	1.59	3.42	1.94	5.34	5.26
L_2	1.18	1.09	1.06	0.91	4.34	3.18	6.12	6.1
L_3	1.28	1.24	1.48	1.46	3.02	2.76	5.66	5.49
L_4	1.58	1.48	1.86	1.64	4.02	2.32	5.24	5.04
L_5	2.03	1.86	1.28	1.16	4.22	3.42	6.1	5.8
L_6	1.61	1.16	1.51	1.49	4.1	3.98	5.38	5.21
L_7	1.93	1.86	1.58	1.53	4.28	4.22	5.8	5.64
L_8	1.8	1.58	1.64	1.59	4.82	4.28	5.56	5.28
L_9	1.66	1.46	1.8	1.78	2.28	2.26	3.96	3.79
L_{10}	1.38	1.32	1.56	1.56	3.64	3.62	4.12	4.08
L_{11}	1.69	1.58	1.68	1.61	2.96	2.88	3.16	3.14
L_{12}	1.73	1.66	1.84	1.82	3.08	3.06	4.24	4.22
L_{13}	1.61	1.54	1.68	1.66	4.16	4.06	2.78	2.68
L_{14}	1.53	1.38	1.56	1.51	2.88	2.82	3.72	3.68
L_{15}	1.63	1.52	1.64	1.62	3.28	3.16	4.46	4.28
Mean	**1.62**	**1.49**	**1.60**	**1.53**	**3.63**	**3.20**	**4.78**	**4.65**
	0.06	0.06	0.06	0.06	0.18	0.19	0.28	0.27
Max	2.03	1.86	1.86	1.82	4.82	4.28	6.12	6.10
Min	1.18	1.09	1.06	0.91	2.28	1.94	2.78	2.68
Range	0.85	0.77	0.80	0.91	2.54	2.34	3.34	3.42
SEm (±)	0.06		0.06		0.19		0.27	
CD at 5%	NS		NS		NS		NS	

Influence of in situ Sugarcane Trash Burning on Soil Microbial Population

The data regarding effect of *in situ* sugarcane burning of sugarcane trash on soil microbial population such as bacteria, fungi and actinomycetes are presented in Table 4. Soil microbial populations such as *viz.*, bacteria, fungi and actinomycetes have been analyzed from pre and post *in situ* sugarcane trash burning soils from 0 to 5 cm soil depth. However, there were significant variation in population of soil bacteria, actinomycetes and fungi due to *in situ* trash burning. The *in situ* burning of trash severally affected bacteria, fungi and actinomycetes in soil. The mean bacterial population was reduced up to 27.70 × 105 cfu g^{-1} soil from 50.06 × 105 cfu g^{-1}. It indicated that the bacterial population was decreased immediately after *in situ* trash burning. The same case was registered in case of fungal population which was reduced to 12.27 from 30.53. The count was reduced to the tune of 50 per cent due to burning of trash. The actinomycetes count was also drastically reduced from 23.66 to 9.21. The drastic decrease in these microflora count due to *in situ* burning of trash showed alarming situation. These reduction, in general deteriorate soil biological health which afterward deteriorates soil physical and chemical health. The crop residues burning destroyed soil organic matter which directly increase soil temperature coupled with moisture loss leads to kill microbial population of fungi, bacteria and actinomycetes. The present result obtained are in close agreement with reports of Azmal et al. (1997), Palese et al. (2004), Okonkwo (2010) and Meena et al. (2014).

Estimated Monitory Loss (Rs. cr. yr^{-1}) due to in situ Burning of Sugarcane Trash in Maharashtra State

The data pertaining to estimated monitory loss (Rs. cr. yr^{-1}) due to burning of sugarcane trash are presented in Table 5.

As per the report published by Commissioner of Sugar, Maharashtra State, during crushing season of 2022-23, total 1052.88 lakh t sugarcane was crushed in Maharashtra State. Out of this cane crushed, considering 10 per cent of sugarcane trash production after sugarcane harvest and looking to the composition of sugarcane trash. It was observed that, it contained better amount of total N, P, K, S and micronutrients *viz.*, Fe, Mn, Zn and Cu. Considering this composition, the price of each of these nutrients in Rs. t^{-1} trash was computed. When total monitory loss due to burning of sugarcane trash in Maharashtra state was estimated by considering annual sugarcane trash production 105 lakh t yr^{-1}. It was observed that there was Rs. 62.5 cr. loss in respect of N, Rs. 246.96 cr. in respect of P, Rs. 507.76 cr. in respect of K, Rs. 171.5 cr. in respect of S, Rs. 1.08 cr. in respect of Fe, Rs. 0.34 cr. in respect of Mn, Rs. 0.293 cr. in respect of total Zn and Rs. 0.223 cr. in respect of Cu was registered. The total monitory loss of Rs. 990.67 cr. yr^{-1} was noticed due to burning of trash in Maharashtra State. This loss is not only economical loss where in the loss to the soil health viz., biological, physical and chemical health. This loss is alarming fact to be noticed. The data on nutrient losses due to *in situ* burning of sugarcane trash and the nutrient content in sugarcane trash, this is a matter of serious thought that easily available nutrients from sugarcane trash is burnt by the farmers which causes great economical loss of the country. The practice of application of additional chemical fertilizers when adequate of amount of organic matter is not available is a wrong approach. If this trash is burnt, there is significant loss of carbon which otherwise might have added in soil, if trash management would have done. The loss of C due to burning is a matter of concern because there are least options to add organic carbon from other sources. The carbon cannot be supplemented through any chemical fertilizers.

Table 4 : Effect of *in situ* Sugarcane Trash Burning on Soil Microbial Population (at 0 to 5 cm Soil Depth)

Location	Bacteria (x 10^5 cfu g^{-1} soil)		Fungi (x 10^4 cfu g^{-1} soil)		Actinomycetes (x 10^4 cfu g^{-1} soil)	
	Pre burning	**Post burning**	**Pre burning**	**Post burning**	**Pre burning**	**Post burning**
L_1	52.11	28.43	32.42	12.32	25.13	10.3
L_2	48.15	26.53	30.13	12.96	24.32	9.8
L_3	45.23	25.56	29.72	11.80	23.63	9.12
L_4	47.62	25.84	28.64	11.32	23.72	9.32
L_5	49.31	27.38	30.68	12.56	23.12	8.48
L_6	51.78	29.17	31.12	12.38	22.47	8.97
L_7	56.42	29.93	32.43	13.98	24.38	9.17
L_8	53.83	27.67	30.72	12.28	23.42	9.84
L_9	52.76	29.73	33.17	12.98	22.92	10.11
L_{10}	49.32	28.92	29.65	11.76	24.43	8.92
L_{11}	51.21	28.23	32.43	12.23	23.27	9.63
L_{12}	48.89	26.81	30.92	12.45	24.11	8.23
L_{13}	46.17	25.13	28.31	11.27	23.87	8.11
L_{14}	50.67	28.97	29.93	12.31	22.39	9.67
L_{15}	47.42	27.18	27.63	11.43	23.78	8.54
Mean	**50.06**	**27.70**	**30.53**	**12.27**	**23.66**	**9.21**
SE (±)	0.78	0.39	0.42	0.18	0.20	0.18
Max	56.42	29.93	33.17	13.98	25.13	10.30
Min	45.23	25.13	27.63	11.27	22.39	8.11
Range	11.19	4.80	5.54	2.71	2.74	2.19
SEm (±)	0.62		0.32		0.19	
CD at 5%	1.79		0.94		0.54	

Table 5 : Estimated Monetary Loss due to (Rs. in Cr. Yr^{-1}) Burning of Sugarcane Trash in Maharashtra State

Location	Total N	Total P	Total K	Total S	Total Fe	Total Mn	Total Zn	Total Cu	Grand total (Rs. in 000)	Monitory loss (Rs. in cr. yr^{-1})
L_1	680316	2058000	5117301	1806000	9699	3663	3341	3469	9681790	968
L_2	680035	2131500	5057798	1764000	10824	3920	2985	1882	9652943	965
L_3	680035	2205000	5533826	1827000	21761	3733	3653	2999	10278006	1028
L_4	704322	2352000	4998294	1774500	8799	3477	2940	2117	9846449	985
L_5	680035	2352000	4938791	1669500	11087	2753	2985	3116	9660266	966
L_6	510026	2352000	4938791	1648500	24486	4037	3096	1999	9482934	948
L_7	680035	2499000	5295812	1617000	18761	2940	3564	2234	10119346	1012
L_8	643604	2572500	4938791	1585500	9137	2963	2784	4057	9759336	976
L_9	680035	2572500	4938791	1680000	8937	3127	2717	1940	9888047	989
L_{10}	510026	2572500	5117301	1890000	7562	3640	2495	1764	10105288	1011
L_{11}	510026	2646000	5117301	1701000	11162	3010	2450	1646	9992595	999
L_{12}	582887	2793000	4819784	1669500	6762	3570	2294	1352	9879149	988
L_{13}	643604	2646000	5057798	1659000	2512	3383	1982	1646	10015926	1002
L_{14}	510026	2499000	5117301	1680000	6275	3547	3363	1529	9821040	982
L_{15}	680035	2793000	5176805	1753500	4887	3523	3296	1705	10416751	1042
Total	9375046	37044000	76164480	25725000	162652	51286	43944	33457	148599866	14860
Average	625003	2469600	5077632	1715000	10843	3419	2930	2230	9906658	991
Rs in cr.	62.5	246.96	507.76	171.5	1.084	0.342	0.293	0.223	990.67	

Note: About 105 lakh t yr^{-1} sugarcane trash production in Maharashtra during year 2022-23.

CONCLUSION

The *in situ* sugarcane trash burning adversely affected soil microflora viz., bacteria, fungi and actinomycetes from 5 cm soil depth, significantly increased soil temperature with significant reduction in soil moisture as well as soil available nitrogen. The practice of sugarcane trash burning in Maharashtra state registered monitory loss of nutrients estimated about Rs. 990.67 cr. yr^{-1}.

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