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Effect of cogenerated bagasse ash on microbial population and enzyme activities in sugarcane grown soil

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ABSTRACT

A field experiment was conducted during 2016-18 on an Inceptisol of Rahuri, Maharashtra to study the effect of cogenerated bagasse ash on microbial population and enzyme activities in preseasonal sugarcane (Sachharum officinarum) var. CoM 0265. The results indicated that the treatments which received 150 % RDK through cogenerated bagasse ash recorded the higher total bacteria (44.11, 45.89 and 32.78 cfu x 10^6 g^{-1} soil), fungi (17.78, 18.89 and 15.89 cfu x 10^5 g^{-1} soil) and actinomycetes (18.33, 19.22 and 15.78 cfu x 10^5 g^{-1} soil) count at earthing up, grand growth and harvest stage of preseasonal sugarcane, respectively. On the other hand, the highest dehydrogenase (13.38, 14.03 and 7.92 µg TPFg^{-1} soil h^{-1}), urease (49.35, 51.68 and 38.15 µg NH_4-N g^{-1} soil h^{-1}), acid phosphatase (17.92, 18.85 and 13.23 µg PNP g^{-1} soil h^{-1}) and alkaline phosphatase (64.81, 65.94 and 39.07 µg PNP g^{-1} soil h^{-1}) enzyme activity in soil were also recorded in T9 (150 % RDK through cogenerated bagasse ash) at earthing up, grand growth and harvest stage of preseasonal sugarcane, respectively. The results of the present study revealed that the microbial population and enzymatic activities of the soil were increased at initial stages and thereafter, progressively decreased with crop growth stages by the application of cogenerated bagasse ash. Application of 150 % RDK through CBA (6.62 t ha^{-1}) along with recommended dose of nitrogen and phosphorous (340 and 170 kg ha^{-1}) through inorganic fertilizers and 20 t ha^{-1} FYM has improved the microbial population as well as enzymatic activities in sugarcane grown soil.

Key words: Cogenerated bagasse ash, RDK, sugarcane, microbial population, enzyme activity

INTRODUCTION

Bagasse ash is one of the industrial wastes obtained from sugar industries during the process of sugar manufacturing. After crushing and extracting juice from sugarcane, the remaining straw is called bagasse and this bagasse is often used as a primary fuel source for sugarmills. When it burned in bulk quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill. The ash produced after cogeneration is called as “cogenerated bagasse ash” (CBA). After combustion of bagasse the ash obtained could be a signifcant source of inorganic nutrients such as P, K, Mg and Ca (Bougnom and Insam 2009; Bougnom *et al.*, 2009). Its ecofriendly use in agriculture as a source of nutrients for crop production is a good alternative for disposal. Bagasse ash is a good source of micronutrients like, Fe, Mn, Zn and Cu. It can also be used as soil additive due to its capacity to supply the plants with nutrients. Presence of essential elements such as N, P, K, Ca, Mg, S, and micronutrients make it a source of plant nutrients and enhances yield of several crops after application. Bagasse ash in combianation with organic manures increases crop productivity, availability of nutrients and activities of microbes in soil (Das *et al.,* 2013, Gonfa *et al.* 2018). Sugarcane industries contribute a significant amount of byproducts as waste. One ton of sugarcane can generate approximately 26 per cent of bagasse and 0.62 per cent of residual ash. This waste is generated in huge quantities leading to potential disposal problems without effective management techniques. Handling and management of these byproducts are huge task, because those require lot of space for storage. However, it provides opportunity to utilize these by-products in agricultural crop production as nutrient source. Integrated nutrient management (INM), involves the integrated use of mineral fertilizer together with organic manures/industrial agricultural wastes in suitable combination complementing each other to optimize input use and maximize production with reducing cost of production and sustain the same without impairing the crop

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quality and soil health. It enables gainful utilization of wastes or underutilized renewable resources. Micro-organisms play an important role in organic matter stabilization and nutrient cycling in soil. The sustainability of soil health to improve soil quality is based on efficient management of soil microorganisms. Enzymatic activities have been found to be very responsive by the addition of organic materials to soil Selvamurugan *et al*. (2011). The enzymatic activities of a soil catalyzes the biochemical activities performed by bacteria and thereby indicates the potential of the soil to permit the basic biochemical processes necessary for maintaining fertility of soil. Therefore, the present study was undertaken with a view to study the effect of cogenerated bagasse ash on microbial population and enzyme activities in sugarcane grown soil.

MATERIAL AND METHODS

Cogenearated bagasse ash was collected from the dumping sites of Padmashri Dr. Vitthalrao Vikhe Patil Cooperative Sugar Factory Ltd., Pravaranagar, Tal. Rahata, Dist. Ahmednagar (Maharashtra) to use in the present investigation. The cogenerated bagasse ash used in the experiment was strongly alkaline in nature with pH 9.51 and had 105.6 g kg^{-1} organic carbon , total N 0.35%, P_2O_5 1.22 %, K_2O 3.85 %, Ca 0.52 %, Mg 0.55 %, Fe 2400 µg g^{-1}, Mn 303 µg g^{-1}, Zn 116 µg g^{-1} and Cu 67 µg g^{-1}, The field experiment was conducted using sugarcane var. CoM 0265 as a test crop during 2016-18 at Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar, (Maharashtra). The experimental soil was clay in texture; taxonomically the soil belongs to the family *Vertic Haplustepts*. The experiment was laid out in randomized block design with nine treatments and three replications consisting of different levels of recommended dose of potassium through cogenerated bagasse ash. The treatment details were: **T_1 :** Absolute control, **T_{2n} :** GRDF - N:P_2O_5:K_20 (340:170:170 kg ha^{-1}) + FYM 20 t ha^{-1} (K through MOP) **T_3:** 0 % RDK through cogenerated bagasse ash **T_4 :** 25% RDK through cogenerated bagasse ash i.e 1.10 t ha^{-1} **T_5:** 50 % RDK through cogenerated bagasse ash i.e 2.20 t ha^{-1} **T_6:** 75% RDK through cogenerated bagasse ash i.e 3.31 t ha^{-1}, **T_7:** 100 % RDK through cogenerated bagasse ash i.e 4.42 t ha^{-1} **T_8:** 125 % RDK through cogenerated bagasse ash i.e 5.52 t ha^{-1} and **T_9:**150 % RDK through cogenerated bagasse ash i.e 6.62 t ha^{-1} N, P_2O_5 and FYM were applied as per the recommendation which are common for T_3 to T_9. Soil samples were collected at earthing up, grand growth and at harvest stages of sugarcane. The total bacteria, fungi and actinomycetes count were assessed by serial dilution plating technique (Halvorsun and Zeiglar, 1993). The activities of dehydrogenase (Casida *et al*., 1964), urease (Tabatabai and Bremmer, 1972), acid and alkaline phosphatase (Tabatabai and Bremmer, 1969) enzymes were assayed as per the standard procedures.

RESULTS AND DISCUSSION

Effect of Cogenerated Bagasse Ash on Microbial Population in Soil

The microbial population in soil at different growth stages of preseasonal sugarcane was significantly influenced by the application of different levels of RDK through cogenerated bagasse ash (Table 1). In general, irrespective of the treatments, total count of bacteria, fungi and actinomycetes increased at the initial stages and thereafter, progressively decreased with crop growth stages. The depletion of the plant nutrients and degradation of the organic matter might be the reason for the reduction of microbial population. The microbial population in soil at different growth stages of preseasonal sugarcane increased with increased levels of RDK through cogenerated bagasse ash over the control. Significantly higher total bacteria (44.11, 45.89 and 32.78 cfu x 10^6 g^{-1} soil, respectively), fungi (17.78, 18.89 and 15.89 cfu x 10^5 g^{-1} soil, respectively) and actinomycetes count (18.33, 19.22 and 15.78 cfu x 10^5 g^{-1} soil, respectively) at earthing up, grand growth and harvest stage of preseasonal sugarcane were recorded in the treatment 150 % RDK through CBA. Whereas, the total bacteria (43.56, 45.11 and 30.89 cfu x 10^6 g^{-1} soil, respectively) and fungi (16.89, 17.89 and 14.78 cfu x 10^5 g^{-1} soil, respectively) count at earthing up, grand growth and harvest stage of preseasonal sugarcane was on par with the treatment 125 % RDK through CBA. The actinomycetes count at harvest stage of preseasonal sugarcane was on

par with the treatment 125 % RDK through CBA (14.89 cfu x 10^6 g^{-1} soil). The significantly lower total bacteria (29.78, 30.33 and 21.00 cfu x 10^6 g^{-1} soil, respectively), fungi (9.78, 10.22 and 8.11 cfu x 10^5 g^{-1} soil respectively) and actinomycetes count (10.00, 10.67 and 7.67 cfu x 10^5 g^{-1} soil) at earthing up, grand growth and harvest stage of preseasonal sugarcane were recorded in absolute control. The microbial population was enhanced due to easily available carbon as a food material to organisms for their prolification which are already present in CBA. Similar results were also reported by Singh *et al*. (2009) and Selvamurugan *et al*. (2011).

Table 1: Effect of cogenerated bagasse ash on total bacteria, fungi and actinomycetes in soil at different growth stages of preseasonal sugarcane

Treatment	Total bacteria (cfux10^6 g^{-1} soil)			Total fungi (cfux10^5 g^{-1} soil)			Total actinomycetes (cfux10^5 g^{-1} soil)		
	Growth stage			Growth stage			Growth stage		
	Earthing up	Grand growth	Harvest	Earthing up	Grand growth	Harvest	Earthing up	Grand growth	Harvest
T_1	29.78	30.33	21.00	9.78	10.22	8.11	10.00	10.67	7.67
T_2	39.00	40.56	26.44	14.56	15.44	12.11	15.00	15.78	12.67
T_3	33.56	34.22	23.67	11.11	12.00	9.56	11.56	12.22	9.44
T_4	35.78	36.78	25.22	12.22	13.11	10.33	12.67	13.33	10.00
T_5	37.78	39.00	26.22	13.11	14.00	11.22	13.78	14.44	11.00
T_6	38.89	40.22	27.67	14.22	15.11	12.00	14.78	15.56	12.22
T_7	41.22	43.00	29.44	15.78	16.56	12.89	16.11	16.89	13.78
T_8	43.56	45.11	30.89	16.89	17.89	14.78	17.00	17.89	14.89
T_9	44.11	45.89	32.78	17.78	18.89	15.89	18.33	19.22	15.78
S.Em. ±	0.57	0.48	0.84	0.46	0.48	0.50	0.34	**0.37**	**0.34**
CD (P= 0.05)	1.72	1.45	2.50	1.37	1.44	1.51	1.01	**1.10**	**1.01**
Initial count		15.7			7.3			6	

Effect of Cogenerated Bagasse Ash on Enzyme Activity in Soil

Dehydrogenase enzyme activity: Dehydrogenase enzyme activity is generally used as a good indicator of biological activity in soils (Selvamurugan *et al*., 2011). Incorporation of organic matter to the soil enhanced soil dehydrogenase activity (Singh *et al.,* 2007). The dehydrogenase enzyme activity in soil differed significantly among treatments at various growth stages of preseasonal sugarcane (Table 2). The dehydrogenase enzyme activity in soil increased in the initial stages and thereafter, progressively decreased with crop growth stages. The soil dehydrogenase enzyme activity was highest with 150 % RDK through CBA at earthing up, grand growth and harvest stage of preseasonal sugarcane (13.38, 14.03 and 7.92 µg TPF g^{-1} soil h^{-1}, respectively) along with recommended dose of nitrogen and phosphorous through inorganic fertilizers and FYM. Significantly lower dehydrogenase enzyme activity in soil was recorded in absolute control at earthing up, grand growth and harvest stage stage of preseasonal sugarcane (7.47, 7.88 and 4.50 µg TPF g^{-1} soil h^{-1}, respectively). The organic material amended soil serve as an electron donor in dehydrogenase process. Dehydrogenase enzymes play a major role in the initial stages of the oxidation of soil organic matter by transferring electrons and hydrogens from substrates to acceptors. The increase in dehydrogenase enzyme activity in soil with increasing levels of CBA might be due to supply of organic carbon and prolonged nutrient availability which leads to increase in microbial activities. Similar findings were also reported by Reddy *et al*. (2010) and Benbi *et al*. (2017).

Urease enzyme activity: Urease enzyme in soil is involved in the hydrolysis of urea to carbon dioxide and ammonia, and plays an important role in the N cycling (Bhatt *et al.,* 2019). The urease enzyme activity in soil at different growth stages of preseasonal sugarcane was significantly influenced by the application of different levels of RDK through cogenerated bagasse ash (Table 2). Like dehydrogenases, the urease enzyme activity in soil also increased in the initial stages and thereafter, progressively decreased with crop growth stages. Singificantly

higher urease enzyme activity was observed at earthing up and grand growth than harvest stage stage of preseasonal sugarcane (49.35, 51.68 and 38.15 µg NH_4-N g^{-1} soil h^{-1}, respectively) in the treatment 150 % RDK through CBA. Whereas, this was on par with the treatment 125 % RDK through CBA at earthing up and grand growth stage of preseasonal sugarcane (48.48 and 50.52 µg NH_4-N g^{-1} soil h^{-1}). The lowest urease enzyme activity in soil was recorded in the treatment absolute control at earthing up, grand growth and harvest stage stage of preseasonal sugarcane (38.15, 39.32 and 28.64 µg NH_4-N g^{-1} soil h^{-1}, respectively). The higher urease enzyme activity in all the treatments over control might be due to addition of amide form of N applied through urea and more availability of N substrate. The increase in urease enzyme activity in soil increased might be due to application of cogenerated bagasse ash which contains essential nutrients and organic carbon and subsequent increase in microbial population. Similar findings were also reported by Saliha *et al.* (2005) and Selvamurugan *et al*. (2011).

Table 2: Effect of cogenerated bagasse ash on dehydrogenase and urease enzyme activity in soil at different growth stages of preseasonal sugarcane

Treatment	Dehydrogenase (µg TPF g^{-1} soil h^{-1})			Urease (µg NH_4-N g^{-1} soil h^{-1})		
	Growth stage			Growth stage		
	Earthing up	Grand growth	Harvest	Earthing up	Grand growth	Harvest
T_1	7.47	7.88	4.50	38.15	39.32	28.64
T_2	11.26	11.80	6.56	46.96	48.36	34.88
T_3	9.71	10.23	5.45	43.63	44.80	31.91
T_4	10.11	10.75	5.74	44.39	45.73	32.43
T_5	10.72	11.13	5.96	45.50	47.02	33.83
T_6	11.18	11.67	6.30	46.26	48.18	34.30
T_7	11.89	12.25	7.09	47.89	49.23	36.40
T_8	12.53	13.13	7.42	48.48	50.52	37.10
T_9	13.38	14.03	7.92	49.35	51.68	38.15
S.Em. ±	0.12	0.20	0.12	0.29	0.45	0.31
CD (P= 0.05)	0.35	0.60	0.36	0.88	1.34	0.94
Initial count		3.7			30	

Acid phosphatase enzyme activity: The significant variation of acid phosphatase enzyme activity in soil was observed at various crop growth stages of preseasonal sugarcane by the application of different levels of RDK through cogenerated bagasse ash (Table 3). Singificantly higher acid phosphatase enzyme activity in soil at earthing up, grand growth and harvest stage stage of preseasonal sugarcane (17.92, 18.85 and 13.23 µg PNP g^{-1} soil h^{-1}, respectively) was recorded with 150 % RDK through CBA along with recommended dose of nitrogen and phosphorous through inorganic fertilizers and FYM. The lowest acid phosphatase enzyme activity in soil was recorded in absolute control (10.33, 10.90 and 6.30 µg PNP g^{-1} soil h^{-1}, respectively) at earthing up, grand growth and harvest stage stage of preseasonal sugarcane. The increase in acid phosphatase enzyme activity in soil might be due to the application of cogenerated bagasse ash along with balance nitrogen and phosphorous through inorganic fertilizers and FYM. Incorporation of organic matter to the soil increased phosphatase activity in the soil (Singh *et al.*, 2007).

Alkaline phosphatase enzyme activity

The application of different levels of RDK through cogenerated bagasse ash has increased the alkaline phosphatase enzyme activity in soil at different growth stages of preseasonal sugarcane (Table 3). Alkaline phosphatase enzyme activity in soil increased up to grand growth stage and decreased at harvest stage of preseasonal sugarcane. Singificantly higher alkaline phosphatase enzyme activity in soil was recorded with 150 % RDK through CBA (6.62 t ha^{-1}) along with recommended dose of nitrogen and phosphorous (340 and 170 kg ha^{-1}) through inorganic fertilizers and 20 t ha^{-1} FYM (64.81, 65.94 and 39.07 µg PNP g^{-1} soil h^{-1}, respectively) and lower alkaline phosphatase enzyme activity was recorded in the treatment absolute control (47.31, 48.44 and 25.18 µg PNP g^{-1} soil h^{-1}, respectively). This implies that CBA along with

organic and inorganic nutrients provide a nutrient rich environment, which is essential for the synthesis of enzymes (Selvamurugan *et al*., 2011).

Table 3: Effect of cogenerated bagasse ash on acid and alkaline phosphatase enzyme activity in soil at different growth stages of preseasonal sugarcane

Treatment	Acid phosphatase (µg PNP g^{-1} soil h^{-1})			Alkaline phosphatase (µg PNP g^{-1} soil h^{-1})		
	Growth stage			Growth stage		
	Earthing up	Grand growth	Harvest	Earthing up	Grand growth	Harvest
T_1	10.33	10.90	6.30	47.31	48.44	25.18
T_2	15.33	16.11	10.44	57.47	58.60	32.07
T_3	13.74	14.27	8.29	52.96	54.09	26.65
T_4	14.00	14.86	8.51	53.41	54.54	27.66
T_5	14.45	15.41	9.10	54.31	55.44	28.68
T_6	15.03	15.93	9.73	55.78	56.91	30.94
T_7	16.17	16.82	11.11	59.62	60.75	34.21
T_8	17.01	17.76	12.03	62.33	63.46	36.92
T_9	17.92	18.85	13.23	64.81	65.94	39.07
S.Em. ±	0.31	0.24	0.29	1.26	0.87	0.84
CD (P= 0.05)	0.92	0.71	0.88	3.77	2.61	2.52
Initial count		7.11			21.63	

Results of the present study demonstrated that the application of cogenerated bagasse ash substantially increased the microbial population and enzymatic activities of the soil throughout the crop growth of sugarcane. Application of 150 % RDK through CBA (6.62 t ha^{-1}) along with recommended dose of nitrogen and phosphorous (340 and 170 kg ha^{-1}) through inorganic fertilizers and 20 t ha^{-1} FYM has improved the microbial population as well as enzymatic activities in sugarcane grown soil. The utilization of cogenerated bagasse ash enhanced the microbial population and enzymatic activities of the soil and also helps to increase the soil fertility besides paving an eco-friendly approach for the safe disposal of the cogenerated bagasse ash.

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