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Effect of different sugar industry solid waste on growth, yield and nutrient uptake by maize

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Abstract
A field experiment was conducted to assess the effect of different sugar industry solid wastes on growth, yield and nutrient uptake by maize during *kharif* 2017 at K. M. Doddi, Maddur taluk, Mandya. The sugar industry solid wastes *viz.*, pressmud (PM) and biocompost (BC) was characterized for various physical and chemical parameters. The response of crop increased with increase in the levels of sugar industry solid wastes application. Significantly higher plant height (44.29, 234.53 and 241.87 cm at 30, 60 DAS and at harvest, respectively) was recorded with application of RDF + BC @ 10 t ha^{-1}, however it was on par with application of RDF + PM @ 10 t ha^{-1} and university package of practice. Significantly higher kernel and stover yield of maize was recorded with RDF + BC @ 10 t ha^{-1}, however it was on par with application of RDF + PM @ 10 t ha^{-1} and university package of practice. Lower kernel and stover yield was recorded in control. Similar trends were observed with respect to nutrient uptake. Higher N (132.44 and 64.32 kg ha^{-1} kernel and stover, respectively), P (31.68 and 26.80 kg ha^{-1} kernel and stover, respectively) and K (58.44 and 134.90 kg ha^{-1} kernel and stover, respectively) uptake was recorded with RDF + BC @ 10 t ha^{-1}.

Keywords: Biocompost (BC), pressmud (PM), growth and yield of maize, nutrient uptake

Introduction
Maize (*Zea mays* L.) is one of the most versatile emerging crop having wider adoptability under varied agro-climatic condition. Globally, maize is known as queen of cereals because of its highest genetic yield potential among the cereals. In India it ranks third after rice and wheat, and it is cultivated in an area of 9.89 m ha with a production of 25.90 mt with a productivity of 2620 kg ha^{-1}. The major maize growing states are Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Gujarat, Karnataka and Himachal Pradesh. In Karnataka, maize is grown in an area of 1.30 m ha with a production of 4.40 mt with a productivity of 2970 kg ha^{-1} (Anon., 2017) [2, 3].

The sugarcane agro-industry is seen as a great opportunity for economic and industrial development in many sugarcane-producing countries. India is the largest producer and consumer of sugar in the world. Among the several industries, sugar industry is the most important which not only contributes substantially to the economic development of the country, but also provides ample employment opportunities directly or indirectly. More than 600 sugar factories are in the country and estimated that the production would go up to 69.40 lakh t in 2019–2020 (Anon., 2017) [2, 3].

Pressmud is a soft, spongy, amorphous and dark brown material. It is the residue obtained from sedimentation of the suspended materials such as fiber, sugar, wax, ash, soil and other particles from the cane juice. It can serve as a good source of organic matter, an alternate source of crop nutrients and soil ameliorant (Bokhtiar *et al.*, 2015) [5].

Bio-compost is by-product obtained by mixing pressmud and distillery spentwash in the ratio of 1: 2.5 and composted for 4-6 weeks. It is rich source of nutrients and ready to be apply as manure to soil.

Maize needs large amounts of nutrients from the soil due to high grain and stover yields. There is a possibility of nutrient mining from the soil if fertilizers are not added as per the requirements for high target yield of maize. Intensification of maize will therefore need nutrient management that produces high yields while preserving soil fertility and the environment.

In order to meet the nutrient requirement for an exhaustive crop like maize, use of organic along with inorganic fertilizers are essential. Availability of FYM is a major challenge in the present day due to dwindling population of animals.

As an alternate source of organic manure sugar industry solid wastes was used in the present study. Objective of the study was to know the effect of different sugar industry solid wastes on soil properties, growth and yield of maize.

Material and Methods

The experiment was conducted at K. M. Doddi, Maddur, located in Mandya, Karnataka, India, which falls under Southern Dry Zone of Karnataka (Agro Climatic Zone No. 6) and is situated at 12° 36' North latitude 77° 4' East longitude and at an altitude of 662 meters above mean sea level.

Treatment details: The experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. The sugar industry solid wastes was applied at different levels along with recommended dose of fertilizer. The experiment comprised of eight treatments. The treatment details are: T_1: Absolute control, T_2: RDF + PM @ 10 t ha^{-1}, T_3: RDF + BC @ 10 t ha^{-1}, T_4: 50 percent RDF + 50 percent N through PM, T_5: 50 percent RDF + 50 percent N through BC, T_6: 75 percent RDF + 25 percent N through PM, T_7: 75 percent RDF + 25 percent N through BC and T_8: POP (RDF+FYM+$ZnSO_4$).

Organic manure analysis

Pressmud and biocompost was collected from Sugars industry and analyzed for various physical and chemical parameters. The physical parameters like bulk density and MWHC was estimated using Keen Raczkowski Cup method as outlined by Piper (1966) [10]. The chemical parameters like pH and EC was determined using Potentiometry and Conductometry method respectively, as outlined by Jackson (1973) [7]. The organic carbon content of the pressmud and biocompost was determined by Wet oxidation method as outlined by Walkley and Black (1934) [15]. For the estimation of N the sugar solid wastes are powdered and was treated with H_2SO_4 and kept for digestion in presences of digestion mixture (K_2SO_4:$CuSO_4$:Se in the ratio of 100:20:1) overnight. The samples were digested in Kjeldahl digestion assembly till a light bluish green residues are obtained. The residue was cooled and diluted to 100 ml using distilled water, filtered and used for further estimation. The N content in sugar industry solid wastes was determined by Kjeldahl distillation method in the presence of 40% NaOH (Piper, 1966) [10]. For other elements the sugar solid watses was powdered (0.5 g) and treated with 10 ml of concentrated HNO_3 and kept for pre-digestion overnight. The samples were then digested with 10 ml of di acid mixture (HNO_3 and $HClO_4$ in 9:4 ratio) until a white residue was left. The residue was cooled and diluted to 100 ml using distilled water, filtered and used for further estimation. The P content in sugar industry solid wastes was determined by Vanado-molybdo phosphoric yellow colour method. The intensity of yellow was read using spectrophotometer at 420 nm wavelength (Piper, 1966) [10]. Potassium was determined using flame photometer as outlined by Piper (1966) [10]. Calcium and magnesium was determined by versenate titration method as outlined Piper (1966) [10]. Sulphur was determined turbidimetrically. The intensity of turbidity was measured using spectrophotometer at 420 nm of wavelength. Micro nutrients and heavy metals were analyzed by making suitable dilution of di-acid extract, the samples were fed to the atomic absorption spectrophotometer using appropriate hallow cathode lamp.

Soil sample analysis

Composite soil samples were collected from the experimental field and analyzed for physical, chemical and biological properties. The soil was sandy clay in texture with neutral pH of 7.55, EC 0.37 dS m^{-1}, SOC 5.80 mg kg^{-1}. The soil in the plot was low in available nitrogen (212.80 kg ha^{-1}), high in available phosphorus (213.99 kg ha^{-1}), medium in available potassium (264.36 kg ha^{-1}) and the secondary nutrients (Ca, Mg and S was 9.50 cmol (p+) kg^{-1}, 3.60 cmol (p+) kg^{-1} and 36.67 mg kg^{-1}, respectively) were in sufficient amounts. The available Fe (10.52 mg kg^{-1}), Mn (2.72 mg kg^{-1}) and Zn (0.98 mg kg^{-1}) contents were present in appreciable amounts. The soil was low in available Cu (0.14 mg kg^{-1}) and B (0.10 mg kg^{-1}).

Other observation

Plant growth parameters were recorded at 30, 60 DAS and at harvest by employing standard procedures and yield parameters were recorded at harvest as per standard protocol. Kernel and stover samples were collected separately from each plot soon after the harvest of the crop. The samples were initially air-dried cut into pieces and then oven dried at 70℃ for overnight, later grounded in willey mill to powder and stored. The powdered kernel and stover samples drawn at harvest from each treatment in each replication were analysed for various parameters.

Results and Discussion

The data pertaining to the characteristics of pressmud and biocompost are presented in Table 1. The analysis of the PM and BC revealed that it has bulk density of 1.08 and 1.04 Mg m^{-3} respectively. The maximum water holding capacity was 60.21 percent in PM and 63.35 percent in BC. The PM has pH of 6.50 and a electrical conductivity of 2.90 dS m^{-1}. The PM and BC has OC (35.08% and 44.07%), total nitrogen (1.80% and 2.22%), total phosphorus (1.02% and 1.50%) and total potassium content (1.28% and 1.83%). The PM and BC contained appreciable amount of secondary nutrients like Na (0.03 and 0.04%), Ca (1.02 and 0.81%), Mg (0.32 and 0.21%), sulphur (30.00 and 34.21 mg kg^{-1}) respectively. The solid wastes (pressmud and biocompost) also contained appreciable quantities of micronutrients like Fe (1202 and 1242 mg kg^{-1}), Mn (253.20 and 566.40 mg kg^{-1}), Cu (77.40 and 71.60 mg kg^{-1}) and Zn (119.40 and 157.20 mg kg^{-1}). PM and BC also contained total heavy metals like Ni of 0.21 and 0.42 mg kg^{-1}, respectively. (Ghulam *et al.,* 2010, Bhosale *et al.*, 2012).

Plant height: Significant result was observed in plant height due to application of varied levels of sugar industry solid wastes and FYM along with inorganic fertilizers at all the growth stages of the maize crop (Table 2). Significantly highest plant height (44.29, 234.53 and 241.87 cm at 30, 60 DAS and at harvest, respectively) was recorded with the application of RDF + BC @ 10 t ha^{-1} (T_3). However, it was on par with the application of RDF + PM @ 10 t ha^{-1} (T_2) (43.77, 228.77 and 230.73 cm at 30, 60 and at harvest, respectively), POP (T_8) (42.93, 218.83 and 222.70 cm at 30, 60 and at harvest, respectively) and 50 percent RDF + 50 percent N through BC (T_5) (42.41, 214.73 and 219.93 at 30, 60 DAS and at harvest, respectively). Significantly lower plant (29.58, 143.87 and 148.60 cm at 30, 60 and at harvest, respectively) was recorder in T_1 (Control) in all the stages of crop growth.

The increase in plant height of maize in sugar solid waste treated treatments might be due to the uptake of N, P and K nutrient in higher amount by maize crop. Hence, there was increase in vegetative growth of the plant and it was attributed to K element by enhanced sugar translocation and turgor pressure in plant cell that leads to enlargement of cell and triggering the meristematic growth of the plant and also due to rapid N mineralization from inorganic fertilizer and adequate supply of all other nutrients from BC, PM and FYM throughout the crop growth period. It also increased the root surface per unit of soil volume, water use efficiency and photosynthetic activity of the crop, it directly affects the physiological processes and better utilization of carbohydrates. Similar results were obtained with Abbasi *et al*. (2014) [1], Kalaivanan and Omar Hattab (2016) [8], Vinod Kumar and Chopra (2016) [14].

Yield parameters: The results revealed that there was significant effect of varied levels of sugar industry solid wastes on yield parameters (cob length, cob weight, number of rows per cobs, number of kernel per row and test weight) (Table. 3). Application of RDF + BC @10 t ha^{-1} significantly increased the cob length (23.10cm), cob weight (216.16g), no. of rows per cob (18.07), no. of kernels per cob (41.67) and test weight (30.37g) it was found to be on par with RDF + PM @ 10 t ha^{-1} (T_2), POP (T_8) and 50 percent RDF + 50 percent N through BC (T_5) and lowest yield parameters was recorded in control. This might be due to better cell division and cell elongation of maize on application of sugar industry solid wastes along with chemical fertilizers. Also attributed to availability of nutrients from sugar industry solid wastes that supplies primary, secondary and micro nutrient which are required for plant growth and development.

Kernel and stover yield: Application of RDF + BC @ 10 t ha^{-1} recorded significantly higher kernel and stover yield (84.98 and 89.34 q ha^{-1}, respectively) which was on par with RDF + PM @ 10 t ha^{-1} (T_2), POP (T_8) and 50 percent RDF + 50 percent N through BC (T_5). Significantly lower kernel and stover yield (51.08 and 55.20 q ha^{-1}, respectively) was recorded in control. The increased yield in maize with varied level application of sugar solid wastes and FYM along with RDF, could be due to increased plant nutrients availability by rapid mineralization and balanced supply of all essential nutrients through organic and inorganic sources. This might have resulted in increased cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and increased nutrient absorption by increased root activity lead to better growth and development of the crop. Hence, it enhances higher cob length (23.10 cm), cob weight (216.16 g), more number of rows per cob (18.07), more number of kernels per row (41.67) and test weight (30.37 g) and this leads to increased kernel and stover yield of the crop. (Rahman, 2012, Prado *et al.*, 2013, Abbasi *et al*., 2014) [12, 11, 1].

Nutrient uptake: The nutrient uptake in plants is a function of growth and availability of nutrients. Higher the availability of nutrients in soil better is the nutrient uptake and plant growth. The nitrogen, phosphorus and potassium uptake by maize kernel and stover increased with the higher levels of sugar industry solid wastes. Higher uptake of N (132.44 and 64.32 kg ha^{-1} kernel and stover, respectively), P (31.68 and 26.80 kg ha^{-1} kernel and stover, respectively) and K (58.44 and 134.90 kg ha^{-1} kernel and stover, respectively) was recorded with the application of RDF + BC @ 10 t ha^{-1} which was on par with RDF + PM @ 10 t ha^{-1} (T_2), POP (T_8) and 50 percent RDF + 50 percent N through BC (T_5). However, lower uptake of N (50.40 and 16.56 kg ha^{-1} kernel and stover, respectively), P (10.09 and 9.94 kg ha^{-1} kernel and stover, respectively) and K (20.45 and 56.30 kg ha^{-1} kernel and stover, respectively) was recorded in control. Increased uptake of nutrients with application of sugar industry solid wastes along with inorganic fertilizer might be due to the fact that organic matter in the solid wastes stimulates higher microbiological activity and enhances nutrient availability to plant crop through mineralization, it attributed to higher uptake of nutrients by plant crops (Solaimalai *et al.* 2001, Kausale *et al*. 2009) [13, 9].

Table 1: Physical and chemical properties of pressmud and biocompost

Parameters	Pressmud	Biocompost
	Values	
Physical properties		
Bulk density (Mg m^{-3})	1.08	1.04
Maximum water holding capacity (%)	60.21	63.35
Chemical properties		
pH (1:10)	6.50	7.80
Electrical conductivity (dS m^{-1}) (1:10)	2.90	3.10
Organic carbon (%)	35.08	44.07
Total nitrogen (%)	1.80	2.22
Total phosphorus (%)	1.02	1.50
Total potassium (%)	1.28	1.83
Total calcium (%)	1.02	0.81
Total magnesium (%)	0.32	0.21
Total sodium (%)	0.03	0.04
Total sulphur (mg kg^{-1})	30.00	34.21
Total iron (mg kg^{-1})	1202	1242
Total copper (mg kg^{-1})	77.40	71.60
Total manganese (mg kg^{-1})	253.20	566.40
Total zinc (mg kg^{-1})	119.40	157.20
Heavy metal		
Pb (mg kg^{-1})	ND	ND
Cd (mg kg^{-1})	ND	ND
Cr (mg kg^{-1})	ND	ND
Ni (mg kg^{-1})	0.21	0.42

ND – Not detected

Table 2: Effect of varied levels of sugar industry solid wastes on growth parameters of maize at different intervals

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
T_1: Control	29.58	143.87	148.36
T_2: RDF+ PM 10 t ha^{-1}	43.77	228.77	230.73
T_3: RDF+BC 10 t ha^{-1}	44.29	234.53	241.87
T_4: 50% RDF+50% N through PM	39.51	211.83	215.13
T_5: 50% RDF+50% N through BC	42.41	214.73	219.93
T_6: 75% RDF+25% N through PM	36.93	202.75	207.07
T_7: 75% RDF+25% N through BC	38.93	206.00	213.20
T_8: POP (RDF+FYM)	42.93	218.83	222.70
S.Em±	1.36	6.88	7.26
CD @5%	4.14	20.87	22.02

RDF- Recommended dose of fertilizers
POP – Package of practice
PM – Pressmud
FYM- Farmyard manure
BC – Biocompost
DAS – Days after sowing

Table 3: Yield attributes of maize as influenced by varied levels of sugar industry solid wastes

Treatment	Cob length (cm)	Cob weight (g)	No. of rows per cob	No. of kernels per row	Test weight (g)
T_1: Control	16.37	105.60	13.64	27.00	23.62
T_2: RDF+ PM 10 t ha^{-1}	22.76	213.10	17.12	40.33	29.75
T_3: RDF+BC 10 t ha^{-1}	23.10	216.16	18.07	41.67	30.37
T_4: 50% RDF+50% N through PM	19.53	193.08	15.87	33.83	26.46
T_5: 50% RDF+50% N through BC	21.50	207.44	16.33	39.30	29.17
T_6: 75% RDF+25% N through PM	18.48	172.90	15.33	30.67	26.10
T_7: 75% RDF+25% N through BC	18.80	174.66	15.67	31.48	26.36
T_8: POP (RDF+FYM)	22.14	209.02	16.67	39.67	29.21
S.Em±	1.12	7.49	0.67	1.01	1.14
CD @5%	3.41	22.72	2.04	3.09	3.46

RDF- Recommended dose of fertilizers
POP – Package of practice
PM – Pressmud
FYM- Farmyard manure
BC - Biocompost

Table 4: Effect of varied levels of sugar industry solid wastes on kernel and stover yield of maize

Treatments	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1: Control	51.08	55.20
T_2: RDF+ PM 10 t ha^{-1}	79.63	85.01
T_3: RDF+BC 10 t ha^{-1}	84.98	89.34
T_4: 50% RDF+50% N through PM	73.38	78.92
T_5: 50% RDF+50% N through BC	74.78	80.37
T_6: 75% RDF+25% N through PM	68.19	73.63
T_7: 75% RDF+25% N through BC	70.84	75.72
T_8: POP (RDF+FYM+$ZnSO_4$)	76.10	82.43
S.Em±	3.43	2.99
CD @5%	10.41	9.04

RDF- Recommended dose of fertilizers
POP – Package of practice
PM – Pressmud
FYM- Farmyard manure
BC - Biocompost

Table 5: Effect of varied levels of sugar industry solid wastes on N, P and K uptake by maize kernel and stover

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	Kernel	Stover	Kernel	Stover	Kernel	Stover
T_1: Control	50.40	16.56	10.09	9.94	20.45	56.30
T_2: RDF+ PM 10 t ha^{-1}	117.85	55.26	26.53	23.80	51.41	124.11
T_3: RDF+BC 10 t ha^{-1}	132.44	64.32	31.68	26.80	58.44	134.90
T_4: 50% RDF+50% N through PM	95.90	37.88	19.07	17.36	42.57	105.75
T_5: 50% RDF+50% N through BC	102.44	45.34	23.18	19.78	44.86	110.91
T_6: 75% RDF+25% N through PM	79.10	30.92	16.36	14.73	36.82	96.46
T_7: 75% RDF+25% N through BC	87.13	33.32	17.71	15.90	39.67	99.95
T_8: POP (RDF+FYM+$ZnSO_4$)	106.54	48.22	23.59	20.90	47.94	117.05
S.Em±	9.91	6.36	3.23	2.43	4.68	7.99
CD @5%	30.07	19.01	9.79	7.19	14.20	24.09

RDF- Recommended dose of fertilizers
POP – Package of practice
PM – Pressmud
FYM- Farmyard manure
BC - Biocompost

Conclusion

The study indicated that RDF + BC @ 10 t ha^{-1} was found to be superior and was on par with application of RDF + PM @ 10 t ha^{-1} and university package of practice. However, there was increase in the kernel and stover yield with application of RDF + BC @ 10 t ha^{-1} which resulted in higher nutrient uptake.

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