Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 3038-3042
Received: 28-03-2019
Accepted: 30-04-2019

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Effect of sugar industry solid waste pressmud and bio compost on soil physical and chemical properties at different intervals during finger millet crop

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Abstract
Integrated nutrient management has paid rich dividends in management of soil fertility thus ensuring good productivity and maintaining soil health. Pressmud biocompost (made of pressmud + spentwash) and well decomposed farm yard manure in various combinations with inorganic nutrients were evaluated on the performance of finger millet. The experiment consisted of eight treatments and was laid out with randomized complete block design and replicated thrice was carried out at M/s Sri Chamundeshwari Sugars Ltd., Bharathinagar, Maddur taluk, Mandya District located in Southern Dry Zone of Karnataka. The results indicated that significantly lower bulk density and increased MWHC was recorded in T_2 (RDF + pressmud@ 10 t ha^{-1}) (1.39, 2.61 Mg m^{-3} and 37.46% respectively). Soil pH ranged from 7.50 to 8.07 30 DAT to harvest and later decreased, EC ranged from 0.33 to 0.51 dS m^{-1}. Higher organic carbon content and Higher CEC was recorded in treatment T_3 (RDF + bio compost 10 t ha^{-1}). The yield of finger millet was high in treatment containing RDF + bio compost 10 t ha^{-1}.

Keywords: Pressmud, bio compost, physical and chemical properties of soil

Introduction
Providing wholesome nutrition to plants is the essence of good plant growth leading to better productivity. An integration of inorganic and organic nutrient sources holds the key to good soil health leading to successful agriculture. The organic nutrient sources are many and are region specific, a point in consideration is the sugarcane industry residues which includes solids such as baggase, bio compost and pressmud and liquids such as molasses and spent wash all of which have many applications of importance is their use in agriculture as a nutrient and organic matter source. Pressmud a fluffy dark brown to black organic by product of sugarcane juice processing and contains organic nutrients, sugars, wax and other biochemical constituents, depending on the process adopted it is referred to as sulphitation press mud (SPM) or carbonation pressmud (CPM) and needs to be cured in open conditions to attain ambient temperature. Organic nutrient sources are organic waste, such as pressmud or filter cake, is generated as a by-product of sugarcane industries and characterized as a soft, spongy, amorphous, and dark brown to brownish material. It is generated during the purification of sugar by carbonation or sulphitation process. It is considered as reject of sugarcane industries that cause problem of storage and environmental pollution. Pressmud supplies a good amount of organic matter and plant nutrient and acts as a soil amendment. It contains 50–70% moisture, which is most favourable for soil micro-organisms. Wide ranging however is costly.

Integrated nutrient management has paid rich dividends in management of soil fertility thus ensuring good productivity and maintaining soil health. In this context pressmud bio compost (made of pressmud + spentwash) and well decomposed farm yard manure in various combinations with inorganic nutrients were evaluated on the performance of finger millet commonly known as "Nutritious millet" as the grains are nutritionally superior to many cereals providing fair amount of proteins, minerals, calcium and vitamins in abundance. It is the cheapest and preferred food crop among many as it is can be digested slowly thereby providing energy throughout the day.

Material and methods
The field experiment was conducted at research block of M/s Sri Chamundeshwari Sugars Ltd., Bharathinagar, is located in Mandya District, which falls under Southern Dry Zone of Karnataka and is situated at 12° 36' North latitude 77° 4' East longitude and at an altitude of 662 meters above mean sea level.

Pressmud and biocompost were sourced from M/s Sri Chamundeshwari Sugars Ltd, Bharathinagar, Maddur taluk, Mandya district and were analyzed for various physico-chemical properties (Table 1). The pressmud and bio compost had BD 1.04 and 1.06 Mg m^{-3} respectively, the maximum water holding capacity 60.21 and 63.35% of respectively. The pressmud and bio compost recorded neutral pH (6.5 to 7.3), electrical conductivity was low (0.34 to 0.45 dS m^{-1}) and the total organic carbon content was 35.08 and 44.07 per cent respectively. The pressmud recorded nitrogen 1.8%, total P, K, Na Ca, Mg and S contents were 1.8%, 1.02%, 0.42% 1.28%, 10.25%, 3.2%, 30 mg kg^{-1} whereas bio compost recorded 2.2% nitrogen and P, K, Na Ca, Mg and S contents were 1.5%, 0.30%, 1.83%, 2.1%, and 34.21 mg kg^{-1} respectively.

The total Fe, Mn, Cu, Zn and B contents in pressmud and bio compost were 1202, 253. 2, 77. 4, 119.4 and 1242, 566.4, 71.6 157.2 mg kg^{-1}, respectively. Except Ni (0.41 and 0.24 mg kg^{-1} respectively), other heavy metals were below detectable limits.

Composite soil samples were collected from 0-15 cm depth from the experimental plot separately before sowing and Analyzed for physical, chemical and biological properties. Initial properties of the soil are given in Table 2.

The soil of experimental site was sandy clay loam in texture with bulk density of 1.48 Mg m^{-3} and MWHC 35.3 percent. Neutral in reaction (pH of 7.50) and non-saline (EC 0.33 dS m^{-1}). The surface soil was high in organic carbon content (1.25%) with cation exchange capacity of 28.23 c mol (p^+) kg^{-1} soil. The initial soil fertility was medium in available N (420.24 kg ha^{-1}), high in available P_2O_5 (140.29 kg ha^{-1}), and available K_2O (310.82 kg ha^{-1}) and sufficient in micronutrients. Similarly, plant samples were analysed for various parameters using standard procedures.

Field experiment was laid out in a randomized complete block design consisting of eight treatments and replicated thrice Viz T_1 (Absolute control), T_2 (RDF +pressmud 10 t ha^{-1}), T_3 (RDF + bio compost 10 t ha^{-1}), T_4 (50% RDF + 50% N through pressmud), T_5 (50% RDF + 50% N through bio compost), T_6 (75% RDF + 25% N through pressmud), T_7 (75% RDF + 25% N through bio compost), T_8 (POP (RDF + FYM), the soil physical properties and NPK were analysed by the method of (Piper, 1966; Page *et al*., 1982) [11, 10], pH and EC (Jackson, 1973) [5], Organic Carbon (Walkley and Black, 1934) [21], Statistical analysis Gomez and Gomez (1984) [4].

Table 1 Physical and chemical properties of pressmud and bio compost

Parameters	Pressmud	biocompost
	Content	
Physical properties		
Bulk density (Mg m^{-3})	1.04	1.08
Maximum water holding capacity (%)	60.21	63.35
Chemical properties		
pH	6.50	7.30
Electrical conductivity (dS m^{-1})	0.34	0.45
Organic carbon (%)	35.08	44.07
Total Nitrogen (%)	1.8	2.22
Total Phosphorus (%)	1.02	1.5
Total Potassium (%)	1.28	1.83
Total Calcium (%)	10.25	8.15
Total Magnesium (%)	3.20	2.10
Sulphur (mg kg^{-1})	30	34.21
Sodium (%)	0.42	0.30
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 metals		
Pb (mg kg^{-1})	ND	ND
Cd (mg kg^{-1})	ND	ND
Cr (mg kg^{-1})	ND	ND
Ni (mg kg^{-1})	0.42	0.21

Table 2: Initial physical and chemical properties of the experimental plot

Parameters		Content
Physical properties		
Particle size distribution	Sand (%)	46.88
	Silt (%)	12.21
	Clay (%)	40.17
	Texture	Sandy clay
Bulk density (Mg m^{-3})		1.48
Maximum water holding capacity (%)		35.3
Chemical properties		
pH (1:2.5)		7.50
Electrical conductivity (dS m^{-1})		0.33
Organic carbon (%)		1.25
CEC [c mol (p^+) kg^{-1}]		28.23

Results and discussion

Significant increase in MWHC of soil after harvest of finger millet was observed due to application of varied levels of pressmud and bio compost (Table 3). MWHC of the soil increased from 35.18% initial to 37.46% at harvest. The treatment T_2 (RDF + pressmud 10 t ha^{-1}) showed significant increase in MWHC (37.24%). The treatment T_3 (RDF+ bio compost 10 t ha^{-1}) was on par with the T_2 followed T_8 (RDF+ FYM 10 t ha^{-1}) (36.88%). The MWHC of the soil increased with increase in the rates of application of pressmud and bio compost and further increased with FYM. MWHC was low in T_1 control (35.18%).

The increase in WHC may be due to increased pore volume due to higher doses of organic solid waste. Similar results were obtained by Tompe and More (1996) [19] who inferred that application of pressmud cake recorded pronounced effect in improving bulk density and water holding capacity of soil. In general, water holding capacity recorded continuous increase with successive increase in doses of pressmud cake while, bulk density decreased with increasing doses of pressmud. The soil physical properties such as water holding capacity, moisture content and porosity improved on addition of compost. Results were observed by Bhosale *et al.* (2012) [1], Samreen Shehzadi *et al.* (2016) [14] and Dotaniya *et al.* (2016) [3].

Significant difference in bulk density of soil was observed on application of pressmud and bio compost (Table 3). Lower BD was recorded in T_2 (1.39 Mg m^{-3}) which was on par with T_3 and T_8 recording 1.40 Mg m^{-3}. Application of organics lead to production of polysaccharides which improved soil aggregation and decreased bulk density. Similar results were recorded by Jamil Khan (2011) where in application of sewage sludge (40 t ha^{-1}), pressmud (20 t ha^{-1}) and bagasse ash (50 t ha^{-1}) recorded slight decrease in dry bulk density 1.28, 1.32 and 1.30 gm cm^{-3} respectively, which was supported by Sinha *et al.* (2016) who reported that addition of bio-compost either alone or in combination with inorganic fertilizer-N significantly improved the organic carbon and availability of nutrients (N, P, K and S) with reduction in bulk density of after harvest of soil. Samreen Shehzadi *et al.* (2016) [14] concluded that application of organic wastes, filter cake and municipal solid waste (MSW) have the best potential to improve soil organic carbon retention, WHC and decreased bulk density. Dotaniya *et al.* (2016) [3] concluded that application of sugarcane industries by-products reduced the recommended dose of fertilizers and improved organic matter and physical properties of soil like WHC, porosity and decreased the bulk density, during the crop production.

Table 3: Effect of varied levels of pressmud and bio compost on changes in soil physical properties at harvest of finger millet

Treatments		MWHC (%)	BD (Mg m^{-3})	PD (Mg m^{-3})
T_1	Absolute control	35.18	1.44	2.67
T_2	RDF + pressmud@ 10 t ha^{-1}	37.46	1.39	2.61
T_3	RDF + bio compost @ 10 t ha^{-1}	37.24	1.40	2.60
T_4	50% RDF + 50% N through pressmud	36.16	1.42	2.64
T_5	50% RDF + 50% N through bio compost	36.47	1.41	2.64
T_6	75% RDF + 25% N through pressmud	35.95	1.42	2.64
T_7	75% RDF + 25% N through bio compost	35.60	1.42	2.63
T_8	POP (RDF + FYM)	36.88	1.40	2.63
	S. Em. ±	0.323	0.007	0.017
	CD @ 5%	0.978	0.020	NS

RDF- Recommended dose of fertilizer
FYM- Farm yard manure
POP- Package of practice

Effect of varied levels of pressmud and bio compost on soil chemical properties

The soil reaction (pH) as influenced by pressmud and bio compost at different stages of finger millet are presented in (Table 4)

The results indicated that there was significant increase in soil pH at 30 days after transplanting when compared to initial pH (7.50) followed by significant decrease in soil pH at different stages of finger millet.

At 30 days after transplanting soil pH significantly increased in all the treatments compared to control (7.50). The soil pH in T_2 (RDF + pressmud @ 10 t ha^{-1}) recorded 8.07 followed by T_3 pH of (8.03) and T_8 (7.96). All other treatments recorded significantly high pH compared to control. The trend was similar at 60 days.

At harvest the pH decreased significantly compared to 60 DAT. There was decrease in pH of T_2 (7.97) over control T_1 (7.57) followed by other treatments which were on par with T_2 and recorded significantly higher pH compared to control. The results clearly indicated that application of pressmud and bio compost enhanced the pH of the soil from 7.50 to 8.07 initially and later there was decrease in pH because pressmud and bio compost contain calcium causing an increasing in pH of soil initially and on decomposition release organic acids and carbon dioxide leading to decrease in pH of soil. Said Ghulam *et al.* (2012) [13] concluded that addition of pressmud decreased pH of the soil from 8.1 to 7.9 as a result of increased levels of pressmud application. The application of pressmud @ 15 to 20 t ha^{-1} would be the most suitable dose for improving the physico-chemical properties of calcareous soil.

This reduction in pH of soil could be due to acidifying effect of organic and inorganic acids produced during the process of decomposition of organic amendments (Prapagar *et al.*, 2012) [12]

The results indicated that there was significant increase in soil EC at 30 days after transplanting when compared to initial EC of 0.33 dSm^{-1} and this was followed by a significant decrease in soil EC at different stages the finger millet growth due to addition of pressmud and bio compost at different levels (Table 4).

At 30 days after transplanting there was significant increase in soil EC in all the treatments compared to control (0.33). Higher soil EC was recorded in T_3 (RDF + bio compost @ 10 t ha^{-1}) which recorded EC of 0.54 dSm^{-1} and was superior to other treatments followed by T_2, T_4, T_5, T_6, T_7, T_8. All other treatments recorded significantly high EC compared to control.

At 60 days significant decrease in soil EC was recorded when compared to 30 days. Higher EC was recorded in T_3 (0.32 dS

m^{-1}) which was on par with the T_2, T_4, T_5, T_6, T_7, and T_8 and lower EC was recorded in T_1 control (0.17 dS m^{-1}).

At harvest the EC decreased significantly compared to at 60 DAT. There was increase in EC in T_3 (0.33 dS m^{-1}) over control T_1 (0.18 dS m^{-1}) followed by all other treatments were recorded significantly higher EC compared to control.

The results clearly indicated that application of pressmud and bio compost enhanced the EC of the soil from 0.33 to 0.54 dSm^{-1} initially and later there was a decrease in EC. The similar findings were recorded. Said Ghulam *et al.* (2012) [13] concluded that addition of pressmud decreases EC of the soil as a result of increasing levels of pressmud application. The application of pressmud @ 15 to 20 t ha^{-1} was most suitable dose in improving the physico-chemical properties soil. Prapagar *et al.*, (2012) [12] suggested that decrease in EC of soil was due to addition of organic matter and leaching of ions. This reduction may be also due to the leaching of soluble salts and the effect of organic and inorganic acids which are produced during the process of decomposition of amendments (Udayasoorian *et al.,* 2009) [20].

The results indicated that there was a significant increase in soil OC at 30 days after transplanting when compared to initial OC (1.25%), the increase in soil OC at different stages of finger millet was due to addition of pressmud and bio compost at different levels (Table 5).

At 30 DAT, the soil OC significantly increased in all the treatments compared to control (1.25%). Higher soil OC was recorded in T_3 (RDF + bio compost 10 t ha^{-1}) recording 1.59% OC and was on par with T_2 (1.57%) which received (RDF + pressmud 10 t ha^{-1}) and T_8 RDF+ FYM 10 t ha^{-1} (1.53%). All other treatments recorded significantly higher OC compared to control.

At 60 DAT and harvest there was no significant difference in soil OC. But higher OC was recorded in T_3 (1.40%) and T_2 (1.36%) at both intervals respectively when compared to control. The increase in OC content may be attributed to recycling of roots, above ground residues and stubbles due to higher biomass production in these treatments, in addition to the C added through manures (Manjaiah and Singh, 2001; Majumder *et al*., 2008) [8, 7]. Pressmud and bio compost are organic in nature and they contain high organic carbon and on addition of these organics to soil, the soil organic carbon content increases due to decomposition by microorganisms. Organic carbon in the soil treated with sugarcane pressmud recorded higher OC than control. In the present study, soil organic carbon content increased considerably due to combined application of organics and higher dose (100%) of inorganics compared to control, suggesting that organics and chemical fertilizer are beneficial to the accumulation of soil organic matter and thus improves soil fertility. Brar *et al*. (2015) [2] confirmed that balanced and integrated use of organic and inorganic fertilizers enhance the accumulation of soil organic matter and improve soil physical properties.

The cation exchange capacity (CEC) of soils differed significantly on application of pressmud and bio compost. Higher CEC (37.67 cmol (P^+) kg^{-1}) was obtained in treatment T_3 (RDF + bio compost 10 t ha^{-1}), this was on par with T_2 (36.87 cmol (P^+) kg^{-1}). Lower CEC (28.21 cmol (P^+) kg^{-1}) was recorded in control. Compared to control all other treatments recorded significantly higher soil CEC at harvest of finger millet (Table 5).

This can be attributed to the higher basic cationic content of pressmud and bio compost and also smaller sized particle which increase the surface area. Soil organic matter and clay particles have large surface areas and have a large number of exchange sites. As a consequence of application of organic amendments, there was increase in organic C stock which resulted in increased soil cation exchange capacity (CEC) (Scotti *et al.*, 2015) [16]. Sarwar *et al*. (2010) [15] noted that cations such as Ca, Mg and K were produced during organic manure decomposition. Besides, Sharma *et al*. (1990) [17] suggested that the use of organic manures have made soil more porous, allowing better root growth and development, thereby resulting in higher CEC. Mohd Hadi Akbar Basri *et al*. (2013) [9] showed that application of organic matter in combination with fertilizers increased the CEC.

Table 4: Effect of varied levels of sugarcane pressmud and bio compost on soil pH and electrical conductivity at different intervals

Treatments		Soil pH			EC (dS m^{-1})		
		30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1	Absolute control	7.59	7.71	7.57	0.31	0.17	0.18
T_2	RDF + pressmud@ 10 t ha^{-1}	8.07	7.97	7.97	0.52	0.30	0.26
T_3	RDF + bio compost @ 10 t ha^{-1}	8.03	7.98	7.96	0.54	0.32	0.33
T_4	50% RDF + 50% N through pressmud	7.95	7.95	7.91	0.45	0.23	0.25
T_5	50% RDF + 50% N through bio compost	7.93	7.89	7.77	0.33	0.27	0.23
T_6	75% RDF + 25% N through pressmud	7.97	7.91	7.82	0.51	0.23	0.27
T_7	75% RDF + 25% N through bio compost	7.95	7.88	7.72	0.47	0.26	0.28
T_8	POP (RDF + FYM)	7.96	7.88	7.88	0.49	0.24	0.29
	S. Em. ±	0.072	0.043	0.128	0.024	0.037	0.027
	CD @ 5%	0.21	0.144	0.412	0.072	0.112	0.082
	Initial value	7.50			0.33		

DAT – Days after transplanting
RDF- Recommended dose of fertilizer
FYM- Farm yard manure
POP- Package of practice

Table 5: Effect of varied levels of sugarcane pressmud and bio compost on soil organic carbon content at different intervals and cation exchange capacity at harvest

Treatments		OC (%)			CEC (c mol (P^+) kg^{-1})
		30 DAT	60 DAT	At harvest	At harvest
T_1	Absolute control	1.25	1.24	1.15	28.21
T_2	RDF + pressmud@ 10 t ha^{-1}	1.57	1.36	1.33	36.87
T_3	RDF + bio compost @ 10 t ha^{-1}	1.59	1.40	1.36	37.67
T_4	50% RDF + 50% N through pressmud	1.43	1.28	1.24	35.91
T_5	50% RDF + 50% N through bio compost	1.45	1.31	1.20	36.17
T_6	75% RDF + 25% N through pressmud	1.43	1.29	1.26	35.58
T_7	75% RDF + 25% N through bio compost	1.42	1.23	1.21	34.80
T_8	POP (RDF + FYM)	1.53	1.30	1.26	36.28
	S. Em. ±	0.046	0.124	0.046	0.284
	CD @ 5%	0.136	NS	NS	0.863
	Initial value	1.25		28.23	

DAT – Days after transplanting
RDF- Recommended dose of fertilizer
FYM- Farm yard manure
POP- Package of practice

Conclusion

The present study on the use of sugarcane pressmud and bio compost prepared from organic residues of sugar mills has benefitted in improving soil physical like in bulk density and water holding capacity and chemical properties like pH and electrical conductively and increasing organic carbon content and cation exchange capacity of soil. Application of T_3 (RDF + bio compost 10 t ha^{-1}) resulted increasing the physical and chemical properties of soil during finger millet crop.

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