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Use of pressmud compost for improving crop productivity and soil health

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Abstract

In India huge accumulation of sugarcane byproducts with a lot of this material not being utilized in a productive manner, while, these byproducts had the great potential when mixed into agricultural soils as organic fertilizer with many of benefits that can improve soil health, and sustainable agronomic productivity. Pressmud is a by-product of sugar industry and for every 100 tons of sugarcane crushed about 3 tons of pressmud cake is left behind as by-product. when this byproduct composted, it converted into a very nutritive organic manure, because of composting is a most promising technology of waste disposal, enabling recycling and solid treatment of waste organic matter and by this process organic solid waste can be biodegraded and make suitable by composting and the final compost products could be used in agricultural field as the fertilizing agent which is rich in micro and macro nutrients with organic carbon or soil conditioner along with it increases the microbial population, prepare beneficial microbial communities, improve microbiological standard and substance which can be manage, stored, convert and generate various important enzymes; and thus applied to the field without adversely affecting the transformation of organics and reduce odorous gas to release in to environment so it is eco-friendly. It is also used to protect the plants from various soil borne diseases and to maintain soil fertility and enhance sustainable crop production in the degraded lands due to continuous and excessive use of chemical fertilizers and pesticides.

Keywords: Pressmud compost, soil health, microbes, soil fertility, crop productivity, carbon sequestration

Introduction

India stand as the second largest producer of sugar in the world after Brazil with 17 percent share in world production with an estimated production of around 354.95 million tons sugarcane in the marketing year 2014-15 along with at present nearly 704 sugar mills are running in the country with annual byproduct production about 8 million tons in the form of pressmud ^[1]. Pressmud as bio compost used to maintain soil fertility and enhance crop production because it is rich in sugar and contains appreciable amount of essential plant nutrients viz., organic carbon, nitrogen, phosphorus, potassium, calcium and magnesium along with traces of micronutrients viz., Zn, Fe, Cu and Mn ^[2], so the beneficial effect of this bio compost for enhancing the soil fertility and thereby improving the crop productivity is well established ^[3]. By applying this organic fertilizer, soil influenced due to continuous and excessive application of chemical pesticides are brought under control i.e. such lands can be made good by treating it with added phosphate solubilizing bacteria and decomposing fungi, which are eco-friendly so it nourishes plants and promotes plant growth, protect the plants from various soil borne diseases. The manufacturing of press mud is achieved by drying the residues to prevent any fungal or bacterial infection ^[4], thereby, pressmud is soft, spongy, amorphous and dark brown white material containing sugar, fiber, and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles ^[5]. A time when cost of chemical fertilizers is increasing day by day and not affordable by farmers, pressmud has promise as a most economic source of plant nutrient for sustainable crop production ^[6] and improvement in the physical (structure, texture, aeration, water-holding capacity, and porosity), chemical (pH, EC, CEC) and biological (microbial dynamics) properties of the composts amended soil ^[7-9]. Since the industrial era (1880), the amount of greenhouse gases viz; CO₂, nitrous oxide (N₂O), and methane (CH₄) significantly increases in the atmosphere (10), which rises the average surface temperature of Earth ^[10] and for this number of emission

sources are responsible among them one of the factor is undecomposed pressmud, a byproduct of sugar industry ^[11]. Carbon sequestration is the transferring of CO₂ into pools of C that can be stored for long periods of time ^[11-12], so, application of pressmud as an organic manure shows 150% increase in organic carbon after first application, as level of initial organic carbon in soil is very low and it has the potential to store more carbon and help in reducing the impact of global warming by releasing toxic gases in environment ^[13].

Pressmud compost

- The organic byproduct from sugar mills is called pressmud which is utilized to provide a nutrient rich, high quality organic matter when it apply to the soil as manure results in better sustainable yield. Pressmud is soft, spongy, amorphous and dark brown white material containing nitrogen, cellulose, lignin, protein, sugar fiber, and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles and all other carbon containing components available in the final product ^[6]



Fig 1: Pressmud compost

Nutrients of press mud compost

The composition varies significantly on the soil conditions, cane varieties, period of supply of cane and geographical variations ^[4].

No.	Nutrients	Ave amount/100g of press mud (%)
1	Organic compound	50
2	Calcium	11
3	Phosphorus	2-3
4	Potassium	1-2
5	Nitrogen	1.5-2.5
6	Magnesium	1
7	Sulphur	0.3
8	Cellulose	11.4
9	Hemi cellulose	10.0
10	Lignin	9.3
11	Protein	15.5
12	Wax	8.4

Microbial biomass of pressmud compost

Organic residues of appropriate quality and quantity act not only as sources of nutrients and organic matter but also may increase the size, biodiversity and activity of the microbial populations in soil ^[15, 16]. Diverse populations of soil bacteria, fungi, protozoa and algae play a crucial role in soil quality and sustainability ^[17]. Pressmud compost is rich in beneficial

which are suitable for bio-fuel and fertilizer production ^[4]. The application of 20 t/ha pressmud saved 25% of the recommended fertilizers and shows significant residual effects on the succeeding crops ^[14]. Contains 25-30% Organic matter. Contains Major plant nutrients like N, P, K, Ca, Mg & S and Minor elements like Fe, Zn, Mn, Cu, B & Mo. Saves the cost on inorganic fertilizers by 15-20%, Improves the structure, texture & quality of the soil, Improves the water holding capacity of the soil as this compost contains fibrous material like decomposed coir waste & other Agriculture biomass. Minimizes the water like requirement of the crop to some extent, Rich in Beneficial Microorganisms which aid in mineralization of plant nutrients in the soil and make them amenable to the plant roots, These microbes produce Enzymes, auxins and other growth Regulators, amino acids and many other organic acids which help in the proliferation of the Root hairs & Lateral roots of the Tap root/Fibrous root system and rectifies the micronutrient deficiency of the soil, increases the biomass yield of crop.

microorganism which aid in mineralization of plant nutrients in the soil with rectifies the micronutrient deficiency of the soil and makes them amenable to the plant roots. These microbes produces enzymes, auxins and other growth regulators, amino acids and many other organic acids which help in the proliferation of the root hairs & lateral roots of the tap root/fibrous root system and finally increases soil health and crop productivity in sustainable manner. Analytical report of press mud compost sample ^[18]

S. No.	Parameters	values
1	Total Bacterial count	3.6 X 10 ⁸ cfu/g
2	Total Fungal count	8.1 X 10 ⁵ cfu/g
3	Total Actinomycetes count	2.5 X 10 ⁵ cfu/g
4	Total Azotobacter sp. count	1.2 X 10 ⁴ cfu/g
5	Total Phosphate solubilizers	2.1 X 10 ⁴ cfu/g

Availability of pressmud in India

India is the largest producer of sugarcane in the world with most important industry to generate sugar for consumption, directly or indirect employment opportunities to poor's, income to growers and byproducts as organic fertilizer for agriculture fields to the substantially development of country's economy. At present time in the country about 704 sugar mills has established with estimated production up to 26

Mt sugar in 2015–16^[19], and annual by-product production is likely more than 8 Mt of pressmud (20). Government of India has seen to solve the problem of disposal of pressmud by encouraging the industries to set up composting units to manufacture good quality compost by using pressmud as raw material.

Effect of pressmud on soil properties

Physical properties

Regular additions of organic materials such as pressmud compost, municipal bio solids, animal manures and crop residues are of most important in maintaining the tilth, fertility and productivity of agricultural soils^[21]. Pressmud or filter cake is one of the important organic byproduct of sugar industry which capable of supplying sufficient amount of plant nutrients to soil, due to its favorable effects on soil texture, structure, water holding capacity, infiltration, soil porosity, hydraulic properties, bulk density of soil and can be linked to most of the fundamental soil properties^[22-24], however, these accompanied by improvements in soil aggregate stability^[25], and these physical environment of the soil ecosystem are critical for a healthy soil and sustainable agriculture. The higher amount of NPK in soil has made it a valuable nutrient resource, which is due to increased SOM by adding pressmud compost^[26]. Addition of pressmud improves soil aeration and drainage in heavy soils, whereas in sandy soils it helps in improving the retention of moisture. When added to agriculture fields it increased the cane yield, improved the juice quality and enhanced the ammonifying power of the soils^[27].

Chemical properties

Pressmud obtained from sulphitation process is acidic in nature and hence can be applied on alkaline soils whereas pressmud obtained from carbonation process contains lime which is useful in acidic soils^[28]. Thousands tons of press mud produced annually cause great disposal problems for the sugar industry and environmental however; recently it is being used as fertilizer in agriculture and for crop production^[29] to mitigate the environmental pollution and increased soil health. In pressmud there is large amount of organic matter, and abundant amount of important micronutrients such as Zn, Cu, Fe and Mn, therefore, press mud will more likely improve the micronutrient distribution and enhance beneficial microbial activities within soil system. Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is enhance the adsorbing power of the soils up to 90% with producing cations such as Ca^{2+} , Mg^{2+} and K^{+} during decomposition^[30]. Composted pressmud contain essential plant nutrients such as nitrogen (N), phosphorus (P) and a number of micronutrients in higher concentrations than in agricultural soils^[31], thus they have a demonstrable fertilizer value and have been used to replace or partially replace inorganic fertilizers to increase soil N^[32], available P and exchangeable potassium (K)^[33], calcium (Ca), and magnesium (Mg)^[34]. Continued decomposition of more stable organic N sources as pressmud compost, over a sustained period regulates the subsequent mineralization of available N in soil^[35] which is balanced by partial biological immobilization by soil microbes^[36] and this balance provides a residual source of N available for plant uptake. The CEC (capacity to retain and exchange cations) of soils is measured as the sum of exchangeable Ca, Mg, K, sodium (Na) and aluminium (Al) cations present per unit weight of soil, however; the level and balance of these ions are important

factors in structural stability, nutrient availability, pH and the soil reaction to fertilizers and other amendments^[37]. As the pressmud, it is rich in Potash and Phosphorus, use of composted material with Potash Mobilizing Bacteria (*Frateuria aurantia*) and Phosphate Solubilizing Bacteria increases the availability of K_2O and P_2O_5 in the wastes. This may be used later like other organic amendments.

Biological properties

Soil organic carbon is a complex and heterogeneous mixture of materials. These materials vary in their physical size, chemical composition and degree of interaction with soil minerals and extent of decomposition. An industrial waste like Pressmud is taken as fertilizer to increase organic carbon in soil, with an intention of utilizing the waste and building up organic carbon in the soil. Application of pressmud greatly increased bacterial and fungal population of soil^[38]. Enhancement in fungal, bacterial and actinomycetes populations by application of pressmud in agricultural soils mark their roles in decomposition of organic materials to release nutrients for plants growth and development. Furthermore, the higher C biomass and N contents in the soils treated with pressmud showed changes in soil organic matter content caused by microbial enzymatic activities. Pressmud application was responsible for a large increase in the number of non-sporeforming bacteria and various fungi including *Neurospora crassa*, *Trichoderma viride*, *Aspergillus sp.* and *Penicillium sp.* An increase in the spore forming fungi Bacillus and Actinomycetes, which have a positive influence on soil aggregate stability, was observed in the final stage during composting of pressmud^[39]. It is important to recognize that the best soil and crop management practices is to achieve a more sustainable agriculture through enhanced growth, numbers and activities of beneficial soil microorganism that, in turn, increase, yield and quality of crops^[40]. Pressmud compost does not include any substances which are unfavorable for microbial action. It also includes plant growth regulators, hormones, auxins, enzymes and vitamins resulting in improvement of soil aeration and better root proliferation^[41]. Microbial biomass is not only used as an indicator of soil quality, it is the main agent that also controls the cycling of important nutrient elements such as C, N, P, S and other nutrients in terrestrial ecosystems. Soil microorganisms play a vital role in soil environment. They are critical factors that determine soil organic matter decomposition, nutrients cycling, soil degradation and bioremediations of soil pollution^[41]. Shifts in the structure and composition of microbial community are strong indicators of soil biological activity, soil quality and crop productivity of terrestrial agro-system^[42]. Addition of pressmud organic manure under different moisture regimes brought out significant changes in microbial activity in terms of microbial population and dehydrogenase activity over control^[40]. Amongst the various treatments, application of press mud resulted in the highest microbial C and N, this might be due to the microbial activities long time storage duration^[43] and acted as an energy source for the autochthonous microorganisms of pressmud, which also significantly increased the microbial numbers (fungi, bacteria and actinomycetes) and total C and N contents in the soils^[44].

Effect of pressmud on sustainable crop production

Soil health is deteriorated because of low organic matter in our soils owing to reduced use of organic manures and rapid decomposition of organic materials as a result of increasing

high temperatures due to climate change and drier conditions as result of rapid deterioration of resource base and declining sustainability of agriculture. Thousands tones of pressmud, which is produced annually cause great disposal problems for the sugar industry and environmentalists. Recently, it is being used as organic fertilizer source in agriculture and for crop production (45-46 and 29). Sugar byproducts being organic in nature are rich source of macro and micronutrients and can be recycled to prevent their disposal in the environment, thus sustaining the balance between economic development and environmental protection^[47]. The application of press mud in agriculture field significantly improved the fertility status by enhancing soil C and N contents of soil. Lower C/N ratios in the amended soils indicated higher N mineralization by microbial activities^[48, 49] Reported that application of pressmud compost to agricultural fields is likely to improve soil health by adding macro and micronutrients and organic matter to soil ultimately crop productivity^[50]. Observed that the pressmud compost application increased the phosphorus use efficiency by wheat (20-48%) and greengram (12-90%) as compared to single super phosphate. It was also reported that the compost increased the quality of grains by increasing the protein and Ca contents. Pressmud applied to sugarcane along with N, P and K fertilizers significantly increased the yield of cane and also quality of rice^[51, 52] found that combined application of 5 tones of pressmud significantly increased sunflower seed yield, seed protein and oil contents as compared to without pressmud. Pressmud is added to fields as organic amendment, which enhances organic matter content of soil, improves soil physical conditions^[53] and also acts as a soil conditioner^[54]. The high amount of NPK contents has made it a valuable nutrient source^[55]. Along with luxurious amount of organic matter, important micronutrients like Zn, Cu, Fe and Mn are also abundant in pressmud compost, which are deficient in calcareous alkaline soils. Therefore, press mud is very efficient in improving the micronutrients distribution and enhancing microbial activities^[57]. Therefore, on the basis of its usefulness established by these investigations, it could be a very good organic fertilizer and soil ameliorating source for sustaining crops and soil productivity in changing climatic environments.

Pressmud as carbon sequester

Along with the international efforts it is necessary to carry out mitigation and adaptation programs at the local level to understand the dynamics of global warming and contribute to mitigating the climate change^[58]. Agriculture is a very diverse industry where a multitude of products are being cultivated and produced. Most of this burning result from household burning of materials, as a fuels source, field burning and release of greenhouse gases (GHGs) and black carbon (C) into the atmosphere^[12], because of no foreseen value^[59]. When these materials are burned, there is a loss of many beneficial things that could otherwise be used for beneficial purposes. Plus, there is the Since the times of the industrial revolution, there has been a significant increase in the amount of carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) and other GHGs found in the atmosphere^[10]. It is essential to ensure that the SOC that is being placed in the soil remains there and is not subjected to quick decomposition. The SOC that is being added to the soil can be comprised of many types of residues from plants, animals, and microbes^[60]. Positive amendments in agricultural practices can lead to a better soil carbon sequestration. Agricultural practices can help to increase the rate of soil

carbon sequestration is 89.41% in soil carbon levels after application of pressmud. Pressmud is a product which can be used as good organic manure when composted properly. The application of sugarcane pressmud is also at low cost with a slower release of nutrients and trace element, high water holding capacity and mulching properties^[61]. Application of pressmud as an organic manure shows 150% increase in organic carbon after first application, as level of initial organic carbon in soil is very low, i.e. 0.66% and it has the potential to store more carbon. During subsequent cropping season it shows the increase in organic carbon content by 36.36% and 30.67% respectively. After application of pressmud 3.5 times increase observed in level of organic carbon is achieved one time increase in level of organic carbon than the initial level after the use of pressmud as mulch. It proves that by adopting improved agricultural practices one can boost the rate of soil carbon sequestration and elucidate the role of organic matter in farming practices, not only for the betterment of soil, but also for mitigating climate change^[62].

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