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Effect of Application of Blended Granite Rock Dust with Solid and Liquid Organic Manures on Yield of Maize (*Zea mays* L.)

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Abstract

A field experiment was conducted to evaluate the effect of blended granite rock dust along with solid and liquid organic manures on yield of maize at Ramagiri, Holalkere Taluk, Chitradurga district, Karnataka, India. The characterization of granite rock dust, panchagavya, jeevamrutha and bio-enriched pressmud compost indicate that, the pH of panchagavya was 5.48, bio-enriched pressmud compost -7.10 and jeevumrutha recorded pH 8.01. Highest organic carbon, N, P, K, Ca, Mg and S contents were recorded in bio-enriched pressmud compost (41.58, 1.37, 2.41, 2.30, 3.83, 2.56 and 2.01 %, respectively) followed by panchagavya (0.92, 0.22, 0.88, 1.15, 0.51, 0.11 and 1.02 %, respectively) and jeevamrutha (0.08, 0.08, 0.53, 0.13, 0.51 and 1.24 %, respectively). Micronutrients *viz*., Fe, Mn and Zn were also higher in bio-enriched pressmud compost than panchagavya and jeevamrutha. Whereas, highest Cu content was recorded in panchagavya followed by bio-enriched pressmud compost and jeevamrutha. Similarly, highest bacteria, actinomycetes and fungi load were observed in case of bio-enriched pressmud compost (21 x 10^5, 15 x 10^4 and 17 x 10^3, respectively) followed by panchagavya and jeevamrutha. At the end significantly, higher kernel yield (87.63 q ha^{-1}) of maize was recorded in the treatment T_{11} which received 75 per cent K + Bio-enriched pressmud compost treated Rock dust @ 6 t ha^{-1} and followed by T_9 treatment (79.59 q ha^{-1}) than compared to the rest of the treatments and this shows the efficiency of bio-enriched pressmud compost and panchagavya in enhancing the nutrient release rate from granite rock dust than jeevamrutha, FYM and rock dust alone applications.

Keywords : Granite rock dust, Bio-enriched pressmud compost, Panchagavya, Jeevamrutha, FYM, Maize production

Rock dust is a pulverized stone, often produced as a by-product of the mining and crushing industries. It has the same mineralogical and elemental composition as that of parent rock. The commonly occurring nutrient elements are Ca, Mg, K, Fe *etc*. in large proportion and minor amounts of P, S, Zn, Cu *etc*. which are not in available form. The elements that are contained in the rock dust become available upon weathering. There are few but consistent reports on the use of multi-nutrient rock and mineral fertilizers in the organic and conventional production systems (Fyfe *et al.,* 2006).

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 (Ghulam *et al.,* 2012). Pressmud supplies a good amount of organic manure (Bokhtiar *et al*., 2001), used as an alternate source of plant nutrient, as a soil amelio rates (Razzaq, 2001) and also as one of the substrates in bio-composting (Chand *et al*., 2011). It contains significant amounts of iron, manganese, calcium, magnesium, silicon and phosphorus and enhanced the

suitability of SPM as a source of nutrient (Yadav and Solomon, 2006).

Panchagavya is one of the widely used traditional organic formulations, which is mostly prepared by farmers themselves. Panchagavya is a fermented product made from five ingredients obtained from cow, such as milk, urine, dung, curd and clarified butter (Amalraj *et al*., 2013). Panchagavya is a traditional formulation derived from gavya used in India to safeguard plants and soil microorganisms. Panchagavya has been shown to increase plant production and also has been shown to have beneficial effects on a variety of crops (Natarajan, 2002). Recently, higher number of cultivable bacterial genera was obtained from the organic formulation prepared using fermented cow manure (Giannattasio *et al*., 2013). In addition, few novel and plant growth-promoting bacteria such as *Larkinella bovis* and *Microbacterium suwonense* were isolated from traditional organic formulations and tested for their plant growth promotion (Anandham *et al*., 2011a).

Jeevamrutha is a plant growth-promoting substance containing beneficial microorganisms that provides the necessary nutritional requirement for growth and yield of a crop. The microorganisms that supply nitrogen like *Azotobacter, Acetobacter, Azospirillum* and phosphorus-solubilizing bacteria like *Pseudomonas* and potash-solubilizing bacteria like *Bacillus silicus* are present in dung that is used to prepare jeevamrutha. Microbial activities will be activated upon the addition of jeevamrutha which further maintains soil productivity (Vanaja *et al.,* 2009).

Now-a-days solid and liquid organic manures like, panchagavya, jeevamrutha and bio-enriched press mud composts are becoming popular to combat the adverse effect of chemical fertilizers. These can supply essential nutrients to the crop plant and also provide several growth promoters and bio-control agents to prevent disease and pest infestation. As such these organic manures can be prepared by using several farm inputs and daily household materials. The cost incurred in preparing these solid and liquid organic manures are very less comparing with the chemical fertilizers and pesticides. In view of the above, the current study focused on evaluating the effect of blended application of granite rock dust along with solid and liquid manures on yield of maize.

Material and Methods

Characterization of Rock Dust

Rock dust was collected from the nearby M-Sand industry and was characterized for particle size distribution, bulk density, particle density, maximum water holding capacity, pH, electrical conductivity, total phosphorus, potassium, calcium, magnesium, sulphur and micro nutrients (Fe, Mn, Zn and Cu) as per the standard protocols as given in Table 1.

The sample used in the experiment was granite rock dust obtained from local M-Sand manufacturing industry (Mavinahole Village, Channagiri Taluk, Davanagere District, Karnataka). Particle size class was determined by sieve method. A known weight (100 g) of dried rock dust sample was passed through sieves of different BSS mesh number (3, 8, 12, 16, 36, 72, 100 and 200) and the material retained on each sieve was collected, weighed and expressed in per cent. For nutrient analysis, finely ground 0.1g of rock dust was oven dried at 100 ^{0}C for 2 hours. Then digested by treating rock dust with perchloric acid and hydrofluoric acid in 1:10 ratio in silica crucibles till the acids get evaporated to dryness and diluted with 5ml of 6N HCl and made up to 2/3rd volume of silica crucible with deionized water. The crucibles were kept on hotplate till residues completely dissolved. The volume of the digested sample was made up to 100 ml with distilled water and used for total elemental analysis.

Preparation of Panchagavya, Jeevamrutha and Bio-Enriched Pressmud Compost

Preparation of Panchagavya

Ingredients : The cow by-products *viz*., cow dung (7kg), cow urine (3 liters), cow milk (2 liters), cow curd (2 liters) and cow ghee (1kg) were collected from Gir cow and jaggery (250g), banana (12

TABLE 1

Methods Followed for Analysis of Physico-Chemical and biological Properties of Rock dust Panchagavya, Jeevamrutha and Bio-Enriched Pressmud Compost

Parameters	Methods	Reference
	Physical properties	
Colour	Visual evaluation	-
Odour	Sensory evaluation	-
Bulk density (g/cc)	Keen Raczkowski Cup	Piper, 1966
Particle density (g/cc)	Keen Raczkowski Cup	Piper, 1966
MWHC (%)	Keen Raczkowski Cup	Piper, 1966
	Chemical properties	
pH (1:2.5)	pH meter method	Jackson (1973)
EC (dS m^{-1}) (1:2.5)	Conductivity meter method	Jackson (1973)
Organic carbon	Walkley and Black wet digetion	Walkley and Black (1934)
Total Nitrogen	Kjeldhal digestion and distillation method	Piper (1996)
Total Phosphorous	Vanado-molybdo phosphoric yellow colour method	Piper (1996)
Total Potassium	Flame photometry	Piper (1996)
Total Calcium	Complexometry using versenate solution	Piper (1996)
Total Magnesium	Complexometry using versenate solution	Piper (1996)
Total sulphur	Turbidometry	Bardsley and Lancaster (1965)
Total Micronutrients Fe, Mn, Zn, Cu	Atomic Absorption Spectrophotometry	Lindsay and Norwell (1978)
	Biological properties	
Bacteria	Nutrient Agar medium andSerial dilution technique	Waksman (1927)
Actinomycetes	Ken knight s Agar medium and Serial dilution technique	Waksman (1927)
Fungi	Martin s rose Bengal Agar and Serial dilution technique	Waksman (1927)

numbers), tender coconut (2 liters), yeast (100g) and water (10 liters) were used in the study.

Procedure : Firstly, cow dung and cow ghee were taken into a clean plastic container, mixed properly until the smell of cow dung decreases, due to the masking effect of ghee used and the mixture was kept undisturbed for 2 days by covering with the wet muslin cloth. Then cow urine and water were added and left the mixture for 15 days in a well-ventilated, clean and shady place covered with wet muslin cloth for proper aeration and also to avoid the interaction of external agents like mosquitoes or any other insects and animals. Then after 15 days, the remaining ingredients like, jaggery, milk, curd, coconut water, yeast and banana were added and the mixture was covered with wet muslin cloth for 21 days for maturation with proper stirring twice a day with the help of wooden stirrer in both the directions. After 21 days, the solution was ready for further usage (Chakraborty and Sarkar, 2019).

Preparation of Jeevamrutha

Ingredients : In this experiment all the by-products of cow were collected from gir cow. Water (200 litres), cow dung (10 kg), cow urine (10 litres), Jaggery (2 kg), pulse flour (2 kg) and soil collected from the experimental plot (500g).

Procedure : The cow by-products were mixed in a proper container and kept in a clean, well ventilated and under the shade by covering it with a wet muslin

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cloth. The mixture was stirred twice a day. After 21 days of maturation the product was ready for usage (Shankaran, 2009).

Enrichment Technique for Generation of Bio Enriched Pressmud

Sugarcane pressmud is the solid waste left over after the filtration of sugarcane juice and distillery spentwash is the liquid waste. Compost is obtained by composting pressmud and spentwash in the ratio 1:2.5 by wind-row method.

In the present experiment the pressmud compost (collected from Shri Chamundeswari Sugars *Ltd*., Bharathi Nagar, Maddur taluk, Mandya District, Karnataka) was enriched by mixing 2g of microbial culture from each pack containing *Bacillus megaterium, Pseudomonas fluorescens* and *Azotobacter chroococcum* were collected and mixed with kg of pressmud compost. The compost was mixed thoroughly and conditioned by sprinkling water twice a week to maintain the moisture content in the compost to 60-70 per cent. The compost was placed under shade, allowed for proliferation of microbial population for 10 days and then used for further experimental works.

Characterization of Panchagavya, Jeevamrutha and Bio-Enriched Pressmud Compost

The physical, chemical and biological properties of panchagavya, jeevamrutha and bio-enriched pressmud compost were analysed to estimate their constituents using standard procedures. The standard procedures followed for estimation of various properties of these solutions are given in Table 1.

Field Experiment to Study the Effect of Bio-Treated Granite Rock Dust on Yield of Maize

Field experiment was conducted at Ramagiri, Holalkere Thaluk, Chitradurga District, Karnataka, India during 2020 and 2021 with twelve treatments following randomized complete block design replicated thrice to assess the agricultural use efficiency of bio-treated rock dust using maize as a test crop. The granite rock dust collected from M-stand industry was treated with panchagavya or jeevamurtha, bio-enriched pressmud compost or farm yard manure in the ratio of 10:1:2, respectively (*i.e*., the treatments with liquid organic manure, for every 10 parts of rock dust, 1 part of panchagavya or jeevamrutha along with 2 parts of farm yard manure as a carbon source was added and for the treatments with solid organic manure, for every 10 parts of rock dust, 2 parts of bio-enriched pressmud compost was added). The bio-treated granite rock dust was cured for fifteen days and used for the experimental plots as per the treatments along with recommended dose of FYM which was applied fifteen days prior to sowing of maize. The recommended dose of fertilizers [150:75:40 (N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ ha^{-1} for irrigated condition] was applied at the time of sowing. Sowing of maize seeds (MAH-14-5) was done by dibbling method with a spacing of 60 cm between the rows and 30 cm between the plants. Finally, at the end after harvest kernel yield from each treatment was recorded.

Treatment details

Treatments	*Details*
T_1	Absolute control
T_2	100% RDK
T_3	75% RDK +Rock dust @ 6 t ha^{-1}
T_4	75% K + Rock dust @ 3 t ha^{-1}
T_5	50% K + Rock dust @ 6 t ha^{-1}
T_6	50% K + Rock dust @ 3 t ha^{-1}
T_7	75% K + Jeevamrutha treated Rock dust @ 6 t ha^{-1}
T_8	50% K + Jeevamrutha treated Rock dust @ 3 t ha^{-1}
T_9	75% K + Panchagavya treated Rock dust @ 6 t ha^{-1}
T_{10}	50% K + Panchagavya treated Rock dust @ 3 t ha^{-1}
T_{11}	75% K + Bio-enriched pressmud compost treated Rock dust @ 6 t ha^{-1}
T_{12}	50% K + Bio-enriched pressmud compost treated Rock dust @ 3 t ha^{-1}

Note : 100% RD-N, P and Zn is common for all the treatment except T_1,

- RD-FYM is used for all the treatments except T_1, T_{11} & T_{12}
- FYM- Farm Yard Manure, POP- Package of Practice.
- RDF- Recommended dose of fertilizers (150:75:40 (N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ ha^{-1} for irrigated condition) and FYM- 10 t ha^{-1}.

Results and Discussion

Rock dust used in the present investigation, a waste product generated in M-Sand producing industry. It is composed of many elements including nutrient elements that are naturally found in the rocks. The application of rock dust in crop production thus may improve the physical and chemical properties of soil. The elements contained in the rock dust are become available upon weathering. Use of this waste in agriculture not only supplies the nutrients but also solves the problem of its accumulation and causing damage to environment. In this regard, in order to evaluate the efficacy of rock dust in crop production, a field experiment was carried out to study the effect of application of blended granite rock dust with solid and liquid organic manures along with the recommended dose of fertilizers and farm yard manure on yield of maize. The results obtained and discussions in these results are presented in this chapter under following headings.

Characterization of Rock Dust

Particle size of the rock dust indicated that particles of > 2 mm size were 7.32 per cent and that of < 2 mm are 92.68 per cent. Out of 92.68 per cent of fine earth material, the highest particles were in the size range of 0.44 to 0.22 mm and particles which were passed through 0.08 mm were 17.86 per cent (Table 2). The size of the particle may varied from source to source.

Table 2

Particle size analysis of rock dust

BSS Mesh Number	Sieve size (mm)	Particles retained on sieve (%)
3	4.75	1.50
8	2.00	5.82
12	1.33	6.14
16	1.00	12.15
36	0.44	10.11
72	0.22	30.18
100	0.16	10.82
200	0.08	5.42
Per cent particles passed finally through last sieve		17.86

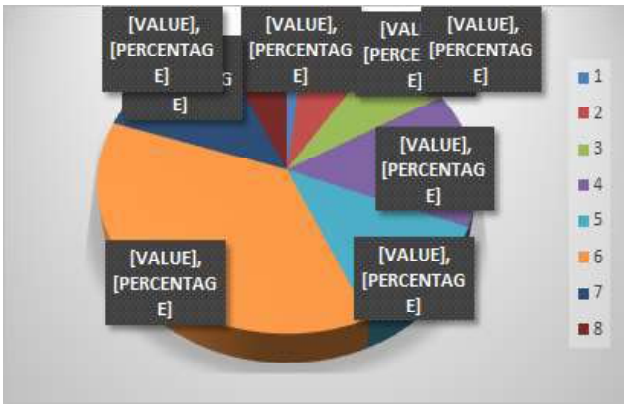

Fig. 1: Particle size classes of rock dust
Note: 1 to 8 which indicates BSS mesh number as presented in the Table 2

For instance, the particles which are obtained from mining sites are coarser in size, if it wass from polishing and M-Sand industries are finer in size (Hassan *et al*., 2013). The particle density of dust (2.09 g/cc) indicates that it is composed of light minerals. The bulk density of 1.52 g/cc indicates that it gets compacted upon settling. The MWHC and per cent porosity were 17.70 per cent and 27.1 per cent, respectively. The lower value of MWHC and porosity suggests that it is fine powder of rock fragments.

The results of the chemical analysis revealed that rock dust was neutral (7.20) in reaction with an electrical conductivity 0.41 dS m^{-1}. The total macronutrients *viz*., P, K, Ca, Mg and S contents were 1.01, 5.74, 8.40, 4.32 and 1.60 per cent, respectively and total micronutrients like Fe, Mn, Zn and Cu contents were 1365, 23, 25 and 67 mg kg^{-1}, respectively. Weerasuriya *et al*. (1993) reported that acidulated mica was a promising multi nutrient fertilizer due to its higher nutrient contents. Whereas, Hinsinger *et al*. (1996) reported similar elemental composition for granite and diorite rock powders which was collected from quarry units in Herne Hill, near Perth (Western Australia).

Characterization of Solid and Liquid Organic Manures

The physical and chemical properties of Panchagavya, Jeevumrutha and bio-enriched pressmud compost are presented in Table 4.

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TABLE 3
Physical and chemical properties of rock dust

Parameters	Value
Physical properties	
MWHC (%)	17.70
P.D (g/cc)	2.09
B.D (g/cc)	1.52
Particle size < 0.08mm in (%)	17.86
Chemical properties	
pH (1:2.5)	7.20
EC (dS m^{-1}) (1:2.5)	0.41
Total phosphorous (%)	1.01
Total potassium (%)	5.74
Total Calcium (%)	8.40
Total Magnesium (%)	4.32
Total Sulphur (%)	1.60
Total Fe (ppm)	1365
Total Mn (ppm)	23
Total Zn (ppm)	25
Total Cu (ppm)	67

The colour of freshly prepared panchagavya was light brown and as the storage period increased the colour turned to darker. It might be due to series of non-enzymatic Maillard's reactions (the reaction between reducing sugars and proteins by the impact of heat), started with the binding of aldehyde group of lactose with ε-amino group of the lysyl - residues (amino-acid radical or residue of amino-acid lysine) from different milk proteins during storage. These reactions will occur due to the formation of pigments responsible for brown-colour, such as pyralysins and melanoidins, polymers such as lacto-lysine of fructose-lysine, as well as due to low-molecular weight organic acids (LMWOAs). The use of cow dung and cow urine enhanced the rate of decomposition with the increment in heat and for that dark brown colour was developed (Kneifel *et al*., 1992; Singh *et al*., 1992).

Freshly prepared Panchagavya possessed a fruity smell. Foul odour was observed after 20 days and progressed up to the end of storage. The reason behind this might be the light sensitiveness of riboflavin which absorbed visible and ultra violet light, converting that energy into highly reactive forms of oxygen. That induced a whole series of oxidative reactions, caused oxidation of fat (Min & Biswas, 2002 and Borle *et al.,* 2001).

The colour of freshly prepared jeevamrutha was moderate green and it turned to darker 20 days after maturation and this is mainly due to the presence of jaggery. Presence of jaggery along with water promoted the growth of microbes and that enhanced the decomposition of applied cow dung in it. Due to that dark green colour and mild foul odour was produced (Ravindra *et al.,* 2016).

In case of solid organic manures like, FYM, Pressmud compost and bio enriched pressmud compost physical parameters like bulk density (BD) and maximum water holding capacity (MWHC) were analysed. The BD values of FYM, pressmud compost and bio enriched pressmud compost was 0.70, 1.04 and 1.08 Mg m^{-3}, respectively. Lower values of BD can be attributed due to porous nature of the manure and greater organic matter content which decreases BD (Rose, 1991; Tompe and More, 1996). The MWHC values of FYM, pressmud compost and bio-enriched pressmud compost was 39.01, 60.21 and 63.35 per cent, respectively. The reason for greater MWHC can be correlated to the smaller surface area of the particles and greater number of micropores which could retain more water on the surface (Rose, 1991; Tompe and More, 1996).

Among the organic manures, the highest pH was recorded by Jeevumrutha (8.01) compared to Panchagavya (5.48). Whereas, the highest EC (10.14 dS/m) and organic carbon (0.921%) contents were recorded in Panchagavya compared to jeevamrutha (1.22 dS/m and 0.082%, respectively) (Table, 4). Pathak and Ram (2013) also found low pH in Panchagavya due to production of several organic acids in it during fermentation. Alcohol (methanol, propanol, butanol and ethanol) production in Jeevumrutha as a by-product of fermentation made it alkaline in nature (Natarajan, 2008).

The highest content of N, P and K (0.22, 0.88 and 1.15%, respectively) were recorded in Panchagavya compared to jeevamrutha (0.084, 0.532 and 0.133%, respectively). There were no differences in calcium content in both panchagavya (0.512%) and jeevamrutha (0.512%), but magnesium and sulphur contents were recorded higher in jeevamrutha (0.153 and 1.022%, respectively) than panchagavya (0.115 and 1.242%, respectively). The micronutrient like, iron, manganese, zinc and copper content were higher in panchagavya (205.80, 7.80, 47.00 and 18.40 ppm, respectively) than jeevamrutha (85.2, 4.6, 4.6 and 14.2 ppm, respectively) (Table, 4). Dhanoji *et al.,* (2018) and Parvathi and Ushakumari (2017) also recorded higher macro and micro nutrient contents in Panchagavya.

All the solid organic manures like, FYM, pressmud compost and bio-enriched pressmud compost were neutral in reaction and recorded pH 7.40, 7.10 and 7.10, respectively, electrical conductivity recorded was 2.40, 2.80 and 2.52 dS m^{-1} and total OC content registered was 17.83, 35.08 and 41.58 per cent, respectively. Similarly, lower organic carbon content in FYM (16.39 ± 1.12) was reported by Zubair *et al*. (2012) and higher organic carbon content (44.07 %) was recorded in pressmud biocompost, made of pressmud and spentwash blending (Prabhavathi and Parama, 2019). The nitrogen content in FYM, pressmud compost and bio-enriched pressmud compost were recorded 0.60, 1.26 and 1.37 per cent, respectively (Table, 4). Similar results were also obtained by Gaur and Singh (1993) wherein 27 per cent increase in nitrogen content, when mechanized compost inoculated with *Azotobacter* and rock phosphate. It was also evident from the experiments of Kapoor *et al*. (1983) that *Azotobacter* inoculation helps in increasing the N content of compost.

The total phosphorus content of FYM, pressmud compost and bio-enriched pressmud compost was 0.56, 1.92 and 2.41 per cent, respectively. The results are evident from Gaur and Singh (1993) who reported that the available P_2O_5 content of city compost was increased by 60-114 per cent where rock phosphate was applied and inoculated with *Aspergillus awamori*. Total potassium values recorded 0.64, 2.00 and 2.30 per cent, respectively. Bio-enrichment of pressmud compost with plant growth promoting rhizobacteria increased the available P and K contents and could act as an efficient biofertilizer (Patil *et al.,* 2013).

Secondary nutrients *i.e.* calcium, magnesium and sulphur content in FYM, pressmud compost and bio enriched pressmud compost) were 1.07, 3.66 and 3.83 per cent, 0.52, 1.60 and 2.56 per cent and 0.08, 1.93 and 2.00 per cent, respectively. The enriched compost (Meena and Biswas, 2015) prepared by using rock phosphate mixed with rice straw and *Aspergillus awamori*, showed the similar increment with respect to secondary nutrients content (0.610 per cent S, 2.830 per cent Ca, 1.990 per cent Mg).

The total iron (Fe) content in FYM, pressmud compost and bio-enriched pressmud compost was 930.00, 1150.20 and 1258.00 mg kg^{-1}, respectively and manganese (Mn) content recorded 89.80, 137.20 and 171.00 mg kg^{-1}, respectively. The total zinc (Zn) in FYM, pressmud compost and bio- enriched pressmud compost recorded was 20.20, 22.80 and 29.00 mg kg^{-1}, respectively. While total copper (Cu) content recorded was 22.60, 24.80 and 32.20 mg kg^{-1}, respectively (Table, 4). There was an increase in trend in nutrient content with bio-enriched pressmud compost and similar results were also recorded by Korai *et al.* (2014).

The microbial population of panchagavya, jeevumrutha and bio-enriched pressmud compost are given in Table 5. Higher bacterial count was noticed in bio-enriched pressmud compost (21 x 10^5) followed by panchagavya (18 x 10^5) and jeevamrutha (10 x 10^5). Highest fungi count was also recorded in bio-enriched pressmud compost (15 x 10^4) followed by panchagavya (11 x 10^4) and jeevamrutha (3 X 10^4). Similarly highest value of actinomycetes was found in bio-enriched pressmud compost (17 x 10^3) followed by panchagavya (15 x 10^3) and jeevamrutha (8 x 10^3). This confirmed that, there is increase in microbial load in compost with bio-enrichment and the results can be evident from Zayed and Motaal (2005) used together the *Aspergillus niger* and *Trichoderma*

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TABLE 5

Biological properties of panchagavya, jeevamrutha and bio-enriched pressmud compost

Parameters	Panchagavya	Jeevamrutha	FYM	Pressmud compost	Bio-enriched pressmud compost
Bacteria (CFU x 10^5 ml^{-1} of sample)	18 x 10^5	10 x 10^5	8 x 10^5	12 x 10^5	21 x 10^5
Actinomycetes (CFU x 10^4 ml^{-1} of sample)	11 x 10^4	3 x 10^4	3 x 10^4	5 x 10^4	15 x 10^4
Fungi (CFU x 10^3 ml^{-1} of sample)	15 x 10^3	8 x 10^3	6 x 10^3	11 x 10^3	17 x 10^3

viride strains as a fungal activator in the presence or absence of FYM for composting of bagasse enriched with rock phosphate. Kapoor *et al.* (1983) were also noticed that there was a 3 to 6 fold increase in the *Azotobacter* population in 3 weeks after inoculation of normal compost and also indicated that the inoculation of *Azotobacter* can be done only after composting process because, it does not have the ability to survive in the high temperature prevailing during composting. At the end of 49 days after composting, the matured biocompost (Rahman *et al*., 2012) was deep black in color with pH of 6.47, increase in bacterial count (242.0 x 10^6 cfu g^{-1}), moisture content (22.16 per cent), total carbon (25.00 per cent) which confirms the efficiency and value addition by bio-enrichment of compost. Similar results of increase in microbial load by using panchagava and jeevamrutha were also observed by Devakumar *et al*. (2018) and Kambar *et al*. (2016).

Kernel Yield

Data on the kernel yield of maize is presented in Table 6. The variability in kernel yield was observed in the first season (2020-2021), second season (2021-2022) and in pooled data.

In the first season, significantly higher kernel yield of 86.77 q ha^{-1} was recorded in the treatment with the application of 75 per cent RDK + Bio-enriched pressmud compost treated Rock dust @ 6 t ha^{-1} (T_{11}) compared to the other treatments and second highest kernel yield (78.81 q ha^{-1}) was recorded in the treatment T_9 (75% K + Panchagavya treated Rock dust @ 6 t ha^{-1}). However, it was on par with the treatment T_{12} (76.55 q ha^{-1}) and T_{10} (73.13 q ha^{-1}). Treatment which received jeevamrutha treated rock dust (T_7) recorded kernel yield of 67.06 q ha^{-1} which was on par with the treatment T_8 (64.85 q ha^{-1}), T_2 (64.85 q ha^{-1}), T_3 (64.07 q ha^{-1}) and T_5 (62.34 q ha^{-1}), but in the treatments with rock dust application @ 3 t ha^{-1} along with FYM (T_4 and T_6) recorded significantly higher values of kernel yield (57.09 and 54.83 q ha^{-1}, respectively) compared to the control treatment T_1 (46.79 q ha^{-1}).

Significantly higher yield (88.49 q ha^{-1}) was recorded in the treatment with the application of 75 per cent RDK + Bio-enriched pressmud compost treated Rock dust @ 6 t ha^{-1} (T_{11}) than compared to the other treatments and second highest kernel yield (80.37 q ha^{-1}) was recorded in the treatment T_9 (75% K + Panchagavya treated Rock dust @ 6 t ha^{-1}) and was on par with the treatment T_{12} (78.09 q ha^{-1}) and T_{10} (76.21 q ha^{-1}). In case of jeevamrutha treated rock dust treatment (T_7) recorded kernel yield of 70.72 q ha^{-1} and was on par with the treatment T_8 (67.63 q ha^{-1}), T_2 (66.56 q ha^{-1}), T_3 (66.72 q ha^{-1}) and T_5 (65.00 q ha^{-1}). Treatments with rock dust application @ 3 t ha^{-1} along with FYM (T_4 and T_6) recorded significantly higher values of kernel yield (57.92 and 53.94 q ha^{-1}, respectively) than compared to the absolute control T_1 (44.76 q ha^{-1}).

The significant increase in kernel yield of maize with the application of 75 per cnt RDK + Bio-enriched pressmud compost treated Rock dust @

TABLE 6

Effect of blended granite rock dust along with liquid and solid organic manures on kernel yield of maize

Treatments	Kernel yield (q ha^{-1})		
	2020-2021	2021-2022	Pooled mean
T_1	46.79	44.76	45.78
T_2	64.58	66.56	65.57
T_3	64.07	66.72	65.39
T_4	57.09	57.92	57.51
T_5	62.34	65.00	63.67
T_6	54.83	53.94	54.39
T_7	67.06	70.72	68.89
T_8	64.85	67.63	66.24
T_9	78.81	80.37	79.59
T_{10}	73.13	76.21	74.67
T_{11}	86.77	88.49	87.63
T_{12}	76.75	78.09	77.08
SEm±	2.16	2.22	2.08
CD @ 5%	6.35	6.51	6.10

Treatments Details

T_1 - Absolute control	T_7 - 75% K + Jeevamrutha treated Rock dust @ 6 t ha^{-1}
T_2 - 100% RDK	T_8 - 50% K + Jeevamrutha treated Rock dust @ 3 t ha^{-1}
T_3 - 75% RDK +Rock dust @ 6 t ha^{-1}	T_9 - 75% K + Panchagavya treated Rock dust @ 6 t ha^{-1}
T_4 - 75% K + Rock dust @ 3 t ha^{-1}	T_{10} - 50% K + Panchagavya treated Rock dust @ 3 t ha^{-1}
T_5 - 50% K + Rock dust @ 6 t ha^{-1}	T_{11} - 75% K + Bio-enriched pressmud compost treated Rock dust @ 6 t ha^{-1}
T_6 - 50% K + Rock dust @ 3 t ha^{-1}	T_{12} - 50% K + Bio-enriched pressmud compost treated Rock dust @ 3 t ha^{-1}

Note: 100% RD-N, P and Zn is common for all the treatment except T_1.

* RD-FYM is used for all the treatments except T_1, T_{11} and T_{12} *FYM- Farm Yard Manure, POP- Package of Practice.

* RDF- Recommended dose of fertilizers (150:75:40 (N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ ha^{-1} for irrigated condition) and FYM- 10 t ha^{-1}.

6 t ha^{-1} may be attributed to improvement in availability of nutrients as consequence of release of nutrients from the added granite rock dust might have influenced the growth and yield of maize. The nutrient element contained in the rock dust is made available slowly upon dissolution of minerals as it is applied with organic manures besides the organic acids that are released by roots caused the dissolution (Barker *et al*., 1998) and thus releasing the nutrients in slow and sustained manner that has helped in getting higher yield in maize. The increase in yield of maize might also be attributed to the supply of readily soluble form of nutrients supplied through urea, SSP and MOP and slow releasing source, rock dust. These findings are in line with those reported by Chathurika *et al*. (2015).

Application of granite rock dust blended with solid and liquid organic manures enhances the mineral dissolution rate through their specialized mechanisms *viz*., production of organic acids, lowering soil pH, acidolysis, chelation, metal complexing ligands and bio-film formation. The study indicated that effective blending of granite rock dust with locally available and prepared organic amendments like bio-enriched pressmud compost, panchagavya and jeevamrutha

could be a potential source of available nutrients for plant growth and development for achieving a better yield and the study also confirmed that granite rock dust, a waste product generated at M-sand manufacturing industries can be effectively used in agriculture with eco-friendly manner.

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