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Response of paper mill sludge and press mud as soil ameliorants on productivity and nutrient uptake in groundnut (*Arachis hypogaea* L.) under mid central table land zone of Odisha

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Abstract
The field experiment was carried out at Regional Research and Technology Transfer Station (OUAT), Mahisapat of Dhenkanal district during *kharif* season of 2016 and 2017 to study the response of press mud as soil ameliorant on productivity of groundnut under Mid Central Tale Land zone of Odisha. The experiment was laid out in a randomized block design with four replications comprising of six treatments T_1-Soil Test Dose (STD), T_2-STD+FYM @ 5 t ha^{-1} , T_3-STD + PMS 0.2 LR, T_4-STD + PMS 0.2 LR + FYM @5 t ha^{-1}, T_5-STD+ Press mud 0.2 LR, T_6- STD +Press mud 0.2 LR +FYM @)5 t ha^{-1}. It was revealed that T_4 recorded significantly higher pod yield (19.45 q ha^{-1}), 100 kernel weight (37.08 g) and shelling percent (67.33) followed by T_3 with pod yield (17.58 q ha^{-1}), 100 kernel weight (36.88 g) and shelling percent (67.18). T_4 was superior over T_1 with the yield advantage of 41.4% and B: C (2.26). The same treatment recorded higher uptake of N, P and K with 111.5, 12.22 and 106.25 kg ha^{-1}, respectively.

Keywords: Groundnut, FYM, paper mill sludge (PMS), press mud (PM), pod yield

Introduction
Groundnut or peanut (*Arachis hypogaea* L.) known as 'King' of oil seed (Sathya Priya *et al*., 2013) [14] is a major rain fed crop. Groundnut oil is edible and finds extensive use as a cooking medium both as refined oil and vegetable ghee. They are rich in protein and vitamins A, B and some members of B_2 group. Their calorific value is 349 per 100 gram seed. It has established its importance as a food, fodder and cash crop for the farmers of India. It finds significant place as a rotation crop in Indian Agriculture. Being a legume with root nodules, it can synthesize atmospheric nitrogen and therefore improve soil fertility. The residual oilcake contains 7-8% N, 1.5% P_2O_5 and 1.2% K_2O and is used as an organic fertilizer. It is also used for manufacturing artificial fiber. It is an important protein supplement in cattle and poultry rations. The haulms (plant stalks) are fed (green, dried or silage) to livestock.

In Odisha, ground nut is grown in an area of 2.67 lakh ha with a production of 4.78 MT and productivity of 1787 kg ha^{-1}. Productivity of groundnut on acid soils is low (850 kg ha^{-1}) due to low pH, cation exchange capacity and available nutrients. Due to the acidic soil reaction the production and productivity of ground nut is decreasing year after year. Acidic soil (pH < 6.5) adversely affects plant growth by restricting availability of P, Ca, Mg, Mo, B and Zn, reducing microbial activity and creating toxicity of Fe and Mn (Sumner and Noble, 2003) [15]. So proper soil amelioration can enhance the yield of the crop by improving the soil parameters.

The maintenance and management of these acid soils are important to obtain higher and sustainable productivity resulting in higher resource use efficiency. (Bolan *et al*., 2003; Brown *et al*., 2008; Caires *et al*., 2008) [1, 2, 3]. Limestone is the most common liming material used to ameliorate acid soils. However, small and marginal farmers of Odisha cannot afford to purchase lime (as pure $CaCO_3$ or $MgCO_3$) because of its high cost. Alternative cheap sources of liming materials like paper mill sludge (PMS) as bi-products of paper mill that contains $CaCO_3$ can be used (Torkashvand *et al.*, 2010; Kar *et al*., 2010) [11, 16, 7] but the quantity of required PMS depends on the paper manufacturing processes, soil type, crop species and cultivars (Noble and Hurney, 2000; Caires *et al.*, 2005) [10, 3].

Similarly, Sugar industries are the most important agro-based industries in India which contribute substantially to the economic development of the country. 579 sugar industries in the country produce 19.0 million tons of white sugar with cane crushing capacity varying from 800 to 10,000 tons per day. Apart from the sugar, these sugar industries discharge a large amount of by-products and waste materials with tremendous pollution load. The annual byproduct production from these industries is to the tune of 7 million tons of press mud, 7.5 million tons of molasses and 45 million tons of bagasse. Molasses is utilized in the distillery for the production of alcohol (Murthy and Chaudhari, 2009) [12]. Press mud, a waste product from sugar mill is yet another source for nutrients which can be utilized for soil amelioration. .

Materials and Methods

A field experiment was conducted at Regional Research and Technology Transfer Station situated at Mahisapat of Dhenkanal district in Mid Central Table Land Zone of Odisha under Odisha University of Agriculture and Technology during *kharif* season of 2016 & 2017. The farm is located in the geographical parallels between 20^0-3'and 21^0-16' North latitudes and 84^0 and 86^0-6' East longitude. The important soil groups of the zone are alluvial (Entisol), black (Vertisol), red-laterite (Alfisol) and lateritic (Oxisol). The soil of experimental site was red, sandy loam in texture & acidic in reaction (pH=5.58) with available N (240 kg ha^{-1}), available P_2O_5 (13.5 kg ha^{-1}) & available K_2O (170 kg ha^{-1}). The experiment was laid out in RBD with six treatments and four replications. The ground nut seed Var. Devi was sown with seed rate of 150 kg ha^{-1} with a row spacing of 30 cm. The intra-row spacing of 10 cm was maintained by thinning operation. The thinning & weeding operations were carried out on 15 & 21 days after sowing. The soil test dose (30:40:40 N P_2O_5 K_2O kg ha^{-1}) was applied to the crop as per treatment. Full dose of P, K & ½ N in form of DAP, MOP & Urea, respectively were applied as basal and rest ½ N after three weeks of sowing. The crop was harvested at physiological maturity. Data on growth parameters (No. of branches/plant and plant height) were taken just before harvesting and the yield parameters such as no. of pods/plant, 100 Kernel wt. (g), % shelling**,** gross yield per plot (kg) and hectare were recorded from the sample plants just after harvesting. Five plants were randomly selected for this purpose from each plot in such a way so that border effect could be avoided. Initial and post-harvest soil samples were collected following the procedure. The composite soil samples were collected treatment wise after harvest and analyzed as per the standard procedure. The plant samples were analyzed for the major nutrients by the standard methods (Chopra *et al*., 1978) [5]. The statistical analysis was done as per the procedure given by Gomez and Gomez, 1984 [6].

Composition of Paper mill sludge: Composition of Press mud:

Neutralizing value	: 60%
Neutralizing value	: 30%
Calcium content	: 25%
Calcium content	: 5%
Magnesium content	: 14%
Magnesium content	: 4%

Results and Discussion

Table 1: Yield and yield attributing characters of groundnut (cv. Devi) as influenced by application of PMS and Press mud

Tr. No	Treatment	No of branches/ plant	Plant height (cm)	No of pods/ plant	100 Kernel wt. (g)	% shelling	Pod Yield (qha^{-1})	% Increase in Yield	B:C
T_1	Soil Test Dose (STD)	5.00	27.13	15.37	36.18	61.13	13.75	-	1.71
T_2	STD+FYM @5 t/ha	5.55	29.58	16.92	36.70	62.25	14.55	6.0	1.65
T_3	STD + PMS @ 0.2 LR	6.60	33.85	21.15	36.88	67.18	17.58	28.0	2.17
T_4	STD+PMS @ 0.2 LR+FYM @5 t/ha	7.15	36.88	22.63	37.08	67.33	19.45	41.4	2.26
T_5	STD+ Press mud @0.2LR	6.00	30.78	18.40	36.40	65.58	16.08	17.0	1.80
T_6	STD+ Press mud @0.2LR +FYM @5 t/ha	6.25	32.60	19.95	37.00	65.78	16.28	18.4	1.89
S.Em(±)		0.10	0.18	0.22	0.29	0.38	0.18	-	-
CD (P=0.05)		0.28	0.54	0.67	0.87	1.13	0.55	-	-

Growth and Yield attributes

T_4 (STD+ PMS @ 0.2 LR+ FYM @ 5 t ha^{-1}) recorded higher plant height (36.88 cm), number of branches per plant (7.15) and number of pods per plant (22.63) followed by T_3 (STD + PMS 0.2 LR) with 33.85 cm, 6.60 nos. and 21.15 nos., respectively. The cumulative effect of paper mill sludge @ 0.2 LR along with FYM @ 5 t ha^{-1} and STD in T_4 might have contributed towards favourable impact in reducing soil acidity and thereby making better availability and uptake of plant nutrients by the crop reflected as increased plant height and other growth parameters (Table -1). This result has been in conformity with Kausale *et al.*, 2009 [8].

Yield

T_4 (STD+ PMS @ 0.2 LR+ FYM @ 5 t ha^{-1}) recorded significantly higher pod yield (19.45 q ha^{-1}) with a yield advantage of 11% over T_3 (STD + PMS 0.2 LR). The combined effect of STD and soil ameliorant (PMS or Press mud) performed better as compared to STD alone. T_4 (STD+ PMS @ 0.2 LR+ FYM @ 5 t ha^{-1}) and T_6 (STD+ Press mud @ 0.2 LR+ FYM @ 5 t ha^{-1}) recorded higher yield advantage of 41.4 and 18.4 per cent over T_1 (STD), respectively. Similarly T_4 was superior over the treatments with higher % shelling (67.33) and 100 kernel weight (37.08g). The application of soil ameliorant accompanied by FYM @ 5 t ha^{-1} indicated the yield advantage of 8.2 to 11 per cent along with higher yield attributing characters over the treatments without FYM. Application of FYM @ 10 to 15 t ha^{-1} increased the pod and haulm yields and improved the yield parameters like shelling percentage compared to the recommended dose of fertilizers (Subrahmaniyan *et. al.*, 2000) [13].

Economics

The highest B:C (2.26) was obtained from T_4 (STD+PMS @ 0.2 LR + FYM @ 5 t ha^{-1}) followed by T_3 (STD+PMS @ 0.2 LR) with B:C value of 2.17. However, the lowest B:C was indicated under the treatment only with STD (1.71).

Effect on Chemical properties of Soil

Table 2: Effect of PMS and Press mud on soil chemical properties

Treatments	pH	Org. C (%)	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})
Soil Test Dose (STD)	5.35	0.56	242.6	14.4	176.8
STD+FYM@5 t/ha	5.57	0.68	250.2	15.8	183.9
STD + PMS @ 0.2 LR	6.3	0.65	258.4	15.6	184.3
STD +PMS@ 0.2 LR+FYM@5 t/ha	6.5	0.72	262.5	16.8	190.5
STD +Pressmud@0.2LR	5.8	0.62	252.3	15.2	182.5
STD +Pressmud@0.2LR +FYM@5 t/ha	6.0	0.67	255.7	15.5	184.8
Initial soil properties	5.58	0.60	240.0	13.5	170.0

Change in soil chemical properties

Application of PMS @ 0.2 LR along with STD and FYM @5 t ha^{-1} increased the pH of soil from 5.58 (initial value) to 6.5. Similarly the organic matter content of the soil was increased from the initial soil status of 0.60 to 0.72%. The Available Nitrogen content (kg ha^{-1}) in the postharvest soil varies from 242.6 to 262.5 kg ha^{-1}. The increase in available N might be due to the accelerate rate of mineralization and decomposition of organic matter resulting from increase in biological activity of the soil. The result indicated higher available Phosphorus content (kg ha^{-1}) in STD +PMS@ 0.2 LR+FYM@5 t ha^{-1} of 16.8 kg ha-^{1} than initial soil status of 13.5 kg ha^{-1}. The improvement in availability might be due to dissociation of Fe and Al phosphate complexes present in the acid soils. The available potassium content (kg ha-1) varied from 176.8 kg ha^{-1}to 190.5 kg ha-^{1} and a higher value was obtained in the application of STD +PMS @ 0.2 LR+FYM@5 t ha^{-1}. The increased in the potassium availability might be due to release of K from non-exchangeable fractions to available form (Chatterjee *et al*, 2005) [4].

Table 3: Effect of PMS and Press mud on total uptake of nutrient

Tr. No	Treatment	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	Soil Test Dose (STD)	64.25	6.97	76.75
T_2	STD+FYM @5 t ha^{-1}	74.00	7.92	84.75
T_3	STD + PMS @ 0.2 LR	102.00	10.87	101.25
T_4	STD+PMS @ 0.2 LR+FYM @5 t ha^{-1}	111.50	12.22	106.25
T_5	STD+ Press mud @0.2LR	83.75	9.45	87.50
T_6	STD+ Press mud @0.2LR +FYM @5 t ha^{-1}	91.25	10.17	96.25
S.Em (±)		1.58	0.21	1.59
CD (P=0.05)		4.74	0.62	4.78

Nutrient Uptake

Application of different sources of lime like PMS and Press mud enhanced nutrient uptake by ground nut crop (Table - 3). T_4 (STD+ PMS @ 0.2 LR+ FYM @ 5 t ha^{-1}) recorded higher uptake of N, P and K with 111.5, 12.22 and 106.25 kg ha^{-1}, respectively. The treatment STD +Press mud @ 0.2 LR + FYM @ 5 t ha^{-1} also recorded N, P, K uptake to the tune of 91.25, 10.17 and 96.25 kg ha^{-1}, respectively. The maximum uptake was found in the treatments where FYM was applied along with other liming materials. Further the increased uptake of nutrients found in ground nut crop was attributed by their availability in lime amended soil (Torkashvand *et al*, 2010) [11, 16].

Conclusion

From the present investigation it was concluded that STD+ PMS @ 0.2 LR+ FYM @ 5 t ha^{-1} recorded the higher pod yield of 19.45 q ha^{-1} and B:C of 2.26 with yield advantage of 41% over STD. The soil properties also improved in the same treatment with decrease in soil acidity. PMS was superior to press mud in enhancing the yield by reducing the soil acidity. The same treatment recorded higher uptake of N, P and K with 111.5, 12.22 and 106.25 kg ha^{-1}, respectively

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