Growth and yield of *Zea mays* in sulphitation pressmud, its compost, vermicompost and NPK

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Abstract : A study was carried out to evaluate the impact of raw sulphitation pressmud, its compost, vermicompost and recommended dose of NPK on growth and yield attributing parameters of *Zea mays* . It was observed that application of raw pressmud, its compost, vermicompost and NPK had decrease the temperature and water holding capacity but significantly increases moisture content, organic matter, and N,P,K and narrows down C:N ratio. Recommended dose of NPK also has same impact except organic matter. The application of composted pressmud raised the dry matter (gm/plant) of the maize significantly to 157 gm/plant, which was highest among all other treatments. Similarly the grain yield was observed maximum in composted pressmud treated soil (4135 Kg/ha). But the biological yield and the stover yield were highest in the soil treated with vermicompost (10890Kg/ha and 6811 Kg/ha respectively). However, the grain: stover ratio and harvest index was recorded maximum in NPK treatment (0.646Kg/ha and 39.28% respectively). The results of this study are in agreement with those various other studies, which have also revealed the importance of organic nutrient sources in improving crop yields.
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1.Introduction.

Certain organic wastes generated by agro-industries may or may not have any economic importance. A proper use of such agro-industrial wastes can be exploits to restore the productivity of the soil if recycled through agriculture besides maintaining healthy environment. Composting is one of the method of utilization of organic waste to produce manure, rich in plant nutrients. The role of earthworms in improving soil fertility is also well known. Many studies have been done on vermicomposting of animal excreta, sewage sludge and agro-industrial wastes (Butt, 1993, Mitchell, 1997 and Edwards, 1998). Pressmud is an organic by-product generated by sugar industries. It is soft, amorphous and whitish-brown material with high temperature and wax content which limits its direct use in the fields. Composting and vermicomposting could be an alternative to promote its use in agriculture. The present study was conducted to evaluate the impact of sulphitation pressmud, its compost prepared by using thermophilic bacteria, vermicompost prepared by using *Eisenia foetida* and NPK on growth and yield of *Zea mays*. The changes in physico-chemical properties of the soil with the application of pressmud, compost, vermicompost and NPK were also evaluated.

2. Methods

2.1 Preparation of compost from sulphidation pressmud-

The sulphitation pressmud was collected from Bidvi sugar mill, Saharanpur. It was composted by using bacterial inoculant, which was procured from VSI , Pune. The aerobic composting was done for a time period of 60 days in wooden windrows after which dark colored, fine particulate compost was obtained. The partial aerobic composting was done in order to lower the wax content and temperature of the sulphitation pressmud.

2.2 Preparation of vermicompost using species *Eisenia foetida*-

The compost obtained from aerobic composting of pressmud was subjected to vermitreatment using species *Eisenia foetida*. The species *Eisenia foetida* was obtained from Shantikunj, Hardwar, Uttaranchal, India.

2.3 Physical and chemical analysis

Physical and chemical analysis of soil(T_0), and soil treated with pressmud (T_1) @ 10t/ha, Compost (T_2)@10t/ha, vermicompost (T_3) @10t/ha and NPK (T_4) in ratio of 120:60:40 were carried out following standard method prescribed in *Trivedy and Goel(1996).* The samples were air dried before analysis. Total organic carbon was determined by following Walkley and black method, while, total nitrogen was estimated by Kjeldhal method.

2.4. Analysis of *Zea mays* growth rate and yield attributing parameters.

In the present study, the seeds of *Zea mays* of pusa early sankar makka-2 and were sown in the month of March, When temperature of the soil was 33.0±0.494˚C. plots of $1m^2$ with five replicates of each was prepared and sown with 15 seeds of *Z.mays*. The composts and fertilizer were applied three days before sowing the seeds.

Urea was applied in 3 splits during the study period *i.e.* $1/3^{rd}$ at sowing time. $1/3^{rd}$ at knee height stage and$1/3^{rd}$ at tesseling stage. Out of these three the last two applications were done in the form of top dressing of the furrows. Single super phosphate (P_2O_5) and Muriate of potash (K_2O) was applied at the time of sowing The plots were watered as and when required.

The data were also statistically analyzed following Gomez and Gomez, (1984).

3. Results and Discussion

3.1 Physical and chemical parameters of field samples.

In the present experiment, the soil temperature at the time of sowing of the seeds was 37.3±0.494ºC , this temperature was higher than that recorded for the treatments with pressmud, composted pressmud, vermicomposted pressmud and finally NPK (33.5, 34.3, 34.0 and 34.4ºC respectively). Soil texture determines the amount of available water it will hold. Rumpel *et al.*, (1998) stated that soil density decreased while porosity and water retention increased significantly with the application of FYM. Among the treatments, the moisture content was reduced significantly under field condition (10.29%), followed by NPK (Table1). The maximum was recorded in raw pressmud with 10.29±0.113% followed by VPM (9.67±0.088%) composted pressmud (CPM), 9.05±0.104 and minimum was not in NPK treatment. Compost is typically slightly alkaline (pH7.0-8.0) but range from pH 5.0-8.5. The pH of finished compost must fall between 5.5-8.5 (Dougherty, 1999). In our study, application of pressmud increased the soil pH (7.57 in T_1), while composted, vermicomposted pressmud and NPK had decreased the soil pH (7.22, 6.78, 6.39 in T_2, T_3 and T_{14} respectively). In the present study where the pH of NPK treated soil was lowered (6.39) and electrical conductivity was increased (0.19S/cm) as compared to the soil. It was also found that sulphitation pressmud, compost and vermicompost significantly raised the carbon percentage of the soil (0.78, 0.67 and 0.66% respectively), but there was no significant response due to the application of NPK. In the present study, application of sulphitation pressmud, its compost, vermicompost and NPK significantly increased the phosphorus percentage of the soil to 0.41%, 0.31%, 0.96% and 0.51% respectively in T_1, T_2, T_3 and T_4. In an incubation study, application of wheat and barley straw to two soils (pH>7.0) increased the sulphur concentration in equilibrium solutions, suggesting that the addition of crop residues to soil would increase available sulphur (Lefroy *et al*, 1994). The total nitrogen percentage of the soil treated with compost and vermicompost was found same as 0.08±0.053% for both (T_2 and T_3) while NPK treated soil showed the maximum value of total nitrogen (0.10±0.095%). Worm casts have a superior bioactive potential presenting plant growth hormone (Tomati *et al.*, 1987**),** worm cast have suppressive effects on some root infecting pathogens. More, (1994) also reported that use of pressmud, dry biogas slurry, FYM increases the contents of organic carbon, available N, P and K in soil among these combination of FYM and pressmud was found most significant. In the present study application of pressmud and NPK decreased the C:N ratio to 7.09 and 4.8 respectively, while compost and vermicompost application increases the C:N ratio to 8.37 and 8.25 respectively. The C:P ratio of the soil shows remarkable decrease after application of pressmud (T_1), compost (T_2), vermicompost (T_3) and NPK (T_4) 1.90, 2.14, 0.693 and 0.932 respectively.

3.2 *Zea mays* growth and yield parameters

Composting is an historic method for maintaining soil fertility through natural nutrient cycling (Inckel *et al*., 1996). In the present study the germination rate was observed 100% in raw pressmud (T_1), while these were found in order of 73.33% and 66,66 % under treatments of composted (T_2) and vermicomposted pressmud (T_3). The present investigation on the application of the four test conditions (T_1, T_2, T_3 and T_4) along with soil showed enormous increase in the shoot length from 172.60 cm in soil to 235.40 cm in composted pressmud respectively. Salih and Wali (1988) also reported that increased rate of nitrogen availability was significant for plant height. Fareh *et al.* (1984) also recorded a diminishing response of increasing level of nitrogen with plant height. In the present study, the root length, root spread and root-shoot ratio was maximum in the treatment with composted pressmud 24.28 cm, 23.67 cm and 0.10 cm respectively. It was observed in our study that cob length and mean number of cob per plant (18.60±0.63 cm and 1.50±0.07 cob/plant) was maximum in composted pressmud but the mean cob weight was highest in the treatment with vermicomposted pressmud (53.80±1.89gm). Singh and Singh (1985) had reported that both FYM and magnesium treatments significantly enhanced the plant height, cob length,

dry matter and grain yield of maize. In the present experiment**,** the dry weight of the maize was recorded maximum in composted pressmud (157.0±8.41gm/plant) followed by vermicompost (151.2±13.52gm/plant), pressmud (148.6±11.34 gm/ plant) and NPK (137.4±9.26gm/plant)**.** Milic and Sario (1988) observed an increase of plant dry weight of maize by *Azotobacter* only when nitrogen was present in sufficient amount. The biological yield of maize, as observed in the present study increases significantly by 13.08%, 53.24%, 54.15% and 37.03% respectively in raw pressmud (T_1), composted pressmud (T_2), vermicomposted pressmud (T_3) and NPK (T_4) treatments as compared to the soil. Grewal *et al.* (1982) reported that organic manures influences the rate of NPK available to maize and thus increases the total mass yield. There was 51.47% increase in stover yield of maize in composted pressmud treatment as compared to the soil (control). Ezumah and Lawson, (1990) also reported significant increase in stover yield of maize, under mixed cropping, fertilized with120 Kg/ha of nitrogen over no nitrogen treated plots. Tripathi and Acharya (1998) reported that chemical fertilizer alone in ratio of 120:60:40 Kg, N:P:K drastically affect maize grain and stover yield to just 0.24 and 1.18 mg/ha respectively In the present experiment, the maximum grain yield of maize was recorded in treatment with composted pressmud (4135Kg/ha) as compared to other treatments of raw pressmud (3071Kg/ha), vermicomposted pressmud (4079Kg/ha) and NPK (3803Kg/ha). Cremenescu *et al.* (1986) found that organic and inorganic fertilizer interacted more significantly to increase the grain yield of maize. In the present experiment the maximum percentage of harvest index was recorded in NPK *i.e* 39.28%, followed by raw pressmud (38.44%), composted pressmud (38.19) and vermicomposted pressmud (37.62%). Kumar and Singh (2001) reported that application of 90 Kg N and 15 t/ha/FYM in maize resulted in maximum harvest index. At maturity, the chlorophyll content of maize was recorded highest in treatment with NPK 0.5432 mg/gm of fresh wt. and lowest in treatment with raw pressmud 0.3540 mg/gm of fresh wt.

Table 1. Values of some selected physico-chemical parameters of soil treated with pressmud T_1), composted pressmud T_2), vermicomposted pressmud T_3) and NPK T_4) under field conditions. The value are mean ±SE of 10 observations each)

Parameters	soil	Pressmud	Composted pressmud	Vermicomposted pressmud	NPK
Temperature ºC)	37.3±0.494	33.5±0.428 p<0.01	34.3±0.260 p<0.01	34.0±0.365 p<0.01	34.4±0.452 p<0.01
Moisture content %)	9.66±0.555	10.29±0.113 p<0.01	9.05±0.104 p<0.01	9.67±0.088 p<0.01	8.73±0.073 p<0.01
pH	7.32±0.053	7.57±0.040 p<0.01	7.22±0.032 p<0.01	6.78±0.023 p<0.01	6.39±0.034 p<0.01
Carbon content %)	0.49±0.060	0.78±0.039 p<0.01	0.67±0.039 p<0.01	0.66±0.021 p<0.01	0.48±0.058 p<0.01
Organic matter %)	0.86±1.000	1.34±0.067 p<0.01	1.15±0.068 p<0.01	1.14±0.037 p<0.01	0.83±0.101 p<0.01
Available phosphorus %)	0.08±0.016	0.41±0.025 NS	0.31±0.007 NS	0.96±0.021 NS	0.51±0.009 NS
Total nitrogen %)	0.060±0.002	0.110±0.014 NS	0.082±0.020 NS	0.080±0.053 NS	0.101±0.095 NS
Total potassium %)	0.0058±0.000	0.0096±0.000 p<0.01	0.0109±0.000 p<0.01	0.0096±0.000 p<0.01	0.0136±0.000 p<0.01
C:N	8.16	7.09	8.37	8.25	4.80

p (based on F test) indicates the level of significance of the difference between the values of control soil) and pressmud, composted pressmud, vermicomposted pressmud & NPK. NS- insignificant

Table 2. The Values of selected parameters for growth and germination rate of *Zea mays* in soil T_0), pressmud T_1), Composted pressmud T_2), Vermicomposted pressmud T_3) and NPK T_4) treatments. The values are mean ± SE of 10 observations each)

Parameters	Soil	Pressmud	Composted pressmud	Vermicomposted pressmud	NPK
Germination rate %)	80	100 (+25%)	73.33 (-83.33%)	66.66 (-16.67%)	80 (0%)
Shoot length cm)	172.60 ±7.44	221.40±5.29 (+28.27%) p<0.01	235.40±7.21 (+36.38%) p<0.01	209.2±8.46 (+21.20%) p<0.01	202.6±9.80 (+17.38%) p<0.01
Root length cm)	16.24± 1.36	17.54±1.40 (+8.00%) p<0.05	24.28±2.28 (+49.50%) p<0.05	18.14±1.22 (+11.69%) p<0.05	17.66±1.02 (+8.76%) p<0.05
Root spread cm)	16.51± 1.51	22.40±0.61 (+35.67%) p<0.01	23.67±0.98 (+43.36%) p<0.01	21.99±1.32 (+33.19%) p<0.01	17.88±0.66 (+8.29%) p<0.01
Root-shoot ratio	0.09	0.07	0.10	0.08	0.08
Cob length cm)	13.40±0.86	16.0±0.07 (+19.40%) p<0.01	18.60±0.63 (+38.80%) p<0.01	15.80±1.19 (+17.91%) p<0.01	15.10±1.07 (+12.68%) p<0.01
Cob weight gm)	28.05±1.71	41.50±0.73 (+47.95%) p<0.01	49.50±0.91 (+76.47%) p<0.01	53.80±1.89 (+91.80%) p<0.01	38.20±0.66 (+36.18%) p<0.01
Number of cob per plant	1.08±0.03	1.36±0.05 (+25.92%) p<0.01	1.50±0.07 (+38.88%) p<0.01	1.36±0.09 (+25.92%) p<0.01	1.20±0.05 (+11.11%) p<0.01
Number of days tasseling produced	70	75	75	74	74

Values in parenthesis shows percent increase or decrease with respect to soil.
p based on Ftest) indicates the level of significance of the difference between the values of control soil) and soil treated with pressmud, composted pressmud, vermicomposted pressmud and NPK. NS, insignificant.

Table 3. The values of selected for yield parameters of *Zea mays* in soil T_0), pressmud T_1), Composted pressmud T_2), Vermicomposted pressmud T_3) and NPK T_4) treatment. The values are mean ± SE of 10 observations each)

Parameters	Soil	Pressmud	Composted pressmud	Vermicomposted pressmud	NPK
Dry weight gm/plant)	118.2± 6.07	148.6± 11.34 (+25.71%) NS	157±8.41 (+32.82%) NS	151.2±13.52 (+27.91%) NS	137.4±9.26 (+16.24%) NS
Biological yield kg/ha)	7064.4 ±225.44	7989 ±250.19 (+13.08%) NS	10826 ±338.28 (+53.24%) NS	10890 ±426.62 (+54.15%) NS	9681 ±337.03 (+37.03%) NS
Stover yield kg/ha)	4497± 146.52	4981 ±175.60 (+10.76%) p<0.01	6691 ±190.13 (+48.78%) p<0.01	6811 ±325.95 (+51.47%) p<0.01	5878 ±220.48 (+30.70%) p<0.01
Grain yield kg/ha)	2566 ±137.78	3071 ±155.31 (+19.68%) p<0.01	4135 ±200.08 (+61.14%) p<0.01	4079 ±167.21 (+59.66%) p<0.01	3803 ±218.39 (+48.20%) p<0.01
Grain to stover ratio kg/ha)	0.570	0.616	0.617	0.598	0.646
Harvest index %)	36.32	38.44 (+5.83%)	38.19 (+5.14%)	37.62 (+3.57%)	39.28 (+8.14%)

Values in parenthesis shows percent increase or decrease with respect to soil.
p based on F test) indicates the level of significance of the difference between the values of control soil) and soil treated with pressmud, composted pressmud, vermicomposted pressmud and NPK. NS, insignificant.

Table 4. Values of chlorophyll content of Zea mays under treatments of T_1, T_2, T_3 and T_4 at different times intervals Chlorophyll content mg/gm of fresh wt) of *Zea mays* in soil, pressmud PM) , composted pressmud CPM) ,vermicomposted pressmud VPM) and NPK treatment following different time intervals. The values are mean ±SE of 10 observations each)

Days	Soil	Pressmud	Composted pressmud	Vermicomposted pressmud	NPK
15	0.0026 ±0.000	0.169 ±0.000 (+6400%) NS	0.0616 ±0.001 (+2296.23%) NS	0.2104 ±0.000 (+7992.30%) NS	0.171 ±0.000 (+6476%) NS
30	0.1026 ±0.000	0.1778 ±0.000 (+73.29%) p<0.01	0.1157 ±0.000 (+12.76%) p<0.01	0.2462 ±0.003 (+139.96%) p<0.01	0.2720 ±0.000 (+165.10%) p<0.01
45	0.1502 ±0.000	0.3106 ±0.000 (+106.79%) NS	0.1268 ±0.000 (+-15.57%) NS	0.2750 ±0.000 (+83.05%) NS	0.2832 ±0.000 (+88.54%) NS
60	0.1608 ±0.000	0.3316 ±0.000 (+106.21%) NS	0.3850 ±0.000 (+139.42%) NS	0.2820 ±0.000 (+75.37%) NS	0.3128 ±0.000 (+94.52%) NS
75	0.2334 ±0.000	0.3276 ±0.002 (+40.35%) p<0.01	0.4188 ±0.000 (+79.43%) p<0.01	0.3296 ±0.000 (+41.21%) p<0.01	0.5404 ±0.000 (+131.53%) p<0.01
AT MATURITY 85 days)	0.2570 ±0.000	0.3540 ±0.000 (+37.74%) NS	0.4280 ±0.000 (+66.53%) NS	0.360 ±0.000 (+40.07%) NS	0.5432 ±0.001 (+111.36%) NS

Values in parenthesis shows percent increase or decrease with respect to soil.
p based on F test) indicates the level of significance of the difference between the values of control soil) and soil treated with pressmud, composted pressmud, vermicomposted pressmud and NPK. NS, insignificant.

5. Conclusion

The results presented in this paper indicates that sulphitation pressmud , its compost and vermicompost holds good nutrient value and can be used as an amendment for *Z.mays* production. The biological yield and stover yield of *Z.mays* were recorded maximum in vermicompost while, the dry weight ad grain yield were observed maximum in compost. NPK treatment showed the maximum harvest index and chlorophyll content of *Z.mays* in the present study.

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