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IMPACT OF INTEGRATED PLANT NUTRIENT MANAGEMENT SYSTEMS ON SOIL PHYSICAL PROPERTIES AND PRODUCTIVITY ENHANCEMENT IN MAIZE (*ZEA MAYS* L.)

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Abstract

A field study was carried out at Experimental farm, Faculty of Agriculture, Annamalai University to find out most efficient and economic combination of different organic and inorganic sources of nutrients to increase the productivity of hybrid maize (*Zea mays* L.) without deteriorating the soil qualities. The experiment consists of ten different treatments with three replications each were carried out in randomised block design. INM practice including pressmud based vermicompost @ 5t ha^{-1} and with recommended dose of NPK showed its best results with respect to yield parameters like number of grains per cob, 100 seed weight and yield. Bulk density and pore space and Organic carbon were recorded maximum in INM practice including pressmud compost @12 t ha^{-1} along with recommended dose of NPK. The difference in available soil nitrogen, phosphorus and potassium due to different organic and inorganic treatments were significantly superior in post harvest soil over control. Among the different organic manures, pressmud based vermicompost @ 5 t ha^{-1} with RDF recorded higher post harvest soil N, P and K. The least soil available nutrient content was noticed in control treatment plot in post harvest soil.

***Key words*:** Maize, vermicompost, cob yield, bulk density

Introduction

Maize (*Zea mays* L.) has high genetic yield potential than other cereal crops. Maize grain contains about 10% protein, 70% carbohydrates, 4.1% oil and 2.3% crude fibre. Due to its high yield potential, it is called as 'miracle crop' and also as 'queen of cereals' (Sudhakar *et al*., 2011). Being a C4 plant, it is very efficient in converting solar energy in to dry matter.

Maize has becoming very popular cereal crop in India because of the increasing market price and high production potential in both irrigated as well as rainfed conditions. Hence the trend of replacing some cash crops with maize in intensive cultivation is observed in present condition.

As heavy feeder of nutrients, maize productivity is largely dependent on nutrient management. Hence heavy doses of these fertilizers are applied to maize. Though these practices helps to increase the production of crop; deterioration of natural resources (*viz.* land, water and air) is also the side of such high input intensive cultivation. Over reliance on use of chemical fertilizers has been associated with declines in soil physical and chemical properties and crop yield (Sudhakar and Kuppusamy, 2007) and significant land problems, such as soil degradation due to over exploitation of land and soil pollution caused by high application rates of fertilizers and pesticide application.

Organic manures not only supply the plant nutrients but also improve soil health. Moreover, the amount of micronutrients present in organic manures may be sufficient to meet the requirement of crop production. But, it is also the fact that optimum yield level of maize production can't be achieved by using only organic manures because of their low nutrient content. Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers. Under such situation, integrated plant nutrient system (IPNS) has assumed a great importance and has vital significance for the maintenance of soil productivity. Hence, joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis.

Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et al*., 2000). It is important to identify the good type of available organic resources which can be used as fertilizers and

their best combination with appropriate proportion of inorganic fertilizers.

Keeping this point in view, present investigation was conducted to find out best combination of organic and inorganic fertilizers for maximum production of maize in sustainable manner without affecting the soil qualities.

Materials and Methods

A field experiment which consists of 10 treatments was conducted at the Experimental Farm, Annamalai University, Tamil Nadu, India during two consecutive seasons in the year 2014. The experimental site was located at 11º24' N latitudes and 79º44' E longitudes with average annual rainfall of 1200 mm. The soil of experimental field was deep with clay loam in texture, neutral pH (7.6), medium in organic carbon (0.55%) and available P_2O_5 (27.0 kg/ha), high in K_2O (278.5kg/ha) and low in available N (210.0 kg/ha).

The treatments includes Absolute Control (T1), Recommended dose of fertilizer (RDF) (T2), Pressmud compost and FYM @ 12 t ha^{-1} along with RDF (T3& T4) and differential dose of Pressmud based vermicompost, FYM based vermicompost and Crop residue based vermicompost @ 5 t ha^{-1} (T5, T6 & T7) and @ 3 t ha^{-1} (T8, T9 & T10) along with RDF for ascertaining the effect of the different treatments on growth and development of maize. The recommended fertilizer dose was 135:62.5:50 kg N, P_2O_5 and K_2O per ha^{-1}. Half dose of N and full dose of P_2O_5 and K_2O were applied basally. The remaining N was applied as top dressing at 30 and 60 DAS in two equal splits. Maize hybrid 'NK 6240' was sown in flat bed at a spacing of 60cm x 25cm with seed rate of 15 kg/ha. The experimental research treatment was fixed by randomized block design with three replications.

Regular biometric observations were recorded at specific time intervals by selecting randomly five plants in each treatment. Crop was harvested at 130 days after sowing for both the years and yield observations were recorded from net plots. Randomly five soil samples from each plot were taken and examined for physico-chemical properties and nutrient status of soil after harvest of maize crop. The trend of observations was same for both the years, hence data was subjected to pooled analysis for interpreting the results, The bulk density was determined as per the procedure determined by Dastane (1967). The organic carbon was determined by wet oxidation method by oxidizing organic matter as described by Walkley and Black (1934). It was expressed in percent. The available nitrogen was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija. (1956). It was expressed in kg ha^{-1}. The content of available P and available K in the solution was estimated by the procedure described by Olsen *et al*. (1954) and Jackson, (1973). It was also expressed in kg ha^{-1}. The data were statistically analyzed and interpreted.

Results and Discussion

Soil Physical Properties

Compared to control all the treatments had lower bulk density (Table 1). Among all other treatments, T3 and T4 showed the best results and had lower bulk density. The beneficial effect of pressmud was observed in the present study is in agreement with the findings of Loganathan (1990) and Dubey and Mandal (1994). The main reason of decreasing bulk density was aggregation of soil particle due to increasing organic matter as well as stability of aggregates which leads to increase the total pore space in soil. Islam *et al.* (2012) have also concluded that addition of organic matter through organic fertilizers decreases the bulk density of soil. Higher bulk density was observed in application of 100% RDF alone and control treatment.

Among all treatments, highest pore space was found in treatments applied with Pressmud compost and FYM @ 12 t ha^{-1} along with RDF followed by Vermicompost treatments. Lowest pore space was found in T1 (Absolute control). The organic residues that are added to the soil undergo microbial decomposition and in this process, various organic products of decay like polysaccharides are released which act as strong binding agents in the formation of large and stable aggregates which helps to improve the physical properties of the soil (Manickam, 1993).

Soil Chemical Properties

Regarding the pH, there was no significant variation found among the treatments and control. In respect of organic carbon, between organic and inorganics, organic treatments showed higher organic carbon content. Among different organic treatments, Pressmud compost (T3) and FYM (T4) @ 12 t ha^{-1} showed higher organic carbon content followed by vermicompost treatments (T5 to T10). This increase in organic carbon content of soil in the aforesaid treatments might be due to the buildup of humus by application of organic manures in these treatments. This was consistent with the views of Balamurugan (2011). Lowest organic matter content was recorded in T2 (inorganic) and was in par with control treatment which shows inorganic treatment has no effect on organic carbon content (Table 1).

The difference in available soil nitrogen, phosporus and pottasium due to different organic and inorganic treatments were significantly superior in post harvest soil over control. Vermicompost application

irrespective of source of preparation enhanced the available soil N, P and K contents (Table 1) at the end of the experiments when compared to their initial status and over recommended dose of fertilizer alone and control. Among the different vermicomposts, pressmud based vermicompost @ 5 t ha^{-1} with RDF (T_5) recorded higher post harvest soil N, P and K. This might be due to the tendency of pressmud based vermicompost amended soils to retain more of available N, P and K at the growth cycle, probably due to the presence of more organic matter (Arancon *et al*., 2006). Further increase in microbial population due to addition of pressmud might have regulated soil temperature and continuous availability of soil moisture and humus content in soil. This might have created favourable soil environment for microbes favouring their sustenance, rapid multiplication and its effect on nutrient availability. Similar observations have also been made by Rangaraj *et al.* (2007). The least soil available nutrient content was noticed in control treatment plot (T_1) in post harvest soil.

Table 1 : Effect of INM practices on soil physical and chemical properties in post harvest hybrid maize soil

Treatments	Bulk density (g cc-1)	% Pore space	pH	Organic carbon (%)	Available N	Available P	Available K
T_1 -Control (No fertilizer and no organic manure)	1.230	36.0	7.4	0.48	184.1	22.3	271.5
T_2- Recommended dose of fertilizer	1.234	37.6	7.4	0.47	187.8	24	276.3
T_3- T_2 + Pressmud compost @ 12 t ha^{-1}	1.270	51.4	7.8	0.55	197.1	27.9	288.3
T_4-T_2 + FYM @ 12 t ha^{-1}	1.262	51.0	7.8	0.54	193.2	26.4	283.2
T_5- T_2+ Pressmud based vermicompost @ 5 t ha^{-1}	1.253	47.5	7.6	0.52	201.4	29.3	294.8
T_6- T_2+ FYM based vermicompost @ 5 t ha^{-1}	1.250	46.6	7.6	0.52	197.2	28	288.6
+ Crop residue based vermicompost @ 5 t ha^{-1}	1.251	46.8	7.7	0.51	193.5	26.4	283.6
- Pressmud based vermicompost @ 3 t ha^{-1}	1.247	44.8	7.5	0.52	197	27.8	287.8
T_9- T_2+ FYM based vermicompost @ 3 t ha^{-1}	1.243	44.1	7.5	0.51	193.1	26.5	283.1
T_{10}- T_2+ Crop residue based vermicompost 3 t ha^{-1}	1.245	44.3	7.6	0.51	191	25.2	279.6
SEd	0.003	0.6	0.5	0.01	1.6	0.6	1.9
CD (p=0.05)	0.007	1.0	NS	0.02	3.1	1.1	3.8

Effect on Growth Attributing Characters

All the growth attributing characters were affected by different treatments. The results of the experiments revealed that vermicompost had distinctly influenced the growth components *viz.* plant height and LAI of maize compared to various composts, recommended dose of fertilizer (RDF) alone and absolute control (Table 2).

Among the different vermicomposts, pressmud based vermicompost @ 5 t ha^{-1} with RDF exhibited accelerated effect on growth components followed by FYM based vermicompost and crop residue based vermicompost in maize. This might be due to presence of nutrients informs that are readily taken up by the plants such as nitrates, exchangeable phosphorus and soluble potassium, calcium and magnesium in pressmud vermicompost (Atiyeh *et al.,* 2000). Besides, there is a significant quantity of vitamins and natural phyto regulators in a balanced form (Madan *et al.,* 1993). The least response was noticed in control treatment.

Effect on Yield Attributing Characters and Yield

The yield potential of maize is determined by yield components and the values of yield components are generally in accordance with that of growth parameters. This was well reflected in the present investigation also.

Among the yield parameters, grain numbers cob^{-1} was greatly influenced by pressmud based vermicompost @ 5 t ha^{-1} compared to FYM based vermicompost and crop residue based vermicompost. This might be due to enhanced dry matter production recorded in this treatment which is responsible for determining higher values in components of yield. 100 grain weight was not influenced by different organic sources of vermicompost and other compost as it was mainly governed by the genetic characters of the cultivar.

Among the various INM treatments, substantial increase in yield attributes *viz.,* cob length, cob diameter and grain numbers cob^{-1} was realized in pressmud based vermicompost @ 5 t ha^{-1} + RDF applied plots which reflected in grain yields. Significantly increased grain yields was recorded in pressmud based vermicompost @ 5 t ha^{-1} + RDF applied plot over other treatments. The aforesaid increased yields in this treatment might be due to higher nutrient uptake and increased photosynthetic efficiency as evident from optimum LAI values recorded. The constant release of N from organic manure, particularly from pressmud based

vermicompost supplemented with NPK fertilizer might have satisfied the demand of the crop at every phenophase of maize crop. This adequate biomass production and improvement in yield parameters have resulted in higher yield in this plot (Balamurugan and Sudhakar, 2012). FYM based vermicompost and crop residue based vermicompost follows the line in descending order in respect of grain yields. The control plot (no fertilizer) recorded the least value of grain yields.

Table : 2 Effect of INM practices on growth and yield attributing characters and yield of hybrid maize.

Treatments	Plant Height			LAI		Grain number cob^{-1}	100 grain weight (g)	Grain yield (kg ha^{-1})
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS			
T_1 -Control (No fertilizer and no organic manure)	69.36	146.03	155.59	3.01	6.39	133	24.35	2698
T_2- Recommended dose of fertilizer	73.26	151.45	162.45	3.13	6.62	188	24.39	3821
T_3- T_2 + Pressmud compost @ 12 t ha^{-1}	83.81	166.38	181.63	3.44	7.12	255	24.47	5199
T_4- T_2 + FYM @ 12 t ha^{-1}	77.27	156.76	169.13	3.25	6.83	223	24.42	4538
T_5- T_2+ Pressmud based vermicompost @ 5 t ha^{-1}	98.54	184.26	205.93	3.78	7.69	320	24.56	6549
T_6- T_2+ FYM based vermicompost @ 5 t ha^{-1}	94.58	179.32	199.48	3.66	7.47	293	24.53	5989
+ Crop residue based vermicompost @ 5 t ha^{-1}	85.13	167.93	184.50	3.48	7.15	258	24.49	5265
- Pressmud based vermicompost @ 3 t ha^{-1}	91.37	175.98	194.27	3.63	7.42	280	24.52	5721
T_9- T_2+ FYM based vermicompost @ 3 t ha^{-1}	87.25	171.03	187.75	3.50	7.19	265	24.50	5410
T_{10}- T_2+ Crop residue based vermicompost @3 t ha^{-1}	79.83	161.26	175.25	3.32	6.89	231	24.44	4704
SEd	1.83	2.29	3.04	0.05	0.09	6.93	0.04	147.20
CD (p=0.05)	3.84	4.80	6.30	0.11	0.20	14.50	NS	307.65

Summary and Conclusion

The results obtained from the field experiments conducted to study the sustainability in yield and changes in soil nutrient availability by maize as influenced by various organic manures, vermicompost and fertilizer were briefly summarized hereunder.

- Maize being an exhaustive crop depletes soil fertility. The study on judicious integrated nutrient management strategy revealed that application of recommended dose of inorganic fertilizer along with pressmud based vermicompost @5 t ha^{-1} to maize not only enhanced productivity of maize over the control and recommended N, P and K respectively, but also improved soil fertility in terms of higher available N, P, K and organic carbon over control.
- INM practice including vermicompost and recommended dose of NPK showed its best results with respect to plant growth parameters.
- INM practice including vermicompost and recommended dose of NPK showed its best results with respect to yield parameters like number of grains per cob and grain yield.
- Bulk density and pore space were also recorded maximum in INM practice including organic manures and recommended dose of NPK.
- Organic carbon was recorded maximum in INM treatment including pressmud compost @ 12 t ha and recommended dose of NPK.

Thus it can be recommended that basal application of pressmud based vermicompost @ 5 t ha^{-1} along with recommended dose of fertilizer could be recommended for growing maize crop to achieve higher production and maintain soil fertility. If the availability of pressmud is limited, FYM based vermicompost can also be recommended to achieve similar maize yields with out detoriating the soil fertility for the farmers in tail end areas of Cauvery delta regions of Tamil Nadu, India.

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