Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 2 (8) July 2013: 61-67

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com

ORIGINAL ARTICLE

Effect of Integrated Nutrient Management on Soil Fertility and Productivity in Maize

R. Lalith Kannan*, M. Dhivya*, D. Abinaya*, R. Lekshmi Krishna* and S. Krishnakumar**
* Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi – 642103, India
** Assistant Professor, Department of Soil Science and Agricultural Chemistry,
Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi – 642103, India

ABSTRACT

A field study was carried out at Vanavarayar Institute of Agriculture, Manakkadavu, during November 2012-January 2013 to study the effect of INM on soil fertility and productivity on maize (Zea mays). Six different treatments with three replications each were carried out in the plot in RBD design.INM practice including vermicompost and recommended dose of NPK showed its best results with respect to leaf area and plant height as compared to other treatments.INM practice including vermicompost and recommended dose of NPK showed its best results with respect to yield parameters like number of grains per cob, 100 seed weight and yield(4112 kg ha^{-1}).Weight of the cob was recorded maximum in INM practice including FYM and recommended dose of NPK. Bulk density and pore space was recorded maximum in INM practice including vermicompost and recommended dose of NPK. Particle densitywas recorded maximum in FYM treatments. Organic carbon was recorded maximum in INM treatment including vermicompost and recommended dose of NPK.

Key words: *INM, bulk density, particle density, organic carbon, microbial activity*

Received 09/06/2013 Accepted 02/06/2013

INTRODUCTION

Maize has high genetic yield potential than other cereal crops. Hence it is called as 'miracle crop' and also as 'queen of cereals'. Being a C4 plant, it is very efficient in converting solar energy in to dry matter. As heavy feeder of nutrients, maize productivity is largely dependent on nutrient management. Therefore, it needs fertile soil to express its yield potential. Ideal soils are rarely found in nature. 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 [1]. Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity. Anthropogenic factors such as inappropriate land use systems, monocropping, nutrient mining and inadequate supply of nutrients are aggravated the situation. To alleviate the problem, INM is an option as it utilizes available organic and inorganic nutrients to build ecologically sound and economically viable farming system. Intensive cultivation, growing of exhaustive crops, use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in the nutrients, but also deteriorated the soil health resulting in decline in crop response to recommended dose of N – fertilizer in the region under such situation, integrated plant nutrient system (IPNS) has assumed a great importance and has vital significance for the maintenance of soil productivity. Organic manures, particularly FYM and vermicompost, not only supply macronutrients but also meet the requirements of micronutrients, besides improving soil health. The use of organics plays a major role in maintaining soil health due to buildup of soil organic matter, beneficial microbes. To sustain the soil fertility and crop productivity the role of organic manures and fermented organic nutrients are very important. The organic fertilizers in addition to nutrients contain microbial load and growth promoting substances which helps in improving the plant growth, metabolic activity and resistance to pest and diseases. Boosting yield, reducing production cost and improving soil health are three inter -linked components of the sustainable triangle. Therefore suitable combination of chemical fertilizer and organic manures cultures need to be developed for particular cropping system and soil. The organic products besides supplying nutrients to the first crop, also provides substantial residual effect of unutilized nutrients on the succeeding crop. The present study was initiated to find out the effect of different combination of organic sources and inorganic fertilizers on the long term basis in maize, to monitor the changes in yield, fertility status and. In crop production, nutrient availability from manure has been recognized for many centuries. Before the introduction of inorganic fertilizer manure was the primary source of nutrients for crop production. Recently there has been a renewed interest in use of farmyard manure. This interest is attributed to concerns for maintaining sustainable agricultural production while preserving the environment. For better utilization of resources and to produce crops with less expenditure, INM is the best approach. In this approach all the possible source of plant nutrients are applied based on economic consideration and the balance required for the crop is supplemented with chemical fertilizers. The combined use of organic and inorganic sources of plant nutrient not only pushes the production and profitability of field crops, but also it helps in maintaining the permanent fertility status of the soil. It is highly desirable to make massive efforts to adopt organic sources as a source of plant nutrients as well as soil productivity in the developing countries. In India, there is sufficient availability of organic manures like animal dung manure (791.6 mt), crop residues (603.5 mt), green manure (4.50 m ha), rural compost (148.3 mt), city compost (12.2 mt) and biofertilizer (0.41 mt) [2] and these may become a good substitute of chemical fertilizers to maintain the soil physico-chemical and biological properties. The incorporation of organic manures improves the nutrient content and uptake. Although organic manures contain plant nutrients in small quantities as compared to the fertilizer, the presence of growth promoting principles like enzyme and hormones besides plant materials make them essential for improvement of soil fertility and productivity.

Keeping the above in view and the known possible reasons, the present study was taken up with the following objectives aiming to develop a sustainable maize production with eco-friendly techniques at profitable levels,

1. To identity the effect of integrated nutrient management on physico-chemical properties of soil.
2. To know the effect of INM on yield and quality of maize.

MATERIALS AND METHODS

The field experiment consists of six treatments. These six treatment combined with three replications each.1. Absolute control, 2. Recommended dosage (RD) of inorganic fertilizers, 3. Farm Yard Manure (FYM), 4. Vermicompost, 5. RD of inorganic fertilizers + FYM, 6. RD of inorganic fertilizers + Vermicompost for ascertaining the effect of the different treatments on growth and development of maize, observations were recorded at 30th day and at the time of maturity.

Soil samples were taken from 0-15, 15-30 and 30-60 cm soil depth before sowing and after harvest of crop in each replication with the help of core sampler. The bulk density was determined by keeping the soil samples under oven at 105^0 C for 48 hours and expressed in g/cc [3].

$$\text{Bulk density (g/cc)} = \frac{\text{Weight of oven dry soil}}{\text{Volume of wet soil}}$$

The weight per unit volume of the solid portion of the soil is called the particle density.

Chemical properties of soil

The soil pH was measured in 1: 2.5 soil: water suspension by Potentiometry [4].

Weigh 20 g of air dry soil passed through 2mm sieve and transfer to a clean 100ml beaker. Add 50ml of distilled water (1:25 ratio). Using glass rod, stir the content and allow it to stand for 30 minutes with intermittent stirring. Wash the electrode carefully with a jet of distilled water and wipe with a piece of filter paper. Stir the soil suspension again just before taking the reading. Measure the temperature of the soil water suspension and set the temperature compensation knob to the suspension temperature. Immerse the electrode into the beaker containing soil water suspension and change the function switch to the particular p^H range. Record the meter reading both in supernatant solution and suspension. Rinse the electrode with a jet of distilled water and dip into distilled water.

The clear supernatant solution of soil water suspension was taken and electrical conductivity was measured using Conductivity Bridge [5]. Switch on the EC meter and allow for 15 minutes for warming up. Standardize the instrument, using saturated gypsum solution or 0.01 M KCl solutions. The EC of saturated gypsum and KCl solution should be 2.2 and 1.41 dS m^{-1}, respectively. Use the same soil water suspension used for measuring pH for the estimation of EC. Stir the content and allow the soil to settle. Wash the electrodes carefully and immerse them into soil solution. Measure the temperature of the suspension and adjust the temperature correction knob to the suspension temperature. Read the EC directly on the display of the meter in dS m^{-1}.

Organic carbon

The organic carbon was determined by Walkley and Black's wet oxidation method by oxidizing organic matter as described by [6]. It was expressed in percent.

Finely powder about 5g of the 2mm sieved soil sample using a ceramic pestle and mortar and sieve through 0.2mm sieve leaving no residue on the sieve. Weigh 0.5g of soil sample into a 500 ml dry conical flask. Run a blank simultaneously without soil. Add 10ml of 1 N potassium dichromate solution using a pipette, swirl the flask gently to wet the soil sample completely and keep it on an asbestos sheet. Rapidly add 20ml of concentrated H_2So_4 using a measuring cylinder or tilting pipette by directing the steam into the suspension. Shake the contents of the flask for 2 to 3 minutes and keep it on the asbestos sheet for 30 minutes. Add about 200ml of distilled water to the flask. Add 10ml of ortho-phosphoric acid and 1ml of diphenylamine indicator. Titrate the content against 0.5 N FAS till the appearance of green colour.

Available nitrogen

The available nitrogen was estimated by alkaline permanganate oxidation method as outlined by [7]. It was expressed in kg ha^{-1}.

Weigh 20g of 2mm sieved soil sample and transfer to a nitrogen distilled flask. Add 20ml of distilled water, 1ml of liquid paraffin (or 1g of paraffin wax) (to avoid frothing) and a few glass beads / porcelain bits (to avoid bumping) to the distillation flask. Add 100ml of 0.32 per cent potassium permanganate. Pipette out 20ml of 2 per cent boric acid solution with double indicator in a 250ml tall-form beaker. Keep the beaker under the delivery end of the condenser in such a way that the delivery end is immersed in the acid. This will capture some of the ammonia being released during the initial phase of distillation as gas. Open the top water to the condenser. Add 100ml of 2.5 per cent sodium hydroxide to the distillation flask. Close the flask immediately and distill the content of the flask at a steady rate collecting the distillate in the 100ml beaker. After few second (after bubbling in the beaker stops) lower the beaker below the collection tube level. This helps to prevent back suction of the distillate into the distillation flask. Continue the distillation for about 30 minutes or until 100ml of distillate is collected in the beaker. Titrate the collected ammonia with 0.02 N H_2SO_4 till the appearance of wine red colour. From the titre value, calculate the amount of nitrogen present in the soil.

Available potassium

The available potassium was extracted with neutral normal ammonium acetate (1 N NH4 OAC) and the content of K in the solution was estimated by Flame photometry [8]. It was expressed in kg ha^{-1}.

Weigh 5g of soil into a 100 mL polythene shaking bottle. Run a blank side by side without soil. Add 25mL of Neutral Normal ammonium acetate (N N NH_4OAc) and shake in a mechanical shaker for 5 minutes @ 180 oscillations per minute. Filter through Whatman No.40 filter paper and collect the filtrate in a 50 mL beaker. Switch on the air compressor and adjust the air pressure as per the instructions given in the instrument. Switch on the flame photometer and allow it for 30 minutes to warm up. Open the LP gas and light the burner. Adjust the fuel knob to a flame with blue cones. Feed N N N_H4OAc and adjust the zero knob to read zero in the digital display. Feed 100 ppm k solution and adjust the standard curve to read 100 in the digital display. Feed the other K standards and prepare standard curve. Feed the sample and find out the sample K concentration using standard curve.

Determination of moisture content

Record the weight of a container (beaker or petridish) and label. Weigh 10 g of soil sample and record the total weight of the sample + container. Dry the samples in oven at 105°C for 48 hr. Record the weight of the container + sample. Record the dry weight of the soil sample (by deducting the total weight minus container weight). Calculate the moisture percent and dry soil weight by following formula

$$\text{Moisture percent (\%)} = \frac{\text{Wet Weight (g)} - \text{dry weight (g)}}{\text{Dry weight (g)}} \times 100$$

Statistical Analysis

The experimental research treatments fixed by randomized block design with three replications. The data were analyzed by using AGRESS software

RESULTS AND DISCUSSION

Plant growth parameters

The leaf area compared to control (T1) all treatments showed higher leaf area. Among all treatments T5 and T2 showed the best results. T5 and T6 were in par with respect to leaf area. Between organic treatments FYM was significantly better than vermicompost. FYM worked as soil conditioner in addition to supplying plant nutrients and resulted in improvement in plant height at different stages of plant growth [9]. Between organic and inorganic, inorganic treatments showed better result 25 Days after Sowing (DAS). At 50 DAS, among all treatments INM (vermicompost + NPK) showed the highest leaf area. It was followed by NPK + FYM treatment. Compared to control INM treatments showed better results. Among organic treatments FYM (T4) had leaves with highest leaf area than vermicompost. T1 and T2

were on par with respect to the leaf area. Inorganic treatment (T2) showed significantly better results than vermicompost (T4) and FYM (T3). At harvest stage, INM (T6) showed the best results. T2 (NPK) and T5 (FYM + NPK) were on par leaf area. Control (T1) showed better results as compared to FYM (T3) and vermicompost (T4). Between organic and inorganic, inorganic treatments showed better result (Table 1).
Regarding the plant height at 25 days after interval, the best results were showed in all the treatments. The T3 and T5 treatments were in par with respect to plant height.T4 showed significant results than T1. T2 showed better results than T1, T3, T4 and T5. The T5 (FYM + NPK) and T6 (vermicompost + NPK) treatments showed the best results and were on par with each other with respect to plant height.T2 (inorganic) showed significantly better results than T4 (vermicompost). The control) and FYM treatments showed poor results and were on par with each other. The plant height at harvest stage the T6 (vermicompost + NPK) showed better results. T5 (FYM + NPK) showed better results than T1 (control), T2 (inorganic), T3 (FYM) and T4 (vermicompost). T2 (inorganic) and T4 (vermicompost) were on par with each other (Table 1).

Soil physical properties

Compared to control (T1) all treatments had higher bulk density. Among all treatments T3, T4 and T6 showed the best results and had low bulk density. The beneficial effect of FYM as was observed in the present study is in agreement with the findings of (10) and (11). T5 and T1 were in par in bulk density. Between organic and inorganic, organic treatments showed better result. Among all treatments T4 showed the best result.T3 and T5 were in par with control (T1) particle density. T6 showed significant results than T2. T2 showed poorest results. Among all treatments highest porespace was found in T6 soils followed by T2 soils. T3 showed better results than T4. Results obtained from T5 were on par with the control. Lowest porespace was found in T4 (Table 2). 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 [12] which helps to improve the physical properties of the soil.

Soil chemical properties

Regarding the pH no significant variation was observed. Owing to the nature and the pattern of mineralization combined use of organic manures improved the physico chemical properties of the soil rather than application of single organic manure. Among all treatments, T5 showed the best result. T5 showed better result than T6. T4 showed slightly better results than T6.Between organic treatments T4was significantly better than T3. Between organic and inorganic, organic treatments showed better result. T3 and T2 were on par with the control treatment T1. By comparing all the results T6 (vermicompost + NPK) plot shows more amount of available potassium followed by T5 (FYM + NPK). When comparing organic and inorganic plots inorganic contain more amount of available potassium. Among all treatments T6 showed higher organic carbon content followed by T5. Between organic and inorganic, organic treatments showed higher organic carbon content. T2 (inorganic was in par with control treatment which shows inorganic treatment has no effect on organic carbon content (Table 3). The decrease in pH of the soil by about one unit from the initial value which could be related to the decomposition and mineralization of organic matter [13]. The decrease in pH (0.2 units) with *Sesbania* green manuring also was reported [14].

Yield parameters

The No of grains per cob compared to control all treatments showed higher number of grains / cob. Among all treatments T5 and T6 showed the best results. T5 and T6 are on par in number of grains. Between organic treatments, FYM applied field was significantly better than vermicompost applied soil. This might be due to the fact that FYM acted as nutrient reservoir and upon decomposition produced organic acids thereby absorbed irons are released slowly for the entire crop growth leading to higher plant height. FYM worked as soil conditioner in addition to supplying plant nutrients and resulted in improvement in plant height at different stages of plant growth [9]. The increase in tiller production with FYM application might be due to the dual benefits of improving the physical environment of rhizosphere region and adequate supply of available plant nutrients. The increased tiller production might also be due to the narrow C: N ratio in FYM, which helped immediate release of plant nutrients from FYM [15]. Between organic and inorganic, organic treatments showed better result. Among all treatments NPK + FYM produced higher cob weight. It was followed by NPK + vermicompost. Compared to control, all the treatments showed better results. Among organic treatments NPK had cobs with high weight than vermicompost. Inorganic treatment showed significantly better results than vermicompost (T4). The Seed weightcompared to control (T1) all treatments showed higher seed weight. Among all treatments T6 showed the best result.T2, T3 and T5 were in par in 100 seed weight. Between organic treatments T3 – FYM was significantly better than T4 – vermicompost. Between organic and inorganic, organic treatments showed better result. Among all treatments T6 showed higher yield followed by T5. T2 (inorganic) was in par with T4 and T3. All treatments showed better results than control treatment (Table 4).

SUMMARY AND CONCLUSION

The results obtained from the field experiments conducted to study the changes in soil nutrient availability by maizw as influenced by various organic manures and fertilizer as well as integrated nutrient management are briefly summerized 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 vermicompost 6 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.

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, 100 seed weight and yield. Weight of the cob was recorded maximum in INM practice including FYM and recommended dose of NPK. Bulk density and pore space was recorded maximum in INM practice including vermicompost and recommended dose of NPK. Particle density was recorded maximum in FYM treatments. Organic carbon was recorded maximum in INM treatment including vermicompost and recommended dose of NPK.

Table 1: Effect of integrated nutrient management practices on growth parameters

Treatments	Leaf area (cm^2)			Plant height (cm)		
	25 DAS	50 DAS	120 DAS	25 DAS	50 DAS	120 DAS
T1 – Absolute control	45.4	479.2	482.3	22.7	120.9	173.1
T2 – RD of inorganic fertilizer	83.0	475.7	646.4	28.5	203.4	216.4
T3 – FYM	56.5	383.0	457.4	27.3	124.8	205.6
T4 – Vermicompost	51.6	454.0	463.3	23.6	152.6	214.3
T5 – RD of inorganic fertilizers + FYM	80.7	494.3	656.7	26.8	223.7	224.2
T6 – RD of inorganic fertilizers+ Vermicompost	80.0	504.4	678.4	31.2	225.4	228.3
SEd	1.2251	3.1754	7.7091	0.2259	3.5150	1.4380
CD(0.05)	2.7297	7.0752	17.1770	0.5034	7.8318	3.2041

Table 2. Effect of integrated nutrient management practices on physical properties of soil

Treatment	Bulk density (g cc^{-1})	Particle density (g cc^{-1})	% pore space
T1 – Absolute control	1.48	2.40	40.0
T2 – RD of inorganic fertilizer	1.54	3.08	49.8
T3 – FYM	1.44	2.40	43.3
T4 – Vermicompost	1.44	2.16	35.7
T5 – RD of inorganic fertilizers + FYM	1.48	2.40	40.0
T6 – RD of inorganic fertilizers+ Vermicompost	1.44	2.71	54.1
SEd	0.003	0.02	0.5
CD(0.05)	0.008	0.05	1.0

Table 3. Effect of integrated nutrient management practices on chemical properties of soil

Treatment	pH	EC (dS m^{-1})	Organic carbon (%)
T1 – Absolute control	7.4	0.37	0.32
T2–RD of inorganic fertilizer	7.4	0.36	0.35
T3 – FYM	7.5	0.38	0.54
T4 – Vermicompost	7.8	0.45	0.70
T5 – RD of inorganic fertilizers + FYM	7.5	0.65	0.74
T6 – RD of inorganic fertilizers + Vermicompost	7.5	0.43	0.84
SEd	NS	0.008	0.01
CD(0.05)	NS	0.018	0.03

Table 4. Effect of integrated nutrient management practices on Yield parameters of maize

Treatments	No of grains / cob	Weight of Cob (g)	100 seed weight (g)	Grain yield Kg ha^{-1}
T1 – Absolute control	410.1	173.1	32.4	1623
T2–RD of inorganic fertilizer	536.7	252.1	42.5	2868
T3 – FYM	563.8	263.0	42.0	2705
T4 – Vermicompost	492.7	219.7	37.7	2760
T5 – RD of inorganic fertilizers + FYM	598.8	284.6	42.5	3896
T6 – RD of inorganic fertilizers + Vermicompost	603.8	273.8	43.6	4112
SEd	4.9251	2.7795	0.2835	61
CD(0.05)	10.9738	6.1931	0.6317	135

Overall Field View

Field evaluation

REFERENCES

1. Duhan, B.S., and Mahendera Singh. (2002). Effect of green manuring and nitrogen on yield and uptake of micronutrients of rice. *J. Indian Soc. Soil. Sci.*, **50** (2): 178-180.
2. Bhattacharya, P. and Chakraborty, G. (2005). Current status of organic farming in India and other countries. *Indian Journal of Fertilizers* **1**(9):111-123.

3. Dastane N.G. (1967). A practical manual for water use research in agriculture. Indian Agricultural Research Institute, New Delhi. (NavabharatPrakashans, 759 Deccan Gymkhana, Poona 4).
4. Piper, C.S. (1966). Soil and plant analysis. Hans publications, Bombay.
5. Jackson, M.L. (1967). Soil Chemical analysis. Prentice Hall of India, Pvt. Ltd., New Delhi: 498.
6. Walkley, A. and C.A. Black. (1934). An estimation of methods for determining organic carbon and nitrogen in the soils. *J. Agric. Sci*., **25**: 598-609.
7. Subbiah, B.V. and C.L. Asija. (1956). A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci*., **25**: 259-260.
8. Jackson, M.L. (1973). Soil Chemical Analysis, Prentice Hall of India (Pvt) Ltd.,New Delhi.
9. Prasad, B. (1994). Integrated nutrient management in rice wheat cropping system. *Fert. News*, **39** (9): 19-25.
10. Loganathan, S. (1990). Effect of certain tillage practices and amendments on physico chemical properties of problem soils. *Madras Agric. J*., **77**: 204-208.
11. Dubey, S.K. and R.C. Mandal. (1994). Effects of amendments and saline irrigation water on soil properties and yields of rice and wheat in a hilly sodic soils. *J. Agric. Sci*., **122**(3): 351-357.
12. Manickam, T.S. (1993). Organics in soil fertility and productivity management. In: organics in soil health and crop production. *Oryza*, **30**: 54-59.
13. Singh, K.D., Verma, N.S. and S.S. Lohia. (1980). Effect of continuous application of FYM and chemical fertilizers on some soil properties. *J. Indian Soc. Soil Sci*., **28**: 170-172.
14. Swarup Anand. (1991). Long term effect of green manuring (*Sesbania aculeata*) on soil properties and sustainability of rice and wheat yield on a sodic soil. *J. Indian Soc. Soil Sci*., **28**: 336-370.
15. Ramesh, S. (1998). Substitution of inorganic N through poultry manure and livestock wastes in low land rice. M.Sc. (Ag.) Thesis, TNAU, Coimbatore.

Citation of this Article
R. Lalith Kannan, M. Dhivya, D. Abinaya, R. Lekshmi Krishna and S. Krishnakumar. Effect of Integrated Nutrient Management On Soil Fertility And Productivity In Maize. Bull. Env. Pharmacol. Life Sci., Vol 2 (8) July 2013: 61-67