J. Soils and Crops 29 (1) 58-62, June 2019

ISSN 0971-2836
NAAS Rating - 4.46
Scientific Journal Impact Factor - 6.736

EFFECT OF PRESSMUD BASED BIOCOMPOST ON YIELD AND QUALITY OF SUNFLOWER

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ABSTRACT

A field experiment was carried out to evaluate the effect of pressmud based biocompost on yield and quality of sunflower. The experiment was conducted during late *kharif* season of 2017 at the Main Agricultural Research Station, UAS, Dharwad by using different quantities of pressmud biocompost and recommended fertilizers. The experiment was laid out in Randomized Complete Block Design (RCBD) with thirteen treatments and three replications. Application of pressmud biocompost @ 4 t ha^{-1} + 100 % RDF recorded significantly highest yield attributes of sunflower like plant height, leaf area index, head diameter, head weight, 100 seed weight, seed filling percentage, seed yield, stalk yield and oil content. Highest crude protein content was observed with the application of pressmud biocompost @ 8 t ha^{-1} + 25 % RDF. Increasing levels of pressmud biocompost along with inorganic fertilizers significantly improved yield and quality parameters of sunflower.

(Key words: Pressmud biocompost, sunflower, yield, quality)

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the important oil seed crop in the world and belongs to the family Asteraceae. In India, sunflower occupies an area of 3.81 lakh hectares with a production of 2.51 lakh tonnes and productivity of 660 kg ha^{-1}. Karnataka is the largest sunflower producing state in India with an average production of 0.98 lakh tonnes and productivity of 445 kg ha^{-1} (Anonymous, 2017).

Fatty acids found in sunflower oil, including a substantial amount of linoleic acid provides fascinating health benefits. Sunflower holds great promise as an edible oilseed crop. India's sunflower production has drastically declined over the past decade. India is the major importer of sunflower oil. This may be attributed to lower percentage of area under irrigation, poor nutrient management practices, loss due to pest and disease *etc*. Nitrogen is crucial for growth and development while, sulphur is important for oil and protein synthesis besides seed yield enhancement.

Pressmud is an important by-product from sugar industries. Distilleries use pressmud to produce bio manure by composting with spentwash, the effluent waste water in alcohol production from molasses. The pressmud based compost is prepared by mixing pressmud and spentwash in the ratio of 1:2.5 on concrete lined yard by windrow method. The pressmud with the application of spentwash is composted with the help of aerobic microorganisms, with a life cycle of 40-50 days. Many distilleries in Karnataka are producing pressmud based biocompost.

MATERIALS AND METHODS

A study was carried out to evaluate the effect of pressmud based biocompost on yield and quality of sunflower. The experiment was laid out in Randomized Complete Block Design (RCBD) with thirteen treatments and three replications. The treatment details were T_1: Pressmud biocompost @ 1. 0 t ha^{-1} + 100 % RDF, T_2: Pressmud biocompost @ 2. 0 t ha^{-1} + 100 % RDF, T_3: Pressmud biocompost @ 4. 0 t ha^{-1} + 100 % RDF, T_4: Pressmud biocompost @ 1. 0 t ha^{-1} + 75 % RDF, T_5: Pressmud biocompost @ 2. 0 t ha^{-1} + 75 % RDF, T_6: Pressmud biocompost @ 4. 0 t ha^{-1} + 75 % RDF, T_7: Pressmud biocompost @ 1. 0 t ha^{-1} + 50 % RDF, T_8: Pressmud biocompost @ 2. 0 t ha^{-1} + 50 % RDF, T_9: Pressmud biocompost @ 4. 0 t ha^{-1} + 50 % RDF, T_{10}: Pressmud biocompost @ 8. 0 t ha^{-1} + 25 % RDF, T_{11}: Pressmud biocompost @ 8. 0 t ha^{-1} , T_{12}:100 % RDF + FYM @ 8.0 t ha^{-1}, T_{13}: RDF Only (Control). Recommended fertilizers (90:90:60 kg N: P_2O_5:K_2O) were applied in the form of Urea, DAP and MOP as basal. Application of 100 kg gypsum ha^{-1}, 10 kg $ZnSO_4$ ha^{-1}, borax @ 0.5 per cent (at flowering stage) and seed treatment with Azospirillum @ 500 g ha^{-1} was common to all the treatments. The soil was clay in texture,

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slightly alkaline in reaction (pH 7.68), low in soluble salts (EC, 0.25 dS m^{-1}), medium in organic carbon content (5.88 g ha^{-1}). The available nitrogen status of the soil was low (226 kg ha^{-1}) whereas, soil was high in available phosphorus (31.2 kg ha^{-1}), potassium (352 kg ha^{-1}) and sulphur (23.40 kg ha^{-1}). Among the DTPA extractable micronutrients, zinc and iron were moderate and manganese and copper were sufficient in the soil. Plant height and leaf area index were recorded at 45 and 60 DAS. Observations on head diameter, head weight, 100 seed weight seed yield and stalk yield were recorded at harvest. Seed filling percentage was calculated by taking the ratio of filled seeds to the total number of seeds and which was expressed in percentage. Seed oil content was determined by Nuclear Magnetic Resonance (NMR) spectrometer against a standard reference sample (Anonymous, 1975). Total nitrogen content in seed was estimated by Kjeldahl digestion and distillation method as outlined by Tandon (1998). Crude protein content was determined by multiplying nitrogen concentration in the seed with the factor 6.25 (Mariotti *et al.*, 2008).

RESULTS AND DISCUSSION

Growth parameters

Plant height and LAI at 45 and 60 DAS were considerably increased upon receiving pressmud biocompost. Highest plant height (163.70 and 230.30 cm) was recorded at both 45 and 60 DAS in the treatment that received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF (T_3), which was on par with treatment T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) at 45 DAS. At 60 DAS, treatments T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF), T_{11} (pressmud biocompost @ 8 t ha^{-1}) and T_{12} (100 % RDF +FYM @ 8 t ha^{-1}) were on par with T_3 (pressmud biocompost @ 4 t ha^{-1} + 100 % RDF). Significantly lowest plant height (123.30 and 197.10 cm) was observed in the treatment that received pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7) followed by T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF).

At 45 DAS, significantly highest leaf area index (LAI) of 1.93 was recorded with pressmud biocompost @ 4 t ha^{-1} + 100 % RDF (T_3), which was on par with the application of pressmud biocompost @ 8 t ha^{-1} + 25 % RDF (T_{10}), whereas lowest LAI of 0.81 was observed with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF treatment. At 60 DAS, significantly highest LAI (2.75) was recorded with the application of pressmud biocompost @ 4 t ha^{-1} + 100 % RDF (T_3), which was on par with the application of pressmud biocompost @ 8.0 t ha^{-1} + 25 % RDF (T_{10}) and pressmud biocompost @ 4 t ha^{-1} + 75 % RDF (T_6). Lowest LAI (1.99) was observed with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with treatments T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13} (RDF Only).

Abbasi *et al*. (2014) reported that application of sugarcane pressmud along with NPK fertilizers showed maximum plant height and stem circumference of sunflower relative to other source of manures (FYM, poultry manure and crop residues).

Yield components

The results showed that, different yield components of sunflower like head diameter, head weight, 100 seed weight and seed filling per cent showed significant improvement with the addition of pressmud biocompost and RDF. Head diameter varied from 15.50 cm to 22.30 cm. Significantly highest head diameter was observed T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, which was on par with T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF) and T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) treatments. Significantly lowest head diameter (15.50 cm) was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13} (RDF Only) treatments.

Different levels of pressmud biocompost had significant effect on head weight. Highest head weight (310.47 g) was recorded with the application of pressmud biocompost @ 4 t ha^{-1} + 100 % RDF (T_3), which was on par with the application of pressmud biocompost @ 8 t ha^{-1} + 25 % RDF (T_{10}) and pressmud biocompost @ 4 t ha^{-1} + 75 % RDF (T_6), whereas lowest head weight (227.37 g) was observed with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_5 (pressmud biocompost @ 2 t ha^{-1} + 75 % RDF) T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13} (RDF Only) treatments.

100 seed weight varied from 4.55 to 6.20 g. Highest 100 seed weight was observed with T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, and it was on par with T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF) T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) T_{11} (pressmud biocompost @ 8 t ha^{-1}) and T_{12} (100 % RDF +FYM @ 8 t ha^{-1}) treatments. Lowest seed weight of 4.55 g was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) treatment.

Seed filling percentage varied from 73.92 to 90.54. Highest filling percentage (90.54 per cent) was observed in T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, which was on par with T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF) and T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) treatments. Lowest value (73.92 per cent) was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_5 (pressmud biocompost @ 2 t ha^{-1} + 75 % RDF) T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13}(pressmud biocompost @ 8 t ha^{-1}) treatments.

Selvamurugan *et al.* (2013) found that yield attributes of groundnut *viz*., number of matured pods, 100 kernel weight and shelling percentage of groundnut were improved by the application of biomethanated spent wash and pressmud biocompost when compared to recommended NPK as chemical fertilizer.

Seed and straw yield

It is evident from the data that, incremental levels of pressmud in combination with inorganic fertilizers significantly increased the seed and stover yield of sunflower. Seed yield varied from 14.95 to 22.14 q ha^{-1}. Highest seed yield (22.14 q ha^{-1}) was observed in T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, which was on par with the application of pressmud biocompost @ 8 t ha^{-1} + 25 % RDF (T_{10}). Significantly lowest seed yield (14.95 q ha^{-1}) was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13} (RDF Only) treatments.

Stalk yield of sunflower varied from 23.28 to 31.16 q ha^{-1}. Highest stalk yield (31.16 q ha^{-1}) was observed in T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, which was on par with T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF) and T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) treatments. Lowest stalk yield (23.28 q ha^{-1}) was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was on par with T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) and T_{13} (RDF Only) treatments.

However, application of lower rates of pressmud biocompost and RDF (T_7 and T_8) resulted in reduced yields than other treatments indicating insufficiency of added fertilizers in meeting the crop demand. The growth parameters were also lower in these treatments. The results are in agreement with many workers. Saliha *et al*. (2005) found that application of pressmud biocompost at the rate of 3 t ha^{-1} recorded significantly higher yield of rice crop. Similarly Meena (2010) also observed improved yield of maize with the application of pressmud biocompost

Oil and protein content

Findings in the present investigation showed that, increasing levels of pressmud significantly improved the oil and protein content in the sunflower seeds. Oil content varied from 33.09 to 39.22 per cent. Highest oil content (39.22%) was observed in T_3 treatment which received pressmud biocompost @ 4 t ha^{-1} + 100 % RDF, which was on par with T_6 (pressmud biocompost @ 4 t ha^{-1} + 100 % RDF) and T_{10} (pressmud biocompost @ 8 t ha^{-1} + 25 % RDF) treatments. Lowest oil content of 33.09 per cent was recorded with the application of pressmud biocompost @ 1 t ha^{-1} + 50 % RDF (T_7), which was significantly lowest from all other treatments.

Crude protein content of sunflower increased with the increasing levels of pressmud biocompost. It varied from 13.42 to 17.79 per cent. Significantly highest crude protein (17.79%) was recorded in the treatment which received pressmud biocompost @ 8 t ha^{-1} + 25 % RDF (T_{10}). The crude protein content in the treatments T_2 (pressmud biocompost @ 2 t ha^{-1} + 100 % RDF), T_3 (pressmud biocompost @ 4 t ha^{-1} + 100 % RDF), T_6 (pressmud biocompost @ 4 t ha^{-1} + 75 % RDF), T_9 (pressmud biocompost @ 4 t ha^{-1} + 50 % RDF), T_{11} (pressmud biocompost @ 8 t ha^{-1}) and T_{12} (100 % RDF + FYM 8 t ha^{-1}) was on par with $T_{10.}$ Lowest crude protein (13.42%) was recorded in the T_7 treatment which received pressmud biocompost @ 1 t ha^{-1} + 50 % RDF and it was on par with T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) treatment.

The increase in oil and protein contents with the application of higher quantity of pressmud biocompost might be due to the fact that, the pressmud contains appreciable amount of sulphur and phosphorus which are directly involved in the oil synthesis, particularly for the formation of phospholipids, phytin and inositol phosphates and esterification of fatty acids. Paramasivam *et al.* (2006) found an increase in oil and protein contents in groundnut crop with the application of pressmud. The treatments T_4 (pressmud biocompost @ 1 t ha^{-1} + 75 % RDF), T_7 (pressmud biocompost @ 1 t ha^{-1} + 50 % RDF) and T_8 (pressmud biocompost @ 2 t ha^{-1} + 50 % RDF) which received lower quantity of pressmud biocompost and fertilizers than other treatments recorded less content of oil and protein. This can be attributed to less availability of nutrients especially sulphur and phosphorus in these treatments.

Table 1. Effect of pressmud biocompost on growth parameters of sunflower

Treatments	Plant height (cm)		Leaf area index	
	45 DAS	60 DAS	45 DAS	60 DAS
T_1	137.90^{e-g}	213.50^{c-e}	1.19^{ef}	2.30^{d-f}
T_2	144.40^{c-e}	219.20^{b-d}	1.41^{cd}	2.46^{b-d}
T_3	163.70^{a}	230.30^{a}	1.93^{a}	2.75^{a}
T_4	130.50^{g-i}	207.50^{ef}	1.01^{fg}	2.15^{fg}
T_5	136.70^{e-h}	211.40^{d-f}	1.15^{ef}	2.27^{ef}
T_6	152.20^{bc}	224.30^{a-c}	1.63^{b}	2.61^{ab}
T_7	123.30^{i}	197.10^{g}	0.81^{h}	1.99^{g}
T_8	127.10^{hi}	201.70^{fg}	0.90^{gh}	2.06^{g}
T_9	141.00^{d-f}	216.50^{b-e}	1.32^{de}	2.37^{c-e}
T_{10}	156.60^{ab}	226.70^{ab}	1.81^{a}	2.69^{a}
T_{11}	145.27c-e	221.60^{a-d}	1.45^{cd}	2.48^{b-d}
T_{12}	149.73^{b-d}	222.80^{a-c}	1.51^{bc}	2.51^{bc}
T_{13}	132.30^{f-i}	208.13^{ef}	1.05^{fg}	2.17^{fg}
LSD	8.97	9.85	0.16	0.16

Table 2. Effect of pressmud biocompost on yield components of sunflower

Treatments	Head diameter (cm)	Head weight (g)	100 Seed weight (g)	Seed filling percentage
T_1	17.77^{e-g}	259.67^{c-g}	5.29^{d-f}	80.17^{c-f}
T_2	19.47^{c-e}	274.47^{b-e}	5.61^{b-e}	83.97^{b-e}
T_3	22.30^{a}	310.47^{a}	6.20^{a}	90.54^{a}
T_4	16.90^{f-h}	244.35^{f-h}	5.11^{ef}	76.38^{fg}
T_5	17.73^{e-g}	251.99^{d-h}	5.24^{d-f}	79.22^{d-g}
T_6	20.87^{a-c}	286.56^{a-c}	5.87^{a-c}	85.58^{a-c}
T_7	15.50^{h}	227.37^{h}	4.55^{g}	73.92^{g}
T_8	16.17^{gh}	235.37^{gh}	4.95^{fg}	75.87^{fg}
T_9	18.50^{d-f}	266.29^{c-f}	5.46^{c-f}	81.33^{c-f}
T_{10}	21.33^{ab}	295.71^{ab}	6.07^{ab}	88.80^{ab}
T_{11}	19.63^{b-d}	278.39^{b-d}	5.69^{a-d}	83.99^{b-e}
T_{12}	20.03^{b-d}	282.17^{bc}	5.86^{a-c}	84.72^{b-d}
T_{13}	17^{f-h}	247.28^{e-h}	5.14^{ef}	78.35^{e-g}
LSD	1.65	25.58	0.48	5.08

Table 3. Effect of pressmud biocompost on yield and quality of sunflower

Treatments	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Oil content (%)	Crude protein (%)
T_1	18.15^{d-f}	26.26^{d-f}	36.58^{cd}	15.98^{b-d}
T_2	19.72^{b-d}	28.05^{b-d}	37.65^{bc}	16.54^{a-d}
T_3	22.14^{a}	31.16^{a}	39.22^{a}	17.58^{ab}
T_4	16.37^{gh}	24.75^{e-g}	35.90^{d}	15.40^{de}
T_5	17.82^{e-g}	26.12^{d-f}	36.54^{cd}	15.88^{cd}
T_6	20.40^{bc}	29.15^{a-c}	38.41^{ab}	17.17^{a-c}
T_7	14.95^{h}	23.28^{g}	33.09^{f}	13.42^{f}
T_8	15.43^{h}	23.91^{f-g}	34.54^{e}	14.06^{ef}
T_9	19.00^{c-e}	27.07^{c-e}	37.00^{cd}	16.77^{a-d}
T_{10}	20.90^{ab}	29.96^{ab}	38.94^{ab}	17.79^{a}
T_{11}	19.87^{b-d}	28.13^{b-d}	37.71^{bc}	16.77^{a-d}
T_{12}	20.27^{b-c}	28.38^{b-d}	37.79^{bc}	16.94^{a-d}
T_{13}	16.56^{f-h}	24.93^{e-g}	35.99^{d}	15.58^{c-e}
LSD	1.67	2.43	1.18	1.45

T_1: Pressmud biocompost @ 1. 0 t ha^{-1} + 100 % RDF, T_2: Pressmud biocompost @ 2. 0 t ha^{-1} + 100 % RDF, T_3: Pressmud biocompost @ 4. 0 t ha^{-1} + 100 % RDF, T_4: Pressmud biocompost @ 1. 0 t ha^{-1} + 75 % RDF, T_5: Pressmud biocompost @ 2. 0 t ha^{-1} + 75 % RDF, T_6: Pressmud biocompost @ 4. 0 t ha^{-1} + 75 % RDF, T_7: Pressmud biocompost @ 1. 0 t ha^{-1} + 50 % RDF, T_8: Pressmud biocompost @ 2. 0 t ha^{-1} + 50 % RDF, T_9: Pressmud biocompost @ 4. 0 t ha^{-1} + 50 % RDF, T_{10}: Pressmud biocompost @ 8. 0 t ha^{-1} + 25 % RDF, T_{11}: Pressmud biocompost @ 8. 0 t ha^{-1} , T_{12}:100 % RDF + FYM @ 8.0 t ha^{-1} (RPP), T_{13}: RDF Only (Control).

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Rec. on 15.08.2018 & Acc. on 02.09.2018

J. Soils and Crops 29 (1) 63-67, June 2019

ISSN 0971-2836
NAAS Rating - 4.46
Scientific Journal Impact Factor - 6.736

EFFECT OF DIFFERENT ORGANICS AND INORGANICS ON AVAILABLE NUTRIENTS OF SOIL IN A VERTISOL UNDER MAIZE (*Zea mays* L.) CROP

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ABSTRACT

A field experiment was undertaken during *kharif* 2016 in order to study the "Effect of different organics and inorganics on available nutrients of soil in a Vertisol under maize crop". The experiment was laid in a randomized block design with thirteen treatments and three replications. Application of 100 per cent RDF + poultry manure recorded highest available major nutrients (N, 356.01; P_2O_5, 61.81; K_2O, 496.71 ; and S, 26.11 kg ha^{-1}) and micronutrients (Zn, 0.97; Fe, 7.91; Mn; 6.90 and Cu, 1.70 mg kg^{-1}) in post harvest soil followed by application of 100 per cent RDF+ sheep manure. The treatments which received organics alone recorded lowest nutrients content in the post harvest soil. The field trial thus, revealed that an integrated supply of organic manures with chemical fertilizers significantly increased the all available major, secondary and micronutrients in both surface and subsurface post harvest soil.

(Key words: Maize, manures, primary and micronutrients)

INTRODUCTION

Maize (*Zea mays* L.) has high genetic yield potential than other cereal crops. Hence, it is called as 'miracle crop' and also as 'queen of cereals'. As heavy feeder of nutrients, maize productivity is largely dependent on nutrient management. Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity. 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 fertilizers. 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, vermicompost, sheep manure and poultry manure, not only supply macronutrients but also meet the requirements of micronutrients, besides improving soil health. To sustain the soil fertility and crop productivity the role of organic manures and fermented organic nutrients are very important.

The field trial thus, revealed that an integrated supply of organic manures with chemical fertilizers significantly increased the all available major, secondary and micronutrients in both surface and subsurface post harvest soil.The organic manures 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.

MATERIALS AND METHODS

The study was conducted in the long term maize experimental field at main agricultural research station (MARS), Dharwad, Karnataka during *kharif,* 2016. The experiment was laid out in randomized complete block design with 13 treatments, replicated thrice. The treatments included, 100 per cent RDF+ FYM (T_1), 100 per cent RDF + Vermicompost (T_2), 100 per cent RDF + Poultry manure (T_3), 100 per cent RDF + Sheep manure (T_4), FYM alone (T_5), Vermicompost alone (T_6), Poultry manure alone (T_7), Sheep manure alone (T_8), 50 per cent RDF +FYM (T_9), 50 per cent RDF + Vermicompost (T_{10}), 50 per cent RDF + Poultry manure (T_{11}), 50 per cent RDF + Sheep manure (T_{12}) and RDF alone (T_{13}). The quantity of Farm yard manure (FYM), Vermicompost (VC), Poultry manure (PM) and Sheep manure (SM) applied was based on their N content to meet RDN in organic alone treatment and on equivalent basis of N in FYM in all other INM treatments. Recommended dose of nitrogen, phosphorus and potassium were applied in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively at the time of sowing of maize.

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After the harvest of crop, the soil samples were collected from a depth of 0-22.5cm and 22.5- 45.0 cm from each treatment and the soil samples were analyzed for the available nitrogen by modified alkaline potassium permanganate method (Sharawat and Buford,1982), phosphorus by chlorostannous reduced blue colour method (Jackson, 1973), potassium by flame photometer method (Sparks,1996), sulphur by turbidimetric method using Spectrophotometer (Sparks,1996) and DTPA-extractable micronutrients(zinc, iron, copper and Manganese) were measured by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

The data regarding available N, P, K and S status in post harvest soil are given in table 1.

Available nitrogen

In surface soil, significantly highest available nitrogen (356.01 kg N ha^{-1}) was recorded in treatment receiving 100 per cent RDF + poultry manure (T_3) followed by T_4 (100 % RDF + sheep manure). Available nitrogen content in sub surface soil (173.01 to 223.82 kg N ha^{-1}) was much lower than surface soil in all the treatments and it did not differ significantly. The higher available nitrogen content of soil due to addition of poultry manure was due to the fact that the C:N ratio of poultry manure is narrow than FYM, vermicompost and sheep manure which accentuates the release of nitrogen in soil and thus contributing to the available pool of nitrogen in soil (Chadwick *et al.,* 2000).

Available phosphorus

In surface soil, the highest available phosphorus (61.81 kg P_2O_5 ha^{-1}) was recorded in treatment T_3 (100 % RDF + poultry manure) followed by T_4 (100 % RDF + sheep manure). Among the treatments with organics alone, poultry manure applied soil (T_7) accounted for significantly higher phosphorus (36.22 kg P_2O_5 ha^{-1}) than other organics. In the subsurface soil, the availability of phosphorus was highest (40.01 kg P_2O_5 ha^{-1}) in 100 per cent RDF + poultry manure (T_3) followed by 100 per cent RDF + vermicompost (T_2). This is attributable to the solubilisation of P by the organic acids released by the organic manures during their decomposition, reduction of P fixation in the soil due to chelation of P with organic ligands and also to the enhanced microbial activity (Sathya, 2010). In addition, phosphorus is relatively immobile nutrient which moves in soil by diffusion and is regulated by soil moisture. Addition of organic manure increases soil moisture content thereby improving the P availability in soil (Boateng *et al*., 2006).

Available potassium

Available potassium content in surface soil ranged from 450.03 to 496.71 kg K_2O ha^{-1} and all the treatments were on par with each other. But, however, the treatments differed significantly for potassium availability in the subsurface soil. The highest available potassium in the surface soil (496.71 kg K_2O ha^{-1}) was recorded in T_3 treatment which received 100 per cent RDF + poultry manure, whereas in the subsurface soil, the highest available potassium was found in treatment which received 100 per cent RDF + sheep manure (T_4). Application of different organic manures alone or in combination with fertilizers did not significantly influence the available potassium status of the surface soil. This might be due to high potassium status of experimental soil (475.13 kg K_2O ha^{-1}) and excess K after crop utilization might have been fixed in the soil in non exchangeable form. The available K status in sub soil was also high but lower than surface soil. Although the treatments influenced its availability in sub soil, all the treatments except those with 100 per cent RDF + organics (T_1 to T_4) were on par with each other.

Available sulphur

The highest available sulphur (26.11 kg S ha^{-1}) was recorded in T_3 which received 100 per cent RDF + poultry manure. Increase in available sulphur due to organic manures application might be due to its direct addition and mineralization of sulphur due to decomposition of organic matter. Similar findings were also observed by Channal (2012). Available sulphur content in sub surface soil was lower than surface soil in all the treatments (13.52 to 21.00 kg S ha^{-1}). The available sulphur content in sub surface soil did not differ significantly.

Micronutrients

The data regarding amount of DTPA- extractable micronutrients in the post harvest soil are given in table 2.

DTPA-extractable micronutrients in the post harvest soil were also maximum in the treatment which received 100 per cent RDF + poultry manure (Zn, 0.97; Fe, 7.91; Mn, 6.90 and Cu, 1.70 mg kg^{-1}) followed by other similar INM treatments. The treatments which received 50 per cent RDF + organics recorded lower values than 100 per cent RDF+ organics except T_{11} but significantly higher than the organic manures alone. The treatment which received only organics recorded lowest available micronutrients in the soil. The RDF treatment T_{13} contained Zn, 0.70; Fe, 7.11; Mn, 6.03 and Cu, 1.20 mg kg^{-1} and was on par with most of the INM treatments. Significantly increased availability of DTPA extractable micronutrients might be due to their direct addition of micronutrients to soil and release of chelating agents which might have prevent micronutrients from precipitation, oxidation and leaching (Sharma *et al.,* 2001). The application of organics alone resulted in significantly lower contents than rest of the treatments. Similar results were reported by Kumar *et al.* (2012) and it was attributed to non-replenishment of micronutrients through chemical fertilizers. The contents of DTPA extractable Cu, Fe, Mn and Zn at the harvest of the crop increased when compared to their initial value due to incorporation of organic manures and the extent of increase was 16.44, 8.37, 10.31 and 11.66 per cent due to poultry manure, 3.87, 7.89, 3.80 and 6.66 per cent due to vermicompost. Vidyavathi *et al*. (2012) reported that the DTPA extractable micronutrients viz., Zn; 1.40, Fe; 7.27, Mn; 8.90 and Cu; 0.86 mg kg^{-1} increased in INM treatment.

Table 1. Effect of different organics and inorganics on available major nutrients at harvest soil

Treatments	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})		S (kg ha^{-1})	
	Soil depth (cm)							
	0 - 22.5	22.5 - 45.0	0 - 22.5	22.5-45.0	0 - 22.5	22.5- 45.0	0 - 22.5	22.5 - 45.0
T_1: 100 % RDF + FYM	348.31^{ab}	216.82^{a}	55.01^{b}	30.01^{b}	478.01^{a}	353.51^{ab}	21.01^{b-d}	17.01^{a}
T_2 : 100 % RDF + VC	352.00^{ab}	217.01^{a}	56.52^{b}	34.31^{ab}	481.02^{a}	356.52^{ab}	22.22^{a-c}	18.72^{a}
T_3: 100 % RDF + PM	356.01^{a}	223.82^{a}	61.81^{a}	40.01^{a}	496.71^{a}	388.71^{a}	26.11^{a}	21.00^{a}
T_4: 100 % RDF + SM	353.31^{ab}	220.02^{a}	59.81^{ab}	32.71^{b}	486.22^{a}	391.02^{a}	23.10^{ab}	18.42^{a}
T_5 : FYM alone	301.31^{d}	191.73^{a}	28.62^{g}	20.62^{c}	451.71^{a}	329.61^{bc}	15.21^{e}	13.52^{a}
T_6: VC alone	304.42^{cd}	206.91^{a}	30.01^{g}	21.71^{c}	450.03^{a}	320.32^{bc}	17.22^{de}	16.52^{a}
T_7 : PM alone	308.70^{cd}	207.31^{a}	36.22^{ef}	22.01^{c}	457.02^{a}	331.81^{bc}	17.91^{c-e}	17.13^{a}
T_8 : SM alone	306.90^{cd}	201.71^{a}	32.51^{fg}	21.32^{c}	455.31^{a}	323.71^{bc}	17.62^{de}	16.50^{a}
T_9 : 50 % RDF + FYM	325.01^{a-d}	192.30^{a}	41.42^{de}	29.22^{b}	463.01^{a}	333.72^{bc}	18.80^{b-e}	13.61^{a}
T_{10} : 50 % RDF + VC	326.72^{a-d}	195.10^{a}	39.31^{e}	30.41^{b}	470.62^{a}	336.01^{b}	19.61^{b-e}	14.02^{a}
T_{11}: 50 % RDF + PM	335.71^{a-c}	211.01^{a}	45.52^{cd}	32.32^{b}	477.31^{a}	352.50^{ab}	20.71^{b-d}	17.41^{a}
T_{12}: 50 % RDF + SM	327.01^{a-d}	208.12^{a}	39.61^{e}	31.80^{b}	478.41^{a}	341.31^{b}	19.80^{b-d}	14.42^{a}
T_{13} : 100 % RDF	322.72^{b-d}	173.01^{a}	49.32^{c}	29.11^{b}	470.42^{a}	292.22^{c}	19.00^{b-e}	15.30^{a}
LSD	27.79	-	4.84	6.78	-	36.36	3.07	-

Note: Initial value of available N = 300.15 kg ha^{-1}, P_2O_5 = 40.16 kg ha^{-1}, K_2O = 475.13 kg ha^{-1} and S = 21.6 kg ha^{-1}Means followed by same latter (s) within a column are not significantly different (DMRT P = 0.05)

Table 2. Effect of different organics and inorganics on DTPA extractable nutrients at harvest soil

Treatments	Zn ($mg\ kg^{-1}$)		Fe ($mg\ kg^{-1}$)		Mn ($mg\ kg^{-1}$)		Cu ($mg\ kg^{-1}$)	
	Soil depth (cm)							
	0 - 22.5	22.5 - 45.0	0 - 22.5	22.5 - 45.0	0 - 22.5	22.5 - 45.0	0 - 22.5	22.5 - 45.0
T_1: 100 % RDF + FYM	0.84^{a-d}	0.31^{a}	7.30^{a-c}	3.30^{a-d}	6.11^{b-d}	3.10^{a}	1.30^{c-e}	0.58^{a-d}
T_2 : 100 % RDF + VC	0.87^{a-c}	0.40^{a}	7.51^{ab}	3.53^{a-c}	6.37^{a-c}	3.23^{a}	1.43^{bc}	0.61^{abc}
T_3: 100 % RDF + PM	0.97^{a}	0.40^{a}	7.91^{a}	3.70^{a}	6.90^{a}	3.63^{a}	1.70^{a}	0.63^{a}
T_4: 100 % RDF + SM	0.92^{ab}	0.42^{a}	7.63^{ab}	3.63^{ab}	6.51^{ab}	3.10^{a}	1.60^{ab}	0.62^{ab}
T_5 : FYM alone	0.57^{f}	0.21^{a}	5.11^{e}	2.67^{e}	4.70^{f}	2.30^{a}	0.52^{f}	0.32^{d}
T_6: VC alone	0.62^{ef}	0.21^{a}	5.51^{e}	2.87^{de}	4.83^{f}	2.50^{a}	0.60^{f}	0.34^{cd}
T_7 : PM alone	0.64^{ef}	0.31^{a}	5.92^{de}	3.10^{cde}	5.20^{ef}	2.70^{a}	0.72^{f}	0.36^{a-d}
T_8 : SM alone	0.63^{ef}	0.30^{a}	5.41^{e}	2.90^{de}	4.83^{f}	2.63^{a}	0.70^{f}	0.35^{b-d}
T_9 : 50 % RDF + FYM	0.75^{c-e}	0.31^{a}	6.12^{c-e}	3.20^{b-d}	5.57^{de}	2.73^{a}	1.10^{e}	0.52^{a-d}
T_{10} : 50 % RDF + VC	0.78^{b-e}	0.32^{a}	6.23^{c-e}	3.30^{a-d}	5.83^{cd}	2.82^{a}	1.14^{de}	0.54^{a-d}
T_{11}: 50 % RDF + PM	0.87^{a-c}	0.41^{a}	6.40^{b-e}	3.57^{a-c}	6.30^{bc}	3.04^{a}	1.38^{b-d}	0.56^{a-d}
T_{12}: 50 % RDF + SM	0.82^{a-d}	0.32^{a}	6.20^{c-e}	3.43^{a-c}	5.87^{cd}	2.89^{a}	1.23^{c-e}	0.55^{a-d}
T_{13} : 100 % RDF	0.70^{d-f}	0.31^{a}	7.11^{a-d}	3.20^{b-d}	6.03^{b-d}	2.76^{a}	1.20^{c-e}	0.58^{a-d}
LSD	0.14	-	1.10	0.42	0.53	-	0.23	0.23

Note: Initial value of DTP extractable Zn = 0.68 $mg\ kg^{-1}$, Fe = 5.13 $mg\ kg^{-1}$, Mn = 4.00 $mg\ kg^{-1}$ and Cu = 1.28 $mg\ kg^{-1}$Means followed by same latter (s) within a column are not significantly different (DMRT P = 0.05)

The field trial thus, revealed that an integrated supply of organic manures with chemical fertilizers significantly increased the all available major, secondary and micronutrients in both surface and subsurface post harvest soil.

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Rec. on 30.08.2018 & Acc. on 23.09.2018