

Original Research Article

Nutrients release pattern of organic manures, municipal solid waste compost, farm yard manure and industrial by – products in *Typic ustifluvent* soil –An incubation study

Abstract

The incubation experiment was carried out to evaluate the best organic sources and industrial by – products and inorganic fertilizers. Farm yard manure, Municipal solid waste compost, Bagasse ash and Rice husk ash were evaluated. . In the incubation experiment, organic sources decreased the pH of soil. Among organic sources application of 100% RDF + FYM@ 25t ha⁻¹(T₅) excelled other treatments by registering the lowest pH of 7.0 at 90 DAI. The FYM application decreased the EC of soil. Among all treatments application of 100% RDF + FYM@ 25t ha⁻¹(T₅) recorded lowest EC of 1.30 dSm⁻¹ at 90 DAI. The organic carbon content of the soil significantly increased due to organic sources. Similarly the nitrogen, phosphorus and potassium content of the incubation mixture were significantly increased over the control.

Key Words: Municipal solid waste, Farmyard manure, Bagasse ash, Rice husk ash

Introduction

The major thrust in the later half of the last century was to increase food production utilizing all possible resources. There must be an optimum nutrient balance for sustainable vegetable production. Recently organic farming is

gaining momentum as a means of sustainable agriculture production. Organic farming completely keeps away the use of synthetic chemical fertilizers and other plant protection chemicals, depending only on naturally available materials for the supply of plant nutrients and for the control of pests and diseases. Though nature farming and organic farming concepts are fast gathering momentum, they are also beset with problems like low yield and poor returns to investment made. In addition it also requires large quantities of good quality organic manures.

Organic sources are traditionally important inputs for maintaining soil fertility and ensuring yield stability. These organic sources supply macronutrients and improve the physical and chemical properties of soil. There is a need for utilizing manures or wastes for supplementing the chemical fertilizer. Keeping the above aspects, incubation experiment were carried out in sandy loam soils of Cuddalore district.

Review of literature

Choice of soil management practices to improve or maintain soil fertility is utmost importance in increasing productivity of vegetable crops. The application of composts and organic amendments influence soil organic matter and nutrients cycling and increase soil nutrients levels. In this context municipal solid waste is increasingly applied in many countries as compost, though it is low in nutrient content and poor fertilizing value, it has beneficial effects on physical and chemical properties of soil (Francesco Montemurro *et al.*2007).

Rapid industrialization and population explosion in India has led to the migration of people from village to cities which generate huge quantity municipal

solid waste (MSW) daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nature status by the year 2020 (Sharma and Shah, 2005). Municipal solid waste (MSW) is largely made up of kitchen and yard waste and their composting has been adopted by many municipalities. Composting of MSW is seen as a method of diverting organic waste materials from landfills while creating a product, at relatively low cost that is suitable for agriculture purpose (Wolkoswki, 2003). This trend may be attributed to economic and environment factors such as municipal landfill capacity costs associated with land filling and transportation of materials, adoption of legislation to protect the environment, decrease the use of commercial inorganic fertilizers, increasing the capacity for house hold waste recycling and improved quality of composted products (Hansel *et al.*, 2006). In aerobic composting the bacterial conversion of the organic present in MSW in the presence of air under hot and moist condition is called composting and the final product obtained after bacterial activity is called compost (humus), which has very high agricultural value it is used as organic manure and it is non-odorous and free of pathogens (Mufeed Sharholy *et al.*, 2008).

Organic matter plays an important role in the improvement of soil physical properties such as the promotion of soil aggregation, improved permeability and moisture holding capacity, the most valued part in organic matter, well decomposed FYM or compost is humus as a chemically identifiable and stable product, outcome of microbial metabolites, laboratory studies have shown that low molecular weight substance from humus are also taken by the plants (Schnitzer and Khan, 1972). They are also known to influence the plant

metabolism, they render the nutrient in to be soil more available by their chelating capacity with micronutrient (Schnitzer and Skinner, 1963). The recent energy crisis and hike in prices of the inorganic fertilizer, necessitate the use of organic manures and industrial by – products in crop production. In this content an attempt was made to augment radish cultivation practice by incorporation of FYM in to the normal fertilizer input requirement.

Bagasse ash is a type of organic wastes which obtained from sugar industry during the process of sugar production. Basically we use Bagasse also in agriculture as organic fertilizer for crop improvement is now-a-days becoming an established practice. Researches considers bagasse ash as a good source of micro nutrients like, Fe, Mn, Zn and Cu (Anguissola *et al.* 1999). It can also be used as soil additive in agriculture farming having its capacity to supply the plants with small amounts of nutrients (Carlson and Adriano 1993).

Paddy husk ash is a highly available amendment in large quantities. It has reasonable quantities of Ca, Mg, K, Na, and other essential elements including P and very little N. The ash increases the soil pH, thereby increasing available phosphorus, it improves the aeration in the crop root zone and also increases the water holding capacity and level of exchangeable potassium and magnesium (AICOAF, 2001).

Materials and Methods

In view of the above, an incubation study was carried out in the Department of Soil Science and Agricultural Chemistry. The experiment was laid out by adopting CRD with three replications. Soils were collected from Vallampadugai

of Cuddalore district of Tamil Nadu, and incubated with FYM, Municipal solid waste compost, Rice husk ash and Bagasse ash. The experiment comprised of a treatment combinations involving Municipal solid waste compost, FYM, Rice husk ash and Bagasse ash replicated thrice in *Typic ustifluvent* soil. The soil was sandy loam in texture with low available nitrogen, medium in available phosphorus and potassium status.

Incubation experiment

An incubation experiment was conducted at Dept. of Soil Science and Agricultural Chemistry, Annamalai University, Chidambaram with an objectives of studying the nutrients release pattern from organic sources, industrial by – products and inorganic fertilizer. 200g of 2mm sieved soil samples was filled in 250 ml (depth 9cm diameter 21 cm) plastic containers. The treatment details are given below. Each treatment was replication thrice. The soil was incubated at room temperature for 90 days at field capacity. The design followed was Completely Randomized Design (CRD).

Treatment details of the incubation experiment

- T₁ - Control – 100 % RDF
- T₂ - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha⁻¹
- T₃ - 100 % RDF + Municipal Solid Waste Compost @ 10 t ha⁻¹
- T₄ - 100 % RDF + Farm Yard Manure @ 12.5 t ha⁻¹
- T₅ - 100 % RDF + Farm Yard Manure @ 25 t ha⁻¹
- T₆ - 100 % RDF + Rice Husk Ash @ 5 t ha⁻¹
- T₇ - 100 % RDF + Rice Husk Ash @ 10 t ha⁻¹

T₈ - 100 % RDF + Bagasse Ash @ 5 t ha⁻¹

T₉ - 100 % RDF + Bagasse Ash @ 10 t ha⁻¹

The soil samples were drawn an 30, 60 and 90th days after incubation and analyzed for pH, EC, organic carbon and available NPK content(Table A).

Table A. Methods of analysis of organic manures and industrial by-products

S.No.	Parameters	Method	Reference
A. Municipal solid waste compost, farm yard manures			
1	Total nitrogen	Micro – Kjeldahl method (Diacid extraction H ₂ SO ₄ :HClO ₄ in 9:4 ratio)	Humphries (1956)
2	Total phosphorus	Vanado molybdate yellow method (Triple acid extraction, HNO ₃ ,H ₂ SO ₄ in 9:2:1 ratio)	Jackson (1973)
3	Total potassium	Flame photometry (Triple – acid extract)	Jackson (1973)
B. Bagasse ash and Rise-husk ash			
4	pH	Potentiometry (1:10 soil : water suspension)	Jackson (1973)
5	Electrical conductivity	Conductometry (1:10 soil : water suspension)	Jackson (1973)

Results

Soil reaction

The application of conventional, non- conventional organic sources recorded lowest pH value at all three stages of incubation period (Table 1). Among organic sources, application of 100 % RDF + FYM @ 5 t ha⁻¹ (T₅) recorded the lowest pH of soil at all three stages of incubation period. The pH values observed with this treatment were 7.0 at 30 DAI, 6.9 at 60 DAI and at 90 DAI. This was followed by the application of FYM @ 25 t ha⁻¹ (T₄) recorded pH of 6.9 at 30 DAI. The treatment (T₅) was on par with T₄ 100% RDF + FYM@ 12.5t ha⁻¹ recorded pH of 7.0 at 60 and 90 DAI. The highest pH at all stages with 100% RDF + Bagasse ash @ 10 t ha⁻¹ (T₉) registered 8.6, 8.72, and 8.84, at 30, 60 and 90DAI respectively.

Electrical conductivity (EC)

The application of conventional organic sources significantly contributed for the reduction of EC in soil (Table 2). The electrical conductivity (EC) of the soil significantly reduced to the tune of 1.30 dS m⁻¹ at 90 DAI with application of 100% RDF + FYM @ 25 t ha⁻¹ (T₅) compared with control (T₁) of 1.35 dSm⁻¹. The lowest EC was found with the addition of 100% RDF + FYM @ 25 t ha⁻¹ (T₅) recorded 1.41, 1.35, 1.30 dSm⁻¹ at 30, 60 and 90 DAI respectively. This treatment however maintained on par with 100% RDF + FYM @ 12.5 t ha⁻¹ (T₄) registered 1.25, 1.30, and 1.31 dSm⁻¹ at 30, 60, and 90 DAI respectively. This was followed T₃ 100% RDF + Municipal solid waste compost @ 10 t ha⁻¹ registered 1.29, 1.30 and 1.31 dSm⁻¹ at 30, 60 and 90 DAI respectively. The highest EC at all stages of incubation experiment was recorded with 100% RDF + Bagasse ash @ 10 t ha treatment (T₉) recorded 1.55 dSm⁻¹ at 30 DAI and 1.66 dSm⁻¹ at 60 DAI and 1.64 dSm⁻¹ at 90 DAI.

Table 1. Effect of organic sources and industrial by- products on soil pH in incubation experiment

Treatments	Soil reaction (pH)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% NPK	7.2	7.1	7.1
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	7.5	7.5	7.5
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	7.5	7.5	7.4
T ₄ – 100% RDF + Farm yard manure @ 12.5 t ha ⁻¹	7.1	7.0	7.0
T ₅ – 100% RDF + Farm yard manure @ 25 t ha ⁻¹	7.0	6.9	6.9
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	7.7	7.8	7.9
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	7.8	7.9	7.9
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	8.3	8.6	8.7
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	8.5	8.7	8.8
Mean	7.68	7.73	7.75
S.Ed	0.50	0.50	0.09
CD (p=0.05)	1.05	1.06	0.20

Table 2. Effect of conventional, non – conventional organic sources and industrial by – products on soil electrical conductivity (EC) in incubation experiment

Treatments	Electrical conductivity (dSm ⁻¹)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% NPK	1.35	1.31	1.31
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	1.30	1.31	1.31
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	1.29	1.30	1.31
T ₄ – 100% RDF + Farm yard manure @ 12.5 t ha ⁻¹	1.25	1.30	1.31
T ₅ – 100% RDF + Farm yard manure @ 25 t ha ⁻¹	1.41	1.35	1.30
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	1.39	1.45	1.41
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	1.40	1.40	1.45
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	1.55	1.56	1.60
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	1.55	1.66	1.64
Mean	1.39	1.41	1.41
S.Ed	0.09	0.09	0.09
CD (p=0.05)	0.19	0.19	0.19

Organic carbon

All the treatments significantly contributed for increasing the organic carbon content of the soil, an essential factor for soil fertility and productivity improved (Table 3).

Though all the treatments were efficient in increasing the organic carbon status, the influence of FYM was found superior followed by municipal solid waste compost. Application of 100% RDF + FYM @ 25 t ha⁻¹ (T₅) recorded significantly highest organic carbon of 2.31, 2.32 and 2.32 g kg⁻¹ at 30, 60 and 90 DAI respectively. This was on par with treatment (T₄) registered 2.27, 2.31, 2.31 g kg⁻¹ at 30, 60 and 90 DAI respectively. This was followed by the treatment T₃ and T₂ throughout the incubation period. Treatment T₆ (100% RDF + RHA @ 5 t ha⁻¹) recorded lowest organic carbon content of 2.06 g kg⁻¹ at 30, 60 and 90 DAI.

Alkaline KMnO₄ – N

The influence of various organic sources, and industrial by – products in increasing the fertility of soil by the way of increased availability of nitrogen at all the stages of incubation study was well evidenced in the present investigation (Table 4).

The nitrogen content of soil failed to differ significantly among the treatments. The highest nitrogen content in the soil was recorded with T₅ (100% RDF + FYM @ 25 t ha⁻¹) recorded maximum N content of 87.0, 88.3, and 89.1 mg kg⁻¹ at 30, 60 and 90 DAI respectively. The control (T₁) maintained the

lowest soil N content of 83.9, 85.0, and 85.9 mg kg⁻¹ at 30, 60 and 90 DAI respectively.

UNDER PEER REVIEW

Table 3. Effect of organic sources and industrial by – products on soil organic carbon in incubation experiment.

Treatment	Organic carbon (g kg ⁻¹)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% RDF	2.1	2.17	2.21
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	2.26	2.30	2.31
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	2.31	2.32	2.32
T ₄ – 100% RDF + Farm yard manure @ 12.5 t ha ⁻¹	2.27	2.31	2.31
T ₅ – 100% RDF + Farm yard manure @ 25 t ha ⁻¹	2.31	2.32	2.32
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	2.06	2.06	2.06
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	2.06	2.07	2.07
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	2.16	2.07	2.07
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	2.16	2.07	2.07
Mean	1.39	1.39	2.19
S.Ed	0.09	0.09	0.14
CD (p=0.05)	0.20	0.20	0.31

Table 4. Effect of organic sources and industrial by – products on Alkaline KMnO₄ – N in incubation experiment.

Treatment	Soil N (mg kg ⁻¹)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% RDF	83.9	85.0	85.9
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	85.06	86.0	87.0
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	85.3	86.3	87.3
T ₄ – 100% RDF + Farm yard manure @ 12.5 t ha ⁻¹	86.1	88.1	89.0
T ₅ – 100% RDF + Farm yard manure @ 25 t ha ⁻¹	87.0	88.3	89.1
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	84.7	85.0	85.7
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	85.0	85.3	86.1
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	83.7	85.1	86.0
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	84.0	85.2	86.1
Mean	85.03	86.09	86.97
S.Ed	5.56	5.63	5.66
CD (p=0.05)	NS	NS	NS

Olsen – P

The positive influence of organic sources and industrial by – products did not significantly influence on soil available P was observed in the present incubation experiment (Table 5)

The highest available P in soil was recorded with T₅, (100% RDF + FYM@ 25 t ha⁻¹) recorded was 11.5 mg kg⁻¹ at 30 DAI, 11.7 mg kg⁻¹ at 60 DAI and 11.8 mg ka⁻¹ at 90 DAI with this treatment(T₅). The treatment (T₁) control recorded the lowest P content of 10.7, 10.8 and 11.0 mg kg⁻¹ at 30, 60 and 90 DAI respectively.

NH₄OAc – K

Application of organic sources, industrial by – products significantly increased the available K content of the soil (Table 6). The highest amount of available K was noticed with the application of 100% RDF + Bagasse ash @ 10 t ha⁻¹ (T₉). It registered 120.3, 121.9 and 123.3 mg kg⁻¹ of K at 30, 60 and 90 DAI respectively. This was followed by the application of 100% RDF + Bagasse ash @ 5 t ha⁻¹ (T₉) which recorded 120.0, 121.3 and 74.53 mg kg⁻¹ of K at 30, 60 and 90 DAI respectively. The control (T₁) recorded the lowest K content of 94.0, 94.1, and 95.0 mg kg⁻¹ at 30, 60 and 90 DAI respectively.

Table 5. Effect of organic sources and industrial by – products on Olsen – P in incubation experiment.

Treatment	Soil P (mg kg ⁻¹)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% RDF	10.7	10.8	11.0
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	10.8	11.1	11.1
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	11.0	11.1	11.2
T ₄ – 100% RDF + Farm yard manure (FYM) @ 12.5 t ha ⁻¹	11.3	11.5	11.7
T ₅ – 100% RDF + Farm yard manure (FYM) @ 25 t ha ⁻¹	11.5	11.7	11.8
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	10.8	10.8	11.0
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	10.8	10.8	11.0
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	10.8	10.8	10.9
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	10.8	10.9	10.9
Mean	11.00	11.11	11.18
S.Ed	0.71	0.72	0.73
CD (p=0.05)	NS	NS	NS

Table 6. Effect organic sources and industrial by – products on NH₄OAc – K in incubation experiment.

Treatment	Soil K (mg kg ⁻¹)		
	30 DAI	60 DAI	90 DAI
T ₁ – control – 100% RDF	94.0	94.1	95.0
T ₂ – 100% RDF + Municipal solid waste compost @ 5 t ha ⁻¹	91.8	94.3	95.3
T ₃ – 100% RDF + Municipal solid waste compost @ 10 t ha ⁻¹	94.2	94.7	95.0
T ₄ – 100% RDF + Farm yard manure (FYM) @ 12.5 t ha ⁻¹	94.4	94.8	95.9
T ₅ – 100% RDF + Farm yard manure (FYM) @ 25 t ha ⁻¹	94.5	95.0	96.1
T ₆ – 100% RDF + Rice Husk Ash @ 5 t ha ⁻¹	118.0	120.0	121.1
T ₇ – 100% RDF + Rice Husk Ash @ 10 t ha ⁻¹	118.3	120.1	121.9
T ₈ – 100% RDF + Bagasse Ash @ 5 t ha ⁻¹	120.0	121.3	122.9
T ₉ – 100% RDF + Bagasse Ash @ 10 t ha ⁻¹	120.3	121.9	123.3
Mean	105.11	106.29	107.80
S.Ed	5.88	6.99	7.21
CD (p=0.05)	12.35	14.0	15.16

Discussion

pH and EC

It is obvious that improvement in chemical properties of soil is the pre requisite for better crop nutrition. All organic sources and industrial by – products used in the incubation experiment significantly improved the chemical properties of soil.

In the incubation experiment carried out, the conventional organic sources greatly reduced the soil reaction (pH) and electrical conductivity of the alluvial soil. The initial soil pH of 7.6 and EC of 1.3 dSm⁻¹. Due to the application of 100% RDF + FYM@ 25t ha⁻¹ (T₅), a reduction in soil pH value of 6.9 at 90 DAI was noticed. The EC value observed with the treatment (T₅) recorded lowest EC value of dSm⁻¹1.30 at 90 DAI. The favourable reduction in pH and EC could be attributed to the prolonged decomposition of added organic sources. Decline in soil pH can have positive impacts on availability of nutrients such as phosphorus, zinc, iron and manganese. (Babbu Singh Brar *et al.* 2015), the reduction in soil pH was mainly due to release of organic acids in the soil upon decomposition of organics. The decrease in pH of the soil amended with FYM might be due to the release of organic acids from the manure (Singh *et al.* 2015).

The decrease in soil EC with the application of FYM is unusual as FYM contains nutrients which normally increase the soil EC. A possible reason for this phenomenon could be that active absorption of nutrients by plants has occurred during the growing period, leaving behind few nutrients in the soil as EC was measured after crop harvest. Moreover the FYM used in this study contained relatively more organic N and P, which produced amino acid and phosphoric acids upon decomposition and hence result in lowering both soil pH and EC. (Zahir Shah *et al.* 2013).

Organic carbon

The organic carbon content of the experimental soil was 2.5 g kg^{-1} and rated low. The organic carbon content of the incubation soil was greatly influenced by the added organic sources. The increase in organic carbon content of soil was in the range of 2.26 to 2.32 g kg^{-1} in the incubation experiment with organic sources. Among treatments $100\% \text{ RDF} + \text{FYM} @ 25 \text{ t ha}^{-1} (\text{T}_5)$ excelled all the treatments by recording 2.31 , 2.32 and 2.32 g kg^{-1} at 30, 60, 90 DAI respectively. The increase in soil organic carbon among organic sources was due to addition of carbon sources through FYM (Kaur *et al.* 2008), The organic carbon content was increased by the addition of organic manures in the soil (Thamaraiselvi *et al.* 2012).

$\text{KMnO}_4 - \text{N}$

In the incubation experiments, the availability of N increased with the application of organic sources. In the incubation experiment application of $100\% \text{ RDF} + \text{FYM} @ 25 \text{ t ha}^{-1} (\text{T}_5)$ registered highest N availability value of 89.1 mg kg^{-1} . The increased N availability with applied organic sources might be due to the increased decomposition of organic sources under favourable soil enrichment and due to reduced volatilization, leaching and denitrifying losses. It might be due to the decomposition of organic matter leads to mineralization of organically found nitrogen. (Singh *et al.* 1998).

Olsen – P

The increased Olsen – P content due to application of organic sources and industrial by – products was well evidenced in the incubation experiment. The experimental soil exhibited medium status of available phosphorus. The increased availability of phosphorus due to application of organic sources and industrial by – products were in the range of 10.7 to 11.5mg kg⁻¹ at 30DAI, 10.8 to 11.7mg kg⁻¹ at 60DAI and 10.9 to 11.8mg kg⁻¹ at 90DAI. Generally the content of the added inputs is the most important factor for phosphorus mineralization in the soil (Hundal and Thind *et al* 1993). In the incubation studies Municipal solid waste compost, FYM, Rice husk ash and Bagasse ash were used as sources for supplementing P nutrition. The FYM, Municipal solid waste compost, Rice husk ash contained 0.42, 0.16, 0.09% total P respectively. The application of FYM enhanced phosphorus availability, (Narwal *et al.* 1990) reported that organics were superior in improving available P. It might be due solubilizing effect of organic acids on organic phosphorus and organic anions retard the fixation of P in by complexing with organic ligands and chelation of P fixing cations like Ca, Mg, Fe, Al, Zn, Mn and Cu. Phosphorus complex with humic and fulvic acid increase the availability of phosphorus to the plants. Similar findings were also reported by Hemalatha and Chellamuthu (2013).

NH₄OAc – K

Application of organic sources and industrial by – products showed on improvement in the K content of soil. In incubation experiment, the highest K availability was observed with the application of 100% RDF + Bagasse ash @ 10 t ha⁻¹(T₉) which registered 123.3mg kg⁻¹. The other industrial by – products viz., Rice husk ash, Bagasse ash, organic sources viz, FYM, Municipal solid waste compost also improved the K status of soil. The organic sources increased

the K availability could be ascribed to the variation in the amounts of total K added through organic sources this rates and around of mineralization (Yadvinder Singh *et al.* 2005). The increase in available potassium content in bagasse ash application might be due to the release of potassium present in bagasse ash. Similar results were also made by Nkana *et al.* (2002).

Conclusion

Incubation experiment

The following are the salient findings of the present study. In the incubation experiment, organic sources decreased the pH of soil. Among organic sources application of 100% RDF + FYM@ 25t ha⁻¹(T₅) excelled other treatments by registering the lowest pH of 7.0 at 90 DAI.

The FYM application decreased the EC of soil. Among all treatments application of 100% RDF + FYM@ 25t ha⁻¹(T₅) recorded lowest EC of 1.30 dSm⁻¹ at 90 DAI. The organic carbon content of the soil significantly increased due to organic sources. The values ranged from 2.31 to 2.32g kg⁻¹ against 2.21g kg⁻¹ in control. The availability of KMnO₄-N and Olsen-P in the soil also increased with the time of incubation. The increase in alkaline KMnO₄-N due to application of 100% RDF + FYM@ 25t ha⁻¹ was to the tune of 89.1mg kg⁻¹ at 90 DAI. The increase in Olsen-P due to application of 100% RDF + FYM@ 25t ha⁻¹ was to the tune of 11.8mg kg⁻¹ at 90 DAI. The NH₄OAc – K in the soil also increased with the time of incubation. The increase in NH₄OAc – K due to application of 100% RDF + Bagasse ash @ 10t ha⁻¹ was to the tune of 123.3mg kg⁻¹ at 90 DAI.

REFERENCES

- AICOAF, (2001) Application of rice husk charcoal, Food and Fertilizer Technology Center for the Asian and Pacific region leaflet for Agriculture: Practical Technologies 4. *Association for International Cooperation in Agriculture and Forestry* (AICOAF), Japan.
- Anguissola, S., Silva, S. and Botteschi, G. (1999) Effect of fly ash on the availability of Zn, Cu, Ni and Cd to chi-cory. *Agriculture Ecosystems and Environment* **72**, 159-163.
- Babbu Singh Brar, Jagdeep Singh, Gurbir Singh and Gurpreet Kaur. (2015) Effect of long term application of inorganic and organic fertilizer on soil organic carbon and physical properties in maize – wheat rotation, *Agronomy* **5**, 200- 238.
- Carlson, C.L. and Adriano, D.C. (1993) Environmental impacts of coal combustion on residues. *Journal of Environment Quality* **22**, 227–247.
- Francesco Montemurro., Michele Maiorana., Grazia Convertini and Donato Ferri. (2007) Alternative sugar beet production using shallow tillage and Municipal Solid Waste Fertilizer, *Agronomy of sustainable development* **27**, 129 – 137.
- Hansel, T.G., Bhandar, T., Christensen Bruun, S. and Jensen, L. (2006) Life cycling Modeling of Environmental Impacts of Application of Processed Organic Municipal Solid Waste on Agricultural land (EASTE WASTE). *Waste Management Research* **124**, 154 – 166.
- Hemalatha, S. and Chellamuthu, S. (2013) Impacts of long-term fertilization on soil nutritional quality under finger millet: Maize cropping sequence. *Journal of Environment Research and Development* 104-106.
- Humphries, E.C. (1956) Mineral components and ash analysis. In: *modern methods of plant analysis*. Springer – Vering, Berlin. **1**, 486-502.
- Hundal, H.S. and Thind, S.S. (1993) Release of phosphorus in flooded soil amended with green manure. *Journal of Indian Society of Soil Science* **41**, 782-783.
- Jackson, M.L. (1973) *Soil Chemical Analysis*. Prentice – Hall of Indian Pvt. Ltd. New Delhi.

- Kaur, T., Brar, B.S. and Dhillon, N. (2008) Soil organic matter dynamics as effected by long – term use of organic and inorganic fertilizers under maize – wheat cropping system, nutr. *Cycl. Agro ecosystem* **81**, 59-69.
- Mufeed Sharholy., Kafeel Ahamed., Gauhar Mahmood and Trieeli, R.C. (2008) Municipal Solid Waste management in indian cites. A review, *waste management Research* **28**, 249 – 467.
- Narwal, R.P., Gupta, A.P. and Antil R.S. (1990) Efficiency of triple super phosphate and mussoorie rock phosphate mixture incubated with sulfitation process pressmud. *Journal of the Indian Society of Soil Science* **38(1)**, 51-55.
- Nkana, J., Demeyer, A. and Verloo, M. (2002) Effect of wood ash application on soil solution chemistry of tropical acid soils: incubation study. *Bioresource Technology* **85**, 323-325.
- Schnitzer, M. and Khan, U. (1972) *Humic substances in the environment*. Marcel Dekker, New York.
- Schnitzer, M. and Skinner, S.I.M. (1963) Chemistry of soil organic matter. *Soil Science* **98**, 197-203.
- Sharma, S. and Shah, K.V. (2005) Generation and disposal of solid waste in Hoshangabad: In: *Book of proceedings of the second international congress of chemistry and environment*, Indore, India. pp. 749 – 751.
- Sharma, S.P., Subehia, S.K. and Sharma P.K. (2002) Long – term effects of chemical fertilizers on soil quality, crop productivity and Sustainability, *Research Buletin*, Palampur, 1-33.
- Sharma, U.C. and Singh, K. (1991) Integrated management of phosphate and farm yard manure in potato-radish cropping sequence on acidic soil. *Journal of the Indian Society of Soil Science* **39**, 468-471.
- Singh, D., Balyan, D.S. and Rana, M.K. (1998) Effect of integrated nutrient management on growth, yield and economics of okra (*Abelmoschus esculentus* (L.) Moonch). *Haryana Journal of Horticultural Science* **26 (3-4)**, 254-257.

- Singh, N.J., Athokpam, S., Devi, K.N. Chongtham, Singh, N.B., Sharma, S. and Dayananda. (2015) Effect of farm yard manure and press mud on fertility status of alkaline soil under maize – wheat cropping sequence, *African Journal of Agricultural Research* **10(24)**, 2421-2431.
- Thamaraiselvi, T., Brindha, S., Kaviyarasi, N.S., Annadurai, B. and Gangwar, S.K. (2012) Effect of organic amendments on the bio chemical transformations under different soil conditions. *International Journal of Advanced Biological Research* **2**, 171-173.
- Wolkowski, (2003) Nitrogen Management Consideration for land spreading Municipal Solid Waste Compost. *Journal of environmental quality* **32**, 1844 – 1850.
- Yadvinder Singh, Pannu, R.P.S., Bijay Singh and C.S. Khind. (2005) Leaching of potassium from organic manures, crop residues and inorganic fertilizer in two soils under flooded and upland moisture regimes. *Journal of Indian Society of the Soil Science* **53**, 207-213.
- Zelalem Bekeko. (2013) Improving and sustaining soil fertility by use of enriched farmyard manure and inorganic fertilizers for hybrid maize (BH-140) production at West Hararghe zone, Oromia, Eastern Ethiopia, *African Journal of Agricultural Research* **8(14)**, 1218-1224.