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Influence of Compost, Industrial Refuse on Yield, Yield Attributes of Maize and Post-harvest Soil Fertility Status

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ABSTRACT

Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. The experimental soil was collected from Varagurpettai village representing heavy textured soil at Cuddalore district. Pot experiment was carried out to study the effect of soil application of RDF as control, Municipal solid waste compost @ 5 and 10 t ha^{-1}, Vermicompost @ 2.5 and 5 t ha^{-1}, Lignite fly ash @ 5 and 10 t ha^{-1}, Bagasse ash @ 5 and 10 t ha^{-1} with 75% and 100% RDF. There were nine treatment combinations replicated thrice in CRD. The results in pot trial conducted in Annamalai University showed that application of 75% RDF with vermicompost @ 5 t ha^{-1} significantly increased yield attributes, grain yield, stover yield, post-harvest organic carbon and NPK status. Composting municipal solid waste compost is seen as a low-cost method of diverting organic waste materials from landfills while creating a product for agricultural purposes. The sugar industrial waste, pressmud, cow dung and earthworms composted for vermicompost. Lignite flyash of Neyveli Lignite Corporation serves as a supplementary source of essential plant nutrients. Bagases ash is one of the wastes obtained from sugar industries. It is capable of supplying sufficient amount of plant nutrients.

Key words: Maize, Municipal solid waste compost, Vermicompost, Industrial refuse, Grain yield

Maize is known as queen of cereals, also called corn is one of the most important cereal crops in the world. In India, maize is the third most important food crops after rice and wheat maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in peri urban areas. In India maize area has reached to 9.2 million ha, production to 27.8 million metric tons and productivity is 3 t ha^{-1} [1]. India currently produces close to 1.5 lakh tonnes of solid waste every day and its biodegradable fraction ranges between 30% and 70% for various Indian cities [2]. To ensure a safe disposal of municipal solid waste and to reduce the required capacity of the disposal site, it is necessary that waste is processed. Amongst the known processing technologies, composting is quite commonly used and it results in production of a stable product that is, compost can be used as a low-grade manure and soil conditioner on forms and orchards [3]. In India 340 million tons of press mud are generated by sugar mills every year. It is well established that a large number of organic wastes can be infested by earthworms and egested as peat-like material termed vermicompost. Vermicomposting is one of the remediation technologies to detoxify and to convert press mud waste biomass into vermicompost [4].

The exponential increase in industrialization is not only assuming large areas of agriculture lands, but simultaneously causing serious environmental degradation as well as to soil. In India, national thermal power plant run more than 70 thermal power plant and subsequently generate about 110 million tons of coal-ash and this is predicted to increase up to 170 million tons per annum Lignite fly ash, a by-product from thermal stations. Lignite fly ash has a potential in agriculture and related application. Essential macronutrients (P, K, Ca and S) and micronutrients (Fe, Mn, Cu, B and Mo) are present in fly ash. Agriculture is the only way and means of utilizing the industrial wastes like fly ash in a controlled manner [5]. Boiler ash is one of the wastes obtained from sugar industries during the process of sugar manufacturing. After crushing and extracting juice from sugarcane, the remaining pulp (Bagasse) is burnt under boilers. It is one of the important organic wastes capable of supplying sufficient amount of plant nutrients [6].

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The study aimed to know the organic sources and industrial refuse of Annamalai University locality is and around area were used to above materials for agricultural supplementary resources for increasing the yield of maize.

MATERIALS AND METHODS

The study involved a pot experiment conducted during 1st September to 25th April 2017 at the Department of Soil Science and Agricultural Chemistry, Annamalai University with maize as a test crop. The soil sample were collected from Varagurpettai village, (*Typic Chromusterts*) of Cuddalore district, Tamil Nadu.

Materials used

Municipal solid waste compost: The organic material mainly vegetable, fruit and kitchen waste were separated manually and subjected to turned windrows composting process by composting of municipal solid waste of Jabalpur city [7]. The nutrient composition of municipal solid waste compost were presented in (Table 1).

Table 1. NPK composition of materials

Materials	Organic carbon (g kg^{-1})	Total N (%)	Total P (%)	Total K (%)
Municipal solid waste compost	270	1.13	2.92	0.53
Vermicompost	139.6	1.59	3.43	0.27
Lignite Flyash	22.5	0.008	0.39	0.48
Bagasse ash	71.5	0.014	0.0052	0.024

Vermicompost: Pressmud collected from the sugar industry. Press mud was spread to 30 cm height in shade and allowed to decompost. The preparation of vermicomposting of sugar industry waste (press mud) mixed with cow dung employing earthworm methodology followed [8]. The nutrient content of vermicompost were mentioned in (Table 1).

Bagasse ash: The extraction of sugar juice from sugarcane, sugarcane bagasse is produced, which is approximately 50% of the sugarcane quality. Bagasse is commonly used as a food in cogeneration to produce steam and generate electricity. In this process, sugarcane bagasse ash remains as the final waste in the sugar production chain. Each ton of burnt bagasse may generate 25-40 kg of bagasse ash and subsequently a considerable amount of SCBA could be generated [9]. It is a by-product generated at industrial plants using biomass as energy source. The resulting bagasse ash is an alkaline material namely of nitrogen, that containing others elements such as potassium (K) and phosphorus (P) which are required for plants. The bagasse ash in dry form collected from Sethiyathoppe cooperative sugar mill. The nutrient composition of bagasse ash was presented in (Table 1).

Lignite fly ash: Lignite fly ash (LFA) obtained from a lignite fired power station, Neyveli Lignite Corporation, Tamil Nadu, India was used for this study. The fly ash produced from the burning of pulverized coal in a coal-fired boiler is a fine grained. The dry form collected from the electro station precipitator and stored in silo or storage tanker at the plant itself. The fly ash contains essential macronutrients are used in this study [10]. Nutrient content of fly ash was presented in (Table 1).

Pot experiment was conducted with an objective of studying the effects of nutrient management on yield, yield attributes and post-harvest nutrient status 20 kg of air-dried processed soil was filled in 35 cm × 30 cm cement pots. The composts and industrial by-products were applied basally. A uniform NPK dose of 135:62.5:50 kg ha^{-1} was applied. Maize seeds (Var. VNR 4211) were dibbled in each pot. The treatment includes T_1: Control – 100% RDF, T_2: 100% RDF + Municipal solid waste compost @ 5 t ha^{-1}, T_3: 75% RDF + Municipal solid waste compost @ 10 t ha^{-1}, T_4: 100% RDF + Vermicompost @ 2.5 t ha^{-1}, T_5: 75% RDF + Vermicompost @ 5 t ha^{-1}, T_6: 100% RDF + Bagasse ash @ 5 t ha^{-1}, T_7: 75% RDF + Bagasse ash @ 10 t ha^{-1}, T_8: 100% RDF + Lignite fly ash @ 10 t ha^{-1}, T_9: 75% RDF + Lignite fly ash @ 5 t ha^{-1}. The design followed was completely randomized block design.

Yield parameters

Weight to cob (g plant^{-1}): The cobs from the plants were removed thoroughly, air dried, cleaned and weighed. The average cob weight was taken as weight of cob in gram per plant.

Cob length (cm): Length of the cob was measured from the base to the tip of the cob and expressed in centimeter.

Cob girth: The circumference measured at the center of the cob using thread. This was taken as girth of the cob and expressed in centimeter.

Number of grains ear^{-1}: Grain number ear^{-1} was obtained by manual counting of number of grains after separation of grains from cob.

Number of cob plant^{-1}: Number of cobs from each plant was counted and average value was recorded.

Hundred seed weight (g): The weight of hundred grains were recorded from the samples drawn from the produce obtained in each of the pot and is expressed in gram per hundred seeds.

Grain yield (g pot^{-1}): At physiological maturity, cobs from the pot were harvested. The mean grain yield obtained in each treatment was expressed in g pot^{-1}.

Stover yield (g pot^{-1}): After drying of straw, the stover yield from each pot was recorded and yield per hectare was calculated. The mean stover yield obtained in each treatment was expressed in g pot^{-1}.

Soil samples collected at Varagurpettai just before the start of the experiment and at harvest were analyzed for the available nutrient. The soil pH and electrical conductivity (EC) were determined in 1:2.5 soil: water suspension as described by [11]. Soil texture was determined by Bouyoucos hydrometer [12]. Organic carbon (0.2 mm sieved) was determined by wet oxidation method of Walkley and Black [13]. For available N was determined by alkaline permanganate [14]. For available P, soil sample was extracted with 0.5 M $NaHCO_3$ (pH 8.5, Olsen *et al.* [15] and P content in the extract was determined by ascorbic acid method [16]. Available K was determined by extracting soil with 1N NH_4OAC followed by measuring the K content using a flame photometer. The cation exchange capacity (CEC) was determined by the method given by [17]. The data were analyzed using AGDATA and AGRES software. Experimental design was adopted based on [18]. The soil sample (Table 2) used in the pot experiment were collected at Varagurpettai village at Cuddalore district. The soil was slightly alkaline (7.6), electrical conductivity was normal (0.3 dSm^{-1}), low in organic carbon, available nitrogen, highest in available phosphorus and medium in available potassium. The soil of experimental site belongs to Adanur series and taxonomically comes under the order vertisol, such order *Usterts* great group *Chromusterts*, subgroup *Typic chromusterts*.

Table 2 Initial properties of soils of experimental site

A	*Mechanical properties*	Content
1	Clay (%)	38.7
2	Silt (%)	15.7
3	Fine sand (1%)	32.4
4	Coarse sand (%)	13.2
5	Textural classification	Clay loam
6	Taxonomical classification	*Typic Chromusterts*
B	*Physical properties*	
1	Bulk density (M gm^{-3})	1.22
2	Particle density (M gm^{-3})	2.65
3	Pore space (%)	54
C.	*Physico-chemical properties*	
1	Ph	7.6 (Slightly alkaline)
2	EC (dSm^{-1})	0.31 (Non saline)
3	CEC [cmol(p^+) kg^{-1}]	22.1 (Medium)
D.	*Chemical properties*	
1	Organic carbon (%)	0.45 (Low)
2	Available nitrogen (kg ha^{-1})	235.2 (Low)
3	Available phosphorus (kg ha^{-1})	38 (High)
4	Available potassium (kg ha^{-1})	226.4 (Medium)

RESULTS AND DISCUSSION

Yield attributes

Application of conventional source (vermicompost) and non-conventional source (municipal solid waste compost) showed an increase in yield components significantly the highest cob length (26.4 cm), cob girth (26.3 cm), cob weight (379.6 g $plant^{-1}$), number of cobs $plant^{-1}$ (2), 100 seed weight (28.9) (Table 3). The reason for increasing the yield attributes might be due to availability of nutrients through application of vermicompost. The integrated use of fertilizer did bring about significant improvement in overall growth of the crop by providing needed nutrient from initial stage and increase in supply of NPK in more synchronize way, at the treatment receiving integrated supply of nutrient from organic manure along with inorganic fertilizer and which expressed in terms of cobs per plant, cob girth, cob length, cob weight with and without husk by virtue of increased photosynthetic efficiency. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants, cob, girth, cob length and cob weight with these treatment [19].

Among industrial by-products the application of 75% RDF + Fly ash @ 10 t ha^{-1} registered cob weight (297.6 g $plant^{-1}$), cob length (23.2 cm), cob girth (23.8 cm), no. of cobs $plant^{-1}$ (1.6), 100 seed weight (28.3). This treatment excelled other treatments, because the integrated waste utilization or conjunctive use of different nutrient sources is an alternative and characterized by reducing the input of chemical fertilizer, but they accumulate the increase availability of nutrients and the released nutrients from the mineralization process has a fertility effect of maize cop [20].

Table 3 Effect of conventional, non-conventional organic sources and industrial by-products on cob weight, cob length, cob girth, number of grains ear^{-1}, number of cobs $plant^{-1}$ and hundred seed weight

Treatments	Cob weight (g $plant^{-1}$)	Cob length (cm)	Cob girth (cm)	No. of grains ear^{-1} (g $plant^{-1}$)	No. of cobs $plant^{-1}$ (cm)	Hundred seed weight (cm)
T_1 – Control – 100% RDF	260.6	22.2	22.9	289	1.6	27.7
T_2 – 100% RDF + Municipal solid waste compost @ 5 t ha^{-1}	355.6	24.9	24.7	339	2	28.4
T_3 – 75% RDF + Municipal solid waste compost @ 10 t ha^{-1}	358.6	25.4	24.8	344	2	28.5
T_4 – 100% RDF + Vermicompost @ 2.5 t ha^{-1}	371.6	25.9	26.2	354	2	28.7
T_5 – 75% RDF + Vermicompost @ 5 t ha^{-1}	379.6	26.4	26.3	359	2	28.9
T_6 – 100% RDF + + Bagasse ash @ 5 t ha^{-1}	261.6	22.3	23.4	290	1.6	28.0
T_7 – 75% RDF + Bagasse ash @ 10 t ha^{-1}	271.6	22.5	23.5	291	1.6	28.1
T_8 – 100% RDF + Lignite fly ash @ 10 t ha^{-1}	293.6	22.7	23.7	293	1.6	28.2
T_9 – 75% RDF + Lignite fly ash @ 5 t ha^{-1}	297.6	23.2	23.8	297	1.6	28.3
Mean	316.7	23.9	24.3	317.3	1.81	28.3
S.Ed.	18.38	1.36	1.38	7.71	0.35	0.69
CD (P=0.05)	38.61	2.87	2.90	16.20	NS	NS

Grain yield

The application of 75% recommended dose of fertilizers (RDF) + vermicompost @ 5 t ha^{-1} (T_5) registered highest grain yield of 416.8 g $plant^{-1}$ (Table 4). The improvement in available nutrient status might be due to the prolonged availability of nutrients from vermicompost and also due to enhance mineralization of native nutrients. Vermicompost not only supplies the macro and micronutrients but also store house of beneficial microorganisms. Application of vermicompost might have helped in better mineralization of native nutrients by creating better soil environment. The increase in grain yield might be due to improvement in yield components [21]. Vermicompost showed increased the growth and yield of maize because of high porosity, aeration, drainage, and water holding capacity presence of beneficial microflora, nutrients such as nitrates, phosphates and exchangeable calcium and soluble potassium and plant growth regulators [22]. Among the industrial by-products application of 75% RDF + Fly ash @ 10 t ha^{-1} (T_9) registered 270 g pot^{-1}. This is due to the supply of nutrients, conducive physical environment leading to better aeration, increase in soil moisture holding capacity, root activity and nutrient absorption and the consequent complementary effect in fly ash have resulted in higher grain yield [23].

Stover yield

The highest stover yield of 545.9 g pot^{-1} (Table 4) was recorded in application of vermicompost (T_5). The significant increase in stover yield under these fertility levels appears to be on account of their influence on yield attributes and indirectly in an increase in plant growth. This may be due to the effect of both vermicompost and municipal solid waste compost application [24].

Table 4 Effect of conventional, non-conventional organic sources and industrial by-products on grain yield and stover yield

Treatments	Grain yield (g pot^{-1})	Stover yield (g pot^{-1})
T_1 – Control – 100% RDF	257.3	329.3
T_2 – 100% RDF + Municipal solid waste compost @ 5 t ha^{-1}	386.9	499.1
T_3 – 75% RDF + Municipal solid waste compost @ 10 t ha^{-1}	393.8	512.0
T_4 – 100% RDF + Vermicompost @ 2.5 t ha^{-1}	408.1	534.6
T_5 – 75% RDF + Vermicompost @ 5 t ha^{-1}	416.8	545.9
T_6 – 100% RDF + + Bagasse ash @ 5 t ha^{-1}	261.0	334.1
T_7 – 75% RDF + Bagasse ash @ 10 t ha^{-1}	262.8	336.4
T_8 – 100% RDF + Lignite fly ash @ 10 t ha^{-1}	265.5	342.4
T_9 – 75% RDF + Lignite fly ash @ 5 t ha^{-1}	270.0	348.3
Mean	324.7	420.2
S.Ed.	16.11	20.89
CD (P=0.05)	33.86	43.89

Table 5 Effect of conventional, non-conventional organic sources and industrial by-products on post-harvest organic carbon NPK

Treatments	Organic carbon (g kg^{-1})	N	P	K
		(mg kg^{-1})		
T_1 – Control – 100% RDF	4.2	111.1	17.5	112.5
T_2 – 100% RDF + Municipal solid waste compost @ 5 t ha^{-1}	5.9	139.1	19.7	121.5
T_3 – 75% RDF + Municipal solid waste compost @ 10 t ha^{-1}	6.0	148.1	20.9	121.7
T_4 – 100% RDF + Vermicompost @ 2.5 t ha^{-1}	6.1	152.9	22.1	120.1
T_5 – 75% RDF + Vermicompost @ 5 t ha^{-1}	6.2	153.1	22.3	120.5
T_6 – 100% RDF + + Bagasse ash @ 5 t ha^{-1}	4.5	111.6	17.6	112.4
T_7 – 75% RDF + Bagasse ash @ 10 t ha^{-1}	4.6	111.7	17.7	112.6
T_8 – 100% RDF + Lignite fly ash @ 10 t ha^{-1}	4.2	111.2	17.8	112.8
T_9 – 75% RDF + Lignite fly ash @ 5 t ha^{-1}	4.3	111.3	17.9	112.9
Mean	5.11	127.7	19.2	116.4
S.Ed.	0.12	3.15	0.47	2.84
CD (P=0.05)	0.26	6.63	1.00	5.98

Post-harvest available nitrogen

Among the different treatments soil application of 100% recommended dose of fertilizers (RDF) + Vermicompost @ 5 t ha^{-1} (T_5) recorded higher nitrogen (153.1 mg kg^{-1}) in soil compared to municipal solid waste compost treated soil (Table 5). This may be due to mineralization of added vermicompost which helped in increasing the available nitrogen status of soil. The increased organic matter due to organics acts as a source of carbon for growth and multiplication of nitrogen fixing microbes in soil. Available nitrogen was increased by vermicompost application [25].

Post-harvest available phosphorus

The application of 100% RDF + Vermicompost @ 5 t ha^{-1} recorded highest value of 22.3 mg kg^{-1} (Table 5). The organic acids released from vermicompost solubilize fixed form of Fe and Al complexes through organic anions and hydroxy acids liberated during organic matter decay. The organic acids released from vermicompost and additional supply of P through organic along with inorganic phosphorus lead to increased phosphorus content in soil [26]. The application of 100% RDF + Municipal solid waste compost @ 10 t ha^{-1} (T_3) recorded value of 20.9 mg kg^{-1}. The greater available P in municipal solid waste compost treatment could be attributed to its higher content as evident from its composition. The application of municipal solid waste compost to soil increased the available P of post-harvest soil [27].

Post-harvest available potassium

The post-harvest available potassium status was increased due to the soil application of conventional and non-conventional and industrial by-products (Table 5). The application of 75% RDF + Municipal solid waste compost @ 10 t ha^{-1} (T_3) registered highest value of 121.7 mg kg^{-1}. The higher potassium in soil involving municipal solid waste compost and inorganic sources might be due to addition of increase amount of K through these sources. The increased potassium content in soil when soil was treated with municipal solid waste compost [28].

Among industrial by-products the application of 75% RDF + Flyash @ 10 t ha^{-1} (T_9) recorded highest value of 112.9 mg kg^{-1}. This is due to a marginal increase in the concentration of potassium in fly ash amended soil was observed by [29].

CONCLUSION

The foregoing discussion led to the conclusion that organic manures and industrial by-products is beneficial for achieving higher productivity of maize in fine textured soils under pot trial. Application of municipal solid waste compost and vermicompost for pot experiment congenial for higher nutrient availability, yield attributes and maize grain yield. The decomposition of organic manures, however supplied soil nutrients and improved soil fertility. The lignite fly ash and bagasse ash are good sources of nutrients to enhance maize yield. To give a conclusive result these inputs should be tested in field trials.

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