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Effect of sugarcane waste on soil properties of coal fly ash affected land in cultivation of *Lycopersicum esculentum*

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ABSTRACT

Management of large volumes of Coal Fly Ash (CFA), a byproduct of thermal power plants is one of the challenging issues to the country along with other environmental aspects. An ecofriendly solution of the problem is the logical necessity of time. Nayakheda is one of the coal fly ash affected land areas around Kota city due to spread of thin layer of CFA from Kota Super Thermal Power Station (KSTPS). The productivity and fertility of land is badly affected for number of local crops. Researches till date show that CFA has immense potential in agriculture and related fields as an additive or soil ameliorating material but proportion has to be decided according to requirements of crops. Therefore, in view of improvement of fertility or amelioration of surface soil physicochemical studies have been carried out with surface soil and different composts prepared by mixing sugarcane waste in different proportions. Sugarcane waste was used to add with organic part. Pot experiments were conducted to study the effect of different proportions of sugarcane waste on soil properties of CFA affected land in cultivation of tomato (Lycopersicum esculentum). According to the best results obtained from the pot experiments, field experiments were also carried out. A significant increase in growth, rate of growth and quality of produce was observed on cultivation of Lycopersicum esculentum in surface soil amended with 50% (v/v) sugarcane waste. In amended soils an increase in available N. K, Ca, Mg, S, Fe, Mn, Zn and Cu contents and improvement in physical properties was observed.

Keywords: Coal fly ash, compost, Sugarcane waste, ecofriendly, ameliorating material, agriculture and related fields, Kota Super Thermal Power Station.

INTRODUCTION

Coal fly ash (CFA) is produced annually from Thermal power plants in millions of tons. CFA is generally used to supplement or replace Portland cement, a primary ingredient in concrete, to reduce raw material costs and strengthen the concrete, structural fills or embankments, soil stabilization etc. CFA is a powdery material made up of tiny glass spheres and consists primarily of silicon, aluminum, iron and calcium oxides [1]. Large volume of CFA occupy large area of land and poses threat to environment.

It is also used as fertilizer or for amendment of soil or to alter the physicochemical properties of soil due to its alkaline character and presence of high concentration of mineral substances, CFA may either have a positive effect or negative effect on plant growth and yield. Because of lower content of sulphur, heavy/toxic elements and radio nuclides, it is safer to apply Indian CFA to agriculture and related fields. Researches till date show that CFA consists of practically all the elements present in soil except organic carbon and nitrogen. The chemical properties of CFA are influenced to great extent by those of the coal type burnt and the technologies used for handling & storage[2-5]. Catalytic action of CFA in number of organic reactions has been proved [6-8].

A great amount of elements (C, N, P, K, Ca, Mg, Cu, Zn and Mn) get into the soil as a result of spread of CFA on surface soil and probably changes the chemical as well as physical properties of soil which in turn may determine the biological properties irrespective of the crop [9-18].

Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice. It is currently used as a bio fuel and in the manufacture of pulp and paper products and building materials. For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tonnes of wet bagasse which is a by-product of the cane sugar industry.

The high moisture content of bagasse, typically 40 to 50%, is detrimental to its use as a fuel. In general, bagasse is stored prior to further processing. For electricity production, it is stored under moist conditions and the mild exothermic reaction that results from the degradation of residual sugars dries the bagasse pile slightly. For paper and pulp production, it is normally stored wet in order to assist in removal of the short pith fibres, which impede the papermaking process, as well as to remove any remaining sugar.

On a washed and dried bases typical chemical analysis of bagasse is Cellulose 45–55%, Hemicellulose 20–25%, Lignin 18-24%, Ash 1–4%, Waxes <1%. Bagasse is an extremely inhomogeneous material comprising around 30-40% of "pith" fibre. This property makes bagasse particularly problematic for paper manufacture and have been the subject of a large body of literature. Therefore in order to improve fertility or productivity the present studies were initiated using sugarcane waste as ameliorating material.

Lycopersicum esculentum, a widely used vegetable and fruit of family Solanaceae was chosen for studies. Production share of major Solanaceous vegetables; brinjal, tomato and chilli in India is about 25% of total production. The Solanaceous fruits when immature are green & change colour on ripening. Tomato one of the most valuable crops of India. The fruits are fried, baked, cooked with meal made into soup, sauce and salad [19-20].

EXPERIMENTAL SECTION

Arche Vikas Tycoon Seed, round shaped deshi type **(Registered seeds from Tycoon Seeds Limited)** variety of Tomato (*Lycopersicum esculentum)* for growing round the year has been chosen for the study.

Amount of seeds, nitrogenous fertilizer (urea) and constituents of reference compost and time chosen for cultivation were following for chosen variety of tomato;

a) Amount of seeds used - 150 gm/hectare (15 mg/m^2)
b) Nitrogenous fertiliser (urea) – 100 k*g*/hectare (10 gm/m^2) (50% at the time of planting and 50% after 4 weeks)
c) Reference soil - scrapped surface soil up to 6 inches depth from selected coal fly ash affected area for study.
d) Time chosen for Pot Experiment—March 2011 and time chosen for Field Experiment__September 2011.

For pot experiments in I week of February 2011 surface soil was scrapped upto 6 inches depth from selected coal fly ash affected area of Nayakheda village and air dried it before mixing with sugarcane waste for converting into compost. Nayakheda is almost 5 km away in the North-West from KSTPS. Due to mishandling and improper transportation from ash ponds to utility stations and also emanated particles of CFA from other modes spread over agricultural land can easily be seen like graeish sheet in the area. As an ameliorating material Sugarcane waste was chosen. After collection it was dried, chopped and stored at room temperature.

Different compositions of compost were prepared by addition of sugarcane waste (from 10% to 60% v/v) in reference soil. For conversion into composts left these admixtures in the form of separate damp heaps covered with perforated polythene sheets for about 1.5 months turning fortnights. Density, texture, water holding capacity, porosity and organic matter were determined for compositions of compost by adopting standard techniques for soil analysis. pH measured potentiomatrically using glass calomel electrode and conductivity with conductivity bridge.

Chemical analysis for nitrate, phosphate, potassium, calcium, magnesium, sulphate, copper, zinc, iron and manganese have been carried out following standard chemical analysis methods (Titrimetrically / Spectrophotometrically / Colorimetrically / Flame photometrically [21-22]). All chemicals used for analysis were of A.R. grade.

Seeds were sown in nursery beds. Uprooted seedlings (approximately height 15 cm) from nursery beds were transplanted in the pots of identical dimensions packed with composts of different constitution. Five pots were prepared for each composition of composts (0%, 10%, 20%, 30%, 40%, 50% and 60%). Chosen variety of

Lycopersicum esculentum was grown according to its requirements of water, support and climatic conditions as referred in standard agriculture literature [18-20] . Plants were irrigated at two or three days interval. Weeding followed by fertilizer application & earthing up was done at every 15 days interval after transplanting. Plants were sprayed with 1% Bordeaux Mixture at monthly intervals. The plants affected by bacterial wilt and mosaic virus were destroyed at time to time. Observations regarding pests and disease attack were recorded time to time.

The plants were allowed to grow till maturity and then harvested. Time of harvesting was 3 months. The food samples were thoroughly washed and dried at 45^{o}C-50°C and powdered in pestle and mortar for analysis. 1 gm of the sample was digested using HNO_3,, perchloric acid and volume was made upto**100** ml for determination of physicochemical parameters.

Radioactivity tests obtained from ESL, Nuclear Power Corporation, Rawatbhata for ^{232} Th, ^{238}U and ^{40}K in a sample of CFA affected soil used for the purpose were within limits not hazardous to human health. Toxic heavy metal analysis for compost giving best results of produce and for produce obtained was carried out and the results showed that uptake of heavy metals was within permissible range.

Field experiments were also carried out in **10m x10m** area for this vegetable. In the third week of July 2011 surface soil of CFA affected land area of chosen village Nayakheda was scrapped upto 6 inches depth, air dried and collected under the shade of a large tree (1.5 months prior to seeds sown). Dried and chopped sugarcane waste was mixed in 50% v/v proportion and then it was kept covered with perforated polythene sheet for 1.5 months turning every fortnight. Damp conditions were maintained throughout the composting period by spreading water time to time. After 1.5 months in the first week of September biomodified compost was ready. Spreaded ready compost all over the chosen field evenly. Sowing of Seeds and remaining procedure of cultivation was completed as done in pots. Samples of culture media and produce were collected and processed for analysis.

RESULTS AND DISCUSSION

The preparation of different composts by application of different amount of sugarcane waste (SCW) (% v/v) resulted in favorable physicochemical changes with bio modification of soil properties. With chosen variety of *Lycopersicum esculentum* an improvement in fertility was observed on addition of sugarcane waste up to 50 % (v/v) in scrapped surface soil.

Table-1 contains results obtained for texture, organic matter, WHC, porosity, density, pH and conductivity determined for different composts prepared for studies. The porosity & WHC increase and density decreases with the increase in percentage of SCW in scrapped surface soil (C_1 to C_5) while in C_6 no significant improvement has been observed. Texture changes were towards loamy clay and organic matter increases with the increase in percentage of SCW. Table-1 also shows pH decreases and electrical conductivity remains almost constant with the increase in percentage of SCW in compost mixture. No considerable improvement in macronutrients (primary and secondary) and micronutrients was observed on analysis of compost but from the observations regarding plants growth, maturation period, quality and quantity of produce it can easily be concluded that bio available proportion of macro and micro nutrients considerably increased during the procedure of biomodification of CFA affected surface soil with organic matter of SCW.

Suitable pH and more suitable physical conditions i. e. better texture, reduced density, increased porosity with suitable WHC help in increasing the availability of nutrients and to assimilate the nutrients by plants. pH plays a vital role in the release of specific nutrients. The availability of nutrients is maximum at pH 5.5 to 6.5.

Table 4 shows the heavy metal analysis of *Lycopersicum esculentum* obtained from compost giving best results. Most of the heavy metals play a vital role in plant physiology. The availability of iron is more than manganese in CFA affected land. The presence of manganese which oxidizes excess ferrous (soluble) into ferric (insoluble) reducing the availability of soluble iron which may cause toxicity. Copper acts as an "electron carrier" in enzymes which bring about oxidation reduction and regulates respiratory activity in plants [23-24].

Table 5 shows the yield of *Lycopersicum esculentum* in various composts. Yield increases on increasing % of SCW upto 50% and then decreases.

Rani Krishna and Kalpana S have investigated that the application of different percentage of CFA and biomodification with organic waste (water hyacinth/grass cuttings + cowdung) resulted in an increase in available nutrients (N, P, Ca, K, Mg, S, Fe, Mn, Zn and Cu) in the soil, with altered physicochemical properties of soil and after deciding the quality and by variation in applied proportion the desirable results for amendment of soil can be obtained [25-31].

Present studies clearly reveal that SCW worked as soil modifier and nutrients supplier in the cultivation of *Lycopersicum esculentum* of family Solanaceae. Results indicate that SCW improved physical and morphological properties of soil, water retention capacity of soil together with increased release of nutrient elements such as calcium, magnesium, sulphur, potassium, copper, phosphorous, zinc etc. On cultivation of *Lycopersicum esculentum* in this compost the edible part (fruit) obtained was comparatively in more quantity, large in size and fine in taste meeting with food quality standards and consumer acceptability. It was found that heavy metals uptake was within permissible limits. The results obtained in field experiments were also quality and quantity wise more encouraging for this.

Table 1 : Physical properties of different composts prepared with SCW for *Lycopersicum esculentum* [% of SCW (C = compost) : C_0 = 00%, C_1 = 10%, C_2 = 20%, C_3 = 30%, C_4 = 40%, C_5 = 50%]

Parameters % of Compost	Texture	Organic Matter (%)	Water holding capacity (%)	Porosity (%)	Density (gm cm^{-3})	pH	Conductivity (μ mho cm^{-1})
C_0	Sandy clay	0.672	43.0	41.10	1.28	7.35	122
C_1	Sandy clay	0.690	43.60	42.35	1.25	7.20	124
C_2	Clay	0.726	43.90	42.85	1.22	7.10	128
C_3	Loamy clay	0.758	44.20	43.25	1.20	6.90	130
C_4	Loamy clay	0.782	44.80	44.10	1.17	6.65	134
C_5	Loamy clay	0.820	45.10	44.30	1.15	6.50	134
C_6	Loamy clay	0.702	45.60	43.90	1.30	6.70	140

Table 2 : Primary nutrients & Secondary nutrients in different composts prepared with SCW for *Lycopersicum esculentum* in %

% of Composts	NO_3^{-1}	PO_4^{-3}	K^{+1}	Ca^{+2}	Mg^{+2}	SO_4^{-2}
C_0	0.0810	0.0040	0.0820	0.52	0.36	0.058
C_1	0.0830	0.0042	0.0825	0.58	0.41	0.065
C_2	0.0835	0.0046	0.0830	0.60	0.45	0.068
C_3	0.0845	0.0052	0.0830	0.65	0.48	0.060
C_4	0.0860	0.0052	0.0840	0.68	0.50	0.052
C_5	0.0866	0.0056	0.0846	0.68	0.55	0.058
C_6	0.0870	0.0056	0.0852	0.70	0.50	0.058

Table 3 : Micro nutrients in different composts prepared with SCW for *Lycopersicum esculentum* (in ppm)

% of Composts	Cu	Zn	Fe	Mn
C_0	0.50	0.76	3.6	1.42
C_1	0.58	0.82	4.0	1.34
C_2	0.62	0.88	4.4	1.26
C_3	0.80	0.92	5.0	1.12
C_4	0.92	0.92	5.5	1.03
C_5	1.08	1.02	5.8	1.10
C_6	1.20	1.12	5.6	0.98

Table 4 : Heavy metal analysis of the *Lycopersicum esculentum* obtained from the compost giving best results (in ppm)

Name of Heavy Metals	Tomato
Cu (Copper)	10.26
Zn (Zinc)	25.75
Cd (Cadmium)	0.10
Pb (Lead)	11.80
Fe (Iron)	95.42
B (Boron)	10.20

Table 5 : Yield of *Lycopersicum esculentum* in different composts prepared with SCW. (Kg/m^2)

Name of Vegetable	C_0	C_1	C_2	C_3	C_4	C_5	C_6
Tomato	2.04	2.14	2.20	2.42	2.56	2.66	2.54

CONCLUSION

Best results in terms of plants growth, maturation period, quality and quantity of produce were obtained with composts containing 50% (v/v) of SCW. Therefore, it can be concluded that 50% (v/v) SCW worked best for ameliorating and improving fertility of CFA affected land area and can be applied (dose 50% v/v) advantageously in cultivation of *Lycopersicum esculentum* of family Solanaceae. No significant difference was observed in frequency and sensitivity of attack of the pests, fruit borer or leaf curl disease towards the plant or edible part of fruit.

It came out that adversely affected agriculture in the area were only those which requires lower soil pH (<7) for growth. Being alkaline in nature CFA increases not only pH of the soil, but also alters physicochemical properties of soil. Present study not only confirms that corrections or amelioration of CFA affected land is possible for desired purpose with organic waste materials like SCW in an economic way.

Utilization of these materials CFA and SCW in proper amount and proper way can act as boon in agriculture. This research work would open new method to improve soil properties and will increase the agricultural productivity, saving the environment from pollution with CFA. Long term studies are under progress.

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