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Research Paper

Application Impact of Coal Fly Ash, and Water Hyacinth on Cultivation of Tomato

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Abstract - *Few pot and field experiments were conducted to study the effect of levels of coal fly ash (CFA) which is a byproduct of Kota Super Thermal Power Station, on physicochemical properties of soil and the yield parameters of Tomato. The objective of the experiment was to study a reaction between the constituents of soil. & CFA to upgrade the quality of soil making it suitable for cultivation of Tomato. Physicochemical studies have been carried out for different composts obtained by successive replacement of CFA for soil/earth in constituents of original and reference composts. Water Hyacinth(Species of Eichornea of family pontederacdia) were used as organic manure. Physiochemical analysis was conducted after the harvest of Tomato. Increase in rate of growth and improvement in quality of produce was observed with the increase in percentage of CFA in the range studied. This study of graded level of CFA amended soils revealed an increase in the content of N. P. K. Ca, Mg, S, Fe, Mn, Zn and Cu.*

Keywords: Coal fly ash, compost, Water Hyacinth, Kota Super Thermal Power Station etc.

Introduction

Coal fly ash (CFA) is produced annually from Thermal power plants in millions 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 radionuclide, 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 burned and the technologies used for handling and 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 CFA used at different doses and may probably change the chemical as well as physicochemical soil properties which in turn may determine the biological properties irrespective of the crop[9-15]. Therefore the study was aimed at the determining the effect of graded levels of CFA on physicochemical properties of soil[16-18]. Therefore in order to enhance percent utilization and to generate acceptability towards waste materials CFA and water hyacinth Tomato *(Lycopersicum esculentum),* a widely used vegetable and fruit of family Solanaceae was chosen.

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].

Material and Methods

S-22 Tycoon Seed, round shaped desi type (Registered seeds from Tycoon Seeds Limited) variety of Tomato 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) Nitrogus fertilizer (urea) – 100K*g*/hectare (10 gm/m^2) (50% at the time of planting and 50% after 4 weeks)

(C) Constitution of reference compost - (3 part (loamy clay) + 1 part of water hyacinth)
(D) Time chosen for cultivation-March / April of 2007.

For pot experiments CFA samples were collected arbitrarily following the standard technique quarter and cone. Samples were air dried and stored at room temperature before mixing it for converting into composts. As organic manure Water Hyacinth was mixed. Different composition of composts were prepared by gradual replacement of soil by CFA (from 10% to 50%) in reference composts. For conversion into composts left these admixtures in separate damp pits (approx. 4 feet in depth) for about 1.5 month. Density, texture, water holding capacity, porosity were determined by adopting standard techniques for soil analysis and pH potentiomatrically using glass calomel electrode and conductivity was measured with conductivity bridge.

Radioactivity tests obtained from ESL, Nuclear Power Corporation, Rawatbhata for ^{232}Th, ^{238}U and ^{40}K in a sample of CFA 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.

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

Experiments for study of plan, growth and quality and yield of produce were carried out in pots. Seeds were sown in reference composts and seedlings were transplanted in the pots of identical dimensions packed with composts of different constitution after reaching definite height (15cm). Chosen variety of tomato 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 one & two months after transplanting. Pests were sprayed with 1% Bordeaux mixture at monthly intervals. The plants affected by bacterial wilt and mosaic were destroyed at time to time. Observations regarding pots and disease attack were recorded time to time.

Ten pots were prepared for each composition of composts (0%, 10%, 20%, 30%, 40% and 50%). 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 sub sample was digested using HNO_3, Perchloric acid and volume was made up to 100 ml.
To find out utility of composts preparation (bioremediation) carried out simultaneous experiments under similar, conditions by growing chosen variety directly in similar mixtures of soil, CFA water hyacinth. field experiments were also carried out in one hectare area for this vegetable. Field prepared by spreading water hyacinth in the field, after ten days of it planting uprooted grass of local areas, after further twenty days of it turning surface soil with grown grass down to one foot of soil depth & covering the field for next fifteen days with perforated polythene sheet.

Results and Discussion

The preparation of different composts by application of different % of CFA resulted in favorable bio physicochemical changes with modification of soil properties, with chosen variety of tomato an improvement in fertility was observed up to 40 % replacement of soil by CFA.

Table-1 contains results obtained for texture, density, porosity and WHC determined for different composts prepared for studies. The porosity & WHC increase and density decreases with the increase in percentage of CFA in reference compost (C_1 to C_4) while in C_5 the trend has got reversed. Texture changes from sandy clay to loamy clay and organic matter decreases with the increase in percentage of CFA. Table-1 also shows pH and electrical conductivity increase with the increase in percentage of CFA in compost mixture due to the increase in salt content like calcium oxide (CaO) and magnesium oxide (MgO), their dissociation possibilities contributed form the alkaline CFA added and increasing quantity of soluble macro and micro nutrients (Table-2 & 3). Released by the added CFA or by the interaction of inorganic constituents of CFA with soil organic matter. With the increase in dose of CFA the availability of most of the macronutrients was found to increase up to certain ratio. The release of the nutrients in the ionic form increasing their bioavailability which can be considered favorable results of chain of chemical reactions among constituents of composts at more suitable pH and physical conditions i.e. better texture, reduced density, increased porosity with appropriate water holding capacity. This helps in increasing the concentration of nutrients and conditions of the soil medium to assimilate the nutrients by plants following specific physiological mechanism

The available nitrogen was measured in terms of NO_3^-. The % of nitrate decreases. The available phosphorous was measured in terms of phosphate. The increase (firstly increase than constant) in concentration of phosphate may be attributed to the available phosphorus present in CFA. Plants take phosphate in HPO_4^{2-} form. The increase is due to the hydrolysis of iron, aluminum and magnesium compounds in CFA and released inorganic acids by CFA. The liberated acids help in the release of available phosphate from the unavailable form without affecting the pH as organic matter present in the soil has a buffering capacity in maintaining the pH.

Potassium is measured in terms of K^+. The availability of K^+ ion is low at higher dose of CFA due to low percentage of clay and cation exchange capacity. Sulphur is taken up by plants in SO_4^{2-} form. At very higher level of CFA C_4 and C_5 the decrease in the SO_4^{2-} may be pertained due to the combined (imbalance) effect of type of soil used, silt,

microbial activity, organic matter and pH. The % of calcium and magnesium increases up to C4 and then decreases. It is reported by some researchers that at higher concentration of

CFA some heavy metals become more active and hinder the microbial activity. pH plays a vital role in the release of specific nutrients. The availability of nutrients is maximum at pH 5.5 to 6.5.

Most of the heavy metals play a vital role in plant physiology. The availability of iron is more than manganese. The results reveal that as the concentration of CFA increases the availability of iron and manganese increases but at the level where iron did not impart any toxicity to plants. It may be attributed to the presence of manganese which oxidizes excess ferrous (soluble) into ferric (insoluble) reducing the availability of soluble iron which may cause toxicity or to the reaction taking place between the carbonate ion and iron which reduces the excess availability of iron to the plants.

During present studies no symptoms of chlorosis were observed although zinc and copper were higher in soil CFA mixtures. Deficiency of manganese may cause chlorosis in plants. If large amount of zinc and copper is present then manganese deficiency is found in plants. This may be due to the physicochemical properties of CFA which on mixing with soil has ameliorated the soil from loamy to silty loam and due to the presence of oxides of calcium and magnesium which maintained alkalinity [23-24]

It is reported that copper helps in the accumulation of calcium and magnesium. In CFA Cu is present in the form of Calcium Oxide (CuO). It reacts with inorganic acids released during the hydrolysis of various compounds and helps in the release of available copper. Copper acts as an "electron carrier" in enzymes which bring about oxidation reduction and regulates respiratory activity in plants [25-30]. Table 4 indicates that copper is increased with the increase in concentration of CFA up to C4 and then decreases but did not impart any toxicity as excess availability was hindered due to alkaline pH, organic matter and clay content. Table 6 shows the yield of tomato in various composts. Yield increases on increasing % of CFA up to 40% of CFA & then decreases. Table 5 shows the heavy metal analysis of tomato obtained from compost giving best results.

Present studies clearly reveal that CFA worked as soil modifier and nutrients supplier in the cultivation of tomato of family Solanaceae. Results indicate that CFA 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 vegetable in this compost the edible part (fruit) obtained was comparatively in more quantity, large in size and soft to cut 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 quality and quantity wise more encouraging for this vegetable.

Constant amount of Water Hyacinth helped in increasing potassium, calcium, phosphorous, organic carbon in the mixture. Resistance to diseases and absorption of nitrogen & phosphorus was increased in compost having 40% CFA which may be due to presence of Sulphur in CFA.

Conclusion

Best results in terms of plants growth, maturation period, quality and quantity of produce were obtained with composts containing 40% (v/v) of CFA of total volume. Therefore, it can be concluded that CFA can be applied (does 40% v/v) advantageously in cultivation of tomato of family Solanceae. The plants and the edible part of vegetable was observed ten times less prone the pest, fruit borer and six times less prone to disease leaf curl.

Utilization of these material CFA and water hyacinth in proper amount and proper way can act as born 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 terms studies are under progress.

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Table 1: Physical properties of different composts prepared with CFA for Tomato [% of CFA (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	0.735	42.5	40.65	1.26	7.43	116
C_1	Sandy clay	0.715	43.0	42.05	1.225	7.46	116.5
C_2	Clay	0.695	43.65	43.50	1.19	7.73	124.5
C_3	Loamy clay	0.680	44.50	45.70	1.16	7.77	132.0
C_4	Loamy clay	0.660	45.75	48.70	1.135	7.725	136.0
C_5	Loamy clay	0.643	46.50	46.30	1.74	7.72	146.5

Table 2: Primary nutrients & Secondary nutrients in different composts prepared with CFA for Tomato in %

% of Composts	NO_3^{-1}	PO_4^{-3}	K^{+1}	Ca^{+2}	Mg^{+2}	SO_4^{-2}
C_0	0.0100	0.0050	0.0810	0.60	0.32	0.050
C_1	0.0999	0.0060	0.0850	0.64	0.34	0.060
C_2	0.0910	0.0064	0.0810	0.75	0.30	0.040
C_3	0.0540	0.0065	0.0840	0.80	0.34	0.010
C_4	0.0510	0.0065	0.0750	0.80	0.50	0.010
C_5	0.0450	0.0065	0.0750	0.75	0.52	0.010

Table 3: Micro nutrients in different composts prepared with CFA for Tomato (in ppm)

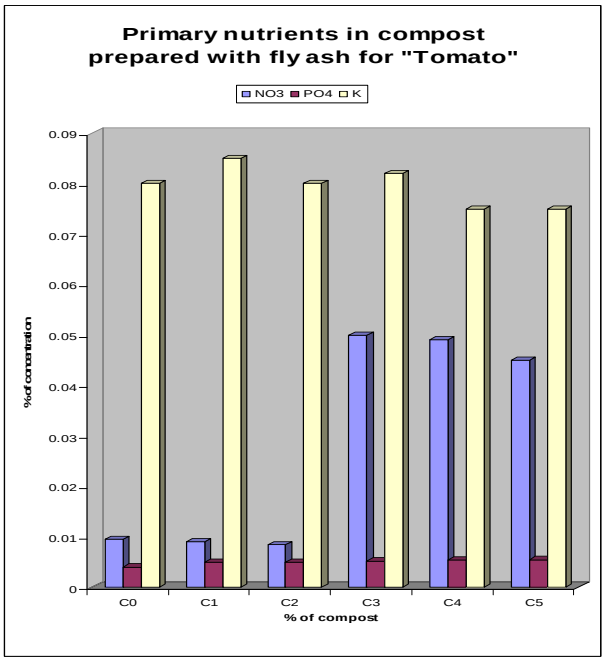
% of Composts	Cu	Zn	Fe	Mn
C_0	0.70	0.80	40	1.60
C_1	0.80	0.80	38	0.60
C_2	1.00	0.60	38	0.60
C_3	1.20	0.70	48	0.82
C_4	1.30	1.30	58	0.99
C_5	1.40	1.50	62	0.80

Table 4: Heavy metal analysis of the tomato obtained from the compost giving best results (in ppm).

Name of Heavy Metals	Tomato
Cu (Copper)	10.98
Zn (Zinc)	25.30
Cd (Cadmium)	0.12
Pb (Lead)	12.27
Fe (Iron)	96.29
B (Boron)	10.82

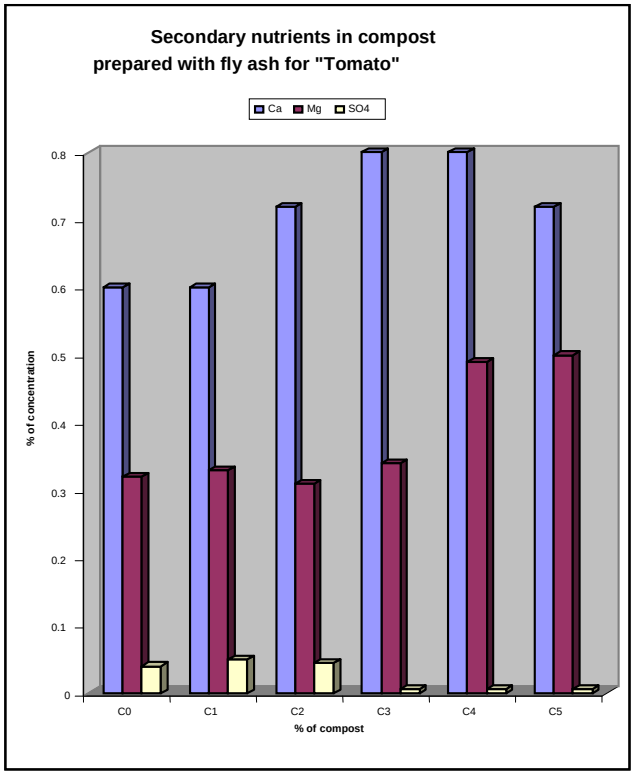
Table 5: Yield of tomato in different composts prepared with CFA. (Kg/m^2)

Name of Vegetable	C_0	C_1	C_2	C_3	C_4	C_5
Tomato	1.6	1.8	2.1	2.2	2.3	2.1



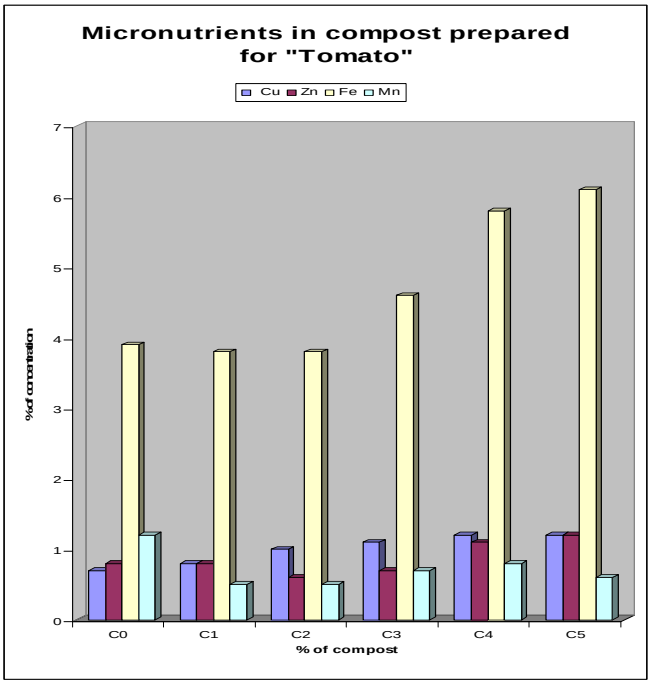
% of Coal Fly Ash: - C = compost C_0 = 00% C_1 = 10% C_2 = 20% C_3 = 30% C_4 = 40% C_5 = 50%

Figure – 1 A_1



% of Coal Fly Ash: - C = compost C_0 = 00% C_1 = 10% C_2 = 20% C_3 = 30% C_4 = 40% C_5 = 50%

Figure – 1 A_2



% of Coal Fly Ash: - C = compost C_0 = 00% C_1 = 10% C_2 = 20% C_3 = 30% C_4 = 40% C_5 = 50%

Figure – 2