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BIOMODIFICATION OF COAL FLY ASH WITH *EICHORNIA* WITH RESPECT TO IMPROVEMENT IN PHYSICOCHEMICAL PROPERTIES FOR CULTIVATION OF *BRASSICA JUNCIA*

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ABSTRACT

Biomodification of coal fly ash with *Eichornia* with respect to improvement in physicochemical properties was done for the cultivation of *Brassica Juncia*. Few pot and field experiments were conducted to study the effect of levels of biomodified coal fly ash (CFA) on physicochemical properties of soil and the yield parameters of *Brassica Juncia*. Physicochemical studies have been carried out for different composts obtained by successive replacement of biomodified CFA for soil/earth in constituents of original and reference compost. In present studies, CFA and water hyacinth of local origin were used. Increase in rate of growth and improvement in quality of produce was observed with the increase in percentage of biomodified CFA up to 30% with lesser use of fertilizers and irrigation water.

Key words: Coal fly ash, Compost, Cow dung, Grass cuttings, Kota super thermal power station (KSTPS), Biomodification.

INTRODUCTION

Thermal power plants produce millions of tonnes of coal fly ash (CFA) annually. CFA products are used to supplement or replace Portland cement, a primary ingredient in concrete, structural fills or embankments, soil stabilization, flowable fill and grouting mixes and mineral filler in asphalt paving. 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.

Its alkaline character and a high concentration of mineral substances have resulted

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in attempts of using it as fertilizer or for amendment of soil or to alter the physicochemical properties of soil. CFA may either have a positive or negative effect on plant growth and yield[2-4].

A great amount of elements (C, 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[5-11]. Therefore, the study was aimed at determining the effect of graded levels of biomodified CFA on physicochemical properties of soil[12-14]. Catalytic action of CFA in number of organic reactions has also been proved[15-17].

Therefore, in order to enhance percent utilization and to generate acceptability towards waste materials, present studies about the effect of soil replacement by CFA from KSTPS on the growth and produce of *Brassica juncia* of family Crucifarae, (Mustard, Seeme Kaduku, Safed-Rai, Sarson) has been carried out in terms of soil health {by determining water holding capacity (WHC), porosity, density, pH, conductivity, nitrate, phosphate, sulphate, potassium, calcium, magnesium, manganese, copper, zinc, iron and organic matter}, quality and quantity of crop produce to recommend dose of CFA along with organic manure. The leaves and tender stems of *Brassica Juncia* are rich in protein, minerals, vitamins A and C. The nutritive value may differ from species to species.

EXPERIMENTAL

Variety Pusa Gold (Registered seeds from Rajasthan State Seed Corporation) of *Brassica Juncia* was chosen for the study.

Amount of seeds, nitrogenous fertilizer (urea), constituents of reference compost and time chosen for the cultivation were following for the chosen variety of *Brassica Juncia*:

(i) Amount of seeds used – 6 kg/hectare

(ii) Nitrogenous fertilizer (urea)–300 kg/hectare (50% at the time of planting and 50% after 4 weeks)

(iii) DAP (Diammonium phosphate) - 150 kg / hectare

(iv) Constitution of reference compost - [3 parts of clayey loam + 1 part of organic manure farmyard waste + DAP (Diammonium phosphate)]

(v) Time chosen for the cultivation—third week of October of year 2005, 2006 and 2007.

Different compositions of composts were prepared by gradual replacement of soil by CFA (from 10% to 50%) and dried *Eichornia* mix. in reference compost. For conversion into composts, these admixtures were left in separate damp pits (approx. 4 feet in depth) for 1.5 months.

Density, texture, WHC, porosity and organic matter were determined by adopting standard techniques for soil analysis and pH potentiometrically. Conductivity was measured by conductivity bridge. Physical properties of different composts prepared with CFA were determined and are given in Table 1.

Chemical analyses for nitrate, phosphate, sulphate, potassium, calcium, manganese, magnesium, copper, zinc and iron have been carried out following standard chemical analysis method- titrimetrically / spectrophotometrically/flame photometrically [18-20]. Only AR grade chemicals were used for analysis.

Seedlings were transplanted in the pots of identical dimensions packed with composts of different constitution after reaching at definite height 5 cm. The chosen variety of *Brassica Juncia* was grown according to its requirement of water, support and climatic conditions as referred in agriculture literature [21-23]. Ten pots were prepared for each composition of composts (0%, 10%, 20%, 30%, 40% and 50% CFA).

Different physicochemical parameters for reference compost, non modified mixture and modified mixtures (composts prepared) were determined and time to time observations were recorded regarding growth of plants with quality and quantity of produce, frequency of diseases and pests attacks. Care has been taken to keep enough leaves on the plants for normal photosynthesis needed for the development of seed stalks[24]. The main problem in *Brassica Juncia* is aphids, which start attacking from January onwards. If the crop is for seed purpose, periodical sprays of malathion can control the aphids. When the crop is for vegetable purpose, less poisonous insecticides like pyrethrum extract or nicotine sulphate are sprayed to control the insect attack.

Experiments for study of plant growth, quality and yield of produce were carried out in pots and fields. The plants were allowed to grow till maturity and then harvested. The food samples were thoroughly washed and dried at 45-50^{o}C and powdered in pestle and mortar for analysis. Seeds were sown in control and different composts prepared with CFA. Growth parameters were observed from percent germination of seeds up to complete growth of plants. Plant height, number of branches and per plant, leaf area, number of pods per branch and number of seeds per pod were determined. Seeds obtained, were subjected to determination of oil, protein contents, fatty acids and carbohydrates.

To find out utility of composts preparation (bioremediation), simultaneous experiments were carried out under similar conditions by growing chosen variety of *Brassica Juncia* directly in unmodified mixture. Similar studies have been carried out for three successive years 2005, 2006 and 2007. In the year 2007, field experiments were also carried out by applying selected dose from previous two years experiments.

Results obtained are summarized in Tables 1-6. [% of CFA (C = compost): C_0 = 00%, C_1 = 10%, C_2 = 20%, C_3 = 30%, C_4 = 40%, C_5 = 50%].

Table 1: **Physical properties of different composts prepared with CFA for *Brassica Juncia***

Parameters / % of compost	Texture	Organic -matter (%)	WHC (%)	Porosity (%)	Density (gm cm^{-3})	pH	Conductivity (μ mho cm^{-1})
C_0	Sandy clay	0.742	52.50	41.95	1.320	5.80	144.0
C_1	Sandy clay	0.735	50.08	43.22	1.305	5.95	148.5
C_2	Clay	0.716	49.06	44.28	1.280	6.10	158.5
C_3	Loamy clay	0.702	48.22	46.10	1.260	6.52	166.8
C_4	Loamy clay	0.682	49.36	45.30	1.265	6.70	178.0
C_5	Loamy clay	0.676	50.54	44.24	1.290	6.95	185.5

Table 2: Primary and secondary nutrients in different composts prepared with CFA for *Brassica Juncia* in %

Nutrients	Primary			Secondary		
% of compost	NO_3^-	PO_4^{-3}	K^+	Ca^{+2}	Mg^{+2}	SO_4^{-2}
C_0	0.0202	0.0062	0.0662	0.58	0.20	0.030
C_1	0.0225	0.0068	0.0692	0.63	0.23	0.040
C_2	0.0238	0.0076	0.0740	0.69	0.28	0.052
C_3	0.0252	0.0084	0.0798	0.78	0.35	0.062
C_4	0.0230	0.0078	0.0755	0.62	0.32	0.068
C_5	0.0208	0.0066	0.0718	0.52	0.24	0.078

Table 3: Micronutrients in different composts prepared with CFA for *Brassica Juncia* in ppm.

% of compost	Cu	Zn	Fe	Mn
C_0	0.62	0.78	4.2	0.66
C_1	0.76	0.82	4.5	0.74
C_2	0.84	0.85	4.9	0.77
C_3	0.90	0.92	5.6	0.85
C_4	0.82	0.82	5.0	0.76
C_5	0.76	0.74	4.2	0.68

Table 4: Yield of *Brassica Juncia* in different composts prepared with CFA in kg / m^2

Name of crop	C_0	C_1	C_2	C_3	C_4	C_5
Brassica Juncia	0.452	0.464	0.486	0.502	0.482	0.473

Table 5: Percentage increase in yield of *Brassica Juncia* in different composts prepared with CFA in comparison to reference compost in kg/m^2

% of composts	% increase in yield
C_1	2.65
C_2	7.50
C_3	11.06
C_4	6.64
C_5	4.65

Table 6: Heavy metal analysis of the *Brassica Juncia* obtained from compost giving best results in ppm.

Name of heavy metal	*Brassica Juncia*
Cu	4.92
Zn	12.86
Cd	00.12
Pb	02.13
Fe	42.86
B	07.36

RESULTS AND DISCUSSION

Table 1 contains results obtained for density, porosity and WHC determined for different composts prepared for studies. As the composition of the compost changes, the porosity increases and density decreases with the increase in percentage of CFA in reference compost from C_1 to C_3 while from C_3 to C_5, the trend got reversed. WHC decreases from C_0 to C_3 and then increases from C_3 to C_5. As the CFA increases, the salt content of mixture increases but after reaching an optimum ratio, the trend got reversed. Increase in porosity improves soil drainage and aeration also. These changes were due to silty nature of CFA. It has low density better porosity and other physical conditions. In control soil, the major portion was clay so on admixing with CFA, the clay content has reduced and silt percentage has increased. Texture changes from sandy clay to loamy clay. Table 1 shows that organic matter decreases from C_0 to C_5 with increase in percentage of CFA.

Table 1 also shows that pH increases from C_0 to C_5 with the increase in percentage of CFA in compost mixture. It may be due to the increase in salt content like calcium oxide (CaO) and magnesium oxide (MgO), which was contributed from the alkaline CFA added and also from the neutralization of H^+ ions by more basic metallic oxides of CFA. The electrical conductivity was increased due to addition of CFA with soil due to the increasing quantity of soluble macro and micro nutrients (Tables 2 and 3) released by the CFA or the interaction of inorganic constituents of CFA with soil organic matter from C_0 to C_5.

With the increase in dose of CFA, the availability of macronutrients is found to increase. The release of the nutrients in the ionic form increasing their bioavailability can be considered due to favourable 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 WHC. This helps in increasing the concentration of nutrients and conditions of the soil medium to assimilate the nutrients by plants following specific physiological mechanism.

At higher level of CFA, the decrease in the macronutrients (primary and secondary) may be pertained due to the combined effect of imbalance clay, silt and sand content, microbial activity, organic matter and pH. 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.

Table 4 shows the yield of *Brassica Juncia* in various composts. It increases up to 30% of CFA and then decreases. Table 5 shows the percentage increase in yield of *Brassica Juncia* in different composts in comparison to reference compost. Table 6 shows the heavy metal analysis of *Brassica Juncia* obtained from compost giving best results.

From present studies, it is concluded that CFA worked as soil modifier and nutrients supplier in the cultivation of *Brassica Juncia*. Best results in terms of plant growth, maturation period, resistance to pests and diseases, quality and quantity of produce were obtained with composts containing 30% (v/v) of CFA. Constant amount of added *Eichornia* helped in increasing potassium, calcium, phosphorous and organic carbon in the mixture. The plant and the edible part of *Brassica Juncia* (seeds) were observed eight times less prone to the pest aphids. Resistance to diseases, absorption of nitrogen and phosphorous was increased in compost having 30% CFA, which may be due to presence of sulphur.

Percentage increase in yield of *Brassica Juncia* (11.06%) was maximum in compost containing 30% CFA in comparison to reference compost. Protein was increased up to 9%, oil was increased up to 5% and increase in carbohydrates was up to 10% in produce obtained from compost having 30% CFA in comparison to reference compost. No considerable change in uptake of toxic heavy metals in seeds of plants could be observed under experimental conditions of the present study.

Utilization of these materials; CFA and *Eichornia* in proper amount and proper way can act as a boon in agriculture sector giving solution of safe and sustainable management of these wastes, which also acts as soil saver and irrigation water saver.

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