

# Performance of Several Crops Grown in Fly Ash Amended Soil

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## ABSTRACT

Fly ash (FA) from Chandrapura Thermal Power Station in Jharkhand, India were used to amend soil from fallow land in the proportion equivalent to 60, 120, 180, 240 tons/ha in selected vegetables and 10, 20, 30, 40, 50% in selected leguminous crops economically grown in the region, and performance of individual species has been evaluated. In both the studies significant improvement has been observed in soil properties and seed germination with the amendment of FA. Species performance has been increased in terms of growth (root & shoot length, root shoot ratio, fresh and dry weight) and yield (In terms of seeds and fruit weight per plant) corresponding to different proportion of amendment. Pigment concentration (Chlorofil a & b) have improved at moderate concentration of FA (120 & 180 tons/ha) in almost all the species. At the highest concentration (240 tons/ha) of FA the pigment concentration has further decreased. Based on the data obtained it is found that fallow land soil amendment at the rate of 20, 30 & 40% and 120 & 180 tons/ha FA improved the physical properties of the soil on one hand and contributed to better growth and yield of crops on the other hand.

## INTRODUCTION

Coal based thermal power plants meets more than 60% of energy demand in the country. The matter of great concern is fly ash; a remnant after combustion of pulverized coal in TPPs. Regular and periodic augmentation of fly ash reserve keeps on policy makers busy to plan for more and more area for disposal at the cost of finite land resources and techno-economically feasible and eco-friendly ways of utilization. Moreover, one can never afford to leave associated environmental problems unattended.

Fly ash is a heterogeneous mixture of amorphous and crystalline phases and is generally considered to be a ferroaluminosilicate element <sup>[7], [15]</sup>. Particles of fly

ash can be found in the size range from 0.01 to 100  $\mu\text{m}$ <sup>[6]</sup>. Chemically, fly ash contains oxides, hydroxides, carbonates, silicates, and sulfates of calcium, iron, aluminum, and other metals in trace amount<sup>[1]</sup>. i.e. almost all the nutrients present in the soil with exception to nitrogen. The pH of fly ash ranges from 4.5 to 12.0<sup>[22]</sup>.

Production of fly ash in India is expected to reach the mark of 170 million tons by 2012<sup>[16]</sup>. From the total yearly production of fly ash 87 percent end up on ash mounds or in lagoons covering several thousand acres of arable land. Only 13% is still recycled and the most widely accepted disposal practices of fly ash are land filling, stock piling and disposal in settling ponds causing air, water and soil pollution, brick and cement manufacturing, asbestos and construction of roads and embankments.

Because of its physico-chemical characteristics (as explained above), fly ash has a vast potential for use in reclamation of degraded land, forestry and agriculture. Application of fly ash into soil has been reported to change the soil texture and structure in a way to improve the availability of soil water, air and nutrient by increasing porosity, water holding capacity, electrical conductivity and hydraulic conductivity<sup>[3], [19]</sup> and decreasing bulk density, and surface encrustation. Soil pH is also affected by fly ash use and thus, it may be used to reclaim both alkaline as well as acidic soils. Fly ash has been tried alone or in combination with materials like farm yard manure, sewage sludge, water hyacinth, microbial cultures, gypsum, and lime and has been found to improve the growth, yield and nutrients uptake of various agricultural crops, plantations, and vegetables.

Forestry attracts more fly ash utilization for growing few economically important trees such as pulp and paper tree, biodiesel crops, firewood, timber wood and plywood trees. Indian fly ash has been found beneficial for the growth of plants due to the presence of several plant nutrients<sup>[1]</sup>. Its amendment in soil brings about an increase in the growth and yield of cucumber, maize, okra, potato, tomato and wheat<sup>[12], [13], [17], [24]</sup>. Several field and greenhouse experiments indicate that many chemical constituents of fly ash may benefit plant growth and can improve agronomic properties of soil<sup>[8], [29] [32], [27]</sup>.

## **STUDY AREA**

Fresh fly ash samples were collected from Chandrapura Thermal Power Station (CTPS) of Damodar Valley Corporation (DVC). It is located in the state of Jharkhand covering an area of 790 hectare of land and is about 45-50 km west of Dhanbad. It is situated at 23° 38'4" N to 23° 4' N latitude and 86° 2'E to 86 ° 8'E longitude of Jharkhand. Damodar a perrineal river flows in the southern boundary of Power Station from west to east. The installed capacity of CTPS is 750 MW (three 130 MW units and three 120 MW units). The power plant in nearby has an associated ash pond for the disposal of bottom ash.

## METHODOLOGY

### Study – I & Study – II

Soil samples were collected from native garden soil of Central Institute of Mining and Fuel Research Dhanbad (CIMFR) in large plastics bags and brought to the laboratory. Soil of the area is coarse, sandy and loam which is slightly acidic in nature.

The Fly ash (FA) and soil were dried for 5 days and passed through 2 mm sieve before making various amendments (manually). Physico-chemical analyses were carried out in triplicate on Soil and their different amendments with fly ash before the growth of each vegetable crop.

### Experimental design:

#### Study - I

Seed of each vegetable crops namely Chick pea (*Cicer arietinum*), Golden gram (*Phaseolus aureus*), Black gram (*Phaseolus mungo*) were obtained from Birsa Agricultural University, Ranchi, Jharkhand. All the seed were sterilized with 0.1 % mercuric chloride for 5 min to avoid fungal contamination and washed with distilled water for three times and soaked in water for 5 h. The soaked seed were evenly shown in pot, filled with the concentration of fly ash in soil as 0%, 10%, 20%, 30%, 40%, 50% and 100%. Five different seeds and one sapling were planted in each pot of different concentration.

The plants were irrigated with tap water (300 ml/day) at regular routine avoiding over saturation of soil and subsequent seepage of water from the pots. Pots were lined with polythene sheet to avoid leaching.

Following germination, seedlings were maintained to 10 individual plants per pot to provide optimal resources and opportunity to arrive to maturity. During the growth period morphological, growth and yield parameters were observed at regular intervals and recorded. After harvest, yield was recorded in all the treatments of both the test crops. The growing plants in each pot were carefully monitored to screen, if any, abnormal morphological, physiological or disease symptoms.

#### Study - II

Seed of each vegetable crops namely Radish (*Raphanus sativus* L.), Tomato (*Lycopersicon esculentum* Mill.), Brinjal (*Solanum melongena* L.), Bottle gourd (*Lagenaria siceraria* Standl.) and Sponge gourd (*Luffa cylindrica* L.) were obtained from Birsa Agricultural University, Ranchi, Jharkhand. Pre showing treatment of seeds was done as described for Study – I. The soaked seed were evenly shown in pot, which were filled with different amendments( 60,120, 180, and 240 t/ha of 7 kg, along with one set of control (Soil) each in pot to a depth of 0.5 cm and watered daily till seed germination. Watering has been done as described in Study – I.

Leaves of plants 40 and 100 days old were used for biochemical analysis (Chlorophyll a, Chlorophyll b, Total Chlorophyll and Carotenoids). 0.1 gm of

(fresh weight) of leaves (Tree replicates) samples were crushed with 10 ml of 80 % acetone v/v. After centrifugation at 10000 rpm for 10 min, optical densities of acetone soluble pigments were determined at 643,645, 480 and 510 nm. Total concentrations of trace elements were determined with nitric perchloric acid (3:1) using (ICP-MS (Perkin Elmer Sciex ELAN DRC II).

### **Analytical Methods (For Study – I & II)**

The physical properties viz. texture, water holding capacity (WHC), bulk density (BD), hydraulic conductivity, porosity, moisture content of FA and soils with and without FA amendment were determined following methods as described in standard books<sup>[4], [21]</sup>.

Chemical Properties namely pH, electrical conductivity, total and available elements (N, P, K and S) of PA and soil with and without PA were also determined using the methods<sup>[4], [21], [30]</sup>.

Trace elements and total concentrations of micronutrient were determined with Open acid digestion method. All analyses were carried out in triplicates using with ICP-MS (Perkin Elmer Sciex ELAN DRC II).

## **RESULT AND DISCUSSION**

### **Study – I**

#### **Germination & Growth**

- Specific gravity of fly ash sample was 2.21g/ cm<sup>3</sup> and bulk density was 1.32 g/ cm<sup>3</sup> in dry state and 1.22 g/ cm<sup>3</sup> in wet state.
- The maximum percentage of fly ash sample was retained by sieve of pore size 150 $\mu$  and minimum was retained by 20 $\mu$  sieve. Fly ash particle that are more than 50 $\mu$  in size, dominates the composition with 80% share.
- The pH of fly ash sample was observed as 7.56 while that of soil is 6.65. With increasing concentration of fly ash in soil, the pH also increases.
- The EC of fly ash has been found to 600 $\mu$ S/cm. pH and EC of different concentration of fly ash in soil is shown in following **table**

Table 1: pH and EC of fly ash sample

<b>Sample No.</b>	<b>Fly ash concentration (%)</b>	<b>pH</b>	<b>EC(<math>\mu</math>S/cm)</b>
1	0 (Soil Only)	6.65	281
2	10	6.72	288
3	20	6.75	296
4	30	6.90	300
5	40	6.91	308
6	50	6.96	358
7	100 (Fly ash only)	7.56	600

- The maximum seed germination has been observed in 20 & 30 % amendment, ranging from (88% to 100%).  
The seed germination is an important index in plant growth and development. In fly ash amended soil an increase in percent germination of seed was

observed in all three species over the control. No inhibitory effect of fly ash on seed germination could be recorded except at 100% fly ash, which was near the control. This observation is in line with <sup>[11]</sup> on wheat <sup>[26]</sup> on maize and rice<sup>[2]</sup> in turf grass. The possible reason for this is may be the role of growth regulators and the balance between promoters and inhibitors, which shifts due to the trace element composition of FA.

- Shoot length has shown maximum values in 30 & 40% amendment for almost all the crops with the exception of gram showing maximum growth in soil with no amendment. Root length on the other hand had shown maximum increase in 40 and 50% amendment. Availability of nutrients and increased WHC, porosity and decreased bulk density appears to be the appropriate reason behind this.

## **Study - II**

### **Effect on Radish (*Raphanus sativus* L.)**

Physico-chemical properties and trace elements of different amendments of fly ash and soil were presented in Table 1. The analysis of the results showed significant increase in pH levels with an increase in fly ash amendment ratio. This may be due to the high content of CaO and MgO in fly ash and acid-neutralizing capacities. In the present study, EC increased with an increase in fly ash amendment ratio. An increase in the level of pH by the addition of fly ash in garden soil might cause the precipitation of soluble cations in the fly ash amended soil and consequently resulted in reduction in EC. The level OC and OM were found to decrease with increase in fly ash ratio. The application of graded levels of fly ashes resulted in an increase in available nutrient (N, P, K, Cr, Co, Ni, Cu, Zn, Fe, Mo, al, Pb, Cd, As, Se. and V) in the soil (Table 2), which modified the physico-chemical soil properties.

The growth parameters are shown in Table 4 and 5 & 7. The plant height was found to decrease in fly ash amendments in comparison to GS, maximum significant decrease was found in 240 t/ha as compared to soil. The root length, shoot and photosynthetic pigment ( Ch a, Ch b, total Chlorophyll and Carotenoid )were found to increase up to 180 t/ha fly ash .The increase in growth parameters at initial amendment of fly ash may be due to the presence of nutrients and essential metals in fly ash.

The accumulation of Cr, Co, Ni, Cu, Zn, Fe, Mo, al, Pb, Cd, As, Se. and V in edible parts after 90 days of treatment in different amendments of fly ash was shown in Table 3. The plants grown in soil have accumulated appreciable amounts of these metals, maximum being in edible part. The concentration of metal in plant increased with increase in concentration of fly ash in different treatments as compared to soil. The blue-green alga, *Anabaena doliolum*, growing on fly ash have been reported to accumulate metals such as Cu, Mn, Zn, Ni and Fe, thereby reducing toxic impacts on the plant growth<sup>[25]</sup>. The accumulation of toxic metal, Cr, was found higher in the plant grown in soil. Enrichment of soils and plants with trace elements by fly ash application has been reported by <sup>[17]</sup>.

### **Effect on (*Solanum melongena* L.)**

The physico-chemical characteristic of soil and their amendment with fly ash were reported in Table 6. The values of organic Carbon and organic matter were increased with the addition of fly ash. The concentration of organic carbon and organic matter was absorbed from 0.75 %-0.86 % and 1.30-1.47% approximately. This was more than normal soil<sup>[9]</sup>.

The application of graded levels of fly ashes resulted in an increase in available nutrient (N, P, K, Cr, Co, Ni, Cu, Zn, Fe, Mo, Al, Pb, Cd, As, Se. and V) in the soil which modified the physico-chemical soil properties.

The data shows that all the plant growth parameters (root length, and fresh weight edible part of brinjal) were significantly increased at all amendment in fly ash combinations as compared to inoculated control set (Table 8, 9 & 10). The plant growth was better in 60 t/ha 120 t/ha 180 t/ha and 240 t/ha combinations irrespective of control, maximum being at 120 -180t/ha level of fly ash. The biochemical parameters (chlorophyll a, chlorophyll b, total chlorophyll and carotenoid) were significantly increased in the treatments with 120 to 180 t/ha fly ash as compared with soil. The decreased level of chlorophyll may have been due to down regulation of chlorophyll biosynthesis by restricting the level of precursors or through targeting -SH groups of aminolevulinic acid dehydratase (ALAD) in the presence of metals<sup>[23], [31]</sup>. The beneficial effect of fly ash at lower levels have already been observed on many crops - soybean, cabbage, chickpea, cucumber, lentil, maize, potato, wheat, tomato etc<sup>[17], [28], [12], [13] & [24]</sup>.

### **Effect on (*Lycopersicon esulentum* Mill.)**

The increases in the pH and EC values could be ascribed, respectively, to the alkaline nature and the higher solubility of the inorganic constituents of fly ash. In fact, the increase in EC could be considered high and likely to suppress normal growth. Especially as the EC values in the range 0.5–1.0 dS/ m can reduce germination and cause burning or wilting of sensitive crops<sup>[7]</sup> CSTPA (Council of Soil Testing and Plant Analysis), 1992).

The amendment of fly ashes up to 180 t/ha resulted in an increase in available nutrient (N, P, K, Cr, Co, Ni, Cu, Zn, Fe, Mo, Al, Pb, Cd, As, Se. and V ) in the soil which modified the physico-chemical soil properties which was reported in Table 6. the shoot length, root length and photosynthetic activity of *Lycopersicon esulentum* Mill.

### **Effect on ( *Lagenaria siceraia* Standl.)**

Physio-chemical properties of coal fly ash depends on their origin and the composition of coal used for combustion. Chandrapura Thermal Station fly ashes are usually alkaline and contain high concentration of Ca, Mg, Na and heavy metals like Fe, Mn, Cu and Zn. The application of graded levels of fly ashes resulted in an increase in available nutrient (N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu) in the soil (13), which modified the physico-chemical properties of soil significantly.

### **Effect on ( *Luffa cylindrica* L.)**

The concentration of heavy metal in soil and their amendment with fly ash are given in Table 13. The addition of fly ash which improve the physico- chemical characteristic of degraded soil. The pH and EC values increased from Control- 240 t/ha where as the respective organic carbon and organic matter decreased. Bulk density decreased from 1.24- 1.17 g/cm<sup>3</sup> where as concentration of Water holding capacity was respectively increased.

The amendment of fly ashes up to 180 t/ha resulted in an increase in available nutrient (N, P, K, Cr, Co, Ni, Cu, Zn, Fe, Mo, al, Pb, Cd, As, Se. and V ) in the soil which modified the physico-chemical soil properties and produced the nutrients for crop production.

The growth parameters such as shoot length and root length were increased up to 180 t/ha followed by decrease 240 t/ha as compared to soil. These finding indicated that lower amendment favored the growth of plants. The photosynthetic pigment like Ch a, Ch b, Total Ch and Carotenoid were increased up to 180 t/ha (Table16 ) . Increase in photosynthetic pigment could be attributed to the presence of essential metal ions present in fly ash. The accumulation of Cr, Co, Ni, Cu, Zn, Fe, Mo, al, Pb, Cd, As, Se. and V in edible parts after 90 days of treatment in different amendments of fly ash was studied. The metal accumulation in the edible part of *Luffa cylindrica* L has been found in the order of Fe>Al>Zn>Cu>Ni>Pb>Cr> As> Se> Mo and V respectively.

Table.2.Physico-chemical properties in different amendments of fly ash with soil before the sowing of seeds of (*Raphanus sativus* L.)

Parameters	Soil	60t/ha	120t/ha	180t/ha	240t/ha
W.Holding capacity(%)	42.13 <sup>d</sup> ± 0.55	53.13 <sup>d</sup> ± 0,04	64.15 <sup>c</sup> ± 0.04	65.72 <sup>b</sup> ± 0.02	65.89 <sup>a</sup> ± 0.02
Moisture content(%)	2.3 <sup>b</sup> ± 0.15	2.56 <sup>c</sup> ± 0.26	3.19 <sup>b</sup> ± 0.20	3.77 <sup>a</sup> ±0.20	3.62 <sup>c</sup> ± 0.11
Specific gravity(g/cm <sup>3</sup> )	1.32 <sup>b</sup> ± 0.02	1.23 <sup>c</sup> ± 0.02	1.32 <sup>b</sup> ± 0.01	1.70 <sup>a</sup> ± 0.04	1.11 <sup>c</sup> ± 0.03
Bulk density(g/cm <sup>3</sup> )	1.25 <sup>a</sup> ±0.01	1.24 <sup>a</sup> ± 0.02	1.24 <sup>a</sup> ± 0.01	1.23a <sup>b</sup> ± 0.04	1.21 <sup>b</sup> ± 0.03
pH	6.3 <sup>d</sup> ± 0.10	6.7 <sup>c</sup> ± 0.15	6.7 <sup>c</sup> ± 0.23	6.9 <sup>b</sup> ± 0.25	7.2 <sup>a</sup> ± 0.30
EC(µS/cm)	55.41 <sup>d</sup> ± 0.12	56.75 <sup>d</sup> ± 0.04	60.8 <sup>c</sup> ± 0.02	62.22 <sup>b</sup> ± 0.04	73.41 <sup>a</sup> ± 0.01
OC (%)	0.82 <sup>d</sup> ± 0.02	0.92 <sup>a</sup> ± 0.02	0.88 <sup>b</sup> ± 0.03	0.87 <sup>b</sup> ± 0.01	0.85 <sup>c</sup> ± 0.02
OM (%)	1.41 <sup>c</sup> ± 0.02	1.59 <sup>a</sup> ± 0.02	1.52 <sup>ab</sup> ± 0.01	1.50 <sup>b</sup> ± 0.01	1.47 <sup>c</sup> ± 0.02
Alkalinity(mg/kg)	39.41 <sup>d</sup> ± 0.02	46.11 <sup>d</sup> ± 0.02	52.83 <sup>c</sup> ± 0.03	60.25 <sup>b</sup> ± 0.01	67.41 <sup>a</sup> ± 0.02
Ca(mg/kg)	2.74 <sup>c</sup> ± 0.01	6.75 <sup>b</sup> ± 0.02	7.14 <sup>ab</sup> ± 0.01	8.15 <sup>a</sup> ± 0.02	9.05 <sup>a</sup> ± 0.03
Mg(mg/kg)	17.8 <sup>c</sup> ± 0.05	17.58 <sup>d</sup> ± 0.02	17.38 <sup>d</sup> ± 0.02	19.74 <sup>b</sup> ± 0.02	20.27 <sup>a</sup> ± 0.01
Na(mg/kg)	6.66 <sup>a</sup> ± 0.01	4.89 <sup>b</sup> ± 0.02	3.55 <sup>d</sup> ± 0.02	4.04 <sup>d</sup> ± 0.02	4.58 <sup>c</sup> ± 0.01
Sulphate	21.61 <sup>d</sup> ± 0.02	35.54 <sup>d</sup> ± 0.13	47.48 <sup>c</sup> ± 0.30	59.41 <sup>b</sup> ± 0.02	63.65 <sup>a</sup> ± 0.41
Chloride	4.41 <sup>d</sup> ± 0.02	7.13 <sup>d</sup> ± 0.03	7.85 <sup>c</sup> ± 0.03	10.36 <sup>b</sup> ± 0.04	11.06 <sup>a</sup> ± 0.02
N(kg/ha)	291 <sup>a</sup> ± 37.85	233 <sup>c</sup> ± 32.14	244.12 <sup>b</sup> ± 20.08	294.44 <sup>a</sup> ±26.46	156.64 <sup>d</sup> ±15.8
P(kg/ha)	9.68 <sup>d</sup> ± 0.15	9.63 <sup>d</sup> ± 0.02	10.43 <sup>c</sup> ± 0.02	10.92 <sup>b</sup> ± 0.02	10.72 <sup>a</sup> ± 0.01
K(kg/ha)	111.66 <sup>a</sup> ±0.15	110.99 <sup>d</sup> ± 0.02	111.10 <sup>c</sup> ±0.02	111.66 <sup>a</sup> ±0.03	111.44 <sup>b</sup> ± 0.01
Cr (mg/kg)	34.31 <sup>d</sup> ± 1.99	67.11 <sup>d</sup> ± 1.96	81.62 <sup>c</sup> ± 1.00	120.43 <sup>a</sup> ± 1.15	90.78 <sup>b</sup> ± 0.86
Co (mg/kg)	5.07 <sup>c</sup> ± 0.15	6.32 <sup>a</sup> ± 0.02	6.69 <sup>ab</sup> ± 0.02	9.36 <sup>b</sup> ± 0.02	7.3 <sup>b</sup> ± 0.01
Ni (mg/kg)	33.5 <sup>d</sup> ± 3.32	62.36 <sup>d</sup> ± 5.85	76.22 <sup>c</sup> ± 10.88	122.53 <sup>b</sup> ±11.66	87.90 <sup>a</sup> ± 11.19
Cu (mg/kg)	20.97 <sup>d</sup> ± 0.66	63.18 <sup>a</sup> ± 2.51	33.76 <sup>c</sup> ± 2.10	46.37 <sup>b</sup> ± 2.30	45.49 <sup>b</sup> ± 2.30
Zn (mg/kg)	600.11 <sup>b</sup> ±6.92	573.87 <sup>a</sup> ± 2.51	509.32 <sup>ab</sup> ± 3.05	519.75 <sup>ab</sup> ±3.25	428 <sup>d</sup> ± 3.20
Fe (mg/kg)	22467 <sup>a</sup> ± 360	19227 <sup>b</sup> ± 262	24209 <sup>a</sup> ± 375	25095 <sup>a</sup> ± 429	23673 <sup>a</sup> ± 360
Mo (mg/kg)	41.43 <sup>c</sup> ± 1.52	53.94 <sup>b</sup> ± 2.08	61.94 <sup>a</sup> ± 2.08	42.44 <sup>c</sup> ± 2.64	43.82 <sup>c</sup> ± 1.52
Al (mg/kg)	31.88 <sup>d</sup> ± 1.99	69.80 <sup>d</sup> ±1.96	102.73 <sup>a</sup> ± 1.00	92.96 <sup>b</sup> ± 1.15	75.19 <sup>c</sup> ± 0.86
Pb (mg/kg)	31.44 <sup>c</sup> ± 1.99	46.43 <sup>b</sup> ± 1.96	39.67 <sup>c</sup> ± 1.00	36.08 <sup>c</sup> ± 1.15	52.34 <sup>a</sup> ± 0.87
Cd (mg/kg)	1.28 <sup>a</sup> ± 0.15	1.77 <sup>a</sup> ± 0.02	0.88 <sup>b</sup> ± 0.02	1.26 <sup>a</sup> ± 0.02	1.71 <sup>a</sup> ± 0.15
As (mg/kg)	3.22 <sup>a</sup> ± 0.03	5.65 <sup>a</sup> ± 0.05	5.96 <sup>a</sup> ± 1.00	6.04 <sup>a</sup> ± 1.15	6.31 <sup>a</sup> ± 0.86
Se (mg/kg)	3.99 <sup>a</sup> ±1.96	4.87 <sup>a</sup> ± 1.99	5.54 <sup>a</sup> ± 1.00	4.43 <sup>a</sup> ± 1.15	5.65 <sup>a</sup> ± 0.86
V (mg/kg)	45.48 <sup>d</sup> ± 1.96	71.56 <sup>c</sup> ± 1.99	77.65 <sup>b</sup> ± 1.97	79.86 <sup>b</sup> ± 2.03	97.88 <sup>a</sup> ± 2.01

Values are mean (n=3) SD, ANOVA  $p < 0:05$ , different superscripts denote significant differences ( $p < 0:05$ ) between means in a column for each parameter according to DMRT.

Table.3.Accumulation of trace elements (mg/kg) of *Raphanus sativus* L growing in different fly ash amendments

Elements	Soil	60 t/ha	120 t/ha	180 t/ha	240 t/ha
<b>Cr</b>	0.95 <sup>a</sup> ± 0.36	0.71 <sup>c</sup> ± 0.06	0.84 <sup>b</sup> ± 0.05	0.93 <sup>a</sup> ± 0.02	0.80 <sup>b</sup> ± 0.07
<b>Co</b>	0.69 <sup>b</sup> ± 0.02	0.26 <sup>d</sup> ± 0.02	0.39 <sup>c</sup> ± 0.02	0.75 <sup>a</sup> ± 0.02	0.19 <sup>d</sup> ± 0.02
<b>Ni</b>	1.14 <sup>a</sup> ± 0.01	0.89 <sup>c</sup> ± 0.03	0.80 <sup>d</sup> ± 0.06	0.94 <sup>b</sup> ± 0.01	0.79 <sup>d</sup> ± 0.02
<b>Cu</b>	9.21 <sup>b</sup> ± 0.02	6.50 <sup>d</sup> ± 0.02	8.00 <sup>c</sup> ± 0.06	9.43 <sup>a</sup> ± 0.01	6.98 <sup>a</sup> ± 0.02
<b>Zn</b>	23.75 <sup>b</sup> ± 2.01	21.32 <sup>b</sup> ± 2.01	32.79 <sup>a</sup> ± 3.06	31.34 <sup>a</sup> ± 2.01	21.09 <sup>b</sup> ± 2.01
<b>Fe</b>	102.49 <sup>a</sup> ± 1.15	47.91 <sup>d</sup> ± 1.16	58.85 <sup>c</sup> ± 2.32	81.82 <sup>b</sup> ± 1.16	52.10 <sup>d</sup> ± 1.16
<b>Mo</b>	0.83 <sup>b</sup> ± 0.02	1.43 <sup>b</sup> ± 0.01	0.85 <sup>b</sup> ± 0.14	2.15 <sup>a</sup> ± 0.53	2.72 <sup>a</sup> ± 0.01
<b>Al</b>	20.20 <sup>b</sup> ± 2.01	22.10 <sup>b</sup> ± 2.01	21.12 <sup>b</sup> ± 2.58	27.30 <sup>a</sup> ± 2.01	13.65 <sup>c</sup> ± 2.01
<b>Pb</b>	4.39 <sup>a</sup> ± 2.01	0.78 <sup>b</sup> ± 0.02	1.54 <sup>b</sup> ± 0.02	1.87 <sup>b</sup> ± 0.02	0.83 <sup>b</sup> ± 0.02
<b>Cd</b>	0.11 <sup>b</sup> ± 0.01	0.06 <sup>c</sup> ± 0.02	1.75 <sup>a</sup> ± 0.02	0.08 <sup>c</sup> ± 0.02	0.09 <sup>c</sup> ± 0.02
<b>As</b>	0.67 <sup>b</sup> ± 0.02	0.25 <sup>d</sup> ± 0.02	0.47 <sup>c</sup> ± 0.03	0.83 <sup>a</sup> ± 0.02	0.66 <sup>b</sup> ± 0.02
<b>Se</b>	0.34 <sup>d</sup> ± 0.02	0.79 <sup>c</sup> ± 0.02	0.46 <sup>d</sup> ± 0.08	1.14 <sup>a</sup> ± 0.02	1.07 <sup>b</sup> ± 0.02
<b>V</b>	0.28 <sup>b</sup> ± 0.02	0.32 <sup>b</sup> ± 0.02	0.62 <sup>a</sup> ± 0.12	0.50 <sup>a</sup> ± 0.02	0.45 <sup>a</sup> ± 0.02

Values are mean (n=3) SD, ANOVA  $p < 0:05$ , different superscripts denote significant differences ( $p < 0:05$ ) between means in a column for each parameter according to DMRT.

Table.4, Effect of various fly ash amendments on shoot length (inch) of (*Raphanus sativus* L.) at different durations

	5 days	10 days	20 days	40 days	90days
Soil	0.60	1.2	1.80	2.47	6.75
60 t/ha	1.50	3.03	4.07	4.87	9.4
120 t/ha	1.57	3.27	4.43	5.00	11
180 t/ha	1.50	3.03	4.23	5.30	13.5

240 t/ha	1.13	2.33	3.13	5.07	12.8
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Table.5. Effect of various fly ash amendments on root length (inch) of (*Raphanus sativus* L.) at 40 and 90 days

S No.	Composition	40 days	90 days
1	Soil	6.18	9.27
2	60t/ha	6.29	9.44
3	120 t/ha	10.34	15.5
4	180 t/ha	9.72	14.58
5	240 t/ha	6.93	10.4

Table.6.Physico-chemical properties in different amendments of fly ash with soil before the sowing of seeds of (*Solanum melongena* L and *Lycopersicon esuulentum* Mill.)

	Soil	60t/ha	120t/ha	180t/ha	240t/ha
<b>W.Holding capacity(%)</b>	42.11 <sup>d</sup> ± 0.55	52.12 <sup>d</sup> ± 0.04	62.14 <sup>c</sup> ± 0.04	65.69 <sup>b</sup> ± 0.02	65.75 <sup>a</sup> ± 0.02
<b>Moisture content(%)</b>	2.3 <sup>c</sup> ± 0.15	2.7 <sup>b</sup> ± 0.26	3.9 <sup>a</sup> ± 0.20	4.1 <sup>a</sup> ± 0.20	3.9 <sup>a</sup> ± 0.11
<b>Specific gravity(g/cm<sup>3</sup>)</b>	1.23 <sup>c</sup> ± 0.02	1.25 <sup>c</sup> ± 0.02	1.32 <sup>b</sup> ± 0.01	1.36 <sup>a</sup> ± 0.04	1.11 <sup>c</sup> ± 0.03
<b>Bulk density(g/cm<sup>3</sup>)</b>	1.27 <sup>a</sup> ± 0.01	1.22 <sup>a</sup> ± 0.02	1.24 <sup>a</sup> ± 0.01	1.24 <sup>a</sup> ± 0.04	1.21 <sup>a</sup> ± 0.03
<b>pH</b>	5.9 <sup>d</sup> ± 0.10	6.4 <sup>d</sup> ± 0.15	6.7 <sup>c</sup> ± 0.23	7.1 <sup>b</sup> ± 0.25	7.2 <sup>a</sup> ± 0.30
<b>EC(μS/cm)</b>	55.45 <sup>d</sup> ± 0.12	56.79 <sup>d</sup> ± 0.04	60.8 <sup>c</sup> ± 0.02	62.19 <sup>b</sup> ± 0.04	73.42 <sup>a</sup> ±0.01
<b>OC%</b>	0.72 <sup>d</sup> ± 0.02	0.85 <sup>c</sup> ± 0.02	0.87 <sup>a</sup> ± 0.03	0.89 <sup>a</sup> ± 0.01	0.85 <sup>b</sup> ± 0.02
<b>OM%</b>	1.24 <sup>d</sup> ± 0.02	1.46 <sup>d</sup> ± 0.02	1.49 <sup>b</sup> ± 0.03	1.53 <sup>a</sup> ± 0.01	1.46 <sup>c</sup> ± 0.02
<b>Alkalinity</b>	39.45 <sup>d</sup> ± 0.12	46.64 <sup>d</sup> ±0.13	52.67 <sup>c</sup> ± 0.12	60.71 <sup>b</sup> ± 0.13	67.72 <sup>a</sup> ± 0.13
<b>Ca(mg/kg)</b>	2.78 <sup>d</sup> ± 0.01	6.75 <sup>d</sup> ± 0.02	7.21 <sup>c</sup> ± 0.01	8.26 <sup>b</sup> ± 0.01	9.15 <sup>a</sup> ± 0.02
<b>Mg(mg/kg)</b>	17.9 <sup>d</sup> ± 0.02	17.25 <sup>d</sup> ± 0.02	17.48 <sup>c</sup> ± 0.01	19.84 <sup>b</sup> ± 0.02	20.25 <sup>a</sup> ± 0.01
<b>Na(mg/kg)</b>	6.76 <sup>d</sup> ± 0.01	7.21 <sup>d</sup> ± 0.02	7.23 <sup>c</sup> ± 0.02	7.52 <sup>b</sup> ± 0.02	7.57 <sup>a</sup> ± 0.01
<b>Sulphate</b>	21.42 <sup>d</sup> ±0.02	35.76 <sup>d</sup> ± 0.13	47.58 <sup>c</sup> ± 0.03	59.91 <sup>b</sup> ± 0.02	63.39 <sup>a</sup> ± 0.41
<b>Chloride</b>	5.68 <sup>d</sup> ± 0.02	7.63 <sup>d</sup> ± 0.03	8.43 <sup>c</sup> ± 0.03	10.92 <sup>b</sup> ± 0.04	11.72 <sup>a</sup> ± 0.02
<b>N(kg/ha)</b>	289 <sup>b</sup> ± 37.83	231 <sup>d</sup> ± 32.17	242.12 <sup>c</sup> ±21.04	296.44 <sup>a</sup> ±25.76	176.64 <sup>d</sup> ±15.87
<b>P(kg/ha)</b>	9.63 <sup>d</sup> ±0.15	9.68 <sup>d</sup> ± 0.02	10.43 <sup>c</sup> ± 0.02	10.59 <sup>a</sup> ± 0.02	10.65 <sup>b</sup> ± 0.02
<b>K(kg/ha)</b>	111.66 <sup>b</sup> ± 1.99	111.44 <sup>d</sup> ±0.22	111.66 <sup>d</sup> ± 0.23	112.78 <sup>a</sup> ± 0.11	111.44 <sup>c</sup> ± 0.14
<b>Cr</b>	72.41 <sup>d</sup> ±1.99	99.76 <sup>d</sup> ±1.96	110.58 <sup>c</sup> ±1.00	147.90 <sup>a</sup> ±1.15	135.39 <sup>b</sup> ± 0.86
<b>Co</b>	8.98 <sup>d</sup> ±0.15	12.18 <sup>d</sup> ±0.02	13.63 <sup>c</sup> ± 0.02	17.65 <sup>a</sup> ± 0.02	16.17 <sup>b</sup> ± 0.01
<b>Ni</b>	20.14 <sup>d</sup> ± 3.32	29.50 <sup>d</sup> ±5.85	42.90 <sup>c</sup> ±10.88	47.99 <sup>a</sup> ±11.66	46.81 <sup>b</sup> ± 11.19
<b>Cu</b>	47.42 <sup>c</sup> ±0.66	56.65 <sup>b</sup> ± 2.51	61.72 <sup>b</sup> ± 2.10	74.87 <sup>a</sup> ± 2.30	60.97 <sup>b</sup> ± 2.30
<b>Zn</b>	570.09 <sup>a</sup> ±6.92	491.40 <sup>c</sup> ±2.51	443.20 <sup>d</sup> ± 3.05	534.66 <sup>b</sup> ± 3.25	476.37 <sup>d</sup> ±3.20
<b>Fe</b>	22536 <sup>d</sup> ± 360	19238 <sup>d</sup> ± 262	24386 <sup>b</sup> ± 375	25215 <sup>a</sup> ± 429	23272 <sup>c</sup> ± 360
<b>Mo</b>	53.10 <sup>b</sup> ± 0.66	52.04 <sup>b</sup> ±2.51	59.94 <sup>a</sup> ± 2.10	41.14 <sup>c</sup> ±2.10	44.82 <sup>c</sup> ± 11.19
<b>Al</b>	34.70 <sup>d</sup> ± 1.52	69.60 <sup>d</sup> ± 2.08	101.33 <sup>a</sup> ± 2.08	90.96 <sup>b</sup> ± 2.64	74.19 <sup>c</sup> ± 1.52
<b>Pb</b>	47.55 <sup>b</sup> ± 1.99	49.43 <sup>b</sup> ±1.96	59.27 <sup>a</sup> ± 1.00	69.99 <sup>a</sup> ± 1.15	36.04 <sup>c</sup> ± 0.86
<b>Cd</b>	3.90 <sup>b</sup> ± 0.15	1.20 <sup>b</sup> ± 0.02	5.54 <sup>a</sup> ± 0.02	3.85 <sup>b</sup> ± 0.02	4.12 <sup>b</sup> ± 0.15
<b>As</b>	3.90 <sup>a</sup> ± 0.03	3.44 <sup>a</sup> ± 0.05	4.48 <sup>a</sup> ± 1.00	5.08 <sup>a</sup> ± 1.15	4.81 <sup>a</sup> ± 0.86
<b>Se</b>	2.00 <sup>a</sup> ±1.96	1.45 <sup>a</sup> ± 1.99	4.21 <sup>a</sup> ± 1.00	3.64 <sup>a</sup> ± 1.15	3.11 <sup>a</sup> ±0.86
<b>V</b>	44.40 <sup>d</sup> ±1.96	84.78 <sup>c</sup> ±1.99	110.03 <sup>b</sup> ±1.97	112.04 <sup>b</sup> ±2.03	114.99 <sup>a</sup> ±2.01

Values are mean (n=3) SD, ANOVA p < 0:05, different superscripts denote significant differences (p < 0:05) between means in a column for each parameter according to DMRT.

Table. 7 .Effect of various fly ash amendments on photosynthetic pigments (mg g<sup>-1</sup> fw) of (*Raphanus sativus* L.) at different durations (40 and 90 days).

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
Soil	0.40	0.22	0.62	0.27	0.52	0.43	0.95	0.52
60t/ha	0.42	0.27	0.69	0.30	0.56	0.56	1.12	0.61
120 t/ha	0.43	0.37	0.80	0.43	0.47	0.59	1.06	0.76
180 t/ha	0.98	0.32	1.30	0.47	0.99	0.67	1.66	0.79
240 t/ha	0.41	0.23	0.65	0.28	0.69	0.59	1.28	0.53

Table 8.Effect of various fly ash amendments on shoot length *Solanum melongena* L. (inch) at different durations

	5 days	10 days	20 days	40 days	100 days
Soil	1.07	1.43	1.70	2.70	24.7
60t/ha	1.17	1.50	1.67	2.93	29.5
120 t/ha	1.17	1.80	1.87	3.20	32.3
180 t/ha	1.10	1.33	1.70	3.27	35.3
240 t/ha	1.13	1.60	1.80	2.77	33.3

Table.9.Effect of various fly ash amendments on root length ( *Solanum melongena* L.) after of treatment

	40 days	90 days
Soil	3.67	5.51
60t/ha	4.57	6.86
120 t/ha	6.18	9.27
180 t/ha	7.22	10.83
240 t/ha	5.34	8.01

Table 10. Effect of various fly ash amendments on photosynthetic pigments (mg g<sup>-1</sup> fw) of (*Solanum melongena* L.) at different durations

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
Soil	1.16	0.58	1.74	0.27	1.17	0.59	1.76	0.53
60t/ha	1.30	0.70	2.00	0.31	1.32	0.78	2.1	0.63
120 t/ha	1.44	0.73	2.17	0.47	1.46	0.86	2.32	0.83
180 t/ha	1.46	0.75	2.21	0.48	1.67	0.98	2.65	0.85
240 t/ha	1.05	0.70	1.75	0.38	1.09	0.76	1.85	0.76

Table. 11. Effect of various fly ash amendments on shoot length of *Lycopersicon esuulentum* Mill. (inch) at different durations

	5 days	10 days	20 days	40 days	100 days
Soil	2.43	3.20	4.60	9.87	22.8
60t/ha	2.77	3.67	5.47	11.43	24.3
120 t/ha	3.03	3.87	5.87	12.23	26.3
180 t/ha	3.03	4.10	5.90	12.60	25.3
240 t/ha	3.03	4.13	6.40	12.57	23.3

Table.13.Physico-chemical properties in different amendments of fly ash with soil before the sowing of seeds of (*Lagenaria siceraia* Standl. and *Luffa cylindrica* L.)

	Soil	60t/ha	120t/ha	180t/ha	240t/ha
<b>W.Holding capacity(%)</b>	39.23 <sup>d</sup> ± 0.04	52.35 <sup>d</sup> ± 0.02	63.56 <sup>c</sup> ± 0.05	65.52 <sup>b</sup> ± 0.03	65.77 <sup>a</sup> ±0.02
<b>Moisture content(%)</b>	2.90 <sup>d</sup> ± 0.01	3.65 <sup>c</sup> ± 0.02	3.20 <sup>a</sup> ± 0.02	3.78 <sup>b</sup> ± 0.02	3.72 <sup>d</sup> ± 0.01
<b>Specific gravity(g/cm<sup>3</sup>)</b>	1.21 <sup>d</sup> ± 0.02	1.23 <sup>c</sup> ± 0.02	1.25 <sup>b</sup> ± 0.01	1.31 <sup>a</sup> ± 0.01	1.11 <sup>d</sup> ± 0.03
<b>Bulk density(g/cm<sup>3</sup>)</b>	1.24 <sup>c</sup> ±0.01	1.25 <sup>b</sup> ± 0.02	1.27 <sup>a</sup> ± 0.01	1.23 <sup>c</sup> ± 0.04	1.17 <sup>d</sup> ± 0.03
<b>pH</b>	5.9 <sup>d</sup> ±0.05	6.4 <sup>d</sup> ± 0.01	6.9 <sup>c</sup> ± 0.02	7.1 <sup>b</sup> ± 0.02	7.2 <sup>a</sup> ± 0.06
<b>EC(µS/cm)</b>	55.28 <sup>d</sup> ± 1.24	56.21 <sup>d</sup> ± 0.43	60.21 <sup>c</sup> ± 0.20	62.22 <sup>b</sup> ± 0.25	72.31 <sup>a</sup> ± 0.60
<b>OC (%)</b>	0.79 <sup>d</sup> ± 0.01	0.83 <sup>c</sup> ± 0.02	0.85 <sup>b</sup> ± 0.01	0.87 <sup>a</sup> ± 0.01	0.85 <sup>b</sup> ± 0.02
<b>O(M%)</b>	1.36 <sup>d</sup> ± 0.01	1.43 <sup>c</sup> ± 0.02	1.46 <sup>b</sup> ± 0.01	1.49 <sup>a</sup> ± 0.01	1.46 <sup>b</sup> ± 0.02
<b>Alkalinity ( mg/kg)</b>	39.59 <sup>d</sup> ± 0.26	46.65 <sup>d</sup> ± 0.20	52.69 <sup>c</sup> ± 0.32	60.19 <sup>b</sup> ± 0.15	67.42 <sup>a</sup> ±0.26
<b>Ca(mg/kg)</b>	2.74 <sup>d</sup> ± 0.01	6.56 <sup>d</sup> ± 0.02	6.59 <sup>c</sup> ± 0.01	7.21 <sup>b</sup> ±0.01	8.52 <sup>a</sup> ± 0.02
<b>Mg(mg/kg)</b>	17.21 <sup>d</sup> ± 0.05	17.23 <sup>d</sup> ± 0.02	17.38 <sup>c</sup> ± 0.02	18.32 <sup>b</sup> ± 0.01	20.16 <sup>a</sup> ±0.02
<b>Na(mg/kg)</b>	6.7 <sup>c</sup> ± 0.01	7.22 <sup>b</sup> ± 0.02	7.25 <sup>b</sup> ± 0.02	7.29 <sup>b</sup> ± 0.01	7.49 <sup>a</sup> ± 0.02
<b>Sulphate</b>	21.36 <sup>d</sup> ± 0.02	35.75 <sup>d</sup> ± 0.02	47.32 <sup>c</sup> ± 0.02	59.11 <sup>b</sup> ± 0.01	63.89 <sup>a</sup> ±0.02
<b>Chloride</b>	6.64 <sup>d</sup> ±0.05	9.66 <sup>d</sup> ± 0.03	10.28 <sup>c</sup> ±0.02	10.59 <sup>b</sup> ±0.04	11.53 <sup>a</sup> ±0.02
<b>N(kg/ha)</b>	281 <sup>b</sup> ±3.78	223 <sup>d</sup> ± 3.21	264.12 <sup>c</sup> ±2.08	290.44 <sup>a</sup> ± 3.25	166.64 <sup>d</sup> ±1.00
<b>P(kg/ha)</b>	9.68 <sup>d</sup> ±0.01	9.73 <sup>d</sup> ± 0.02	10.41 <sup>b</sup> ± 0.02	10.54 <sup>a</sup> ± 0.02	10.21 <sup>c</sup> ± 0.01
<b>K(kg/ha)</b>	111.66 <sup>a</sup> ±1.15	110.43 <sup>b</sup> ± 2.00	110.66 <sup>b</sup> ±2.00	111.10 <sup>b</sup> ± 3.00	111.04 <sup>b</sup> ±1.00
<b>Cr (mg/kg)</b>	78.36 <sup>d</sup> ± 1.99	103.75 <sup>d</sup> ± 1.97	124.32 <sup>b</sup> ±1.01	136.01 <sup>a</sup> ± 1.15	113.68 <sup>c</sup> ±0.87
<b>Co (mg/kg)</b>	10.66 <sup>b</sup> ± 0.15	13.37 <sup>b</sup> ± 0.02	16.62 <sup>a</sup> ± 0.02	16.54 <sup>a</sup> ± 0.03	12.30 <sup>b</sup> ± 0.02
<b>Ni (mg/kg)</b>	25.09 <sup>c</sup> ±0.30	34.72 <sup>b</sup> ± 0.60	43.94 <sup>a</sup> ±1.09	45.02 <sup>a</sup> ± 1.17	37.28 <sup>b</sup> ± 1.19

<b>Cu (mg/kg)</b>	50.28 <sup>a</sup> ± 0.60	78.58 <sup>a</sup> ± 1.22	62.47 <sup>a</sup> ± 1.95	67.19 <sup>a</sup> ± 2.03	59.89 <sup>a</sup> ± 2.00
<b>Zn (mg/kg)</b>	681.33 <sup>a</sup> ±6.92	601.40 <sup>b</sup> ± 3.00	452.22 <sup>d</sup> ±2.01	576.94 <sup>c</sup> ± 3.00	477.31 <sup>d</sup> ±3.00
<b>Fe (mg/kg)</b>	22404 <sup>a</sup> ± 360	19227 <sup>a</sup> ± 262	24326 <sup>a</sup> ± 375	25190 <sup>a</sup> ± 429	23208 <sup>a</sup> ± 360
<b>Mo (mg/kg)</b>	36.79 <sup>a</sup> ± 0.01	34.81 <sup>a</sup> ± 0.02	36.71 <sup>a</sup> ± 0.02	25.34 <sup>b</sup> ± 0.02	28.41 <sup>b</sup> ± 0.01
<b>Al (mg/kg)</b>	80.75 <sup>c</sup> ± 1.99	71.90 <sup>d</sup> ± 1.97	108.51 <sup>a</sup> ±1.01	87.39 <sup>b</sup> ± 1.15	54.10 <sup>d</sup> ±0.87
<b>Pb (mg/kg)</b>	77.11 <sup>a</sup> ±1.99	70.24 <sup>b</sup> ± 1.94	50.84 <sup>c</sup> ± 1.01	71.73 <sup>b</sup> ± 1.17	73.32 <sup>a</sup> ± 0.84
<b>Cd (mg/kg)</b>	3.56 <sup>d</sup> ±0.05	4.01 <sup>d</sup> ± 0.02	5.63 <sup>c</sup> ± 0.02	5.80 <sup>b</sup> ± 0.02	7.43 <sup>a</sup> ± 0.02
<b>As (mg/kg)</b>	3.95 <sup>a</sup> ± 0.03	4.01 <sup>a</sup> ± 0.06	4.30 <sup>a</sup> ± 0.09	5.17 <sup>a</sup> ± 0.09	5.24 <sup>a</sup> ± 0.08
<b>Se (mg/kg)</b>	1.30 <sup>b</sup> ± 0.01	2.31 <sup>a</sup> ± 0.02	4.03 <sup>a</sup> ± 0.02	3.37 <sup>a</sup> ± 0.01	4.39 <sup>a</sup> ± 0.02
<b>V (mg/kg)</b>	64.38 <sup>d</sup> ± 1.96	97.34 <sup>c</sup> ± 1.99	97.84 <sup>c</sup> ± 1.97	122.86 <sup>a</sup> ± 2.03	115.43 <sup>b</sup> ±2.01

Values are mean (n=3) SD, ANOVA  $p < 0:05$ , different superscripts denote significant differences ( $p < 0:05$ ) between means in a column for each parameter according to DMRT.

Table.12.Effect of various fly ash amendments on root length of *Lycopersicon esuulentum* Mill. (inch) at different durations (40 and 100 days)

Soil	6.42	9.63
60t/ha	6.87	10.305
120 t/ha	7.38	11.07
180 t/ha	7.94	11.91
240 t/ha	6.14	9.21

Table.14.Effect of various fly ash amendments on photosynthetic pigments (mg g<sup>-1</sup> fw) of (*Lycopersicon esuulentum* Mill.) at 40 and 100 days

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
Soil	0.90	0.44	1.34	0.27	0.97	0.65	1.62	0.52
60t/ha	0.96	0.57	1.52	0.29	1.06	0.67	1.73	0.58
120 t/ha	1.01	0.59	1.60	0.43	1.09	0.78	1.87	0.76
180 t/ha	1.08	0.59	1.67	0.46	1.23	0.89	2.12	0.79
240 t/ha	0.98	0.37	1.35	0.26	1.01	0.65	1.66	0.51

Table.15.Effect of various fly ash amendments on shoot length of *Lagenaria siceraia* Standl. (inch)

	5 days	10 days	20 days	40 days
Soil	4.30	6.43	11.63	25.80
60t/ha	5.63	10.47	17.17	31.50
120 t/ha	7.43	10.07	21.20	32.73
180 t/ha	7.53	12.77	21.47	36.37
240 t/ha	6.53	11.43	23.30	35.27

Table.16.Effect of various fly ash amendments on root length of *Lagenaria siceraia* Standl. (inch) at 40 days

Soil	6.03
60t/ha	7.77
120 t/ha	10.25
180 t/ha	9.72
240 t/ha	7.09

Table.17.Effect of various fly ash amendments on photosynthetic pigments (mg g<sup>-1</sup> fw) of at (*Lagenaria siceraia* Standl.) at 40 and 100 days

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
Soil	1.16	0.58	1.74	0.27	1.17	0.59	1.76	0.51
60t/ha	1.30	0.70	2.00	0.37	1.32	0.78	2.1	0.73
120 t/ha	1.44	0.73	2.17	0.46	1.4	0.86	2.26	0.82
180 t/ha	1.46	0.75	2.21	0.48	1.47	0.98	2.45	0.85
240 t/ha	1.05	0.70	1.75	0.37	1.25	0.76	2.01	0.76

Table.18.Effect of various fly ash amendments on shoot length of *Luffa cylindrica* L.(inch)

	5 days	10 days	20 days	40 days
Soil	4.2	6.2	11.2	24.2
60t/ha	5.0	10.1	16.4	30.8
120 ton/ha	6.8	9.5	20.6	36.3
180 ton/ha	7.1	9.6	21.6	36.1
240 ton/ha	6.2	11.2	22.4	35.1

Table.19.Effect of various fly ash amendments on root length of *Luffa cylindrica* L.(inch) at 40 days

Soil	3.93
60t/ha	4.59
120 t/ha	6.27
180 t/ha	7.46
240 t/ha	5.47

Table.20. Effect of various fly ash amendments on photosynthetic pigments ( $\text{mg g}^{-1}$  fw) of (*Luffa cylindrica* L.) at 40 and 100 days

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
Soil	0.90	0.44	1.34	0.26	0.95	0.65	1.6	0.49
60t/ha	0.96	0.57	1.52	0.37	0.98	0.67	1.65	0.65
120 t/ha	1.01	0.59	1.60	0.45	1.07	0.78	1.85	0.76
180 t/ha	1.08	0.59	1.67	0.47	1.09	0.89	1.98	0.83
240 t/ha	0.98	0.37	1.35	0.34	0.95	0.65	1.6	0.64

## CONCLUSION

The application of graded levels of fly ashes resulted in an increase in available macro and micro nutrient (N, P, K, Cr, Co, Ni, Cu, Zn, Fe, Mo, Al, Pb, Cd, As, Se, V) up to 180 t/ha where as concentration of micronutrients was decreased 240 t/ha.

The plant growth parameters (shoot and root length) of vegetable crop were significantly increased at all amendment in fly ash combinations as compared to inoculated control set. The plant growth was better in 60 t/ha 120 t/ha 180 t/ha and 240 t/ha combinations irrespective of control, maximum being at 120 -

180t/ha level of fly ash. The bio-chemical parameters (chlorophyll a, chlorophyll b, total chlorophyll and carotenoid) were significantly increased in the treatments with 120 to 180 t/ha fly ash as compared with soil. The concentration of metal in plant increased with increase in concentration of fly ash in different treatments as compared to soil. The plants growing in soil and 240 t/ha of fly ash showed a different trend as Fe> Zn> Al>Cu>Pb> Ni > Mo > Cr >, Co > As> Se > V> and Cd.

Fly ash acts as an excellent soil modifier and conditioner, a very good liming agent, and a source of essential plant nutrients for appreciably improving the texture and fertility of the degraded soil, with significant increase in the crop yield over the control, together with better residual effects, especially amendment of 180 t/ha of fly ash. In general, the optimum dosage of fly ash was 180 t/ha for both one-time and repeat applications, and overall maximum yield was obtained on repeat application of the same dosage of fly ash. The uptake and carryover of certain trace and heavy metals in soil and crop produce were well within permissible limits.

Soil application of fly ash at lower levels 20 – 30 % and (120-180 t/ha) were found beneficial for the plant growth and yield of vegetable crops in the present study. Thus, fly ash has potential to increase the fertility of poor soil on one hand and toxicologically safe to yield of crops as compared to soil. However, at higher application levels of fly ash reduction has been measured in growth and yield parameters of crops. This study show that the available nutrients present in fly ash were beneficial for certain levels for utilization of a particular plant species. Hence, there is an opportunity with fly to be used as an eco-friendly non-conventional fertilizer at 120 and 180 t/ha levels respectively. At the same time, it will be a safe and eco-friendly disposal option for huge amount of fly ash. However, there is a need of detail and time series study to declare fly ash totally safe and eco-friendly to be used as a soil ameliorator.

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