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Original Article

Effect of Flyash Amended Soil on Growth and Yield of Indian Mustard (*Brassica Juncea*)

Sarita Gautam[1] , Annapurna Singh[2], Jaspal Singh[3], Shikha[2*]
[1]National Thermal Power Corporation, Jhajjar, Harayana, INDIA
[2+2*]Dept. of Environmental Science, Babasaheb Bhimrao Ambedkar (Central) University, Lucknow-25 U.P. INDIA
[3]Dept. of Environmental Science, Bareilly College, Bareilly-243005 U.P. INDIA

ABSTRACT
The present study investigates the effect of fly-ash amended soil on the growth, yield and biochemical characteristics of Indian mustard Brassica juncea, and it was observed that a 2:3 ratio (40%) of fly ash to soil supported maximum growth and yield. An increase in dry matter accumulation, chlorophyll and protein content were observed in fly ash amended soil 40% (fly ash to soil ratio) when compared to control (100% soil) suggesting that fly ash can be used as a soil amendment to solve the problem of fly ash disposal.
KEYWORDS: *Morphological parameters, biochemical assay, soil amendment*

INTRODUCTION

Fly-ash is the finely dispersed solid waste consisting of partially or completely burnt or unburnt particles of carbon resulting from the burning coal. It constitutes approximately 70% of the total amount of residue generated in coal fired thermal power plants equipped with electrostatic precipitators (ESPs) or bay filters installed to trap fly-ash escaping from chimneys [1]. These particles owing to their sufficiently small size (ranging from 0.02µm to over 300µm) and light weight get carried out via the flue gas from boiler chimneys [1, 2].A huge quantity of fly-ash is generated annually from 85 thermal power plants in India [3]. The total quantity of fly-ash generated during 2004-05 was 112 million tonnes and is likely to increase to 170 million tonnes by the end of the eleventh five year plan. Great emphasis is being laid on ways and means of utilising fly-ash. By the year 2004-05 about 38% of the total fly-ash generated was utilised in construction works [2], 28% fly ash was being utilized to manufacture cements, 2%for making bricks till year 2006 [4], 17% as landfill material and reclamation of acidic or sodic soil [5, 6] and most importantly fly ash is used as an agricultural input Jala and Goyal [7], Sajwan *et al* [8] to act as soil conditioners.

The utility of fly-ash as a soil amendment has been so far tested for *Helianthus annus* Pandey *et al* [9], *Lycopersicon esculentum* Khan *et al* [10], *Beta vulgaris*, *Triticum aestivum* L., *Esculenta moench*, *Oryza sativa* L. and *Zea mays* L Kalra *et al* [11],*Cassiasiamea* Tripathi *et al* [3], *Prosopis juliflora* L. Rai *et al* [12]. The present study involves the evaluation of the effect of fly-ash incorporation at variable concentration on seed germination, photosynthetic pigment, dry matter production, content of macromolecules (carbohydrates and proteins), etc. and overall growth of Indian mustard "*Brassica juncea*".

MATERIALS AND METHODS

Material collection

The fly ash used in this study was collected from Feroz Gandhi Thermal Power Plant (NTPC), Unchahar, U.P., India Garden soil was taken from the premises of Babasaheb Bhimrao Ambedkar University, Rae bareli Road, Lucknow, as control.

Physicochemical characterization of fly ash

Both fly ash and soil were tested for various physicochemical characteristics. pH was estimated through a potentiometer (Toshniwal Industries Manufacturing Pvt. Ltd. CL-54), organic carbon was estimated by titrimetric method and heavy metals were estimated using an atomic absorption spectrophotometer (Varian AA240FS). Phosphate was estimated using an ultra violet spectrophotometer (Shimadzu 1601).

Experimental set-up

Different amendments of fly-ash and soil were prepared by mixing these two in different ratio10%, 20%, 40%, 60%, 80% and 100% fly ash to soil and coded as C, T_1, T_2, T_3, T_4, T_5 and T_6 respectively. Equal number of seeds was sown in each pot. Seed germination was observed every week till the complete germination of sown seeds took place in control devoid of fly ash. Ten plants were planted in each pot and two plants were harvested at the end of every month for analysis upto three months starting from December 2010 to February 2011.

Morphological parameters

The plants were harvested and washed carefully to remove the dust particles adhering to the surface. Root hairs were wiped carefully to prevent breakage. They were then blotted with a blotting paper.Root and shoot length and number of leaves was counted thrice at a month's interval each. Dry matter weight was taken after partitioning the plant into leaf, stem and roots followed by drying at 40^{o}C for two hours and then at 85^{o}C for 24 hours.

Biochemical assay

Chlorophyll content of plant leaves was estimated by Arnon's [13] method using 80% acetone for preparing leaf extract. This was followed by centrifugation and measurement of the optical density of the clear supernatant.Protein content was assayed by Lowery [14] method as modified by Herbert *et al* [15]. 10% Trichloroacetic acid was used to prepare leaf extract followed by centrifugation after which the pellet was mixed with 1N NaOH followed by heating. This solution was further centrifuged and 0.5ml of the supernatant was mixed with 5ml of reaction mixture and allowed to stand for 15min. 0.5ml of folin's reagent was added to get a blue coloured solution. The absorbance was read at 650nm. Carbohydrate content in leaves was estimated by Ashwell's [16] method using anthroneand sulphuric acid as the cardinal reagents and nitrate content in leaves was estimated by following method of Catalado *et al* [17].

RESULTS

Physico-chemical parameters of fly-ash and soil

The physico-chemical analysis of fly-ash and soil (Table 1) revealed that fly ash had an alkaline pHand soil pH increased with an increase in the ratio of the fly ash. The concentration of heavy metals like Fe (23.67ppm), Mn (24.12 ppm) and Zn (0.960 ppm) were found higher in fly-ash as compared to soil [(Fe,9.59 ppm), Mn (1.03 ppm), Zn (0.180ppm)]. The concentration of phosphate (12.6 ppm) was also higher in fly-ash as compared to soil (8.1 ppm).

Morphological characteristics of the plant

The effect of fly ash on the various morphological parameters of *Brassica juncea* was studied.

Seed germination

Effect of fly ash amendment (Figure1) revealed maximum percentage seed germination in the control (soil devoid of fly ash amendment) as recorded at the end of the second week. The percentage of seed germination was found to decrease with an increase in the concentration of fly ash. Although a marginal decline in percentage seed germination was observed up to T_2 an approximate 30% decline was recorded for T_6 (fly ash devoid of soil). Fig.1

Root length and shoot length

Effect of fly ash amendment on root length and shoot length of *Brassica juncea*(Figure 2) revealed that both the length of root and shoot were observed maximum in the amendment in T_4(2:3, fly ash and soil) as recorded on 30, 60 and 90 days of experiment. The length of root increased gradually from T_1 (28.50%) to T_4 (28.55%) and then decreased from T_4 (33.34%) to T_6 (44.5%)as compared to control.

Number of leaves, flowers and pods

Effect of fly ash amendment was studied with respect to the number of leaves, flowers and pods per plant. Results in Table-2 revealed that the number of leaves and flowers per plant increased

from control to T_4. However, the number of pods showed a 100% increase from control to T_3 (2:3 fly ash and soil). A maximum of twelve pods was observed in T_3 (2: 3 fly ash and soil).

Dry weight of root, stem, leaves and pods

The dry weight of root (83.62 mg), stem (89.93 mg), leaves (19.75 mg) and pods (65.85 mg) were observed highest in T_4 (3:2 fly ash to soil) at the end of the experimental period. However, the dry weight of root, stem, leaves and pods were found only 66.50 mg, 84.83 mg, 15.08 mg, 46.22 mg, respectively in control at the end of ninety days. Although the dry weight of plant parts were found to increase with increasing ratio of fly ash as observed in T_4, with a further increase in the ratio of fly ash at T_5 and T_6, a decline in the dry weight of plant parts was observed (Table 3).

Effect of fly ash on Biochemical parameters of *Brassica juncea*

The effect of fly ash amendment on the various biochemical parameters of *Brassica juncea* was studied.

Effect on pigments

The chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content [Figure 3 (a)] in general was found to increase from control to T_4 (80%, 184.76%, 43.32% and 44.4% respectively)followed by a decrease in the same from T_4 to T_6 (81.9%, 86.74%, 79.48%, 57.91% respectively).

Protein and carbohydrate contents

Effect of fly ash amendment on the protein and carbohydrate content of *Brassica juncea* was studied. Results Fig.3 (b) revealed a 45.80% increase in the protein content in the treatment T_4 when compared to control. However, with an increase in fly ash amendment beyond T_4 a concentration dependent decline was observed till T_6. The maximum protein content (212.33 µg gm^{-1} fresh weight) was observed in T_4. In contrast the maximum carbohydrate content (297.03 µg gm-1 fresh weight) was observed in control (0:1; fly ash and soil). A decline in carbohydrate content was recorded throughout the amendment range from T_1 to T_6. A 68.02% reduction was observed at T_6 when compared to control (0:1; fly ash to soil).

Nitrate content

Nitrate content of leaves was maximum in control (24.85µg/gm) and showed a 19.36% decrease from control to T_6. The minimum content of nitrate was observed in 100% fly ash.

DISCUSSION

The results of the physico-chemical analysis of fly-ash and soil indicates that fly ash has an alkaline pH [18] and fly ash amendment was found to enhance the pH of soil which could be due to high content of CaO and MgO with acid neutralizing properties [19, 3]. It is also obvious that the concentration of metals like Fe, Mn, and Zn is higher in fly-ash as compared to soil. The high phosphate content of fly ash as compared to soil may be one of the reasons of an increased productivity of plants upon fly ash amendment.

The morphological characteristics e.g., root length, shoot length, dry weight, number of leaves, flowering and fruiting (number of pods) of *Brassica juncea* growing in different concentrations of fly-ash reveals an overall increasing pattern from control to T_4 (60% fly ash) except in the case of number of pods which was higher in T_3 (40% fly ash), beyond which these parameters decreased from T_4 (60% fly ash) to T_6 (100% soil). This result coincides with the findings of Niyaz *et al* [23] on *Eclipta alba* L. The seed germination decreased from control (no fly ash) to T_6 (100% fly-ash). This was most likely due to increased impedance offered by the soil / ash matrix to germinating seeds [11]. The biochemical parameters like chlorophyll content, carbohydrate, protein and nitrate content as analyzed for various treatments showed varying results. Protein and chlorophyll content increased from control to T_4 (60% fly-ash) and decreased from T_4 to T_6 (100% fly ash). Similar findings were made by Gupta *et al* [19] on *Phaseolus vulgaris* and Niaz *et al* [18]on *Eclipta alba.* An increase in carotenoid content from control to T_4 points may be an indicator of strengthening of the defence mechanism of the plant as carotenoids play an important role in protecting chlorophyll pigments under stress conditions [20]. Both the nitrate and carbohydrate content estimated in plant leaf revealed gradual decline from control to T6 (100% fly-ash). Decrease in concentration of carbohydrate and nitrate with increasing concentration of fly ash from control to T_4 may be due to the utilisation of the plants carbon and nitrogen resources in making up plant proteins whose concentrations show a positive rise in the same treatments. Fly

ash when added to soil in suitable proportions i.e., 40 – 60% fly ash with 60 – 40% soil, respectively, positively affected the growth of *Brassica juncea.*

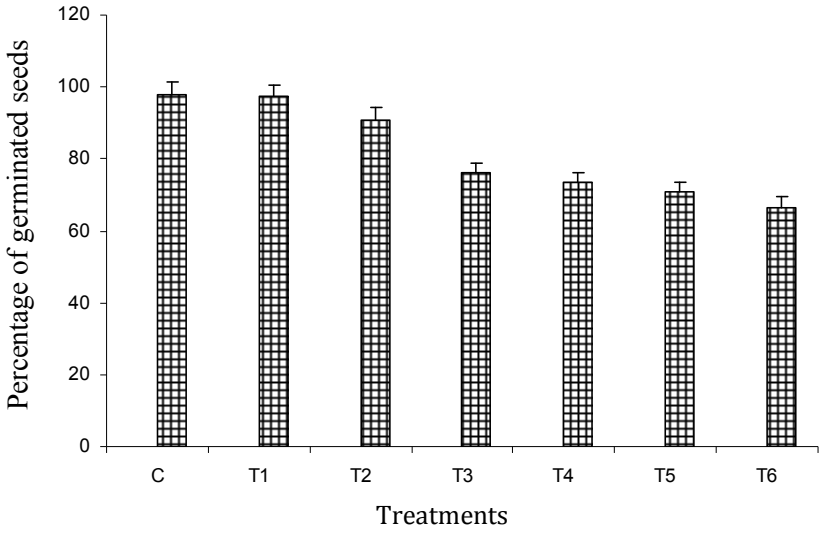

Fig1. Effect of fly ash amended soil on the percentage seed germination of *Brassica juncea*

Fig.2a

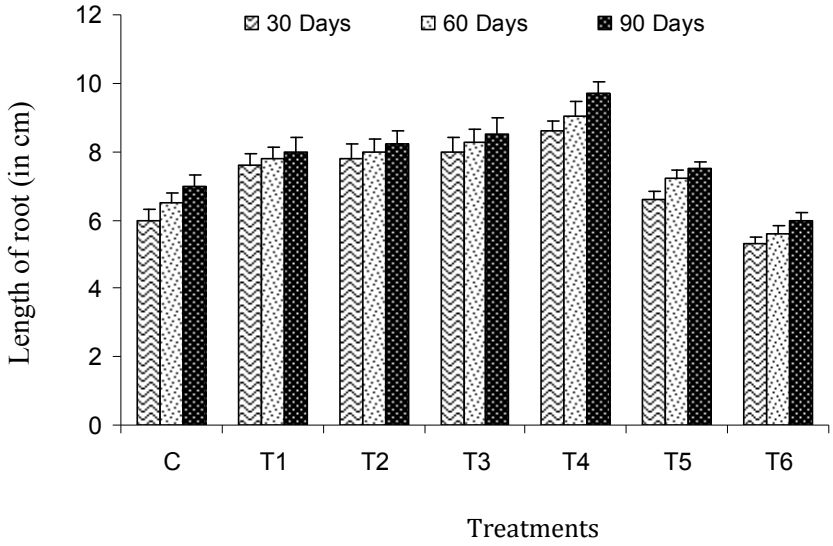

Fig.2b

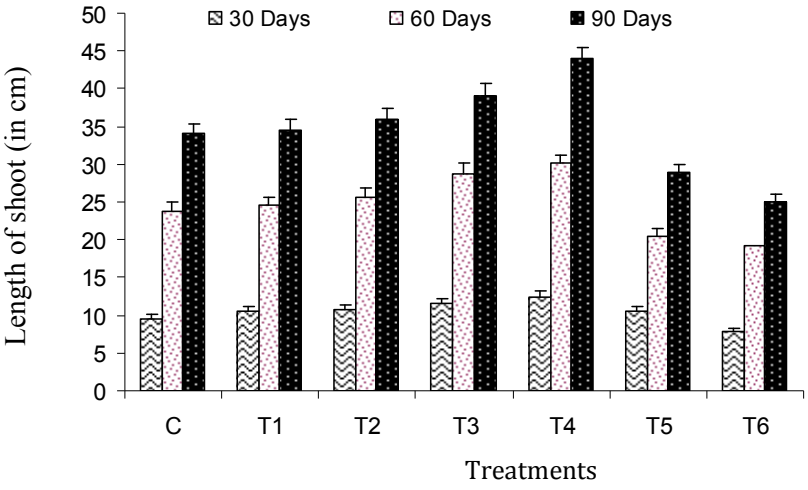

Fig.2 Effect of fly ash amended soil on the root length (Fig.2a) and shoot length (Fig.2b) of *Brassica juncea*

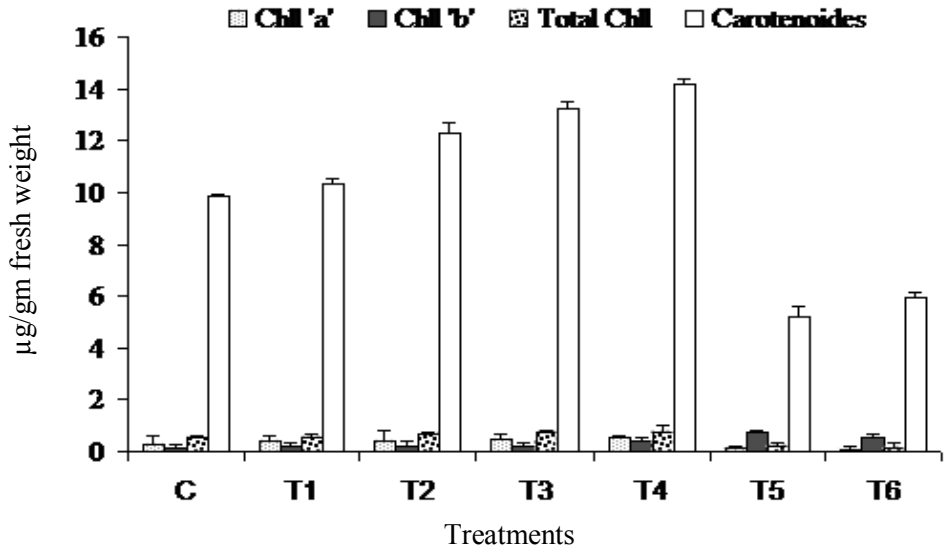

Fig.3: Effect of fly ash on pigment content.

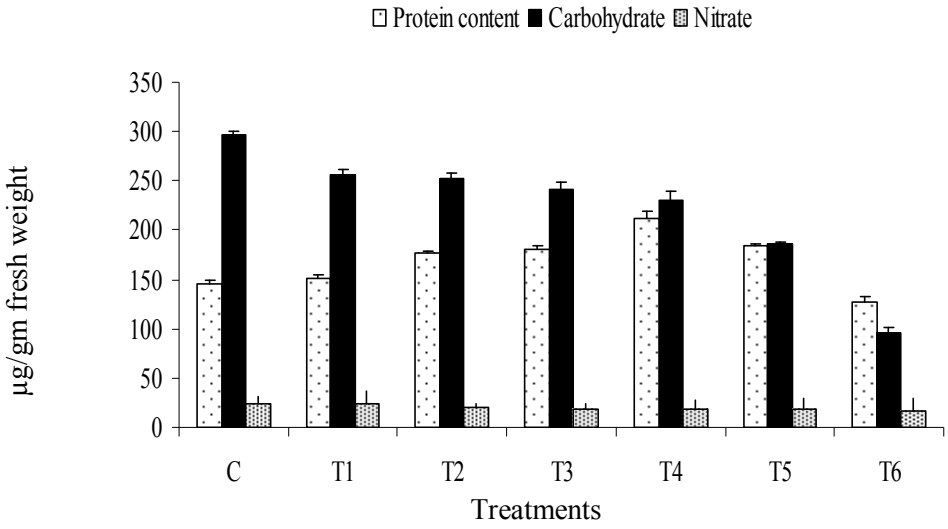

Fig.4: Effect of fly ash on protein carbohydrate and nitrate content

Table 1: Comparative analysis of Soil and fly ash

Parameters	Soil	Fly ash
pH	7.3	8.9
Organic Carbon (%)	0.33	0.36
Cu	2.80 ppm	0.600 ppm
Fe	9.59 ppm	23.67 ppm
Mn	1.03 ppm	24.12 ppm
Zn	0.180 ppm	0.960 ppm
Phosphate	8.1ppm	12.6 ppm

Table 2. Effects of fly ash on number of leaves, flowers and pods at different days.

Treatment	Leaves			Flowers		Pods
	30 D	60 D	90 D	60 D	90 D	90 D
C*	5±0.4	6±0.6	4±0.2	4±0.2	3±0.2	6±0.5
T1	5±0.4	8±0.8	4±0.2	6±0.5	3±0.2	8±0.7
T2	6±0.5	10±1.0	3±0.2	7±0.6	4±0.2	8±0.7
T3	6±0.5	12±1.1	4±0.2	10±0.9	5±0.4	12±1.1
T4	8±0.8	14±1.2	5±0.4	8±0.6	5±0.4	10±0.9
T5	7±0.7	9±0.9	3±0.2	5±0.4	3±0.2	6±0.6
T6	4±0.2	6±0.5	2±0.1	3±0.2	2±0.1	4±0.2

Table 3. Effect of fly ash on morphological parameters on *Brassica juncea* dry weight (mg gm^{-1} fresh weight) at different days.

Treatment	Root			Stem			Leaf			Pod
	30D	60D	90D	30D	60D	90D	30D	60D	90D	90D
C*	35.00±1.2	52.75±2.4	66.50±3.1	17.25±0.6	53.69±2.4	84.83±4.5	19.79±0.6	24.7±0.7	15.08±0.3	46.22±2.2
T1	35.70±1.4	53.19±2.4	68.67±3.1	20.64±0.8	54.26±2.5	85.69±4.6	19.86±0.6	32.6±1.1	16.02±0.3	56.87±2.5
T2	39.33±1.8	58.05±2.6	74.87±4.2	20.78±0.8	55.04±2.5	88.75±4.7	20.6±0.7	39.5±1.8	11.85±0.2	56.87±2.5
T3	40.87±2.0	60.05±2.8	79.87±4.2	21.93±0.8	55.89±2.5	89.86±4.8	20.65±0.7	47.04±2.2	15.07±0.3	66.32±3.1
T4	41.13±2.0	63.95±3.0	83.62±4.8	23.00±0.82	56.46±2.6	89.93±4.8	39.32±1.8	55.05±2.5	19.75±0.4	65.85±3.1
T5	29.52±0.9	43.12±2.0	56.72±2.6	15.00±0.5	40.02±2.0	69.04±3.4	17.06±0.5	31.55±1.0	10.32±0.2	43.80±2.1
T6	23.08±0.5	35.08±1.2	44.17±2.2	13.95±0.4	32.04±1.1	56.13±2.5	15.68±0.4	22.32±0.5	7.90±0.1	10.52±0.2

C*= Control, T=Treatment

CONCLUSION

The present study revealed that the fly ash could be beneficial in improving the soil quality and plant growth. The most suitable treatment for improved plant growth and crop yield for oil yielding plant *Brassica juncea* is 40%, fly ash with soil as it gives the maximum crop yield (maximum number of pods). Since *Brassica juncea* grows well in fly-ash it can be used as an ideal plant for ash mound reclamation.

RECOMMENDATIONS

Eventually the following recommendations can be made based upon the study:

1. The use of fly ash as a soil amendment should be seen as a profitable alternative to fly ash disposal and hence promoted.
2. Not only *Brassica juncea* but fly ash amendment trials should be made for other species as well.

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REFERENCES

1. Roy, W.R., Theiry, R.G., Schuller, R.M. & Suloway, J.J. (1981). Coal fly ash: A review of the literature and proposer classification system with emphasis on environmental impacts. *Environ. Geol. Notes*, 96:69.
2. Prakash, S., Mohanty, J.K., Das, B. & Venugopal, R. (2001). Characterisation and removal of iron from fly ash of talcher area, Orissa, India. *Mineral Eng*., 14:123-126
3. Tripathi, R.D., Ram, R.C., Sinha, L.C., Jha, A.K. & Srivastava, S.K. (2005). Bulk use of Pond ash for Reclamation of waste/alkaline Land for agriculture Purposes. Use of Ash in Agriculture, NTPC Report.
4. Bhattacharjee, U. & Kandpal, T.C. (2002). Potential of fly ash utilization in India. Energy 22(1):151-166.
5. Plank, C.O. & Martens, D.C. (1974). Boron availability as influenced by application of fly ash to soil. Soil Scie. Societ. of America., 38:974-977.
6. Taylor E.M., Jr. & Schuman, G.E. (1988). Fly ash and lime amendment of acid coal spoil to acid revegetation.Environ. Qual., 17:120-124.
7. Jala, S., Goyal, D., (2006). Fly ash as a soil ameliorant for improving crop production – a review. Bioresour. Technol., 97:1136-1147.
8. Sajwan, K.S, Paramasivan, S., Alva, A.K. & Sahi, S.V. (2007). Fly ash organic by product mixture as soil amendment. Springerlink Netherland, 69:387-399.
9. Pandey, V., Mishra, J., Singh, S.N., Singh, N., Yunus, M. & Ahmad, K.J. (1994). Growth response of *Helianthus annus* L. grown on flyash amended soil.Environ. Biol., 15:117–125.
10. Khan, R., Mujeebur & Khan, W.M. (1996). The effect of fly ash on plant growth and yield of Tomato. Environ. Poll., 92: 105-111.
11. Kalra, N., Joshi, H.C., Choudhary, A., Choudhary, R. & Sharma, S.K. (1997). Impact of fly ash incorporation in soil on germination of crops,Bioresour. T*echnol.,* 61:39-41.
12. Rai U.N., Pandey, K., Sinha, S., Singh, A., Saxena, R. & Gupta, D.K. (2004) Revegetating fly ash landfills with *Prosopis juliflora* L.: impact of different amendments and Rhizobium inoculation. *Environ. Int*., 30(3):293-300.
13. Arnon, D.I. (1949). Copper enzymes in isolated chloroplast, polyphenol oxidase in *Beta vulgaris*. *Plant physiol.,* 24:1-15.
14. Lowry, O.H., Rosebrough, N.J., Farr, A. L. & Randall, R.J. (1951). Protein measurement with the Folin phenol reagent. Biol. Chem., 93:265-275.
15. Herbert, D., Phipps, P.J. & Strange, R.E. (1971). Chemical analysis of microbial cells. *Methods in Microbiol*., 5B:209-344.
16. Ashwell, G. (1957). Clourimetric analysis of sugars. Methods in Enzymol., 3:73-105.
17. Catalado, D.A., Haroon, M., Schrader L.E. & Youngs, V.L. (1975). Rapid colorimetric determination of nitrate in plant tissue by nitration of salysilic acid. Comm. *Soil Science and Plant Anal*., 6:71-81.
18. Niaz, T., Hisamuddin, A. & Roabab, M.I. (2008). Impact of Fly Ash Amended Soil on Growth, Quality and productivity of *Eclipta*, Trends in Biosci., 12:46-48.
19. Gupta, A.K., Dwivedi, S., Sinha, S., Tripathi, R.D., Rai, U.N. & Singh S.N. (2007). Metal Accumulation and growth performance of *Phaseolus vulgaris* grown in fly ash amended soil.Bioresour. Technol., 98:3404-3407.
20. Kenneth, E., Pallet, K.E. & Young, J. (2000). (Eds. In: Alscher, Ruth, G., Hess, John, L.): Carotenoids Antioxidants in Higher Plants, CRC Press, p.60-81.
21. Adriano, D.C.., Page, A.L., Elseewi, A.A., Chang, A.C., & Steaughaan, I. (1980). Utilisation of Fly Ash and Other Coal residues on Terrestrial Ecosystems: a review. *Environ. Qual*., 9:333-344.
22. Mishra, L.C. & Shukla, K.N. (1986). Edaphic properties of fly ash from a coal fired power plant at Kanpur, India. Environ. Poll. Series B, *Chem. and Physic*., 11(1):55-66.

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