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Effects of Fly Ash on Plant Growth

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Abstract : *Fly ash is a waste product of thermal power stations. In view of its potential disposal problem, this investigation was carried out to search an economical and eco-friendly solution of its disposal by using it as a nutrient source in agriculture for growth and yield of mung bean (Vigna radiata L.). Soil analyses revealed that fly ash amendment had improved the chemical and mineralogical properties. Soil nutrients like nitrogen, phosphorus, potassium increased significantly in fly ash amended soil. At lower levels of amendments, fly ash significantly induced the growth performance: % seed germination, stem length, root length, number of leaves, leaf surface area, percentage of moisture content, chlorophyll content in leaves and overall growth of mung bean plants. However, at higher doses, fly ash inhibited the growth of mung bean plant. It is concluded that up to a certain level fly ash amendments could be beneficial for Indian agricultural fields and can be utilised as feasible management strategy for the disposal of this major industrial waste.*

Keywords : *Vigna radiata, soil, fly ash, chemical analyses, growth performance.*

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Introduction :

Fly ash is a finely divided residue resulting from the combustion of coal. Every year 85 million tonnes of fly ash is produced by 82 thermal power stations operating in the country. According to Pujara and Dash (2006), fly ash is a serious problem due to its physical characteristics and sheer volumes generated. The impact of coal residue on health and environmental consequences has been reviewed extensively (Agrawal and Sinha, 2001). It has been proved that fly ash disturbs the ecology through soil, air and water pollution.

Despite the deleterious effects of fly ash, it continues to be the potential source of macro and microelements (Mehra et al., 1986). The alkaline nature of fly ash has its use as amendment in agricultural fields.

Several researchers (Karmakar et al., 2010;

Basu et al., 2006; Thetwar et al., 2007) have investigated with fly ash to increase the crop yield of *Triticum aestivum, Medicago sativa, Hordeum vulgare, Cynodon dactylon, Eulaliopsis binata, Vigna unguiculata* and *Trifolium repens.* Fly ash amendment of soil resulted in improved seed germination rate in *Triticum aestivum, Vigna radiata* and *Vigna mungo* (Mahale et al., 2012). The growth of brinjal plant was better in fly ash amendments as reported by Gond et al. (2013) and Swamy et al. (2010) experiment revealed that amendments of fly ash in soil using *Allium cepa* species increased root number, root length and leaf number.

In view of the above facts, an experiment was designed with the objective to evaluate the effects of fly ash incorporation at variable concentrations on rate of seed germination, stem length, root length, number of leaves, leaf surface area, percentage of moisture content, chlorophyll content in leaves and overall growth of mung beans (*Vigna radiata*)

Materials and Methods :

The experiment was carried out in the campus of Patna Women's College. Garden soil was collected from Kankarbagh area. Fly ash was collected from Mahan Fly ash Brick, Bhabha Colony, Hanuman Nagar, Patna which brings fly ash from Synergy Ecotech Pvt. Ltd., Fatuha, Patna and this brings fly ash from Kanti Thermal Power Station, Muzaffarpur.The chemical characteristics of the soil and fly ash was determined in the Soil Research Centre under Fishery Department. 500 gm of soil was taken. Soil and fly ash was mixed homogenously in different proportions (0%,5%,10% and 15% fly ash designated as S_0, S_5, S_{10} and S_{15} respectively) and was kept separately in four different containers. Three replicates for each treatment were maintained along with control (0% fly ash). Chemical characteristics of fly ash amended soils were also determined. Mung beans (*Vigna radiata L.*) were sown in containers. Proper care was taken throughout the experiment. The growths of these plants were observed for 15 days. Readings were taken at an interval of 5 days.Fresh weight analysis of the plants was done immediately. For dry weight analysis, plants were oven-dried at 100 overnight (Landolt and Kandeler,1987). Percentage of moisture content was calculated by taking difference of the two. The contents of foliar pigments were estimated spectrophotometrically using 80% acetone (Lichtenthaler and Wellburn, 1983).

After 15 days, chemical characteristics of fly ash amended soils were determined. Statistical analysis was done.

Results and Discussion :

Chemical analyses of soil, fly ash and fly ash amended soil in different concentrations were done. Values have been given in Table 1 and 2 respectively. Table 1, shows that the carbon content in fly ash was more which may be due to the presence of coal dust. The results indicate that the fly ash and fly ash amended soils had elevated amounts of all the parameters tested (Tables 1 and 2). This may account for enhanced plant growth. In the present study, it was observed that the soil parameters in comparison to those of the original had improved few days after sowing (Table 3). This may be due to the fact that fly ash acts as a soil conditioner. It is capable of improving the chemical characteristics of soil.

Results clearly show that *Vigna radiata* plant responded positively to fly ash amendments. Seed germination, plant height, number of leaves, leaf surface area, plant biomass and foliar pigments increased significantly. Similar effects have been reported by earlier workers (Thenmuzhi et al., 2010; Juwarkar and Jambhulkar, 2008; Varma and Schuepp, 1995). Seed germination increased by 25% and 10% with 5% and 10% fly ash amendments respectively while decreased by 40.5% with 15% fly ash amendments (Table 4). Increase in germination % of seeds may be due to

the fact that fly ash amendments enhance aeration. Major increases in the stem length and root length were recorded with a maximum of 13.2% and 14.2% respectively at 5% fly ash amendments. At 10% fly ash amendments both enhanced by 5.43% and 7.11%. The growth characteristics of stems and roots tended to decline by 11.26% and 32.6% respectively in treatments containing 15% fly ash amendments. Number of leaves increased by 34.33% and 21.66% in 5% and 10% fly ash amendments respectively. There was a decline by 28.33% with 15% fly ash amendments. There was 17.69% and 10.56% gain while 1.49% loss of leaf surface area upon 5%, 10% and 15% fly ash treatments respectively (Table 5). Moisture content of the plants (Table 6) increased by 1.12% and 0.3% with 5% and 10% fly ash amendments respectively while decreased by 3.08% with 15% fly ash amendments. Increase in the moisture content (biomass accumulation) is an indicator of plant growth.

Study of the effects of fly ash on foliar pigment contents (Table 7) revealed some interesting facts. Chlorophyll a and chlorophyll b increased by 0.06% and 27% respectively with 5% fly ash amendments whereas by 6.7% and 1.10% respectively with 10% fly ash amendments. Chlorophyll a and chlorophyll b decreased by15% and 31% respectively with 15% fly ash amendments. The pigments may have elevated the photosynthetic activity which resulted in improved growth of the plant.

Enhancement in growth performance indicates that the utilizable plant nutrients present in fly ash are supportive to the growth of plants.

Stimulation in plant growth at lower application of fly ash to the soil clearly indicates the easy availability of essential nutrients present in the fly ash to the plants which not only enhanced seed germination but also stimulated the seedling growth at subsequent stages (Singh et al.,1997).

Excessive uptake of the elements and their subsequent accumulation in the plants may have accounted for the reduced growth of the plant at higher fly ash concentration. The similar results were observed in other plants also under the influence of fly ash (Ajaz and Tiyagi, 2003; Ajaz et al., 2004).

Conclusion :

The results of the present study indicate that it is advantageous to apply various soil amendments. Productivity of soil can be increased by adding fly ash in appropriate combination as they stimulate the microbial activity which provides the nutrients (N, P, K) and organic carbon to soil and maintains a healthy (positive) nutrient balance.

The growth of mung bean (Vigna radiata L.) increased at lower fly ash doses, mainly upto 10% but decreases afterwards. In total, our observations showed that at lower levels, fly ash application might be beneficial for mung beans and can be utilized as soil fertilizer or nutritional supplement; but at higher levels, fly ash incorporation is potentially harmful for crops.

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Table 1. Chemical analyses of soil and fly ash

Parameters	Unit	Soil	Fly ash
pH	–	6.5	7.5
Organic Carbon	%	1.0	1.5
Nitrogen	kg/ha	60.0	8.78
Phosphorus	kg/ha	10.0	5.9
Potassium	Kg/ha	20.0	54.0

Table 2. Chemical analyses of fly ash amended soil before sowing

Parameters	Unit	S_0	S_5	S_{10}	S_{15}
pH	–	6.5	7.0	7.0	7.0
Organic Carbon	%	1.0	1.1	1.0	1.0
Nitrogen	kg/ha	60	45	50	50
Phosphorus	kg/ha	10	8	10	10
Potassium	Kg/ha	20	18	20	20

Table 3. Chemical analyses of fly ash amended soil 15 days after sowing

Parameters	Unit	S_0	S_5	S_{10}	S_{15}
pH	–	6.5	7.5	7.5	7.5
Organic Carbon	%	1.0	1.5	1.5	1.5
Nitrogen	kg/ha	60	65	50	60
Phosphorus	kg/ha	15	15	10	15
Potassium	Kg/ha	26	28	24	20

Table 4. Effect of different fly ash amended soil on percent seed germination of *Vigna radiata*

Parameter	S_0	S_5	S_{10}	S_{15}
% Seed Germination 24 hours	48	60	44	24
48 hours	56	72	52	36
72 hours	64	80	56	40

Table 5. Effect of different fly ash amended soil on growth of *Vigna radiata* (mean ± S.E.)

Parameters	Unit		S_0	S_5	S_{10}	S_{15}
Shoot length	cm	5 DAS	8.9 ± 0.15	9.8 ± 0.1	8.7 ± 0.11	7.7 ± 0.15
		10 DAS	9.5 ± 0.17	10.9 ± 0.09	9.8 ± 1.17	9.0 ± 0.17
		15 DAS	11.9 ± 0.10	13.7 ± 0.24	13.2 ± 0.26	10.1 ± 0.15
Root length	cm	5 DAS	6.7 ± 0.05**	8.3 ± 0.10**	6.3 ± 0.08**	2.9 ± 0.17*
		10 DAS	7.2 ± 0.11	8.3 ± 0.13	6.6 ± 0.21*	4.3 ± 0.15*
		15 DAS	9.7 ± 0.11	10.1 ± 0.20	8.5 ± 0.33**	6.2 ± 0.22*
No. of leaves	–	5 DAS	2.0 ± 0.0	2.3 ± 0.3**	1.6 ± 0.2**	1.3 ± 0.5
		10 DAS	2.0 ± 0.5**	3.0 ± 0.5**	2.6 ± 0.3**	1.6 ± 0.3**
		15 DAS	2.6 ± 0.33	3.6 ± 0.3	3.0 ± 0.5**	2.0 ± 0.57**
Leaf surface area	cm^2	5 DAS	168.1 ± 2.7	190.4 ± 1.6	174.8 ± 1.9	160.7 ± 2.9
		10 DAS	178.4 ± 3.2	211.6 ± 1.7	196.1 ± 3.0	186.2 ± 3.58
		15 DAS	224.7 ± 1.4	272.5 ± 4.4	264.8 ± 2.9	207.6 ± 3.5

Values are mean of 3 replicates; *p < 0.01; **p < 0.05

Table 6. Effects of different fly ash amended soil on biomass of *Vigna radiata*

Parameters	Unit		S_0	S_5	S_{10}	S_{15}
Plant fresh weight	gm	5 DAS	0.42 ± 0.25*	0.85 ± 0.20*	0.45 ± 0.90	0.45 ± 0.21
		10 DAS	1.22 ± 0.33	1.32 ± 0.12**	1.08 ± 0.10**	1.25 ± 0.11**
		15 DAS	1.37 ± 0.14**	1.43 ± 0.11	2.86 ± 1.15*	1.16 ± 0.03
Plant dry weight	gm	5 DAS	0.14 ± 0.02	0.14 ± 0.01	0.13 ± 0.10*	0.12 ± 0.01*
		10 DAS	0.15 ± 0.02	0.11 ± 0.01*	0.14 ± 0.01	0.11 ± 0.06*
		15 DAS	0.08 ± 0.03	0.10 ± 0.01	0.21 ± 0.05*	0.14 ± 0.02*
Moisture Content %		5 DAS	66.66 ± 0.23	84.70 ± 0.50	71.11 ± 0.90**	73.3 ± 0.80
		10 DAS	87.70 ± 0.30	91.66 ± 0.91	87.03 ± 0.80	91.2 ± 0.45
		15 DAS	94.1 ± 0.70	93.0 ± 0.81	92.60 ± 0.95	87.9 ± 0.30

Values are mean of 3 replicates; *p < 0.01; **p < 0.05

Table 7. Effects of different fly ash amended soil on the concentration of chlorophyll a, chlorophyll b in 80% acetone with respect to different time durations

Parameters	Unit		S_0	S_5	S_{10}	S_{15}
Chl. a	µg/ml	5 DAS	21.37	21.29	21.09	18.48
		10 DAS	28.00	21.92	23.01	19.29
		15 DAS	23.14	20.07	27.97	28.11
Chl. b	µg/ml	5 DAS	9.75	10.30	10.25	10.24
		10 DAS	21.37	10.58	11.53	7.40
		15 DAS	12.30	10.40	21.15	20.12

References :

Agrawal TP, Sinha AN (2001). Fly ash – uses and abuses, in Upadhyay SN, Rai BN and Mishra PK (eds.) : ***Proceeding of IAEM National Conference on Recent Advances in Waste Management***, 23 – 25 February. IT BHU, Varanasi.51 – 53.

Ajaz S, Azam MF Tiyagi SA (2004). Utilization of fly ash for the management of ***Rhizoctonia solanai*** infesting bottle gourd. ***Archives of phytopathology and Plant protection.*** 37(4): 269-274.

Ajaz S Tiyagi SA (2003). Effect of different concentrations of fly ash on the growth of cucumber plant, ***Cucumis sativus. Archives of Agronomy and Soil Sci.*** 49(4): 457-461.

Basu M, Mahapatra SC, Bhadoria PBS (2006). Exploiting fly ash as soil ameliorant to improve productivity of Sabaigrass (***Eulaliopsis binata***) under acid lateritic soil of India. ***Asian J. Plant Sci.*** 5(6): 1027 – 1030.

Gond DP, Singh S, Pal A, Tewary BK (2013). Growth yield and metal residues in ***Solanum melongena*** growth in fly ash amended soils. ***Journal of Environmental Biology***. 34: 539 – 544.

Juwarkar AA, Jambhulkar HP (2008). Restoration of fly ash dumps through biological interventions. ***Environmental Monitoring and Assessment.*** 139 (1-3): 355-365.

Karmakar S, Mittra BN, Ghosh BC (2010). Enriched coal ash utilization for augmenting production of rice under acid lateritic soil. ***Coal combustion and gasification products.*** 2: 45 – 50.

Landolt E, Kadeler R (1987). ***The family of Lemnaceae – a monographic study.*** 2:638.

Lichtenthaler HK, Wellburn AR (1983). Determination of total carotenoids and chlorophyll a and b of leaf extract in different solvents. ***Biochemical Society Transactions*** (11): 591-592.

Mahale NK, Patil SD, Sarode DB, Attrade SB (2012). Effect of Fly Ash as an Admixture in Agriculture and the Study of Heavy Metal Accumulation in Wheat (***Triticum aestivum***), mung bean (***Vigna radiata***) and urad beans (***Vigna mungo***). ***Pol. J. Environ. Stud.*** 21(6): 1713 – 1719.

Mehra A, Farago ME, Banerjee DK (1986). Impact of fly ash from coal fired power stations in Delhi, with particular special reference to metal contamination. ***Environ. Monitor. Assess***. 50: 15 – 35.

Pujara GK, Dash PM (2006). Fly ash – problem and management aspect***. Envis News Centre Environ. Stud.*** 3(1): 1 – 8.

Singh SN, Kulshreshtha K, Ahmad KI (1997). Impact of fly ash soil amendment on seed germination, seedling growth and metal composition of ***Vicia faba L. Ecological Eng.*** 9: 203-208.

Swamy N, Dash N, Nahak G, Deo B, Sahu RK (2010). Effect of coal fly ash on Growth, Biochemistry, Cytology and Heavy Metal Content of ***Allium Cepa. New York Science Journal***.3(5):10 – 16.

Thenmuzhi R, Rejina K, Madhusudhan K, Nagasathya A (2010). Study on effectiveness of various biofertilisers on the growth and biomass production of selected vegetables. ***Research Journal of Agriculture and Biological Sciences.*** 6(3): 296-301.

Thetwar LK, Deshmukh NC, Jangde AK (2007). Studies on the effects of fly ash and plant hormones on soil metabolic activities. ***Asian J Chem***.19(5): 3515 – 3518.

Varma A, Schuepp H (1995). Mycorrhization of the commercially important micro propagated plants, critical review. ***Biotechnol.*** 15: 313-328.