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Effect of coal ash on physio-morphological and bio-chemical parameters of cashew (*Anacardium occidentale* L.)

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The industrial wastes and by-products which are generated in large amounts pose problems for safe disposal. The industrialists and environmentalists are finding difficulty in recycling of some of the industrial wastes. One such industrial waste causing environmental pollution is coal ash. Coal ash is one of the major solid waste product from thermal power plants. Basically, coal ash is ferro-alumino-silicate containing high potassium, sodium, calcium, magnesium and sulphur contents. There is a thumb rule that for every megawatt of power generated, one acre of land is required for the disposal of ash at a height of 8-10 m (Patnaik, 1992). Therefore with the promotion of more and more coal based thermal plants, the ash generation is getting multiplied geometrically and disposal of ash required large patches of land causing reduction in cultivable land. There are several reports on the use of coal ash as a soil amendment to field crops. Coal ash acts as a feasible alternative to lime for amelioration and amendment of acid soils. Potential of coal ash as amendment and micronutrient supplier has been identified. Furr *et al.* (1979) cultured a variety of vegetables, millets and apple trees in poly pots of neutral soil amended with coal ash showed enhanced absorption of B, Cu, Co, Fe, Mg, Mn Mo, Se and Zn. Coal ash can, therefore, be used as a fertilizer or soil conditioner. Efforts are being made to device strategies on purposeful use and safe disposal of huge amount of coal ash produced. The effect of coal ash on cashew plants in Odisha has not been studied. It is relevant in the present scenario that the state has a number of thermal plants. Hence, the study intends to find out the effective levels of coal ash on the growth and development of cashew plants in the nursery and to evaluate its tolerance level of the plants.

The experiment was carried out in the Regional Research and Technology Transfer station, OUAT, Semiliguda, Odisha during 2006-2007 with the support of National Aluminum Company (NALCO), Damanjodi Unit, Koraput, Odisha. To have control over the experiment, a pot culture trial by using coal ash was carried out in cashew (local variety) in the nursery under open condition. The place is characterized by warm and moist climate with hot and humid summer and cool winter. Coal ash was obtained from NALCO, Damonjodi, Odisha. The physico-chemical composition of coal ash as reported by NALCO is presented in Table 1 and 2. The mechanical composition of garden soil was estimated by Bouyoucos hydrometer method (Piper, 1996). The soil fraction of coarse sand (50.45%), fine sand (24.3%), silt (15.30%) and clay (9.45%) indicating a sandy loam texture of the experimental soil. The chemical composition of garden soil such as organic carbon (0.47%), total nitrogen (0.075 %), available P (23.4 kg/ha) and available K (110 kg/ha) were determined as per standard procedures (Jackson, 1967).

Table. 1. Physico-chemical properties of coal ash*

Sl. No.	Characters	Results
1.	Structure of coal ash	Amorphous
2.	Mixing Ability	Free from
3.	Colour	Gray
4.	Moisture Content	0.3 -16%
5.	Water Holding Capacity	46.58%
6.	E.C.	0.30 mS/cm
7.	pH (1:2.5, soil : water)	6.9

(*Source: Annual Report-1999-2000, NALCO, Damonjodi, Odisha)

Table. 2. Chemical composition of coal ash*

Sl. No.	Chemical Constituents	Composition (%)
1.	Si_2O_3	66.74
2.	Al_2O_3	28.87
3.	Fe_2O_3	21.94
4.	CaO	16.84
5.	MgO	2.91
6.	SO_2	1.20
7.	K_2O	1.20
8.	P_2O_5	0.75
		mg kg^{-1} Coal ash
9.	B	15
10.	Ba	350
11.	Co	15
12.	Cr	100
13.	Cu	75
14.	Ga	15
15.	Li	25
16.	Mo	400
17.	Pb	15
18.	Sb	25
19.	Zn	250
20.	V	100

(*Source: Annual Report-1999-2000, NALCO, Damonjodi, Odisha)

The pot culture experiment was conducted in a completely randomized block design with 5 replication and 5 treatments. The treatments were randomly allocated to each replication using Fisher's random table. Different levels of coal ash along with the mixture of garden soil + FYM + sand (in 2:1:1 ratio) was kept initially in the polythene bags (size 9"x 5" with 200 gauge) and then transferred and re-potted in the polythene bags of size 12"x 8" with 400 gauge. The soil and coal ash were mixed in different proportion by volume. The treatment schedule was 100% soil mixture + 0% coal ash (T_1), 75% soil mixture + 25% coal ash (T_2), 50% soil mixture + 50% coal ash (T_3), 25% soil mixture + 75% coal ash (T_4), 0% soil mixture + 100% coal ash (T_5).

The observations on germination percentage, seedling characteristics and the plant growth parameters were recorded at periodic interval. Germination of cashew nuts were recorded on the 30th day and expressed in percentage. The seedling characteristics such as germination percentage, seedling height, collar diameter and root length were determined at 60th day. The various growth parameters such as plant height, stem girth, total biomass were recorded from 6 months to 24 months after sowing at intervals of 6 months. The leaf chlorophyll content was calculated by using the formula recommended by MacLauchlan and Zalik (1963). The leaf nutrients were estimated as per standard procedures (Jackson, 1967; Piper, 1996). Sulphur was estimated by turbidometric method (Massoumi and Cornfield, 1963) and micronutrients employing atomic absorption spectrophotometer. Boron was estimated by employing Azomethaine-H indicator (Jackson, 1967).

The data obtained on various growth parameters, yield attributing and biochemical characters were analyzed statistically and the variances were tested at 5% level of significance, standard error of mean and least significant difference (0.05) were calculated for comparing the mean values as per Sukhatme and Amble (1995).

Germination and seedling characteristics

The data presented in Table 3 revealed that significantly higher germination percentage of cashew nut was recorded in 50:50 coal ash and soil media which was statistically at par with 25:75 coal ash and soil. The minimum germination was obtained in the treatment with 100% ash. The study indicated that the germination percentage decreased with increase in coal ash concentration in the media

Table. 3. Effect of coal ash on germination and seedling characteristics of cashew at 30 days after sowing

	Treatment	Germination	Seedling characteristics		
		(%)	Height (cm)	Collar diameter (cm)	Root length (cm)
T_1	Coal Ash:Soil (0:100)	87.00	28.10	0.65	5.10
T_2	Coal Ash:Soil (25:75)	92.30	29.00	0.76	5.40
T_3	Coal Ash:Soil (50:50)	93.50	29.20	0.76	5.45
T_4	Coal Ash:Soil (75:25)	90.00	26.30	0.63	5.20
T_5	Coal Ash:Soil (100:0)	80.00	25.50	0.50	3.80
SE (m) +		0.582	0.225	0.019	0.65
LS.D. (0.05)		1.793	0.694	0.059	0.202

soil. Increase in germination is attributed to higher moisture content in 50:50 coal ash and soil composition. The moisture content in 50:50 coal ash and soil composition promoted better germination. Treatment with 100% coal ash inhibited germination of the cashew seeds might be due to poor physical environment in the poly bags created by compactness of coal ash treatment (T_5). The present finding confirmed the earlier findings of Pawer *et al.* (1988), Wong and Wong (1989) and Sarangi *et al.* (1997).

The seedling characteristics determined by height, collar diameter and root growth were significantly influenced by the coal ash concentration in the growing media. The 50:50 and 25:75 coal ash and soil composition was found to be conducive for better growth of cashew seedlings. The seedling height, collar diameter and root length were recorded minimum in the media having lone 100% coal ash. The coal ash concentration above 50% in the media as well as the media devoid of coal ash was not found giving favorable effect on the growth of cashew seedlings. The higher seedling vigour of cashew might be due to better moisture availability as well as favourable growing environment of the media. At early stage of growth the seedlings were sensitive to variation in the soil moisture content and the compactness of the growing media. Earlier reports revealed that fly ash was the most suitable for land application, because it improved seedling growth without increasing trace elements levels in plant parts or soil solutions. The present findings are in agreement with the previous works that coal ash considerably increases the plant height, even when the plants are in seedlings stage of a number of annual crops like soybean (Mishra and Shukla, 1986), rice, amaranthus, sesamum and okra (Sarangi *et al.* 1997).

Growth, biomass and chlorophyll content

Coal ash had a positive effect in increasing plant height in cashew over the period of study (Table 4). The data revealed a considerable variation in plant height among the treatments. It was observed that the maximum height was recorded in 50:50 coal ash and soil combination in the growing media and the minimum height was recorded with the highest concentration of coal ash. Similar trend was observed with stem girth of cashew. It was contemplated that coal ash as a supplement with soil in the growing media improved the vegetative growth because of presence of trace elements in coal ash. This result is also in consonance with the findings of Srivastava *et al.* (1995) which suggests that coal ash can be successfully used for cashew.

The effect of coal ash on cashew plant after 24 months resulted in the maximum increase of biomass with 50:50 coal ash and soil combination while the minimum biomass was recorded in plants grown only in soil without coal ash (Table 4). The fertility status of the soil, which was improved by addition of coal ash, might have aided higher nutrients acquisition in the plant parts thus increased the bio-mass content of the whole plant. The result of present study is in close proximity with the findings of many other investigators Fall *et al.* (1977), Furr *et al.* (1979) and Mishra *et al.* (1997). However, the effect of coal ash was least on total chlorophyll content since the variation between the treatments was subtle.

Nutrient acquisition

Macronutrients

The plant nutrients content have been influenced by the use of coal ash in the growing medium (Table 5). It is indicated from the table that

Table. 4. Effect of coal ash on growth, biomass and chlorophyll content of cashew seedlings after 24 months

	Treatment	Plant height (cm)	Stem girth (cm)	Total Bio-mass (g/plant)	Chlorophyll content (mg/g)
T_1	Coal Ash:Soil (0:100)	162.40	8.10	101.00	2.15
T_2	Coal Ash:Soil (25:75)	180.00	8.80	120.00	2.18
T_3	Coal Ash:Soil (50:50)	182.40	8.50	120.50	2.20
T_4	Coal Ash:Soil (75:25)	157.00	8.30	119.50	2.19
T_5	Coal Ash:Soil (100:0)	122.30	7.20	120.50	2.18
SE (m) +		0.351	0.076	1.096	0.035
LS.D. (0.05)		1.082	0.234	3.378	NS

coal ash content in various proportion had positive effect on N and P content of the leaves. The treatment having 100:00 coal ash and soil (T_5) registered the maximum N and P in the leaves. Such an additive effect of coal ash might be due to efficient nitrogen and phosphorus assimilation in the presence of certain micronutrients in coal ash particularly copper and molybdenum and activities of certain enzymes. It has been envisaged that nitrogen application must be accompanied by copper fertilizer which helps in enhancement of yield (Thiel and Finck 1973). Moreover, nitrogen has specific effects on Cu availability and mobility including sequestration of Cu – complexes to amino acids and proteins. On the contrary, Mo is directly involved in nitrogen metabolism *vis-a-vis* protein synthesis. Apart from this, Mo is also reported to have essential role in Fe absorption and translocation in plants, the micronutrients which have its own discrete function. The leaf potassium content although varied between the treatments, it was found to be non significant. However, the level of leaf potassium content remained high under the influence of coal ash treatment at 75: 25 coal ash and soil in the growing medium. In general the increase in leaf N, P and K content by application of coal ash has already been reported earlier (Sethi, 1996 and Satpathy, 1997) in crops like guava and vegetables.

The data pertaining to secondary nutrient status of cashew seedlings (Table 5) revealed a general increase in the Ca, Mg and S concentration in the leaf due to the presence of coal ash in the potting mixture. However, no significant difference was found among the treatments.

Micronutrients

The leaf nutrient status in relation to the micro nutrients such as Mn, B, Mo, Fe, Cu and Zn were found to be higher in the treatments having high proportion of coal ash in the growing medium and the lowest was recorded with the treatment receiving no coal ash (Table 6). After application of coal ash in graded doses to plants, the elements are absorbed by the plants to certain extent. The results of the present study are in conformity with the findings of Wong and Wong (1989). Furr *et al.* (1979) cultured a variety of vegetables, millets and apple trees on poly pots amended with coal ash showed enhanced absorption of B, Cu, Co, Fe, Mg, Mn Mo, Se and Zn. From the present study it is ascertained that the proportion of coal ash in soil is most important and in the present context, 50:50 coal ash and soil composition in the threshold level was found obtain better crop growth.

The present study envisaged that combination of 50:50 soil and coal ash mixture consistently increased the seed germination, seedling growth, biomass, vegetative growth and chlorophyll content of cashew plants in the current investigation while 100% coal ash in the growing media reduced the above mentioned attributes. The leaf nutrient status

Table. 5. Leaf analysis: effect of coal ash on major and minor nutrients of cashew seedling

	Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
T_1	Coal Ash:Soil (0:100)	1.76	0.32	1.54	0.98	0.46	0.27
T_2	Coal Ash:Soil (25:75)	1.77	0.33	1.55	0.99	0.47	0.29
T_3	Coal Ash:Soil (50:50)	2.03	0.31	1.56	1.12	0.48	0.32
T_4	Coal Ash:Soil (75:25)	2.14	0.39	1.57	1.22	0.50	0.37
T_5	Coal Ash:Soil (100:0)	2.20	0.41	1.53	1.42	0.54	0.43
SE (m) +		0.030	0.012	0.045	0.45	0.03	0.03
LS.D. (0.05)		0.093	0.038	NS	NS	NS	NS

Table. 6. Leaf analysis : effect of coal ash on micronutrients of cashew seedling

	Treatment	Mn (mg/kg)	B (mg/kg)	Mo (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
T_1	Coal Ash:Soil (0:100)	213.00	61.40	57.40	133.00	26.00	19.60
T_2	Coal Ash:Soil (25:75)	219.40	63.50	60.30	134.40	28.40	22.60
T_3	Coal Ash:Soil (50:50)	220.40	65.60	61.40	145.50	29.40	28.65
T_4	Coal Ash:Soil (75:25)	221.50	69.40	63.20	145.70	30.50	25.70
T_5	Coal Ash:Soil (100:0)	231.40	70.60	64.40	148.40	31.70	29.70
SE (m) +		0.628	0.113	1.256	0.984	0.924	3.37
LS.D. (0.05)		1.933	0.348	3.870	3.034	2.846	NS

in relation to nutrients like N, P, K, Ca, Mg, S and the micronutrients Zn, Mn, B, Mo, Fe and Cu were found to be higher quantity in the treatments with high coal ash proportion in the growing medium and the lowest was recorded with treatment having no coal ash. The present investigation suggests that application of coal ash in certain proportion along with organic manure is beneficial in terms of growth parameters and nutrient acquisition in cashew.

References

Fall, J. R., Joseph, L. and Wochok, Z. B. 1977. Soybean growth on fly ash amended strip mine spoils. *Plant and soils* **48:** 478-484.

Furr, A. K., Parkinson, T. F., Pakkala, I. S. and Lisk, D. J. 1979. Elemental content of apple, millet and vegetables grown in pots of neutral soil amended with fly ash. *J. of Agril. and Food Chemistry,* **28**(2): 406-409.

Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

Machlachan, S. and Zalik, S. 1963. Plastid structure, chlorophyll concentration and free amino acid composition of a chlorophyll mutant of barely. *Canadian J. Bot.* **41:** 1053-62.

Massoumi, A. and Cornfield, A.H. 1963. A rapid method of determining sulphate in water extracts of soils. *Analyst*, **88**(10): 321-322.

Mishra, L.C. and Shukla, K.N. 1986. Elemental composition of corn and soybean grown on fly ash amended soil. *Environ pollution,* **12**(4): 313-321.

Mishra, P.C., Mishra, T.K. and Sarangi, P.K. 1997. Potential of fly ash in Agriculture. In: *Proc. on work shop on Integrated soil and waste management organized by Orissa environment programme* on 22-23 April, Bhubaneswar. Orissa India, pp.76-78.

Pattnaik, G.C. 1992. Monitoring control and disposal management of fly ash *vis-a-vis* pollution abatement in NTPC's stations. ENCONEN, pp. 47-54.

Pawar, K., Dubey, P.S. 1988. Germination behaviors of some important crop species in fly ash incorporated soil. *Advancement of crop and monitoring of environment progress in ecology*, **10**: 295-305.

Piper, C. S.1996. Soil and plant analysis. Hans. Publication, Bombay.

Sarangi, R.K., Kathiresan, K., Periaswamy, R., Ganeshan, U. and Subramanian, A.N. 1997.Fly ash induced growth in Mangroves. In: *Proceedings of National Seminar on bio utilization of fly ash* (Eds. Tripathy, S.N), *Berhempur, Odisha,* pp.97-100.

Satpathy, S. 1997. Effect of Fly ash on growth and development of tomato and brinjal, M.Sc. thesis submitted to Orissa University of Agriculture and Technology, Bhubaneswar – 751 003.

Sethi, B.K., Rath, S. and Kar, M. 2001. Crusher mill deposit on phyllosphere affecting the biochemical and yield attributing characters of cashew nut. *J. Res. Orissa Univ. Agric. & Tech.* **19**(1&2): 80-82.

Sethi, K. 1996. Effect of fly ash on growth, development and nutritional status of guava. M.Sc. thesis submitted to Orissa University of Agriculture and Technology, Bhubaneswar – 751 003.

Srivastava, R., Kumar, A. Rai, A.M. and Singh, I. 1995. Biological method of fly ash stabilization through afforestation on ash dump guards near thermal power station, Panki (Kanpur). *Indian Forester*, **12**: 81-87.

Sukhatme, P.V. and Amble, V. N. 1995. Statistical methods for Agricultural workers. ICAR, New Delhi.

Thiel, H. and Finck, A.1973. Ermittlung von Gren Zwerten optimater Kupfer-versorgung for Hafer and Sommergerste Z. Pflanzenernachr, Bodenkd, **134**:107-125.

Wong, J.W.C. and Wong, M.H. 1990. Effect of fly ash on yields and elemental composition of two vegetables *(Brassica parachinensis and Brassica chinensis). Agriculture, Ecosystems and Environment*, **30**(34): 251-254.

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