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CHANGES IN GROWTH CHARACTERS AND NUTRIENT ACQUISITION OF GUAVA (*Psidium guajava* L.) IN RESPONSE TO COAL ASH

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Coal ash management would remain a great concern all over the world. Several studies proposed that there is an ample scope for safe utilization of coal ash as a soil ameliorant that may improve physical, chemical and biological properties of the soil and is a source of readily available plant micro and macro nutrient. With this concept a pot culture experiment was carried out in the eastern ghat high land zone of Odisha, India under open condition in the nursery. Different levels of coal ash and soil mixture were used in different combinations to check their effect on the physio-morphological and biochemical parameters of guava. The study on the effect of varying levels of coal ash on guava revealed that the combination of 50:50 and 25:75 coal ash and soil mixture increased the seed germination, seedling characteristics, biomass, vegetative growth and chlorophyll content of the seedlings. The increase in growth traits was attributed to increase in nutrient acquisition of plants grown under above combinations. On contrary 100% coal ash in the growing medium reduced seed germination, seedling vigour, growth and biomass per plant. The leaf nutrient status of N, P, K, Ca, Mg, S and the micro nutrients Zn, Mn, B, Mo, Fe and Cu were found to be higher in the treatments having higher proportion of coal ash in the growing medium than other treatments and the lowest was recorded in control (no coal ash). The findings suggest that application of coal ash in certain proportion is beneficial in terms of growth parameters and nutrient acquisition in guava.
Keywords: Coal ash, guava, germination, growth, nutrient acquisition

INTRODUCTION

The industrial wastes and by-products which are generated in large amount pose problems for safe disposal. The industrialists and also the environmentalists are finding difficulty in recycling of some of the industrial wastes, one such difficult to handle industrial waste is coal ash. Coal ash is one of the major solid waste products and environmental pollutant from thermal power plant. Basically, coal ash is ferro-alumino-silicate characteristically high in potassium, sodium, calcium, magnesium and sulphur content. With the promotion of more and more coal based thermal plants, the ash generation is getting multiplied geometrically. Disposal of these large amounts of ash required large patch of land causing reduction in cultivable land. There is a thumb rule that for every mega watt of power, one acre of land is required for disposal of ash accumulating to a height of 8-10 m in ash pond (Patnaik, 1992).
Being fine in particle size, coal ash can readily escapes to the atmosphere along with flue gases and becomes a source of atmospheric pollution. They may get deposited in the pulmonary tissue of the respiratory tract and gain entry into the blood stream. Deposition of coal ash particles on crop canopies reduces yield of crops due to impaired photosynthetic activities. Moreover, coal ash deposited on the fodder crops makes it unfit for cattle feeding. Indian coal ash also contains toxic and heavy metals. Though heavy metals are found in detectable quantity, their concentration is less when compared to other countries (Sushil *et al*., 2006).
There are several reports of 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 and acid mine spoils (Chang *et al*., 1977). Potential of coal ash as amendment and micronutrient carrier 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. Since it is composed of mostly silt size particles, addition of fly ash to sandy soil could permanently alter soil texture, increase micro porosity and improve water retention capacity (Ghodrati *et al*., 1995).
Coal ash management would remain a great concern all over the world. However, several studies proposed that there is an ample scope for safe utilization of coal ash as a soil ameliorant that may improve physical, chemical and biological properties of the soil and is a source of readily available plant micro and macro nutrients.
Guava was selected as test crop because it is one of the important fruit crop in Odisha. Because of the hardy nature of the plants, it has high adaptability to wide range of soil and climatic condition. Moreover, this crop is commercially grown in different areas more particularly in the industrial belt of Odisha. The effect of coal ash on guava plants in

Odisha has not been studied. It is relevant in the present scenario that the state has a number of thermal plants which release this pollutant, i.e. fly ash. Hence, the present study intends to find out the optimum level of coal ash on the growth and development of guava plants in the nursery and to assess the tolerance level of the plants to coal ash.

MATERIALS AND METHODS

The experiment was carried out in the Regional Research and Technology Transfer station, Odisha University of Agriculture and Technology, Semiliguda, Koraput in the state of 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 guava (cv. Allahabad Safeda) 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 National Aluminum Company Ltd, Damonjodi, Koraput, Odisha. 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 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).

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 (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 irrigation was provided to the guava plants by the help of hose pipe with rose can as per requirement.

The observations on germination percentage, seedling characteristics and the plant growth parameters were recorded at periodic interval. Germination of guava seeds was recorded on the 30th day. The seedling characteristics such as germination per cent, seedling height, collar diameter and root length were determined at 60th day. The longest root was taken for measurement of root length which was measured from its emergence point of the seed to the tip. 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 measured by using the protocol recommended by Mac Lauchlan 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 spectro-photometer. 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 variance was tested at 5% level of significance. The standard error of mean and least significant difference (0.05) were calculated for comparing the mean values of the treatments (Sukhatme and Amble, 1995).

RESULTS AND DISCUSSION

***Germination and seedling characteristics*:** The data presented in Table 1 revealed that significantly higher germination percentage of guava seed was recorded in 25:75 coal ash and soil media which was statistically at par with 50:50 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 soil. Increase in germination is attributed to higher moisture content in 25:75 coal ash and soil composition. The moisture content in

Table 1. Effect of coal ash on germination and seedling characteristics of guava

Treatment		Germination (%)	Seedling characteristics		
			Height (cm)	Collar diameter (cm)	Root length (cm)
T_1	Coal Ash:Soil (0:100)	75.20	38.30	1.20	7.20
T_2	Coal Ash:Soil (25:75)	78.20	40.10	1.60	7.50
T_3	Coal Ash:Soil (50:50)	77.20	41.20	1.70	7.40
T_4	Coal Ash:Soil (75:25)	73.40	39.30	1.50	7.10
T_5	Coal Ash:Soil (100:0)	67.00	31.00	1.10	6.20
SE (m) $\pm$		1.795	1.689	0.122	0.344
LS.D. (0.05)		**5.531**	**5.205**	**0.376**	**NS**

25:75 coal ash and soil composition promoted better germination. Treatment with 100% coal ash inhibited germination of the guava 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 and Dubey (1988), Wong and Wong (1990) 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 25:75 and 50:50 coal ash and soil composition was found to be conducive which enhanced the general growth of guava 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 did not have any favorable effect on the growth of guava seedlings. The higher seedling vigour of guava might be attributed to better moisture availability as well as favorable growing environment of the media. At early stage of growth it was observed that the seedlings were sensitive to variation in the soil moisture content and the compactness of the growing media. Since coal ash is composed of mostly silt size particle, its addition to garden soil could alter soil texture, increase micro porosity and improve water retention capacity (Ghodrati *et al.*, 1995). Earlier reports revealed that fly ash was the most benign for land application, because overall 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 seedling height in number of annual crops like rice, amaranthus, sesamum, okra (Sarangi *et al.*, 1997) and soybean (Mishra and Shukla, 1986).

***Growth, biomass and chlorophyll content*:** Coal ash had a positive effect in increasing plant height of guava over the period of study (Table 2). 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 manifested with stem girth of guava. 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 Srivastav *et al.* (1995) which suggests that coal ash can be successfully used for guava.

The effect of coal ash on guava plant at 24 months resulted in maximum biomass with 50:50 coal ash and soil combination while the minimum was recorded with only soil and no coal ash (Table 2). 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 that of 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. Invariably, the highest coal ash concentration adversely affected the plant metabolism vis-à-vis its growth which might be attributed to higher concentration of heavy metals in the system leading to toxic effect (Sushil *et al*., 2006; Donaldson and Borm, 1998).

Nutrient acquisition:

***Macro nutrients*:** The data revealed that the N, P and K contents did not vary significantly among the treatments (Table 3). However, it is observed from the present investigation that the level of N, P and K value increased with the increasing proportion of coal ash combination in the soil. Such an additive effect of coal ash might be due to efficient nitrogen, phosphorus and potassium assimilation in the presence of certain micro nutrients in coal ash particularly copper and molybdenum and activities of certain enzymes (Marschner, 1996). It has been envisaged that nitrogen application must be accompanied by copper fertilizer for its proper assimilation into biomolecules resulting in higher productivity (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

Table 2. Effect of coal ash on growth, biomass and chlorophyll contents of guava plant

Treatment	Plant height at 24 months (cm)	Stem girth at 24 months (cm)	Total Bio-mass at 24 months (g/plant)	Chlorophyll contents (mg/g)
T_1 Coal Ash:Soil (0:100)	202.00	8.86	104.00	4.22
T_2 Coal Ash:Soil (25:75)	217.60	9.70	122.25	4.25
T_3 Coal Ash:Soil (50:50)	222.40	9.80	124.60	4.27
T_4 Coal Ash:Soil (75:25)	207.30	8.70	112.65	4.28
T_5 Coal Ash:Soil (100:0)	169.40	7.50	104.60	4.18
SE (m) $\pm$	4.429	0.639	1.822	0.211
LS.D. (0.05)	**13.645**	**NS**	**5.615**	**NS**

involved in nitrogen metabolism vis-à-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 (Padmanabhan *et al.* 2008). 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 endorsing the present finding.

The data pertaining to secondary nutrient status of guava (Table 3) revealed that the leaf Ca content did not show any significant difference among the treatments. But the Mg and S content exhibited significant difference among the treatments. The combination of 100:0 coal ash and soil mixture exhibited the maximum Mg and S acquisition in the soil mixture and the minimum was recorded with only soil and no coal ash. This might be due to higher acquisition of the above nutrients in the plant parts. Reports pertaining to effect of coal ash in increasing the minor nutrient levels have been corroborated by Wong and Wong (1990).

***Micro nutrients*:** 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 coal ash proportion in the growing medium and the lowest was recorded with the treatment receiving no coal ash (Table 4). Lower concentration of coal ash reduced leaf Mn, B, Mo, Fe, Cu, Zn content where as higher concentration of coal ash enhanced it. Coal ash contains a higher quantity of heavy metals like Cd, Pb and other metals such as Co, Cu, Fe, Mn, Mo, B. After application of coal ash in graded doses to plants, the elements are absorbed by the plants and to certain extent after utilization accumulated in the plant tissue (Sushil *et al*., 2006 and Donaldson and Borm, 1998). Our results are in conformity with the findings of Wong and Wong (1990). Furr *et al*. (1979) cultured a variety of vegetables, millets and apple trees on potted soils amended with coal ash showed enhanced absorption of B, Cu, Co, Fe, Mg, Mn Mo, Se and Zn. From the study it is evident that the dose of coal ash is most important because the higher dose of coal ash might be detrimental to the plant growth. From the present study it is ascertained that 50:50 coal ash and soil composition in the threshold level was found to obtain better crop growth.

***Conclusion*:** The present research envisaged that combination of 25:75 and 50:50 soil and coal ash mixture consistently increased the seed germination, seedling growth, biomass, vegetative growth and chlorophyll content of guava plants in the current investigation while 100% coal ash in the growing media reduced the above mentioned attributes. The leaf nutrient status 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 guava.

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Table 3. Effect of coal ash on major and minor nutrients of guava

Treatment		N(%)	P(%)	K(%)	Ca(%)	Mg(%)	S(%)
T_1	Coal Ash:Soil (0:100)	2.32	0.29	2.20	1.85	0.53	0.30
T_2	Coal Ash:Soil (25:75)	2.47	0.29	2.23	1.76	0.55	0.31
T_3	Coal Ash:Soil (50:50)	2.53	0.30	2.24	1.83	0.57	0.30
T_4	Coal Ash:Soil (75:25)	2.54	0.31	2.25	1.95	0.58	0.32
T_5	Coal Ash:Soil (100:0)	2.45	0.32	2.26	2.49	0.67	0.35
SE (m) $\pm$		0.122	0.028	0.049	0.076	0.012	0.009
LS.D. (0.05)		**NS**	**NS**	**NS**	**NS**	**0.036**	**0.028**

Table 4. Effect of coal ash on leaf micro nutrients of guava

Treatment		Mn (mg kg^{-1})	B (mg kg^{-1})	Mo (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
T_1	Coal Ash:Soil (0:100)	38.20	76.40	71.40	129.40	31.10	23.70
T_2	Coal Ash:Soil (25:75)	39.20	77.30	76.30	131.40	33.80	24.20
T_3	Coal Ash:Soil (50:50)	39.20	80.40	77.40	139.00	34.20	22.80
T_4	Coal Ash:Soil (75:25)	41.20	87.40	80.00	171.40	42.00	24.40
T_5	Coal Ash:Soil (100:0)	56.20	82.30	80.10	216.00	48.00	27.24
SE (m) $\pm$		0.376	2.031	0.888	2.022	0.693	0.493
LS.D. (0.05)		**1.160**	**NS**	**2.737**	**6.231**	**2.135**	**1.520**

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