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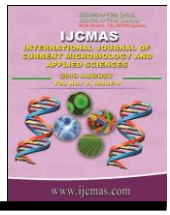

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Effect of Fly Ash Amended Growing Media on Germination, Growth and Graft Success of Cashew (*Anacardium occidentale* L.)

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A B S T R A C T

Fly ash management would remain a great concern all over the world. Several studies indicated that there is an ample scope for safe utilization of fly 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 at the Horticulture Research Station, OUAT, Bhubaneswar, under naturally ventilated poly house condition during 2017 and 2018. Different proportion of fly ash and garden soil mixture were used to study their effect on seed germination, seedling growth and survival % of cashew grafts. The results of the study envisaged that the media comprising of 70% garden soil mixture and 30% fly ash increased the seed germination, seedling growth and vigour and graft survival (%) in cashew. The media amended with 30% fly ash and 70% garden soil exhibited maximum gross return, net return with B: C.

Introduction

Fly ash is one of the major solid waste products and environmental pollutant from thermal power plant. Basically, Fly 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, fly 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 fly ash particles on crop canopies reduces yield of crops due to impaired photosynthetic activities. Moreover, fly ash deposited on the fodder crops makes it unfit for cattle feeding. Indian fly 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 fly ash as a soil amendment to field crops. Fly 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 fly ash as amendment and micronutrient carrier has been identified. Fly ash amendment has been reported to modify soil pH, improve soil texture, water retention and stability and provide essential plant nutrients for increasing crop production (Ram and Reginald, 2010; Riehl *et al.*, 2010). Furr *et al.,* (1979) cultured a variety of vegetables, millets and apple trees in poly pots of neutral soil amended with fly ash showed enhanced absorption of B, Cu, Co, Fe, Mg, Mn Mo, Se and Zn.

Fly 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). Fly 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 fly 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.

Fly ash can be utilised as a media for nursery raising of different planting materials. Favourable crop response to fly ash depends directly on the proper combination of fly ash, soil mixture and plant species to be grown. Cashew (*Anacardium occidentale* L.) was selected as test crop because it is one of the important plantation crop of Odisha which is grown in marginal waste land. 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. It is relevant in the present scenario that the state has a number of thermal plants which release this pollutant, i.e. fly ash. The optimum levels of fly ash to be amended with garden soil for nursery raising of cashew have not been standardized. Hence, the work have been undertaken to study the effect of fly ash on cashew seedling and optimise the fly ash proportion for safe production of cashew grafts.

Materials and Methods

The experiment was carried out during 2017 and 2018 at Horticulture Research Station (HRS), Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. To have control over the experiment, a pot culture trial by using fly ash was carried out in Cashew (cv. BPP-8) in the nursery under naturally ventilated poly house condition. Different proportion of fly ash and garden soil mixture were used to study their effect on seed germination, seedling growth, and survival % of grafts of cashew at nursery stage. The experiment was conducted comprised of 6 treatments and 4 replications and executed following Completely Randomized Design. The details of treatments were, T_1 : Soil mixture (SM)100% + Fly ash (FA) 0%, T_2 : Soil mixture (SM) 90% + Fly ash (FA) 10%, T_3: Soil mixture (SM) 80% + Fly ash (FA)

20%, T_4 : Soil mixture (SM) 70% + Fly ash (FA) 30%,T_5 : Soil mixture (SM) 60% + Fly ash (FA) 40% and T_6 : Soil mixture (SM) 50% + Fly ash (FA) 50%.

The garden soil, farm yard manure and fly ash were used for preparation of the media for undertaking the nursery experiment. The garden soil collected from the field has been used as media for the study. Farm yard manure used in the media was prepared basically by using cow dung, cow urine, waste straw and other dairy wastes. Fly ash used as media in the experiment was obtained from Talcher Thermal Power Plant (TTPC), Talcher, Odisha. The physico- chemical properties of garden soil, farm yard manure and fly ash was determined before their application to the experimental media (Table 1).

The soil mixture comprising of garden soil and farm yard manure was prepared by mixing the individual components by weight basis @ 2:1. Then the fly ash and soil mixture were mixed properly treatment wise as per the requirements. The final mixture of fly ash and soil mixture were filled in polythene bag of 25 cm x 15 cm size with 300 gauge thickness.

The filled pots were arranged in beds over the thick polythene sheet. The filled in polythene bags were kept inside the naturally ventilated poly house. The fully matured seed nut of cashew variety BPP-8 (H-2/16) of current season was collected from AICRP on cashew, OUAT, Bhubaneswar for conducting the experiment. The heavy seeds which sink in water were selected for the experiment and these were soaked in cold water overnight before sowing. Each polythene bag was punched with 15 to 20 holes all around. Seed nuts were dibbled at a depth of 2.5cm in the pot mixture in slanting manner keeping stalk end upward. The pots were covered with paddy straw. Light irrigation was provided by the help of rose can just after sowing. Regular watering was done as per requirement. The covering straw layer was removed after start of the germination. The grafting of seedling was done at 60 DAS following soft wood grafting method. The necessary care and management, plant protection measures and weeding was taken during the course of investigation as and when required.

The observation on germination was recorded from day of initiation. The observations on germination percentage, seedling characteristics and the plant growth parameters were recorded at periodic interval. Vigour index was computed at 60 DAS as per the formula suggested by Abdul Baki and Anderson (1973) as mentioned below.

Vigour index = Standard germination percentage x (Shoot length + Root length)

The leaf chlorophyll content of plants was measured at 6 month after grafting by the help of chlorophyll meter. The data obtained on seed germination and various growth parameters 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

Fly ash amended with garden soil mixture in the present study showed significant variation in number of days taken for initiation of germination, germination % and vigour of seedling (Table 2). The cashew seeds sown in T_4: SM 70% + FA 30% recorded the minimum days for initiation of germination (10.0) which was comparable with T_3: SM 80% + FA 20%. The maximum days taken for initiation of

germination (13.0) were recorded in T_6: SM 50% + FA 50%. From the study it is clearly showed that germination of cashew seed was found earliest at 20-30% fly ash amendment with garden soil. Whereas, germination was delayed both at higher as well as lower dose of fly ash application.

The germination of cashew seed was counted up to 25 DAS. The germination % was observed maximum (92.37) at 30% amendment of fly ash with 70% garden soil mixture (T_4), which was at par with 20% fly ash amendment. The fly ash application beyond 30% and below 20% significantly reduced the seed germination in cashew. The minimum germination (84.98%) was obtained when seeds were sown in the media having garden soil mixture and fly ash at 50: 50 level (T_6). Since the fly ash contains many growth promoting nutrients, it might induce higher germination. The higher germination recorded in the treatment might be due to availability of required moisture content and better physical environment. The present finding confirmed the earlier findings of Wong & Wong (1989), Kalra *et al.,* (1997), Rath and Mohapatra (1997), Sarangi *et al.,* (1997) and Swain *et al.,* (2012). Singh *et al.,* (1997) studied the impact of fly ash as soil amendment on seed germination of *Vicia faba* L. and found that at lower rate of fly ash application enhanced seed germination, while higher application either delayed or inhibited this processes drastically.

The vigour of seedling recorded at 60 DAS was significantly varied by different proportion of garden soil and fly ash mixture. The maximum vigour of seedling was noticed in T_4: SM 70% + FA 30% (4454.27) which is higher than all other treatments. The minimum seedling vigour (1675.25) was observed in T_6: SM 50% + FA 50%. The fly ash concentration above 30% in the media as well the media devoid of fly ash was not found giving favourable effect on vigour of seedling. This might be due to the fact that at early stage of growth the seedlings could have affected by variation in the soil moisture content and the compactness of the growing media. The increased vigour of seedlings at 20-30% fly ash amended media might provide favourable environment, moisture and nutrient to the germinated seedlings.

Panda and Tikadar (2014) reported that increase in concentration of fly ash decrease seed germination in rice and least germination was seen in 100 % fly ash. The study revealed that the fly ash in low concentration could be beneficial in improving plant growth and early seedling vigour of rice plants, while adverse effects was observed at higher levels. The present findings are in agreement with the previous works that fly ash considerably increases the seedling vigour of a number of crops like pomegranate (Swain *et al.,* 2013), rice, amaranthus, okra, seasamum (Sarangi *et al.,* 1997) and soybean (Mishra and Shukla, 1986).

Vegetative growth and survival percentage of seedlings and grafts

The vegetative growth of cashew seedling such as shoot length and seedling diameter was recorded up to 60 DAS (Table 2, 3 and 4). The results indicated that addition of fly ash at 30% level with garden soil mixture (T_4) showed higher shoot length and seedling diameter at 60 DAS. The number of leaves of seedling recorded at 60 DAS was also observed higher in the above composition. The maximum survival percentage of seedlings for root stocks of 88.70% was noticed in T_4: SM 70% + FA 30% which is significantly superior over all other treatments and the minimum of 59.04 % was observed in T_6: SM 50% + FA 50%. However, leaf growth and root growth of cashew were not influenced by the addition of different levels

of fly ash in the garden soil mixture. This shows that the available nutrients present in the media having 30% fly ash was found beneficial in increasing the plant growth. Rizvi and Khan (2009) reported higher growth of eggplant at 20% level of fly ash amendment. The beneficial effect of fly ash at lower dose (10-30%) have already been observed by Swain *et al.,* (2013) in pomegranate, Swain *et al.,* (2012) and Sethi (1996) in guava and Kuchanwar and Matte (1997) in groundnut.

Table.1 Physico-chemical properties of media used in the experiment

Parameter	Soil	FYM	Fly Ash
Chemical properties			
pH	5.7	7.06	7.6
OC	0.50 %	10.14 %	0.09 %
N	155.12 kg/ha	0.48 %	0.04 %
P	63 kg/ha	0.29 %	0.11 %
K	178 kg/ha	0.32 %	0.05 %
Ca	192 mg/kg	0.20 %	0.80 %
Mg	168 mg/kg	0.24 %	0.36 %
S	123 kg/ha	0.16 %	0.13 %
B	0.45 mg/kg	0.13 %	0.03 %
Fe	54.32 mg/kg	0.76 %	0.65 %
Mn	19.44 mg/kg	0.01 %	0.03 %
Cu	0.6 mg/kg	0.00 %	0.00 %
Zn	0.97 mg/kg	0.00 %	0.00 %
Cd	0.012 mg/kg	0.014 mg/kg	0.09 mg/kg
Pb	0.094 mg/kg	0.012 mg/kg	0.18 mg/kg
Co	0.03 mg/kg	0.01 mg/kg	0.3 mg/kg
Ni	0.55 mg/kg	0.11 mg/kg	1.24 mg/kg
Physical properties			
Texture	Sandy loam	---	Amorphous
WHC	19.50%		44.67%
EC	0.012 ds/m	0.038 ds/m	0.089 ds/m
BD	1.57 mg/m^3	0.93 mg/m^3	1.05 mg/m^3

Table.2 Effect of fly ash amended soil mixture on seed germination, growth and vigour of cashew seedling

Treatment	Days taken for initiation of germination	Germination percentage (%) at 15 DAS	Germination percentage (%) at 25 DAS	Shoot length of seedling (cm) at 60 DAS	Seedling diameter (cm) at 60 DAS	Root length (cm)	Root diameter (cm)	Vigour of seedling at 60 DAS
T_1: SM 100% + FA 0%	12.25	52.90 (46.68)	87.48 (69.25)	29.60	0.58	10.70	0.67	2131.87
T_2: SM 90% + FA 10%	12.50	69.00 (56.45)	89.55 (71.12)	33.30	0.62	12.17	0.70	3138.12
T_3: SM 80% + FA 20%	10.75	69.83 (56.87)	91.63 (73.25)	36.20	0.67	12.72	0.73	3416.78
T_4: SM 70% + FA 30%	10.00	75.65 (61.26)	92.37 (74.00)	42.50	0.70	13.37	0.76	4454.27
T_5: SM 60% + FA 40%	12.75	43.90 (41.43)	88.30 (70.21)	31.40	0.55	10.75	0.68	1850.38
T_6: SM 50% + FA 50%	13.00	40.81 (39.05)	84.98 (67.32)	31.02	0.53	10.02	0.65	1675.25
SEm (±)	**0.637**	**4.363**	**0.442**	**0.979**	**0.008**	**0.832**	**0.043**	**1.331**
C.D. at 5%	**1.908**	**13.063**	**1.326**	**2.930**	**0.025**	**NS**	**NS**	**3.986**

Table.3 Effect of fly ash amended soil mixture on growth and survival percentage of cashew seedling

Treatment	No. of leaves/seedling	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Survival % of seedlings for root stocks
T_1: SM 100% + FA 0%	11.25	12.05	5.90	71.11	64.33 (53.37)
T_2: SM 90% + FA 10%	12.75	12.27	5.95	73.51	66.92 (54.97)
T_3: SM 80% + FA 20%	12.50	12.40	6.05	75.07	72.10 (58.15)
T_4: SM 70% + FA 30%	13.25	12.60	6.07	76.63	88.70 (71.21)
T_5: SM 60% + FA 40%	11.00	12.07	5.92	71.64	65.75 (54.10)
T_6: SM 50% + FA 50%	10.50	11.85	5.72	67.86	59.04 (50.38)
SEm (±)	**0.377**	**0.489**	**0.142**	**1.774**	**2.777**
C.D. at 5%	**1.126**	**NS**	**NS**	**NS**	**8.315**

Table.4 Effect of fly ash amended soil mixture on growth and survival percentage of cashew grafts

Treatment	Graft height (cm)	Graft diameter (cm)	Root length (cm)	Root diameter (cm)	No. of leaves/ graft	Leaf area (sq. cm.)	Chlorophyll content of leaves (spad value)	Total biomass per graft (g) on dry weight basis	Survival percentage of grafts
T_1: SM 100% + FA 0%	50.50	0.90	12.74	0.80	11.0	120.50	10.06	18.40	62.68 (52.34)
T_2: SM 90% + FA 10%	54.60	1.02	14.23	0.91	11.3	140.30	10.19	16.80	70.88 (57.71)
T_3: SM 80% + FA 20%	59.50	1.12	15.31	1.02	13.5	146.50	12.03	18.70	75.27 (60.68)
T_4: SM 70% + FA 30%	65.70	1.32	18.32	1.21	15.5	169.26	15.29	25.50	81.03 (67.35)
T_5: SM 60% + FA 40%	45.50	0.82	12.24	0.82	10.5	126.50	10.12	14.30	60.00 (50.81)
T_6: SM 50% + FA 50%	43.00	0.76	11.05	0.68	9.5	109.50	9.26	12.20	50.54 (45.30)
SEm (±)	**1.429**	**0.060**	**1.520**	**0.056**	**0.413**	**6.298**	**1.202**	**1.309**	**0.721**
C.D. at 5%	**4.262**	**0.181**	**NS**	**0.168**	**1.234**	**18.782**	**3.600**	**3.904**	**2.163**

Table.5 Economics of graft production under different combinations of garden soil and fly ash mixture

Treatment	Graft success %	No. of grafts produced	Cost of production of graft (Rs)	Gross return (Rs)	Net return (Rs)	B : C ratio
T_1: SM 100% + FA 0%	62.68	15.84	285	388.08	103.08	1.36
T_2: SM 90% + FA 10%	70.88	19.00	355	465.50	110.50	1.31
T_3: SM 80% + FA 20%	75.27	22.37	405	548.07	143.07	1.35
T_4: SM 70% + FA 30%	81.03	29.86	460	731.57	271.57	1.59
T_5: SM 60% + FA 40%	60.00	15.66	320	383.67	63.67	1.20
T_6: SM 50% + FA 50%	50.54	11.02	265	269.99	4.99	1.02

Sale price: Rs. 24.50 per cashew graft

In the present investigation, the growth parameters of cashew graft were significantly varied by the influence of different proportion of fly ash and garden soil mixture. The graft height, graft diameter, root diameter, number of leaves and leaf area of graft were increased with increasing level of fly ash in the media and the maximum being at 30% fly ash and 70% garden soil mixture (T_4). However, higher level (>30%) of fly ash amendment in the media were found harmful effect. The root length of graft was not influenced by the different proportion of garden soil and fly ash mixture.

As regards the chlorophyll content of leaves and total biomass production of graft, these were recorded maximum value in media having 30% fly ash and 70% garden soil mixture (T_4). The increased growth response and biomass production of the cashew graft might be attributed to increased availability of macro and micro nutrients and moisture in the soil mixture (Gupta *et al.,* 2002). Panda and Tikadar (2014) reported that the total chlorophyll found to be more in 25% of fly ash concentration followed by 100 % of fly ash and least was observed in control condition, while SPAD index was decreased with the increase of fly ash concentration in the incorporated soil. The enhancement in chlorophyll contents is attributed to increase in concentration of chlorophyll a and b being proteins due to presence of micronutrients in fly ash. The micronutrients have catalytic role in activating enzymes required for protein synthesis. Stimulation in graft growth at 30% level of fly ash amendment to the garden soil clearly indicates that certain essential macro and micro elements present in the fly ash and garden soil mixture would have readily available to the plant (Petruzzelli *et al.,* 1987 and Swain *et al.,* 2013).

The survival percentage of grafts was significantly influenced by different proportion of garden soil and fly ash mixture. The graft success % increases with increasing level of fly ash concentration in the media up to 30% fly ash (T_4) amendment (81.03) and thereafter it was found to decrease with increasing level of fly ash. The minimum graft survival percentage was recorded in T_6: SM 50% + FA 50% (50.54). This might be due to the rich nutritional status and better physical conditions of this mixture which contains organic matter and mineral substances facilitate better growth and survival. The increase in graft success was mainly attributed to increase in nutrient acquisition of plants grown under above combination (Swain *et al.,* 2013)

Economics of graft production

The economics of different treatments were worked out taking into account the total seedlings produced, market price of inputs and sale price of grafts (Table 5). The media comprising of 30% fly ash and 70% garden soil (T_4) showed the maximum cost of production and the minimum was estimated in the media having 50% garden soil and 50% fly ash. The media having 30% fly ash and 70% garden soil (T_4) exhibited maximum gross return, net return with B: C. This is mainly due to the fact that the media comprising of 30% fly ash and 70% garden soil (T_4) is comparatively cheaper and produce higher successful seedlings.

The media comprising of 70% garden soil mixture and 30% fly ash increased the seed germination, seedling growth and vigour and graft survival (%) of cashew without having any adverse effect. The media amended with 30% fly ash and 70% garden soil exhibited maximum gross return, net return with B: C. Hence, fly ash in certain proportion could be recommended to be used effectively as soil amendment and fertilizer resulting its safe utilization and avoid dumping problem.

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