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Impact of fly ash on germination and initial seedling growth of vegetable hummingbird [*Sesbania grandiflora* (L.) Poiret]

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ABSTRACT

Impact of fly ash (FA) was studied on germination and initial seedling growth performance of *Sesbania grandiflora* during 2016-2017. Growing media was prepared by admixing FA to forest soil (S) at five concentrations (%) 20, 40, 60, 80 and 100 (w/w). The experimental design was CRD with six treatments and three replications. Freshly collected seeds were washed with cold water and sown at 2.0-3.0 cm depth in germination trays filled with media of different treatments. Significant ($P<0.05$) variation in germination period, rate, capacity and index with respect to FA concentration in media was observed ($n=100$). Maximum rate (86.67%) and index (2.04) were found in media having 20% FA after 30 days of sowing. After 90 days of transplanting significant difference ($P>0.05$) in seedling survival rate, plant height, diameter growth, nodules per plant and seedling quality index were observed. The survival rate (91.57%), plant height (62.07 cm) and root nodule number was (31.67) and seedling quality index (0.66) were maximum at 40% FA. It is concluded form the present investigation that FA can be admixed @ 20% (w/w) in forest nurseries for improving germination and @40% (w/w) for promoting seedling growth and quality improvement.

Key words: Forest nursery, fly ash added substrate, germination catalyst, pollution control

INTRODUCTION

Coal fired thermal power plants have been the backbone of power supply in India. Lignite is the prime grade used in these power plants which generates about 30-45% ash as compared to imported high quality coal which has low ash content in the order of 10-15%. Thus, huge quantities of fly ash (FA) are being produced at thermal power stations requiring large area of precious land for proper disposal. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China, in that order (Kishor et al., 2010; Senapati, 2011). About 196.44 million tons of Fly ash is being generated from 167 thermal power stations, during the year 2017-18. Tough there is a stringent government regulation for cent percent utilization of FA, only 67.13% have been utilized (CEA, 2018).

FA is ultrafine in nature and contains a number of toxic metals such as arsenic (As), barium (Ba), mercury (Hg), chromium (Cr), nickel (Ni), vanadium (V), lead (Pb), zinc (Zn) depending upon the source of coal (Dwivedi and Jain 2014). Thus, proper disposal and management of such a huge quantity of FA possessing potential threats of air and water soil pollution is a great challenge (Rawat et al., 2018). Utilization of FA for a particular purpose depends up on its elemental content which is primarily controlled by type of coal and its source. FA is being used in manufacturing cement, concrete, bricks, wood substitute products, in road construction, wasteland reclamation, filling of underground mine spoils etc. (Kaur and Goyal, 2015). In India major sectors include construction of roads and embankments, production of cement, mine-filling, reclamation of low-lying areas, making bricks and tiles (Environment Annual Reports, 2014-15).

Various studies indicate that, there is scope for utilization of FA in agriculture and forestry sector. Indian FA is having low bulk density, high water holding capacity and porosity, rich silt-sized particles, alkaline nature, negligible solubility, and reasonable plant nutrients. FA contains almost all the plant nutrients except nitrogen, phosphorous and humus, which can be supplemented by organic matter (Sharma and Karla, 2006). Many researchers have explored its potential use in agriculture. Beneficial effects of FA on plant nutrition have been studied and it was found beneficial for growth of many plants. Crop plants of the families *Brassicaceae, Chenopodiaceae, Fabiaceae, Leguminoceae* and *Poaceae* are most tolerant to FA toxicity (Cheung et al., 2000). Still then a large quantity of FA is being dumped in ash ponds and lagoons. Some of the FA contains deadliest toxic metals like arsenic, mercury, cadmium, chromium and selenium. These toxic metals along with other toxicants can cause cancer and neurological damages in humans. They can also harm and kill wildlife, especially fish and other water-dwelling species (Ahmad et al., 2014). The current status of utilization of FA in India is only 60-70% (CEA, 2018), providing a wide scope for searching new avenues.

One of the most potential areas of utilization is in forestry sector where it can be consumed either in nursery or for tree plantation activities. This will help in locking the toxic heavy metals in the wood biomass for longer period of time. FA as planting material in forest nursery is not a new concept. Goyal et al. (2002) reported its use in nursery as growing media but commercial use is scanty or absent. Hence attempt is made to know its impact on seed germination and growth of seedlings at early stages. *Sesbania grandiflora* (Fabaceae) was selected because of its nitrogen fixing ability and multiplicity of products. The plant is valued for medicine, food, fibre, gum, fuel wood, soil improvement and ornamental plantation. It is an ideal species for rehabilitating eroded soils, degraded waste land and mine spoils (Karmakar et al., 2016). Sesbania species is tolerant to metal toxicity and used to remediate lead, zinc, copper and chromium polluted soils (Chan et al., 2015).

MATERIALS AND METHODS

The experiment was conducted in College of Forestry, Odisha University of Agriculture and Technology, Bhubaneswar situated at 20° 15' N latitude and 85° 52' E longitude with altitude 25.9 m amsl. Fly ash (FA) was collected from one of the silages of Indian Metals and Ferro Alloys (IMFA) Limited, Choudwar, Cuttack (Odisha). The mean monthly temperature, relative humidity and rainfall of the experimental site given in Fig.1.

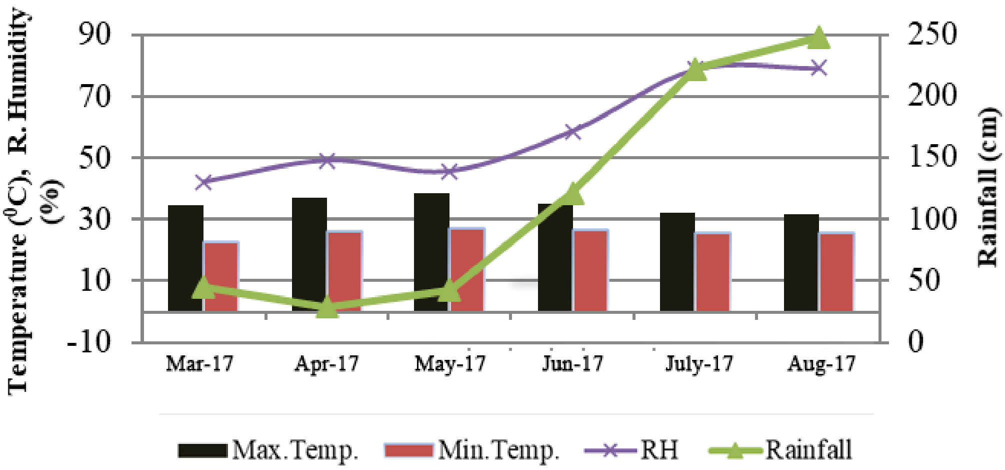

Fig. 1. Climatic parameters of the experimental site

Growing media preparation and analysis for physicochemical properties

Growing media was prepared by mixing FA to forest soil (S) at concentrations (%) 20, 40, 60, 80 and 100 weight by weight. There were six treatments (T_1-20% FA+S, T_2-40% FA+S, T_3-60% FA+S, T_4-80% FA+S, T_5-100% FA) including control (T_6-S). The growing media was analysed for physical and chemical properties. Bulk density (BD) and water holding capacity (WHC) was determined by using the protocol given by Piper (1966). pH and electrical conductivity (EC) were measured following protocol given by Jackson (1967), organic carbon (OC) was estimated as per Walkley and Black (1934). Available nitrogen, phosphorus and ammonium acetate extractable potassium were estimated as per the procedure given by Subbiah and Asija (1956), Olsen et al. (1954) and Merwin and Peech (1951) respectively. The physical and chemical properties of growing media are given in Table 1.

Table 1. Physicochemical properties of fly ash, forest soil and fly ash substratum

Property	Forest soil (S)	Fly ash (FA)	FA substrate (Forest soil + FA % (w w^{-1})			
			S+ 20% FA	S + 40% FA	S + 60% FA	S+ 80% FA
pH		8.12	7.06	7.26	7.39	7.65
EC(dS m^{-1})	6.41	0.68	0.62	0.93	1.11	1.28
N (kg ha^{-1})	0.21	0.002	106.15	92.67	79.17	37.50
P (kg ha^{-1})	125.50	6.70	48.23	33.59	18.91	14.69
K (kg ha^{-1})	56.13	146.43	496.41	506.12	539.53	613.15
OC (%)	474.36	0.005	0.519	0.464	0.382	0.261
BD(g cm^{-3})	0.570	0.69	1.38	1.21	0.95	0.76
Pore space (%)	1.48	49.52	43.2	44.4	46.25	49.35
WHC (%)	32.8	58.2	43.25	45.84	48.72	54.33

Values are mean (N=Arithmetic mean); FA- Fly ash; FS- Forest soil, EC- Electrical conductivity, NPK- Available nitrogen, phosphorous and potash, OC- Organic carbon, BD- Bulk density, WHC- Water holding capacity.

Seed treatment and sowing

Germination study

Freshly collected seeds were gently scrapped in sand paper and soaked in cold water for 24 hours prior to sowing (Shafiq et al., 2019). Eighteen germination trays having dimension 90 cm (L) × 45 cm (B) × 15 cm (H) were filled with above six mentioned growing media to the brim leaving 3.0 cm. Hundred seeds per replication (totalling 300 seeds per treatment) were sown at 2.0-3.0 cm depth, covered with paddy straw and kept at open nursery condition. Regular watering was made as per the requirement. Observations pertaining to germination parameters were recorded daily up to 30 days after sowing. Germination period was determined by observing the day taken for first germination (DTFG) to 30th day when about 80-85% seeds have germinated. Based on the number of seeds germinated the following parameters were calculated as per the standards given by Czabatore (1962) and AOSA (1983).

Germination percentage = (Number of seeds germinated) / (Number of seeds sown) × 100

Germination capacity = (Total seeds germinated + viable seeds) / (Total No of seeds sown in all replications) × 100

Germination Value = PV × MDG

Where, PV = Peak value of Germination

MDG = Mean daily Germination

Germination Index = (No.of germinated seeds) / (Days of first count) + Σ of no.of germinated seeds / (Days of final count)

Seedling growth study

After completion of germination study, seedlings were transplanted into poly pots (22.86 × 12.7 cm) containing growing media of above mentioned treatment combinations. Growth parameters such as shoot length, collar diameter and number of leaves were assessed monthly after 30 days of transplanting for 3 months. Total shoot length was measured by using ruler (taken from the apical bud of the plant to the base of the shoot) and stem diameter by using electronic digital calliper (6"/150 mm, accuracy ± 0.01 mm, Mitutoyo- CD-6″ASX: 500-196-30).

For recording the quantitative parameters pertaining to root growth, the entire seedling was dipped in a bucket of water at 90 days to remove adhering soil from it. It was then carefully washed so that no damage was made to root system. Length of roots (starting from collar region to the end point) and number of root nodules were recorded. Thoroughly washed seedlings (without damage to root and shoot) were dried under sun for 30 minutes. The shoot was cut from the collar portion and weighed. Then the root and shoot samples were put in paper bags separately and were oven dried at 80°C until constant weight observed. Growth observation was based on 45 numbers of randomly selected plants from each treatment. The seedling quality index (SQI) was calculated by using the formula as described by Dickson et al. (1960).

SQI = Seedling dry wt. (g)/[Height (cm)/Diameter (mm) + Shoot dry wt. (g)/Root dry wt.(g)]

The experiment was completely randomized design with three replications. The collected data were analysed with a general linear model using SPSS software version 20 for windows operating system. Means were analysed according to the Duncan Multiple Range Test (DMRT) at $P < 0.05$.

RESULTS AND DISCUSSION

Fly ash is a noxious solid waste seeking proper disposal and management. It has some multifarious utility. Still ample amount left unutilised at disposal sites of thermal power plants polluting air and water. There exists a vast scope for utility in forestry sector as potting mixture ingredient and soil improvement material at difficult sites prior to plantation. The matrix of application depends upon the elemental composition of FA to be used, tolerance limit of plant species selected and physiochemical property of plantation site soil or growing media in which FA need to be added. Fertility status of poor degraded waste lands and problematic soils are successfully improved by FA addition to varying degrees in different agro-climatic situation. Enhancement in crop yield and vegetative growth tree species have been reported by many workers when applied judiciously (Kumar et al., 2002; Sinha et al. 2005; Ramesh et al., 2008; Chaudhary et al., 2009; Krzaklewski et al., 2012; Behera et al. 2018)

Effect of substrate on seed germination

The biochemical process of seed germination is affected by a number of intrinsic and environmental factors. Effective pre sowing treatment of seed reduce unfavourable endogen window. The exogenous variable mainly the substrate and climatic condition can be managed successfully to achieve maximum germination rate. Substrate property especially pH and water retention capacity have a marked impact on germination. pH affects germination either by increasing the osmotic pressure of the media to a plant that will retard or prevent the intake of water or by causing toxicity to the embryo (Rashid, 2004).

During this course study, it was revealed that FA have a significant ($P < 0.05$) impact on seed germination parameters like germination period, rate, capacity and index, however did not have any impact on the number of days taken for first germination (NDFG) and germination value (Table 2). Addition of FA to growing media reduced germination period in a dose-depended manner due to an increase in pH towards alkalinity. Similar type of observations was reported by Behera et al. (2020) in *Leucaena leucocephala*.

The highest seed germination percent (86.67%) was observed in growing media having 20% fly ash (T_1) and was significantly (P>0.05) higher than other treatments (Table 2). The germination rate of 79.33% in T_2, 69.33% in T_3 and 66.67% in control (T_6) respectively are statistically at par (P>0.05) with each other. Minimum germination rate (34.67%) was observed in substrate having 100% FA (T_5, Table 2). The increased germination rate (86.67%) in 20% FA admixed growing media was attributed to the improvement in the physicochemical condition of germinating media over control (66.67%, Table 2). The reduction in germination rate beyond 60% FA addition (w/w) in media was due to enhanced pH and elemental toxicity. Higher pH and metals like Cu^{2+}, Zn^{2+} at higher EC are reported toxic to embryo and reduces biological activity during germination process (Gupta et al., 2000). There existed negative relationship between FA rate with germination percentage, germination capacity but it was positive with DTFG, germination period and germinative index (Table 2).

Table 2. Effects of substrates on germination of *S. grandiflora* seeds at 30 days after sowing

Parameters→ / Treatments↓	DTFG	G. Period	GP (%)	GC	GV	GI
T_1	8.67_{cd}	6.67_{b}	86.67_{d}	89.33_{cd}	25.33_{cd}	2.04_{c}
T_2	8.33_{bcd}	6.0_{ab}	79.33_{bc}	85.33_{cd}	26.00_{d}	1.94_{c}
T_3	7.67_{abc}	4.66_{ab}	69.33_{bc}	72.00_{bc}	17.67_{bcd}	1.73_{bc}
T_4	7.33_{ab}	4.67_{ab}	54.67_{b}	58.67_{b}	12.00_{ab}	1.35_{bc}
T_5	7.0_{a}	4.0_{a}	34.67_{a}	40.00_{a}	7.33_{a}	0.34_{a}
T_6	9.0_{d}	9.33_{c}	66.67_{bc}	93.33_{d}	16.67_{bc}	1.00_{ab}
Statistical analysis						
P (0.05)	0.01	0.001	0.001	0.001	0.004	0.03
SE	0.21	0.48	11.94	14.47	7.4	0.17
F	4.8	9.35	4.51	4.93	1.87	6.9
Linear Regression analysis (y = concerned parameter, x = FA rate)						
y=	9.04-0.81x	8.32-0.84x	84.2-0.69x	99.68-0.89x	24.29-0.6x	1.8-0.4x

Treatments T_1=(20% FA+S), T_2=(40% FA+S), T_3=(60% FA+S), T_4=(80% FA+S), T_5=(100% FA), T_6=(Soil/ Control), FA- fly ash, S- Forest Soil, DTFG- Days taken for first germination, GP- Germination Percentage, GC- Germination Capacity, GV- Germination Value, GI- Germination index, Mean values followed by same letter are statistically indifferent.

Effect of substrate on seedling growth

After 90 days of transplanting significant difference (P>0.05) in survival rate, plant height, diameter growth, mean root length, nodules per plant and seedling quality index of *S. grandiflora* was observed. But no significant difference (P>0.05) in number of leaves was recorded (Table 3).

Highest seedling survival rate (91.57%) was found in substrate containing 40% FA (T_2) which and was statistically (P>0.05) indifferent from treatment T_2 (87.16%) and control (83.2%). The maximum survival rate (91.57%) of seedlings in substrate containing 40% FA (T_2) was due the improved aeration and water retention capacity of substrate. The survival rate decreased linearly with increased concentration of FA up to minimum 37.90% in growth media having 100% FA (Table 3).

The maximum height (62.07 cm) was found in treatment having 40% FA and it was statistically at par with Treatment T_1 (58.83 cm), T_3 (56.06 cm) and control (54.8 cm). The diameter growth was maximum in treatment T_2 (5.89 cm) and statistically at par with control (5.37 cm), T_1 (5.02 cm) and T_3 (4.5 cm). Longer mean root length was recorded in treatment T_3 (23.50 cm) and statistically at par with Treatment T_1 (22.25 cm), T_3 (21.27 cm) and control (22.50 cm). 31.67 numbers of root nodules were found in growing media having 40% FA (T_2) and statistically at par with T_1 (17.33) and control (16.25). A similar trend in growth of seedlings with respect to FA concentration was also reported by Gupta et al. (2000) and Pandey et al. (1996).

The vigour in seedling height, diameter and root growth of this species at 40% FA was due to light alkali pH, improvement in availability of nutrients in ionic form at rhizosphere solum and improved nitrogen fixation rate (Table 2), and reduced or no attack of nursery insect and pest. Goyal et al. (2002) observed 10% increase in the growth of *Eucalyptus tereticornis, Acacia auriculiformis* and *Casuarina equisetifolia* during early 6 months, grown in FA amended soils [ESP FA@18–24% (v/v)]. Good root nodulation per plants (31.67) in substrates having 40 % FA could be attributed to uptake of optimum amount of metals by the roots. However, the nodulation rate decreased after 40% FA linearly up to 100% FA which is due to the reduced ability of nitrogen fixing bacteria with increasing stress level (Faizan and Kaushar, 2010). The depressive nodulation effect was substantiated by reduced plant height, collar diameter growth, and seedling quality index. Further the plants grown in 40% FA were observed to be very healthy. Better seedling quality index in T_2 (0.66) was obviously due to the improved availability of micronutrients that supported higher biomass production and shoot: root ratio (Gupta et al., 2000).

Table 3. Effects of substrate on growth and quality of *Sesbania grandiflora* seedlings at 90 DAT

Parameters→ Treatments↓	Survival (%)	Plant height (cm)	Collar diameter (cm)	Number of leaves	Mean root length (cm)	Nodules per plant (No.)	SQI
T_1	87.16_{cd}	58.83_{c}	5.02_{bc}	9.37_{c}	22.25_{b}	17.33_{ab}	0.64_{c}
T_2	91.57_{d}	62.07_{c}	5.89_{c}	10.63_{cd}	23.50_{ab}	31.67_{b}	0.66_{c}
T_3	72.14_{bc}	56.06_{bc}	4.5_{bc}	11.73_{d}	21.27_{b}	10.50_{a}	0.52_{bc}
T_4	56.30_{b}	45.27_{b}	3.69_{ab}	6.87_{ab}	14.83_{a}	3.67_{a}	0.38_{ab}
T_5	37.90_{a}	32.60_{a}	2.6_{a}	6.03_{a}	12.17_{a}	2.0_{a}	0.21_{a}
T_6	83.2_{cd}	54.8_{bc}	5.37_{c}	8.83_{c}	22.50_{b}	16.25_{ab}	0.54_{bc}
Statistical analysis							
P (0.05)	0.001	0.001	0.002	NS	0.008	0.01	0.004
SE	4.93	2.73	1.2	0.53	0.72	0.50	0.04
F	15.48	8.64	7.87	9.8	5.45	5.14	6.4
Linear Regression analysis (y = concerned parameter, x = FA rate)							
y =	95.6-0.81x	62.0-0.63x	6.0-0.82x	-	24.4-0.1x	23.1-0.2x	0.66-0.03x

Treatments T_1=(20% FA+S), T_2=(40% FA+S), T_3=(60% FA+S), T_4=(80% FA+S), T_5=(100% FA), T_6=(S Control-1), FA- fly ash, S- Forest Soil, SQI-Seedling Quality Index, Mean values followed by same letter are statistically indifferent.

CONCLUSION

S. grandiflora being a rhizobial legume tree is well accomplished for improving barren waste land. The results of present investigation recommends FA should be admixed at 20% (w/w) level in nursery beds for early sprouting and improving germination percentage. However, it should be admixed at 40% in potting mixture for production of healthy and quality planting material. Further study is necessary to quantify the economic benefit or net profit gain from utilizing FA in forest nursery.

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REFERENCES

Ahmad, M.A., Shahnawaz, M., Siddiqui M.F. and Khan, Z.H. 2014. A statistical review on the current scenario of generation and utilization of fly-ash in India. *Int. J. Curr. Engin. Technol.* **4**(4): 2434-2438.

AOSA. 1983. *Seed vigor testing handbook: Contribution No. 32 to the handbook on seed testing,* Association of official seed analysts, Lincoln, NE, USA.

Behera, M.C., Lachungpa, O., Mohanty, T.L. and Nayak, H. 2018. Eco-friendly utilization of fly ash in forest nursery for quality planting material production of *Peltophorum pterocarpum* (DC) K. Heyne. *Ecol. Environ. Conserv*. **25** (1): 365-372.

Behera, M.C., Lachungpa, O. and Mohanty, T.L. 2020. Impact of fly ash on germination and initial seedling growth of *Leucaena leucocephala* (Lam.) De Wit. *Indian J. Ecol.* **47**(1): 117-122.

Chan, G.Y.S., Ye, Z.H. and Wong, M.H. 2015. Comparison of four Sesbania species to remediate Pb/Zn and Cu mine tailings. *Environ. Manage*. **32**(2): 246–251.

Chaudhary, D.R., Ghosh, A., Chikara, J. and Patolia, J.S. 2009. Elemental content of three plant species growing on abandoned fly ash landfill. *Indian For*. **135**(3): 393-402.

Cheung, K.C., Wong, J.P.Z., Zhang, Z.Q., Wong, J.W.C. and Wong, M.H. 2000. Revegetation of lagoon ash using legume species *Acacia auriculiformis* and *Leucaena leucocephala*. *Environ. Pollut.* **109**(1): 75–82.

Czabator, F.J. 1962. Germination value - an index combining speed and completeness of pine seed germination. *For. Sci.* **8**: 386–396.

Dickson, A., Leaf, A.L. and Hosner, J.F. 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. *For. Chron.* **36**(1): 10-13.

Dwivedi, A. and Jain, M.K. 2014. Fly ash – waste management and over view: A review. *Recent Res. Sci. Technol*. **6**(1): 30-35.

Faizan, S. and Kausar, S. 2010. Impact of coal ash on growth, yield, biomass and nodulation of lentil (*Lens culinaris*). *J. Indust. Pollut. Contr*. **26**(2): 161-165.

Goyal, D., Kaur, K., Garg, R., Vijayan,V., Nanda, S.K., Nioding, A., Khanna, S. and Ramamurthy, V. 2002. Industrial fly ash as a soil amendment agent for raising forestry plantations. *TMS Annual Meeting,* pp. 251-260.

Gupta, M., Kumar, A. and Yunus, M. 2000. Effect of fly-ash on metal composition and Physiological responses in *Leucaena leucocephala* (lam.) de. Wit. *Environ. Monitor. Assess.* **61**: 399–406.

Jackson, M.L. 1967. *Soil chemical analysis*, Oxford IBH publishing house, Bombay.

Karmakar, P., Singh, V., Yadava, R.B., Singh, B., Singh, R. and Kushwaha, M. 2016. Agathi [*Sesbania grandiflora* L. (Agast)]: Current status of production, protection and genetic improvement. In: *National Symposium on Vegetable Legumes for Soil and Human Health*, pp. 153-161.

Kaur, R. and Goyal, D. 2015. Mineralogical studies of coal fly ash for soil application in agriculture. *Particul. Sci. Technol*. **33** (1): 76–80.

Kishor, P., Ghosh, A.K. and Kumar, D. 2010. Use of fly ash in agriculture: A way to improve soil fertility and its productivity. *Asian J. Agric. Res*. **4**(1): 1-14.

Krzaklewski, W., Pietrzykowski, M. and Wos, B. 2012. Survival and growth of alders (*Alnus glutinosa* (L.) Gaertn. and *Alnus incana* (L.) Moench on fly ash technosols at different substrate improvement. *Ecol. Eng.* **49**:35– 40.

Kumar, A., Vajpayee, P., Ali, M.B., Tripathi, R.D., Singh, N., Rai, U.N. and Singh, S.N. 2002. Biochemical responses of *Cassia siamea* Lamk. grown on coal combustion residue (Fly-ash). *Bull. Environ. Contam. Toxicol*. **68**: 675–683.

Merwin, H.D. and Peech, M. 1951. Exchangeability of soils potassium in the silt and clay fractions as influenced by the nature of the complimentary exchangeable cations. *Soil Sci. Soc. Am. Proc.* **15**: 125-128.

Olsen, R., Cole, C.V., Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorous by extraction with sodium bicarbonate. *USDA Circular*. **939**:1-19.

Pandey, O.N., Sarkar, A.K. and Sharma, V.N. 1996. Growth of certain tree species in fly ash amended soil. *Proc. NS-EWM*, pp. 183-191

Piper, C.S. 1966. *Soil and plant analysis*. Hans Publisher, Bombay.

Ramesh, V., Korwar, G.R., Mandal, U.K., Prasad, V.N.S., Sharma, K.L., Yezzu, S.R. and Kandula, V. 2008. Influence of fly ash mixtures on early tree growth and physicochemical properties of soil in semi-arid tropical Alfisols. *Agrofor. Syst.* **73**: 13–22.

Rashid, M.M. 2004. Salt Tolerances of some multipurpose tree species as determined by seed germination. *J. Biol. Sci.* **4**(3): 288–292.

Rashid, M.M., Hoque, A.K.F. and Iftekhar, M.S. 2004. Salt tolerances of some multipurpose tree species as determined by seed germination. *J. Biol. Sci.* **4**(3): 288-292.

Rawat, R., Pathak, B. and Fulekar, M.H. 2018. Plant diversity at fly ash disposal site of thermal power plant Gandhinagar, Gujarat. *Indian J. Ecol*. **45**(3): 528-532.

Senapati, M.R. 2011. Fly ash from thermal power plants: waste management and overview. *Curr. Sci.* **100**(12): 1791-1794.

Shafiq, M., Shahid, H., Iqbal, M.Z., Kabir, M. and Farooqi, Z.R. 2019. Effects of auto exhaust emission on germination and certain seedling growth parameter of *Sesbania grandiflora* (L.) Poiret (hummingbird tree). *COJ Tech. Sci. Res*. **1**(5): 1-8.

Sharma, S.K. and Karla, N. 2006. Effect of fly ash incorporation on soil properties and productivity of crops: A review. *J. Sci. Indus. Res*. **65**: 383-390.

Sinha, S., Rai, U.N., Bhatt, K., Pandey, K. and Gupta, A.K. 2005. Fly-ash-induced oxidative stress and tolerance in *Prosopis juliflora* L. grown on different amended substrates. *Environ. Monitor. Assess.* **102**: 447–457.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci.* **25**(8): 259-260

Walkley, A. and Black, I.A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* **37**(1): 29-38.