Characteristics of fly ash and its influence on the germination of amaranthus seeds

Abstract

The physical and chemical properties of fly ash collected from three different thermal power stations were studied and the fly ash with neutral to alkaline pH was utilized as a medium for the germination of amaranthus seeds. The germination test was carried out using a completely randomized design with two replications at Agricultural College and Research Institute, Madurai. The various fly ash was analyzed for its physical and chemical properties with standard methods. The fly ash with a slightly alkaline pH was selected and media was prepared with soil, vermicompost and farm yard manure. The seeds of an amaranthus crop were sown and the germination percentage, days to germination, shoot length, root length and vigour index were recorded. The collected fly ashes were recorded with low bulk density, alkaline pH with quantities of micro and macronutrients. The fly ash of Tuticorin has a slightly alkaline pH (8.03) and was utilized for media preparation. Among the different media, the media with treatment Fly ash + Soil + Vermicompost (1:1:4) + Bio Fertilizer has recorded higher germination percentage, shoot length, root length, vigour index, lower days to germination with 94.6%, 18.3 cm, 4.8 cm,16.17 and 2.8 respectively. The vermicompost is best for the enrichment of fly ash compared to farm yard manure.

Keywords: Fly ash, farm yard manure, vermicompost, amaranthus

1. INTRODUCTION

The need for energy production has been increasing day by day for electricity production. The majority of the energy is produced by the combustion of coal. So, the byproduct fly ash produced by coal combustion has also been increasing day by day. Fly ash is the fine powdered particles which particle been collected from the flue gas through an electrostatic precipitator. Fly ash is silt-sized, made up of tiny glass-like particles ranging in size from 0.01 to 100 µm [1]. In India, the production of fly ash reached 270.82 million tonnes during the year 2021-22 [2]. In previous years, disposal of fly ash pollution had been a challenging one as it caused pollution and pollution of the environment. But now, it has been utilized in many areas like cement production, road embankment, bridge construction, waste water treatment process. Even though it has been used in many areas, its utilization in agriculture stands in the way out. Fly ash contains many micro and macro nutrients required for crop production. It can act as fertilizer. It can also act as an ameliorating agent for the soil that improves the physical properties of the soil. The vermi compost and farm yard manure are the organic sources that supplement the macro nutrients which enhance crop growth and the properties of soil. The vermicompost comprises 0.5 – 1.50% N, 0.1-0.3 % P_2O_5, 0.15-0.56% K_2O and farm yard manure comprises 0.5 % N, 0.2 % P_2O_5, 0.5 % K_2O. Amaranthus stands as one of the earliest varieties of food plants, exhibiting its superiority as a rich source of calcium, potassium, iron, zinc, magnesium, substantial carotenes, and vitamin C content. An examination of the seeds and leaf extracts of Amaranthus through pharmacological analysis has unveiled the potential of its bioactive compounds in preventing various serious conditions such as diabetes, hyperlipidemia, and diarrhea. Additionally, it possesses impressive antioxidant, antihelmintic, antimalarial, anti-inflammatory, and antifungal properties. Amaranthus adopts the C4 photosynthetic pathway for sustenance, which makes the plant highly resilient to harsh environmental conditions. In this study, the fly ash with neutral pH was selected and mixed with soil, vermicompost, farm yard manure and bio fertilizer

at different proportions and the prepared mixture has been used as medium for the germination and growth of an amaranthus crop.

2. METHODOLOGY

2.1 Experiment

The samples of fly ash from three different thermal power stations viz. Neyveli Lignite Corporation (NLC), Tuticorin Thermal Power Station (TTPS), Mettur Thermal Power Station (MTPS) were collected. Totally, four samples were gathered, two from NLC, one from TTPS and one from MTPS. The gathered samples were analyzed for their physical and chemical properties. The fly ash with neutral pH has been selected and utilized for germination tests. The Soil was collected from the field of Agricultural College and Research Institute (AC & RI), Madurai. The vermicompost was collected from the vermicompost production unit, Dept of Soils and Environment, AC & RI, Madurai. The farm yard manure was collected from the animal husbandry unit, AC & RI Madurai. The bio fertilizers such as azophos, vesicular arbuscular mycorrizha (VAM), potassium reducing bacteria (KRB) were bought from Dept. of Agricultural Microbiology, AC & RI, Madurai. The mixture has been prepared with different proportions on a weight basis. The germination test was conducted in the germination room, Dept of Seed Science and Technology, (AC & RI), Madurai. It was done on the seedling tray with different growing media. Then five rows with five hills were created for seeds. The amaranthus seeds were sown at 2 seeds per hill. The germination percentage, shoot length, root length, days to germination and vigour index were calculated.

2.2. Experimental design

The study was laid out on a completely randomized design with 9 treatments and 2 replications.

2.3 Treatments

The germination trays were filled with following treatments, T_1 Absolute control (Red Soil + Sand+ Farm Yard Manure) T_2 (Fly ash + Soil + Farm Yard Manure (1:1:1) + Bio Fertilizer), T_3 (Fly ash + Soil + Vermicompost (1:1:1) + Bio Fertilizer), T_4 (Fly ash + Soil + Farm Yard Manure (1:1:2) + Bio Fertilizer), T_5 (Fly ash + Soil + Vermicompost (1:1:2) + Bio Fertilizer), T_6 (Fly ash + Soil + Farm Yard Manure (1:1:3) + Bio Fertilizer), T_7 (Fly ash + Soil + Vermicompost (1:1:3) + Bio Fertilizer), T_8 (Fly ash + Soil + Farm Yard Manure (1:1:4) + Bio Fertilizer), T_9 (Fly ash + Soil + Vermicompost (1:1:4) + Bio Fertilizer).

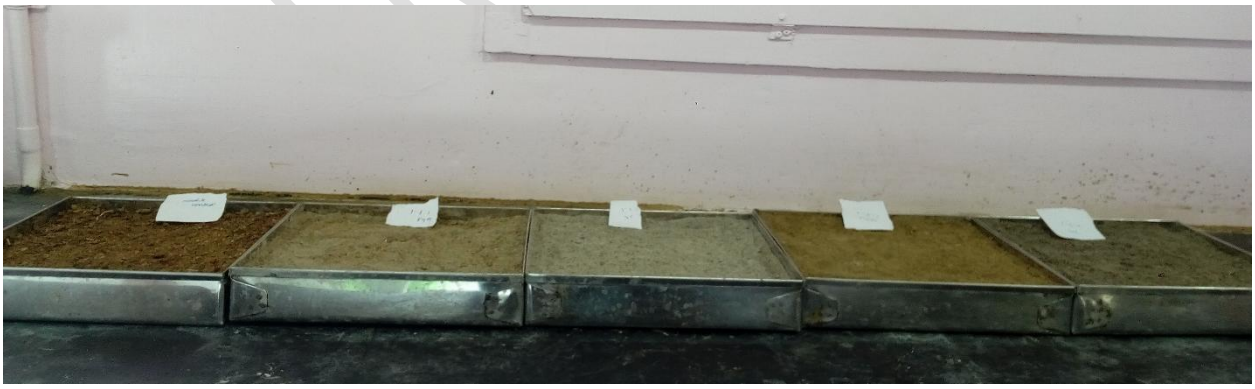

Fig 1. Growing media prepared with different treatments

2.4 Analysis of physical and chemical properties

The fly ash samples, soil, vermi compost and farm yard manure undergoing analysis for physical and chemical properties. The physical properties of bulk density, particle density and porosity were measured by core method [3]. The chemical properties pH, EC, CEC were analyzed by potentiometry method in soil water suspension 1:2.5 ratio, Conductometry method in soil water suspension 1:2.5 ratio, Neutral Normal NH4OAc respectively [4]. Then, organic carbon by Chromic acid wet digestion method [5] Total nitrogen by Micro Kjeldahl digestion and distillation [6] total phosphorus by Ammonium phosphomolybdate method [7] total potassium by flame photometry method [4] available nitrogen by Alkaline Permanganate Method [8] available phosphorus by Calorimetric method [9] available potassium by flame photometry method [10] available Sulphur by turbidimetry method [11] Exchangeable calcium and magnesium by Versanate titration Method [4] total micro nutrients by triacid extract- atomic absorption spectroscopy available micro nutrients by DTPA extract- Atomic Absorption Spectroscopy [12]

2.5. Seed quality parameters

The germination test was conducted in seedling tray with different media. The seeds were sown for each treatment and kept in germination chamber, kept at a temperature of $25\pm10^{o}C$ with relative humidity $96\pm2\%$. After 14 days, the count of normal seedlings has been noted and the germination percentage has been calculated using the following formula [13]

$$\text{Germination percentage} = \frac{\text{Total seeds germinated}}{\text{Total number of seeds}} \times 100$$

The shoot length and root length of the seedlings were noted and the vigor index of amaranthus seeds were calculated with following formula

$$\text{Vigour Index} = \text{Germination percentage} \times \text{Total seedling length (cm)}$$

2.5. Statistical analysis

To assess the seedling growth, the shoot length, root length, germination percentage, days to germination and vigor index parameters were statistically analyzed to determine its significance.

3. RESULTS AND DISCUSSION

The gathered fly ash from three different power stations was analyzed for its physical and chemical properties. The results were tabulated in table 1. From the table, it can be known that fly ash differs in all its properties, as the properties of the fly ash completely depend on the type of coal used, the method of coal combustion, and the type of boiler used. [14] Bulk density is the measure of the weight of the soil per unit volume as expressed in Mg m^{-3}. The increase of bulk density in the fly ash sample indicates the meager environment for the growth of crops. The bulk density of the fly ash in the present study comes between 1- 1.30 Mg m^{-3}, which indicates that it has a lower bulk density as suggested by [15]. On the basis of bulk density, these fly ashes can be suitable for agriculture [16] The particle density of the fly ash ranges between 2.07-3.96 Mg m-3 The porosity indicates the amount of pore space present in the sample. The fly ash from the mettur has more porosity of 68.75%, which is followed by Tuticorin and neyveli 2. The fly ash from neyveli 1 has low porosity. The pH is an important parameter for the growth of crops and it indicates the reaction of the fly ash whether it is acidic or alkaline in nature. The fly ash from our country is mostly alkaline in nature due to low the Sulphur content and sulphur of hydroxide and carbonates of Calcium and Magnesium [17]. The pH of both the neyveli fly ash samples and mettur are highly alkaline. The Tuticorin fly ash sample comes slightly alkaline. Due to the high pH of the fly ash samples, the electric conductivity is also more in it. Among the primary macro nutrients, it contains high potassium, followed by phosphorus and the least amount of nitrogen. In the case of secondary micro

nutrients, Calcium is high, followed by magnesium and least goes for Sulphur. Then, for micro nutrients-iron is followed by copper, manganese and zinc.

Table 1. Physical and chemical properties of different fly ash

Properties	Neyveli 1	Neyveli 2	Tutucorin	Mettur
Bulk density (Mg m^{-3})	1.05	0.65	1.00	1.25
Particle density (Mg m^{-3})	2.07	1.82	2.86	3.96
Porosity (%)	47.37	64.52	65.00	68.75
pH	9.63	8.72	8.03	8.81
Electrical Conductivity (dS m^{-1})	1.64	1.14	0.07	0.16
Organic Carbon (%)	0.096	0.168	0.036	0.126
Available Nitrogen (mg/kg)	34.18	37.14	36.23	33.45
Available Phosphorusmg/kg)	9.74	8.23	11.36	9.53
Available Potassium(mg/kg)	57.32	42.15	65.27	54.31
Available Sulphur (ppm)	2.8	3.6	3.1	3.4
Exchangeable Ca (meq/100g)	30.6	49.5	16.1	24.8
Exchangeable Mg (meq/100g)	24.8	44.5	13.2	18.6
Available Fe (ppm)	7.1634	4.3294	3.1433	1.9334
Available Cu (ppm)	0.9194	0.5678	0.3166	0.6082
Available Zn (ppm)	0.0195	0.0189	0.0186	0.0193
Available Mn (ppm)	0.0332	0.0238	0.0277	0.0266

The pH is an important factor for crop growth as it decides the tolerance of crop growth. Some of the crops are only tolerant to acidic and alkaline pH. The majority of the crops are grown at the neutral pH only. So the fly ash with neutral to alkaline pH has been selected and mixed with some other components viz. soil, farm yard manure, vermicompost. The physical and chemical properties of the individual media components are given in table 2.

Table 2. Analysis of media components

Properties	Red Soil	Sand	Soil	Farm Yard Manure	Vermi Compost
Bulk density (Mg m^{-3})	1.21	1.26	1.33	0.53	0.61
Particle density (Mg m^{-3})	2.36	2.38	2.40	0.84	0.92
Porosity(%)	48.72	52.94	44.58	63.09	66.30
Texture	Sandy loam	Sand	Sandy clay loam	-	-
pH	6.80	7.96	7.85	7.2	7.1
EC	0.19	0.32	0.28	0.5	0.82
CEC (C mol (p^{+})kg^{-1})	10.8	18.62	16.22	-	-
OC (%)	0.7	0.5	1.3	5.14	6.3
Total Nitrogen	-	-	-	0.3	0.8
Total Phosphorus	-	-	-	0.16	0.3
Total Potassium	-	-	-	0.43	0.24
Available Nitrogen (kg/ha^{-1})	175	156.2	168.5	-	-
Available Phosphorus (kg/ha^{-1})	18	12.36	10.50	-	-
Available Potassium (kg/ha^{-1})	180.6	179	173	-	-
Available Sulphur (ppm)	7.5	5.2	3.8	-	-
Exchangeable Ca (meq/100g)	4.23	3.8	6.5	-	-

Exchangeable Mg (meq/100g)	1.61	2.9	5.3	-	-
Available Fe (mg/kg)	1.16	1.66	5.62	-	-
Available Cu (mg/kg)	1.65	0.24	1.86	-	-
Available Zn (mg/kg)	1.21	0.74	1.26	-	-
Available Mn (mg/kg)	1.38	1.26	1.33	-	-

After the preparation of different media, they were analyzed for their physical and chemical properties (Table 3). The media were prepared with the same components at different proportions to know the efficiency of the fly ash,as if it is beneficial or not.

Table 3. Analysis of seedling media

Properties	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Bulk density (Mg m^{-3})	1.16	1.13	0.96	1.02	0.85	0.96	0.85	0.9	0.86
Particle density (Mg m^{-3})	1.80	1.52	1.47	1.48	1.41	1.45	1.39	1.41	1.33
Porosity (%)	35.5	32.89	31.91	33.80	42.25	25.65	35.33	36.17	44.44
pH	7.42	7.15	7.28	7.24	7.21	7.33	7.16	7.38	7.12
EC (dS m^{-1})	0.86	0.26	0.29	0.31	0.23	0.27	0.21	0.33	0.18
Organic Carbon (%)	1.81	3.93	4.10	4.49	4.74	3.15	3.37	4.63	4.66
Available Nitrogen (mg/kg)	47.21	49.13	47.32	51.64	51.73	53.81	56.34	54.29	67.84
Available Phosphorus (mg/kg)	11.27	17.11	22.35	19.95	25.42	21.64	27.77	24.28	29.33
Available Potassium (mg/kg)	15.88	19.21	25.42	20.21	26.12	22.24	27.81	23.25	28.67
Available Sulphur (mg/kg)	5.87	6.35	7.12	6.92	7.67	7.12	7.81	7.56	7.95
Available Calcium (mg/kg)	4.8	3.6	3.8	3.4	3.7	3.3	3.6	3.2	3.5
Available Magnesium (mg/kg)	2.6	1.8	1.7	1.5	1.4	1.2	1.1	0.9	1.0
Available Fe (mg/kg)	12.65	13.48	14.19	13.84	14.25	14.52	15.14	15.51	15.82
Available Cu (mg/kg)	0.97	2.05	2.31	2.29	2.39	2.48	2.54	2.79	2.72
Available Zn (mg/kg)	0.92	2.94	3.79	3.23	3.82	4.85	4.26	6.08	6.22
Available Mn (mg/kg)	5.51	9.34	9.80	10.15	10.67	11.36	11.52	11.73	11.81

For amaranthus seeds, 14 days is the essential period to find out its efficacy. After 14 days, the germination percentage, shoot length, root length and vigour index of amaranthus were recorded. Then the number of days until germination was noted. Then the parameters were statistically analyzed to know its significance. (Table 4)

Fig 2. Fly ash + Soil + Vermicompost (1:1:4) + Bio Fertilizer (Best treatment)

Table 4. Effect of growing media on germination of amaranthus

Treatment	Germination percentage	Days to germination	Shoot length (cm)	Root length (cm)	Vigour Index
T_1	88.3	3.6	8.6	2.1	9.44
T_2	86.4	4.1	7.5	1.6	7.80
T_3	89.7	3.7	8.2	2.3	9.41
T_4	90.3	3.5	8.7	2.8	10.38
T_5	91.2	3.2	9.8	3.6	12.22
T_6	91.4	3.3	10.2	3.1	12.15
T_7	92.8	2.9	11.5	4.2	14.56
T_8	91.6	3.1	10.8	3.9	13.46
T_9	94.6	2.8	12.3	4.8	16.17
SEd	2.16	0.07	0.16	0.06	0.24
CD	4.54	0.14	0.34	0.12	0.50

From the table it can be seen that T_9 (Fly ash + Soil + Vermi Compost (1:1:4) + Bio Fertilizer) has recorded a higher germination percentage (94.6%), which is on par with the treatments T_4, T_5, T_6, T_7 T_8. The lowest days for germination were seen on T9 (Fly ash + Soil + Vermi Compost (1:1:4) + Bio Fertilizer), which was on par with T_7 (Fly ash + Soil + Vermicompost (1:1:3) + Bio Fertilizer). The maximum vigour index was recorded at T_9 (Fly ash + Soil + Vermi Compost (1:1:4) + Bio Fertilizer), which is followed by T_7 (Fly ash + Soil + Vermicompost (1:1:3) + Bio Fertilizer. In the present study, the treatment with vermicompost at a higher proportion has recorded a positive effect on the germination of amaranthus than the treatment with farm yard manure of the same proportion. It might be because the vermicompost is a good nutrient source and its efficacy to improve the soil properties. Similar results have been seen by Alidadi et al., ([8] on the tomato crop and by Suthar S [19] on the garlic crop. As the vermi compost is well decomposed by earthworms, it provides the best results when compared with farm yard manure which is undecomposed.

4. CONCLUSION

From the present study, the physical and chemical properties of four fly ashes have been studied. As the pH of the fly ash samples is alkaline in nature, it can be utilized as an amendment to the acidic soils. These fly ashes contain micro and macro nutrients. It can be enriched with some other components like vermi compost, farm yard manure and supplied as fertilizer to the crops. With respect to seedling media prepared, it can be further developed into potting media for the growth of other crops in urban horticulture.

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CONFLICTS OF INTEREST

Authors have declared that no competing interests exists.

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