Effect of Fly Ash Amendment on Growth Performance of *Tagetes Patula* (African Double Mix Variety)

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ABSTRACT

Application of fly ash to soil has become an alternative to chemical fertilizers up to some extent due the presence of many essential elements (S, B, Na, Ca, P, Zn & Mn) into it. The present study was conducted to study the effect of various concentration of fly ash (0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% 90% & 100%) on heavy metal tolerance and growth responses of Tagetes patula (African double mix variety).The plants grown on soil amended with 10% fly ash have shown the maximum growth performance and the significant increase in plant biomass & plant height (shoot length, root length) was observed upto 30% fly ash amendment. Fly ash amended plants further amended with farmyard manure which slightly improve the performance of this plant. The results indicated that Tagetes patula may be used for extraction of metals.

Keywords: *Biomass, Fly Ash, Heavy Metals, Tagetes Patula.*

1. INTRODUCTION

Heavy metals are the main group of inorganic contaminants and a considerable large area of land is contaminated with them by disposal of waste from municipal waste incinerators, metalliferous mines, smelting, electroplating, tannery and coal based thermal power plant (Garbisu *et al*, 2003 and Halim *et al*, 2003). Among industrial wastes, coal based thermal power plants have significant importance, as production of electricity in India is mainly dependent on coal fired thermal power plants and the Indian coal used in thermal power plants have huge amount of ash contents (35-45%) (Sahu *et al*, 1994; Mathur *et al*, 2003; Inam and Sahay, 2015), which produced 150-170 million tones of FA per year (MOEF, 2007; Gautam *et al*, 2012) . Out of this large scale production only a minor percentile of fly ash (<15%) is being used for preparing bricks ,ceramics and cements (Pandey *et al*, 2009) and major amount of it remains unutilized and its disposal to large land area creates environmental health hazards due to high concentration of toxic heavy metals such as Cu, Cd, Pb, Ni, Cr etc (Lee et al, 2006 and Tiwari et al, 2007). Such large scale production of flyash by thermal power plants poses formidable environmental challenges (because of potential toxicity and high persistence of heavy metals) regarding its disposal to the soil and overall impact on environment. So, clean up of the heavy metals contaminated soil is one of the most difficult tasks for environmental engineers. A number of conventional methods have been developed to remediate metal contaminated soil (soil flushing, solidification/stabilization, vitrification, thermal desorption and encapsulation) which can be used at highly contaminated sites but are not applicable to large areas due to high energy input and expensive machineries beside this they destroy soil structure and decrease soil productivity (Chhotu & Fuleker, 2009).

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Other methods used for above said purpose are microbes or plant associated bioremediations. The microbes associated bioremediation is most applicable for sites contaminated with organic pollutants but several researchers have suggested that such bioremediation has limited potential to remediate metal polluted environments as heavy metals are not-subject to degradation (Marschner, 1995).

But the plant associated bioremediations (Phytoremediation), is gaining a lot of importance in recent times since it is a cost effective, promising and environment friendly technology as plants harvest solar energy for its nutrition and have extensive root system which extract and concentrate heavy metals from contaminated site. It includes several subsets such as phytoextraction, phytostabilization, rhizofiltration and phytovolatilization and has unique ability to concentrate essential and nonessential elements from the soil through the roots. Recently for the phytoremediation of heavy metals contaminated fly ash, researchers are focusing the attention on selection of appropriate plants and enhancement of metal tolerance & accumulation efficiency of the plants soil amendments to make the technology more feasible.

2. MATERIALS AND METHODS

2.1 Sample Collection and Soil Sample Amendment with Fly Ash: Fly ash samples were collected randomly from dumping sites of Jharli Thermal Power Plant, Jhajjar, Haryana, India, in large plastic bags and mixed together. The soil samples were collected from D.A.V. College of Engg. & Tech., Kanina (mohindergarh), Haryana. Fly ash as well as soil samples were air dried for 7 days and then passed through 2.37mm sieve. Then soil sample were amended with different proportions of flyash as detailed below: 10%(10% fly ash& 90% soil), 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% , 100% and soil served as control.

2.2 Reagents: The analytical grade reagents were used. Certified aqueous standards of heavy metals were used to prepare the standards curve for AAS. The reagents, samples and standards were stored in polyethylene containers and preserved at low temperatures.

2.3 Physico-chemical Analysis of Different Amendments: pH and EC of the samples were analysed by digital pH and conductivity meter (Model SLT-720 & SLT-615) by dissolving 10 gm of soil or fly ash in 100 ml of distilled water after proper stirring and settling. Organic carbon and organic matter were estimated using methods of Kalra and Maynard (1991).

For heavy metals analysis samples were digested on hot plate till brown fumes were stopped by using acid digestion technique in which 1 gm of fly ash sample was dissolved in 10 ml 3:1 percent solution of conc. HNO_3 and H_2SO_4. Samples then cooled and total 50 ml volume of each sample was made by using double distilled water. Filtered and stored in well washed plastic bottles and were analysed through AAS by standards methods (APHA, 1998; Trivedi and Goal, 1986).

2.4 Experimental Design

Pots were filled with 10%(10% fly ash & 90 % soil), 20%, 30%, 40%, 50%, 60%, 70%, 80% , 90% and 100% fly ash contaminated soil in triplicates along with one triplicate set of control soil.

The seeds of *Tagetes patula* were sterilised with 0.1% mercuric chloride for 5 minutes to avoid fungal contamination, washed with distilled water and soaked in water overnight. Soaked seeds were evenly sown (@ 4 seeds/ pot) in all the pots in triplicate having control and fly ash contaminated soil. After one week seedling plants were thinned so, that one plant remains in one pot and are kept under natural conditions for full developments, which are irrigated at regular intervals as and when required.

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Similar experimental design was set with 10 gm of farmyard manure amendment in each control and fly ash contaminated pot.

2.5 Harvesting of the Plants: The fully grown plants of *Tagetes patula* were harvested from control soil, fly ash contaminated soil and farmyard manure amendment soil after 90 days and repeatedly washed with double distilled water.

2.6 Determination of Metal Tolerance: Root length, shoot length, plant height, wet and dry biomass of harvested plants was measured for the determination of metal tolerance in different fly ash contaminated samples and farmyard amended samples.

2.7 Digestion of Harvested Plant Materials & Soil Samples : Harvested plants were air dried for 3 to 5 days and then oven dried at 80 ^{O}C till constant weight attained. The root & shoot parts were separated and homogenized by grinding in a stainless steel blinder. Then grinded material was sieved from 2.37 mm sieve and kept for further analysis.One gram each of soil, roots and shoots were taken into a 100 ml beaker and digested into 42 ml of tri acid mixture(HNO_3: $HClO_4$: H_2SO_4 in 5:1:1 ratios) at 80 ^{0}C till the transparent solution appeared. The digested material was cooled, filtered with Whatmann no. 42 and maintained to 50 ml with distilled water in well washed plastic bottles and then were analysed for different heavy metals by AAS.

3. RESULTS AND DISCUSSION

Physico-chemical properties of different amendments of fly ash and control soil were presented in table-1. Data analysis revealed that the control soil used in this experiment was slightly acidic, while fly ash amended soils were alkaline in nature. The alkaline nature of fly ash amended soils may be due to the presence of CaO and MgO in fly ash. EC decreased with increase in flyash amendment ratio due to the precipitation of soluble cations by alkalinity of flyash in fly ash amended soil. Organic matter and organic carbon were found decreased with increase in flyash ratio.

The level of different heavy metals in fly ash and control soil was presented in table2. The analysis of result showed the significantly higher level of all the heavy metals (Cr, Cd, Co, Mn, Ni, Cu, Pb) in fly ash than the control soil.

Table-1. Physico-Chemical Analysis of Control Soil, Flyash and Fly Ash Contaminated Soil

S. No.	Physical Parameter	Soil	Flyash	Flyash Contaminated Soil (%)								
				10	20	30	40	50	60	70	80	90
1	**pH**	6.0	8.5	7.1	7.3	7.5	7.5	7.6	7.9	8.0	8.1	8.4
2	**EC**	750	320	690	650	620	580	530	480	400	340	320
3	**Organic Matter (%)**	3.8	3.0	2.8	2.8	2.9	2.7	2.7	2.7	2.7	2.8	2.9
4	**Organic Carbon (%)**	2.3	1.8	1.8	1.8	1.7	1.5	1.6	1.6	1.6	1.7	1.7

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Table-2
Level of Heavy Metals Concentration (Mg Kg-^{1} Dw) in Flyash and Soil

S.No	Parameters	Flyash	Soil
1	Cr	21.7	14.3
2	Cd	1.87	1.35
3	Co	3.86	2.08
4	Mn	104.96	3.07
5	Ni	15	3.49
6	Cu	10.817	3.0
7	Pb	1.67	1.05

The flyash amended soil showed the significant increase in the growth parameters such shoot length, plant height, plant biomass (wet & dry) upto 20% flyash amendment in comparison to control soil. But the root lengh was found constant upto 20% flyash amendment. After 20% flyash amendments all flyash amended soil showed significant reduction in all the growth parameters in comparison to control soil (Table-3). The reduction in all the growth parameters clearly indicated that fly ash amendment has caused heavy metal stress in the soil environment. The fly ash contaminated soil was amended with 10 gm of farm yard manure and result analysis revealed a slight increase in all growth parameters in all fly ash contaminated soils (Table-4).

Table-3 Effects of Flyash Amendments on Growth Parameters of *Tagetes Patula*(African Double Mix)

S. No.	Plant Growth Parameters	Control Soil	Flyash	Flyash Amendments (%)								
				10	20	30	40	50	60	70	80	90
1	**Root length(cm)**	15	7	15	15	11	10	10	9	8	7.3	7.2
2	**Shoot length(cm)**	60	25	63	62	56	45	40	38	32	29	28
3	**Plant height(cm)**	75	31.5	79	78	66	55	50	47	40	37	36
4	**Wet biomass(gm)**	65	30.1	70	70	50	45	43	40	36	32	32
5	**Dry biomass(gm)**	29	14.5	30	29	21	19	17	16	15.5	15.1	15

Table-4Effects of Farmyard Manure Amendments on Growth Parameters of *Tagetes Patula* (African Double Mix): Each Pot is Amended with 10 Gm of Farm Yard Manure

S. No.	Plant Growth Parameters	Control Soil	Flyash	Flyash Amendments (%)								
				10	20	30	40	50	60	70	80	90
1	**Root length(cm)**	15	7	15	15	13	11	10	9.5	8	7.5	7.2
2	**Shoot length(cm)**	62	25.5	65	62.5	59	48	42	39	33	30	28.2
3	**Plant height(cm)**	77	32.0	81	78	72	59	52	48	41	37	36
4	**Wet biomass(gm)**	74	31.0	82	72	60	51	45	43	38	34	33
5	**Dry biomass(gm)**	31	14.7	33	30	24	20	18	17	16	15.6	15

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4. CONCLUSION

The present study revealed that the fly ash could be beneficial in improving the soil quality and plant growth. The most suitable treatment for improving the growth of African double mix variety of the Tagetes *patula* plant is 10%, fly ash with soil as it gives the maximum growth but the growth was found with significant improvement upto 30% flyash amendment with soil. This plant survive in all the fly ash amendments which indicates that the double mix variety of the Tagetes *patula* can tolerate heavy metal pollution and can be used as an ideal plant for ash mound reclamation.

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