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Performance of Vegetable Plants Grown in Fly Ash Amended Soil

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ABSTRACT: Fly ash can be used for reclaiming the problem of soil and enhance the vegetable productivity depending upon the nature of soil and fly ash. Fly ash from Chachai thermal power plant in Anuppur district is used to amend soil. The physical, chemical and biological properties of problem soil when mixed with fly ash can improved and enhance the available micro and macro nutrients for vegetable plants. It has been registered that fly ash contains high concentration of macro nutrients like Ca, Mg, K, P and S, and hence vegetable plants shows a better performance in terms of germination, growth in root and shoot length, height of plants, fresh and dry weight and yield (in terms of seed and fruit weight per plant). The higher amount of fly ash can accumulate micro macro elements up to toxic level and hence reduction in root and shoot length of plants, fresh and dry weight and yield occurs.

Keywords: Fly ash; macro nutrients-calcium, magnesium, potassium, phosphorus and sulphur; Micro nutrients- root and shoot length; fruits and seeds yields.

INTRODUCTION: Indian thermal power plants produce near 180 million tons of fly ash every year, which is expected to reach 300 million tons since the end of 2016.Many scientists have been observed that the disposal and dumping of fly ash becomes the most notable pollutants of soil and ground water. Therefore it is not only concerned agricultural uses of land Area but also its risk to human society and ecosystems. (Rayalu et al. 2001, Gupta A. K. 2001, Kumar et al. 2003,Pandey et al 2009, Agarwal et al. 2011). Fly ash is a heterogeneous mixture of crystalline and amorphous phases and is considered to be Ferro alumino silicate elements (Mogazi, D. Lisk & D. J. Weinstein 1988 and Mattigold S. V. & Anisworth.C.C.1990).

Fly ash is formed by glossy particles ranging in size from 0.01 to 100 µm that are combustion byproduct of coal (Davison et al. 1979). It is also notable that the physical and chemical features of the fly ash generally depend on the nature of coal being processed in coal based thermal power plants.

It has been documented that the physical and chemical properties of fly ash produced by different power plants varied from each other significantly. Some workers have recorded the magnitudes of P and Al contents in fly ash in various small ranges to be little or negligible. Besides its major components are represented by the compounds of Al, Fe, and Si, however the smaller concentration of Ca, Na, K, P, S and Ti were also documented to vary notable in fly ash (Pathak et al. 1996, Kalra et al. 1999 and Nidhi Jamwal 2003). Adriano et al (1980) have reported that at certain occasion the fly ash amended soil may cause deficiency of Phosphorus, because it usually converts in to insoluble complexes binding with available Fe and Al in certain acidic fly ash. Page et al. (1970), Lau and Wong (2001) have highlighted the notable increase in soluble Ca, Mg and B contents after the addition of fresh un weather fly ash with natural soil. Adriano et al. (1980) has further explained that the leached fly ash coming from surface rain water may be significantly useful in lowering the B content in such agricultural lands. Mishra et al. (1997) and Banerjee (1998) have also suggested that the amendment of weathered fly ash with soil is more suitable to improve organic productivity of growing crops. Kabata Pandias and Adriano (1995), Kishku et al. (2000) have studied the growth rate in certain plant species by altering the concentration of arsenic by using fly ash.

Fly ash has a vast potential for use in reclamation of degraded land. It has been regis-

tered that the application of fly ash into agricultural soil can change soil texture and improves the availability of soil water, air and nutrients by increasing porosity, water holding capacity, electrical conductivity, work ability root penetration, moisture retention capacity and decreasing bulk density and surface encrustation. Soil pH is also affected by fly ash use and thus it may be used to reclaim both alkaline as well as acidic soils.

MATERIAL AND METHODS:

Study Area: Fresh fly ash samples were collected from Chachai Thermal Plant, which is located in the district Anuppur, M. P. Anuppur district is situated between $22^0$38'-24^0 45'north latitude and $80^0$30'-$82^0$12'east latitude forming the southern part of Vindhya region of M.P. The area of this large district is situated between the south Vindhyachal and north of Maikal mountain ranges. It consists of mainly the wide ranges of plateau and hills with an average height of about 1500 ft. from the mean sea level. There are two important mountain ranges Kaimpur and Khainjna in the north and Maikal and Amarkantak in the south-west.

Soil samples were collected from five sampling native sites covering North, South, East, West and Central zone areas of Chachai Thermal power Plant in plastic bags and brought to the laboratory (named as A,B,C,D and E respectively for convenience).

The fly ash and soil samples are dried for three days and passed through 2 mm sieve before making 10, 20, 40, 60, 80 and 100 % amendments of soil. Physical chemical analysis is carried out in triplicate set of soil and different % of amendments made with fly ash before the further studies.

Healthy seeds of Wheat (Triticum aestvum), Onion (Allium cepa), Mustard (Brassica nigra), Barley (Hordeum vulgare) and Barbati (Vigna sinensis) were taken for germination in experimental soil samples containing different % of fly ash and in natural named as control soil. All the seeds were sterilized with 0.1% $HgCl_2$ with pure water and soaked in water for 5 hours. The soaked seeds were shown in pots filled with prepared amendment soil e.g. 10%, 20%, 40%, 60%, 80% and 100% and control one. The pots were irrigated with water at regular interval. The numbers of seed germinated and root and shoot length of seedlings in experimental pots are noted and presented in the Tables 3 and 4 respectively.

RESULTS AND DISCUSSION: On observing the different sets of fly ash amended soil, the changes occur in various physical and chemical properties like moisture content, water holding capacity, sp. gravity, bulk density, specific (sp.) Conductivity, organic carbon, Ca, Mg and Fe contents. The results indicate that the moisture contents of experimental soil were found to be higher in all the sets in compare to control one. Percentage of moisture, water holding capacity, sp. gravity, sp. conductivity, organic carbon and Mg has registered in an increasing order up to 60% concentration as compare to control and then it declined up to 100% concentration. The values of bulk density were recorded with a gradual decrease from 10 to 100% concentration as compared to control. The pH of control set soil was noted 6.7, where as in experimental sets the pH values were documented in a range of 7.1 to 8.7. The quantitative changes in Ca and Fe were noted in every experimental set and control set.

The present experiments have revealed the facts that soil containing 10 to 20% of fly ash favored the process of seed germination and growth of seedlings of all the considered plant species. More over the rate of seed germination increased gradually with the increase of fly ash from 10 to 20% of all sets. Besides this the increasing trend of seed germination was recorded with the increase of fly ash 10 to 40% in experimental sets for the seeds of Hv. It is evident from the data presented in the table 3 that the seeds of all selected plant species have shown a decline trend with the increase of fly ash from 40 to 100%. The maximum decline in seed germination was recorded in all sets containing 100% of fly ash. Therefore a positive relation of seed germination with increasing fly ash only from its 10 to 20% except the Hv most of the sets containing more than 20% of fly ash had shown a negative relationship with the rate of seed germination of all the selected plant species.

It has been noticed that the root and shoot length of Ta, Ac, Bn and Vs were found to increase regularly with the increase of fly ash up to 40% in a range of 4.89-6.32, 2.12-

3.25, 1.61-3.21 and 2.6-3.44 in case of root length and 8.92-10.23, 5.14-6.42, 6.02-6.49 and 6.97-8.78 in case of shoot length, while in 60 to 100% of fly ash it declined gradually for all experimental sets except Hv which declined from 80% to 100% of fly ash. In case of Hv it has been recorded that root and shoot length was found to increase regularly with the increase of fly ash up to 60% in a range of 4.7-2.6 and 8.18-5.12 respectively.

Table 1: The mean values of certain physical and chemical parameters of soil samples.

S. No.	Parameters/Sample Code	A	B	C	D	E	Mean
1.	Coarsed Sand %	0.39	0.48	0.45	0.37	0.25	0.388
2.	Fine sand %	40.8	35.9	44.6	42.4	45.0	42.34
3.	Silt %	15.0	12.4	9.8	7.9	6.5	10.32
4.	Clay %	16.6	17.4	19.3	12.5	15.6	16.28
5.	OM %	0.76	0.69	0.38	0.52	0.71	0.612
6.	WHC %	35.00	40.00	41.00	37.00	44.00	39.4
7.	Moisture %	0.73	1.25	0.98	0.69	0.55	0.84
8.	pH	6.7	7.0	5.2	6.1	6.4	6.34
9.	SP. Conductivity at 30^0C	20.4	21.6	20.8	22.2	21.6	21.32
10.	SP. Gravity gm./cm^3	1.29	1.32	1.25	1.51	1.46	1.366
11.	Bulk Density gm./cm^3	1.66	1.39	1.28	1.24	1.11	1.36
12.	$CaCO_3$ %	3.46	3.15	4.42	2.98	2.31	3.264
	Soluble Salts						
13.	Na %	0.24	0.22	0.26	0.16	0.19	0.214
14.	K %	0.23	0.21	0.29	0.33	0.31	0.274
15.	Ca %	3.23	3.85	1.86	3.3	2.34	2.916
16.	Mg %	1.76	2.19	1.68	0.86	1.81	1.66
17.	Nitrate Nitrogen	.0016	.0019	.0014	.0017	.0011	.0015
18.	Total Carbon	.48	.45	.59	.51	.38	0.482
19.	Total Nitrogen	.22	.23	.13	.15	.11	0.168
20.	Total Phosphorus	.65	.61	.55	.59	.51	0.582
21.	Total Iron	6.61	6.16	6.23	6.19	5.88	6.214

Table 2: The Quantitative Value of Certain Physical and Chemical Parameters of Fly Ash Amended Soil.

S. No.	Parameters/% Amended Soil	Control	10%	20%	40%	60%	80%	100%
1.	Moisture %	1.24	1.4	2.6	3.5	4.1	3.9	3.4
2.	WHC %	43.67	44.4	46.2	47.6	48.8	49.5	50.9
3.	SP. Gravity gm./cm^3	1.23	1.25	1.29	1.31	1.35	1.28	1.12
4.	Bulk Density gm./cm^3	1.27	1.26	1.24	1.22	1.20	1.13	1.07
5.	pH	6.7	7.1	7.2	7.4	7.6	8.2	8.7
6.	SP. Conductivity Mhos/cm	21.32	23.5	24.8	26.1	26.9	27.5	28.1
7.	Organic Carbon	1.21	1.25	1.31	1.33	1.39	0.81	0.12
8.	Ca	3.85	5.71	6.13	6.42	4.18	2.25	1.37
9.	Mg	1.76	2.2	2.4	2.7	3.1	1.90	1.82
10.	Fe	6.61	6.72	6.98	6.02	5.73	4.31	4.02

Table 3: Average Percentage of Seed Germination.

S. No.	% of Fly Ash	Ta	Ac	Bn	Hv	Vs
1.	Control	68.66	62.00	59.66	62.00	52.66
2.	10	73.33	70.66	71.00	73.00	66.33
3.	20	84.00	77.33	77.33	79.66	73.00
4.	40	71.00	59.66	48.33	79.66	46.33
5.	60	50.66	40.00	42.00	35.33	35.33
6.	80	42.00	30.66	30.66	28.33	28.33
7.	100	35.33	24.00	22.00	24.00	24.00

Table 4: Average Root and Shoot Length of Seedlings.

S.No.	% of Fly Ash	Ta		Ac		Bn		Hv		Vs	
		In cm									
		Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
1.	Control	4.22	8.86	1.98	4.82	1.54	5.69	2.3	4.02	2.3	6.11
2.	10	4.89	8.92	2.12	5.14	1.61	6.02	2.6	5.12	2.6	6.97
3.	20	5.12	9.95	2.93	6.32	1.72	6.18	3.1	6.23	3.13	8.12
4.	40	6.32	10.23	3.25	6.42	3.21	6.49	4.5	6.83	3.44	8.78
5.	60	6.14	9.89	2.41	2.75	2.81	4.81	4.7	8.18	2.92	5.8
6.	80	4.43	9.08	2.11	2.46	2.13	4.22	2.5	3.7	2.43	2.8
7.	100	3.75	6.45	1.53	1.12	1.31	2.11	2.1	2.6	2.14	2.1

CONCLUSION: Fly ash is a waste product of Thermal Power Plant and it can change the soil's physical and chemical properties. The economical condition of local inhabitants (near Thermal power plant) can be improved by the use of Fly ash, because it provides suitable conditions and essential nutrients to enhance the plant growth resulting major production of crops and vegetables.

Aitkin et al. (1984) and Kalra et al. (2003) have been reported that application of 5 to 10 t/ha/yr. has modified the soil health, quality of crops produce, up take of nutrients and toxic heavy metals, ground water quality etc. All the essential plants nutrients are available in Fly ash (Druzina et al. 1983) and its addition to soil enriches the macro and micro nutrients which have favorable effect on crop productivity (Martine and Beahm 1987). Amendment of Fly ash to soil also neutralizes soil acidity and increase ion exchange capacity, WHC and pore size (Elsuoi et al. 1981).

Singh N. B. and M. Singh (1986) have also confirmed that on applying Fly ash to soil in a low range, the significant increase in electrical conductivity due to increase in cations and anions. The improvement in the plant growth and yield have also been observed on several vegetable, pulses, cereals and other crops with fly ash amended soil (Wong and Wong 1989, Singh 1989, Mishra and Shukla 1986, Singh and Khan 1994, Khan et al. 1997, Rai ,Gupta and Pal 2003).

It may be suggested that the maximum degree of seed germination with rapid growth of seedlings may be obtained at certain optimum pH. The value of pH developed at various magnitudes in experimental soil might be occurred due to availability of high level cations, anions and other dissolved inorganic components of fly ash (Shrivastava and Sahai 1986, Raja ram et al. 1988, Elcey and Tiwari 1991, Patel and Kumar 1991).

The prevention and retardation in experimental plants is more than 40% level of fly ash might have been occurred due to high increase in pH values and greater development of alkalinity in soil medium. The same findings have also been reported by Adriano (1980), Kalra and Joshi (1997), Rai et al. (2004) and Pasha et al. (1990) observed that amendment of soil with fly ash up to 40% improves plant growth, yield, and chlorophyll contents of cucumber. Singh et al. (1984) reported that Soyabean plant grown in 25% and 50% fly ash showed significant improvement in plant growth, yield, leaf pigment, protein and oil content of seeds. The similar observations have been reported by Singh (1989), Khan (1989), Kumar, Kishor and Ghosh (2010) Shemdoe (2010) Ansari,Gupta, Yunus (2011) Singh, Pandey and Singh (2011) Singh, Prasad, Pal, Tiwari and Sinha (2011).

Further increase in fly ash levels from 40% onwards caused decline in yield and plant growth and other parameters. Fly ash contains very low percentage of Nitrogen (Wong and Wong 1986 & 1989).

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