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Seasonal Variations in the Growth and Yield of Chilli Plants in Fly Ash Amended Soil

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Abstract : *The present project work is based on the evidences which prove that fly ash is a good soil nutrient modifier. The research work was carried out to see the visible changes in the growth and yield of chilli plants(Capsicum annuum) in summer and rainy seasons from May to September, 2018 in different soil-fly amendments. Observations of shoot length, root length, number of leaves, germination rate, leaf surface area, fresh weight, dry weight, moisture content and foliar pigments prove that amendments of 10% and 15% fly ash applications are potentially favorable for plant growth and its yield. Hence, it can be used in agriculture.*

Keywords: *Capsicum annuum, fly ash, foliar pigments, nutrient modifier, moisture content.*

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Introduction:

A developing country like India comes with a highly impactful and wide-spread coal-based economy. Coal-based thermal power plants produce large quantities of combustion residues. The solid waste residue includes bottom ash, slag and fly ash. Fly ash is that portion of the residue that has sufficiently small and enough particle size to be carried away from the boiler in the fuel gas. Fly ash accounts for approximately seventy percent of the solid waste produced from coal combustion. Every year 85 million tonnes of fly ash is produced by 82 thermal power stations operating in the country. Fly ash is a serious problem due to its physical characteristics and sheer volumes generated. The impact of coal residue on health and environmental consequences has been reviewed extensively.

Europe is reusing 40-50% of their coal fly ash (Adriano et.al., 1980) and Japan is reusing 60%(Wong and Wong, 1989), whereas the United States has consistently reused only 20-30% (Chang et.al., 1977; Theis and Gardner 1990). Although many fly ash reutilization projects have given positive results, most are still perceived as experimental primarily due to the environmental

implications. A thorough knowledge of the physical characteristics, chemical composition and properties is essential to understand any possible environmental impacts. Once the impacts can be confidently predicted, a larger market can be encouraged to reuse fly ash.

From extensive studies carried out by various research and development agencies on varied agro-climatic conditions and soil crop combinations with broad objectives of building confidence towards safe disposal and scientific utilization of fly ash, it has been shown that fly ash has a vast potential for use in agriculture (Singh 1989).For agricultural related studies a large number of demonstrative trials executed by different technological institutes and laboratories at various sites in dispersed locations across the country under varied agro-climatic conditions on a spread of crop forestry and horticulture species had brought into focus fly ash as an important resource material (Furr and Parkinson, 1977; Cervelli et.al. 1987; Jacobs et.al. 1991; Schutter and Fuhrmann, 1999; Jha et.al. 2000; Dhankhar and Sushma, 2003).

Several research investigations with fly ash have proven to increase the crop yield of *Triticumaestivum*, *Medicago sativa*, *Hordeumvulgare*, *Cynodondactylon*, *Eulaliopsis binate*, *Vignaunguiculata* and *Trifoliumrepens* (Basu et.al. 2006; Thetwar et.al. 2007; Karmakar et.al. 2010). Fly ash amendment of soil resulted in improved seed germination rate in *Triticumaestivum*, *Vigna radiate* and *Vignamungo* (Mahale et.al. 2012). The growth of brinjal plant was better in fly ash amendments (Gond et.al. 2013). Amendments of fly ash in soil using *Allium cepa* species increased root number, root length and leaf number (Swamy et.al. 2010).

In view of the above facts, a study was designed to record the growth and yield of chilli plants (*Capsicum annuum*) with several soil-fly ash amendments under different agro-climatic conditions.

Materials and Methods:

Garden soil of Kankarbagh area of Patna was taken in use and the experiment was carried out in the same over the time interval of May-September of the year 2018. Fly ash was collected from Synergy Ecotech Pvt. Ltd., Fatuha which receives fly ash from Kanti Thermal Power Station, Muzaffarpur. The physio-chemical characteristics of the soil and fly ash samples, of 500gms each, were determined in the Central Soil Testing Laboratory, Mithapur, Patna. The differences in the nutrient content, pH, electrical conductivity, organic carbon, nitrogen and phosphate was noted. Several homogeneous soil-fly ash amendments were prepared at the start of summer (S) and rainy (R) season (0%, 5%, 10%,15% and 20% designated as S-0; S-5; S-10; S-15 and S-20 respectively for summer season and similarly R-0, R-5, R-10, R-15 and R-20 for rainy season) and were kept in five different earthen flower pots. S-0 and R-0 being the control setups with 0% fly ash amendments. Physio-chemical analyses were also done for the amendments before sowing and after sowing chilli seeds. Summer season readings were recorded from 15th of May to 15th of July, 2018 and the rainy season readings were recorded from 15th of July to 15th of September, 2018. Observations were taken at the interval of 15 days for a particular season. Germination rate, shoot length and number of leaves were carefully observed and recorded.

At the end of each season analysis of leaf surface area, root length, fresh weight, dry weight, moisture content and content of foliar pigments were done. Leaf surface area was calculated on

mm^2 graph paper. Root length was measured after plants were taken out from the soil after the marked soil level. Digital balance was used for the immediate fresh weight determination of the plants. For dry weight analysis, plants were oven-dried at 100°F overnight and weighed on analytical balance (Landolt and Kandeler, 1987). Moisture content was calculated by taking differences of the fresh and dry weight. Fresh leaves measuring 0.5gms were taken out from each pot and homogenized in 80% acetone. Thesamples were centrifuged at 10,000 rpm for 900 seconds at 25.7^{0}C. The supernatant liquid was carefully transferred into separate test-tubes. It was then used in the determination of foliar pigments by UV – Visible spectrophotometer (Lichtenthaler and Wellburn, 1983).

Results and Discussion:

The chemical analyses of soil and fly ash shows an abrupt increase in the nitrogen content in the soil sample than in fly ash. However, fly ash records show a much constant and limited nutrient content. The garden soil collected was more alkaline in nature and also had higher electrical conductivity. The phosphate content for soil was greater whereas fly ash had more organic carbon content which may be due to the presence of coal dust (Table 1, Table 2, 3 and Table 8, 9). In the present study, it was observed that amendments had almost constant nutrient content which increased with increasing percentage of fly ash. This may be due to the fact that fly ash acts as a soil conditioner. Fly ash shows visible improvement in the chemical characteristics of the soil.

The results of bio-efficacy studies showed that soil - fly ash amendments enhanced the shoot length (Table 4, Table 10), number of leaves (Table 5, Table 11), germination rate (Table 6, Table 12), leaf surface area (Table 6, Table 12), plant biomass (fresh and dry weight), moisture content (Table 6, Table 12), foliar pigment contents (Table 7, Table 13) and root length (Table 14) parameters. Similar effects have been reported by earlier workers (Varma and Schuepp, 1995; Juwarkar and Jambhulkar, 2008; Thenmuzhi et.al, 2010). This indicates that the nutrients present in fly ash were supportive to the growth and yield of plants.

Stimulation in plant growth at lower applications of fly ash clearly indicates the easy availability of essential nutrients present in fly ash to the plants to which the plants reacted positively showing enhanced germination and other growth parameters at subsequent stages (Singh et. al., 1997). The increase in germination percentage may also be due to the reason that fly ash applications provide aeration to the soil.

Excessive uptake of elements or their subsequent application in the soil and plants may have accounted for the reduced and stunted growth of plants at higher concentrations of fly ash application. The similar results were observed in other plants also under the influence of fly ash (Ajaz and Tiyagi, 2003; Ajaz et.al. 2004).

Enhanced biomass shows the positive effect of fly ash applications and the increased moisture content also reveals that plants were healthy and had proper vascular conductivity which may be due to decreased electrical conductivity or soil salinity (Patriquin et.al.1993). The increase in foliar pigment contents shows that fly ash must have resulted in improved photosynthetic activity of the plants.

Conclusion:

The present study shows that fly ash is a good soil nutrient modifier which is advantageous to plant growth at certain levels of application. Appropriate soil – fly ash combinations stimulate the microbial activity which provides balance of soil

nutrients as in case of nitrogen, phosphate, organic carbon and also reduces the level of electrical conductivity which ultimately resulted in better yield and growth of chilli plants.

The growth of chilli plants gave more positive response to lower concentrations of fly ash applications, here 10% and 15%. In summer season 10% amendment gave better results while in rainy season 15% amendments was favorable.

At lower concentrations fly ash can be used as a soil fertilizer or nutritional supplement. Higher concentrations may prove potentially harmful to the growth and production of crops. Hence, fly ash can be a plus point in agriculture economy but only at limited levels.

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Table 1. Chemical analysis of soil and fly ash

Parameters	Unit	Soil	Fly Ash
pH	–	8.16	7.5
Electrical conductivity	dsm^{-1}	2.21	0.56
Organic Carbon	%	0.91	1.5
Nitrogen	Kg/ha	395	8.78
Phosphate	Kg/ha	16	5.9

Values are mean of 3 replicates.

Table 2. Showing nutrient content of soil amendments taken before the start of summer season

Parameters	S-0	S-5	S-10	S-15	S-20
pH	8.16	8.04	8.25	8.27	8.21
Electrical conductivity (EC : dsm^{-1})	2.21	1.52	1.59	1.68	1.6
Organic carbon (OC : %)	0.91	0.61	0.53	0.54	0.63
Nitrogen (N : $kgha^{-1}$)	395	299	273	277	306
Phosphate (P_2O_5 : $kgha^{-1}$)	16	42	27	71	45

Values are mean of 3 replicates.

Table 3. Showing nutrient content of soil amendments taken at the end of summer season

Parameters	S-0	S-5	S-10	S-15	S-20
pH	8.49	8.36	8.5	8.47	8.5
Electrical conductivity (EC : dsm^{-1})	0.425	0.562	0.496	0.425	0.399
Organiccarbon (OC : %)	0.69	0.59	0.6	0.8	0.82
Nitrogen (N : $kgha^{-1}$)	325	293	296	360	367
Phosphate (P_2O_5 : $kgha^{-1}$)	28	28	14	15	25

Values are mean of 3 replicates.

Table 4. Average shoot length variations (in cms) for summer season

Amendments	15 days	30 days	45 days	60 days
S – 0	–	2.0	2.3	2.7
S – 5	–	0.6	2.0	2.5
S – 10	–	2.0	3.0	3.8
S – 15	–	–	2.5	2.6
S – 20	–	0.7	1.1	1.6

Values are mean of 3 replicates.

Table 5. Average number of leaves for summer season

Amendments	15 days	30 days	45 days	60 days
S – 0	–	3.0	4.0	15.0
S – 5	–	3.5	4.0	16.0
S – 10	–	3.33	4.0	19.0
S – 15	–	–	5.0	15.0
S - 20	–	3.5	6.0	16.0

Values are mean of 3 replicates.

Table 6. Variations in several other morphological parameters after the total summer time duration

Amendments	Total germination	Leaf surface area	Fresh weight (in gms)	Dry weight (in gms)	Moisture content
S – 0	8	100.00	0.294	0.0608	0.2332
S – 5	8	66.66	0.217	0.0443	0.1727
S – 10	7	91.66	0.909	0.1511	0.7579
S – 15	8	150.00	0.900	0.2596	0.6404
S - 20	6	133.33	0.486	0.0676	0.4184

Values are mean of 3 replicates.

Table 7. Showing foliar contents for the samples of summer season

Amendments	Chlorophyll–a	Chlorophyll–b	Carotenoids
S – 0	-126.043	6.1887	2.87778326
S – 5	-62.4655	2.9102	1.93935661
S – 10	-248.2425	11.7238	11.9212424
S – 15	-358.459	17.6654	9.79534985
S - 20	-196.9695	9.1192	6.26024096

Values are mean of 3 replicates.

Table 8. Showing nutrient content of soil amendments taken before the start of rainy season.

Parameters	R - 0	R - 5	R - 10	R - 15	R - 20
pH	8.16	8.04	8.25	8.27	8.21
Electrical conductivity (EC : dsm^{-1})	2.21	1.52	1.59	1.68	1.6
Organic carbon (OC : %)	0.91	0.61	0.53	0.54	0.63
Nitrogen (N : $kgha^{-1}$)	395	299	273	277	306
Phosphate (P_2O_5 : $kgha^{-1}$)	16	42	27	71	45

Values are mean of 3 replicates.

Table 9. Showing nutrient content of soil amendments taken at the end of rainy season.

Parameters	R - 0	R - 5	R - 10	R - 15	R - 20
pH	8.59	8.57	8.61	8.64	8.62
Electrical conductivity (EC : dsm^{-1})	0.221	0.210	0.184	0.178	0.179
Organic carbon (OC : %)	0.285	0.30	0.285	0.315	0.30
Nitrogen (N : $kgha^{-1}$)	194.78	199.6	194.78	204.42	199.6
Phosphate (P_2O_5 : $kgha^{-1}$)	48	28	49	54	39

Values are mean of 3 replicates.

Table 10. Average shoot length variations (in cms) at the end of rainy season.

Amendments	15 days	30 days	45 days	60 days
R – 0	2.1	4.0	4.5	5.2
R – 5	1.9	3.1	4.1	5.6
R– 10	2.3	3.8	4.0	5.5
R – 15	1.9	2.5	3.6	5.6
R - 20	2.0	3.5	4.0	5.5

Values are mean of 3 replicates.

Table 11. Average number of leaves at the end of rainy season.

Amendments	15 days	30 days	45 days	60 days
R–0	5	15	30	34
R–5	2	19	25	30
R–10	4	12	28	40
R–15	2	18	32	42
R–20	4	16	26	36

Values are mean of 3 replicates.

Table 12. Variations in several other morphological parameters after the total rainy season time duration

Amendments	Total germi-nation	Leaf surface area	Fresh weight (in gms)	Dry weight (in gms)	Moisture content
R–0	16	55	0.151	0.0098	0.1412
R–5	15	45	0.136	0.0060	0.1300
R–10	18	70	0.169	0.0106	0.1584
R–15	19	75	0.172	0.0166	0.1554
R–20	15	60	0.184	0.0111	0.1729

Values are mean of 3 replicates.

Table 13. Showing foliar contents for the samples of rainy season

Amendments	Chlorophyll–a	Chlorophyll–b	Carotenoids
R–0	-281.87475	13.7046	7.91394318
R–5	-349.4155	17.5919	17.2522031
R–10	-430.3945	22.4358	6.78037838
R–15	-312.36175	15.3225	8.8320552
R–20	-376.68375	18.8163	9.70834086

Values are mean of 3 replicates.

Table 14. Comparative Root length variations at the end of experiment

Amendments	Summer season (S)	Rainy season (R)
0%	5.8	5.0
5%	5.3	8.0
10%	8.5	5.5
15%	9.5	10.5
20%	6.2	4.0

Values are mean of 3 replicates.

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