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IMPACT OF COAL ASH ON GROWTH, YIELD, BIOMASS AND NODULATION OF LENTIL (*LENS CULINARIS*)

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ABSTRACT

A green house experiment was conducted to study the effect of various coal ash concentrations (0%, 5%, 10%, 25%, 50%, 70% and 100% v/v) with normal field soil on growth, yield, biomass and nodulation of lentil. Application of 5%, 10% and 25% coal ash with soil caused a significant increase in plant growth, yield and biomass and nodulation of lentil. 25% amendment caused a significantly higher increase compared to 5% and 10% due to availability of optimum amount of micronutrient for various physiological processes. Deleterious effect as observed at higher concentration, the maximum being with 100% coal ash. High level of heavy metals in coal ash is harmful to plants due to their toxic concentrations. At low concentration, heavy metals are better for plant growth, yield and biomass.

INTRODUCTION

Disposal of coal ash by thermal power plant in low lying areas is a serious environmental problem. Between 85-95% of the ash is generated in the form of bottom ash, the remaining 5-15% goes to stack is trapped in the precipitators, if fitted. However, a considerable amount (10-15%) escapes from the stack and is subsequently deposited over a large area falling on soil and aerial parts of the plants (Khan and Khan, 1996). A large amount of research has already been done in India and abroad on the yield of agricultural crops using coal ash but presence of heavy toxic/trace elements in it, has been a cause of concern (Ciravolo and Adriano, 1979). Use of coal ash in proper doses in agriculture may minimize the problem of its disposal. Legume is an important winter crop which provides pulse, an important source of protein. Legumes are chosen as they also contribute to increase in soil fertility, growth for the other crops of biological nitrogen fixation by them.

The process of biological nitrogen fixation by symbiotic bacteria in leguminous crops is of immense importance both from economic point of view. The symbiotic relationship results in the formation of wart like outgrowths on host roots and are called 'nodules'. They are formed due to the production of root nodule forming exudates like amino acids, sugars and organic acids around the host root (Whipps, 1990). Lentil is an important pulse crop of winter season and it is grown under rain-fed conditions in India (Faizan, 2002).

MATERIALS AND METHODS

The coal ash used in this study was procured from

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Harduaganj power plant situated about 15 km away in the north east of Aligarh Muslim University. A total of seven treatments of coal ash and soil in pots were given (0, 5, 10, 25, 50, 75 and 100% v/v coal ash and soil respectively). Surface sterilized seeds of lentil with carrier inoculants of Rhizobium sp. were sowed and watered after 90 days. Root and shoot dry weight is taken and they are added to get the biomass of plant and yield is calculated by weighing weight of 100 seeds. Nodules were plucked and counted. Functional nodules were recognized by their pink color. Over dried nodules were weighed. Analysis of heavy metals in coal ash was done by the method of Lindsey and Norwell (1978) while the analysis of heavy metals in seeds was done by standard procedures (Jackson, 1977). The data were analyzed using single factorial analysis (Dospekhov, 1984). LSD were calculated at P=0.05. Duncan's multiple range tests was employed to denote the differences between treatments.

RESULTS AND DISCUSSION

1. Characterization of coal ash and total metal concentration

The results obtained during the course of present investigation are given in Table 1. The coal ash was found to have an alkaline pH (8.8-9.0) due to low sulphur content of coal. Electrical conductivity (EC) of coal ash was 8.8 ds m^{-1} indicating the presence of soluble cations and anions (Elseewi *et al*. 1978). The carbon content, organic carbon and nitrogen content were found to be 0.06%, 0.1% and 0.001% respectively. This indicates that during combustion process carbon and nitrogen content were oxidized to their respective oxides (Adriano *et al*. 1980).

2. Nodulation, plant growth, yields and dry weight

Application of coal ash at 25% caused a significant increase in nodule number $plant^{-1}$, number of functional nodules $plant^{-1}$ and dry weight of the nodules. Increased nodulation at 255 coal ash content may be attributed to be due to uptake of optimum amount of metals by the plants (Table 2). Increased nodulation probably enhances the site of root infection for *Rhizobium* and hence leads to higher rate of biological nitrogen fixation (Singh, 1996). The symbiotic activity was reduced with increasing dose of coal ash as evidenced by less number of nodules in comparison to that of control, the ability of *Rhizobium* sp to fix nitrogen is reduced with increasing stress (Lal and Khanna, 1994). The depressive effect of heavy metals in coal ash is directly related to decline in biomass, length and yield of plant. All these parameters decreased in the presence of large amount of heavy metal in coal ash. Percent reduction in biomass and length of plant was observed in 100% coal ash amended soil in chickpea (Faizan and Khan, 2004). Plant growth, biomass and yield show their maximum peak at 25% coal ash amended soil (Fig. 1). Better nodulation at 25% coal ash content is observed because of availability of micronutrients for various physiological processes. So, coal ash is preferred in low concentration for the productivity of the plant. Use of coal ash in agriculture may reduce menace of ash and its disposal problems. Similar increase in growth of eggplant at lower fly ash amendment level has been recorded (Rizvi and Khan, 2009). The observed responses of the plants regarding their growth also supported by other workers like Srivastava et al., (1995) on *Lactuca sativa*; Krejsl *et al.* (1996) on bean; Tripathi and Sahu (1997) on wheat; Kalra *et al*. (1998) on wheat, chickpea, mustard and lentil; Bharti *et al*. (2000) on green gram; Yasmeen (2002) on *Lagenaria leucantha*; Pathan *et al*. (2003) on *Cynodon dactylon* (L.) Pers. Cv. Winter green; Parveen (2006) on Ocimum sanctum; Parveen *et al*. (2006) on Mentha citrate; Hisamuddin and Singh (2007) on *Pisum sativum.*

3. Heavy Metal intake

A general trend increase in heavy metal accumulation by seeds with increasing coal ash levels was observe in all, seeds were analyzed for the level of accumulation of nine metals. The metals may be arranged as follows in order of decreasing level in seeds at 25% coal ash level: Fe>Mn>Zn>Cu>Co>Cd>Pb>Cr>Ni.

As regards the relative uptake of these metals as indicated by percent increase over control at 25% level of coal ash may be arranged in decreasing order as follows:

Ni>Cr>Zn>Fe>Co>Pb>Cu>Mn>Cd.

An account of different metal concentration and their percent increase at 25% level of coal ash is given (Fig. 2). Toxicity produced by coal ash at high levels might be due to toxic high level of micronutrients and heavy metals. The presence of elevated level of heavy metal ion triggers a wide range of cellular responses including changes in gene expression and synthesis of metal detoxifying peptides.

CONCLUSION

Addition of coal ash from Harduaganj power plant

Table 1. Physico-chemical characteristics of fly ash amended soils

Characteristics	Percent fly ash (v/v)						
	0	5	10	25	50	75	100
Moisture (%)	2.45	2.32	2.01	1.94	1.82	1.72	1.19
Porosity (%)	30.20	33.25	34.40	38.10	52.40	70.50	76.50
Water holding capacity(%)	39.40	41.50	46.37	53.80	60.50	75.70	86.20
pH	7.20	7.30	7.40	7.80	8.0	8.50	8.80
Conductivity (dsm-1)	4.10	4.3	5.0	5.80	6.0	7.5	8.8
Bicarbonate (%)	0.25	0.28	0.59	0.79	1.28	2.17	2.56
Chloride (%)	0.256	0.132	0.315	0.519	0.791	1.29	1.85
Carbonate (%)	0.202	0.210	0.217	0.382	0.611	0.795	1.07
Soluble salt (%)	1.312	1.408	1.600	1.858	1.920	2.40	2.186
Organic carbon (%)	0.69	0.61	0.51	0.36	0.21	0.10	0.06
Organic matter (%)	1.18	1.05	0.87	0.60	0.36	0.17	0.10
Nitrogen (%)	0.149	0.170	0.151	0.048	0.031	0.027	0.001
Phosphorus (%)	0.102	0.112	0.125	0.212	8.0	8.50	8.80
Potassium (%)	0.31	0.42	0.43	0.58	0.65	0.70	0.85
Calcium (%)	0.15	0.21	0.26	0.38	0.58	0.72	1.06
Magnesium (%)	0.085	0.089	0.074	0.231	0.385	0.530	0.910
Cadmium (%)	0.28	0.95	1.20	2.01	2.14	3.12	4.28
Copper (%)	1.18	1.20	1.25	1.29	1.31	1.39	1.65
Zinc (%)	1.29	1.31	1.35	1.37	1.41	1.51	1.56
Manganese (%)	1.69	1.73	1.79	1.85	1.95	2.13	2.31
Cobalt (%)	3.20	3.31	3.41	3.50	3.51	3.57	3.6
Lead (%)	0.39	0.42	1.48	1.95	2.35	3.01	3.90
Chromium (%)	0.42	0.49	0.95	1.05	1.41	2.1	2.8
Nickel (%)	0.36	0.65	0.99	1.56	1.92	2.02	2.71
Iron (%)	5.8	5.9	6.1	6.2	6.3	6.32	6.5

Table 2. Impact of coal ash application in soil on nodulation in Lentil

Coal ash level in soil (%)	Nodule number plant^{-1}	Functional nodule number plant^{-1}	Dry weight of nodules plant^{-1}
0	6±3b	5±1c	0.0079±0.001d
5	8±2b (+33.33)	7±2b (+40.0)	0.0084±0.003c (+6.32)
10	8±2b (+33.33)	7±1b (+40.0)	0.011±0.001b (+39.24)
25	13±1a (+116.66)	12±3a (+140)	0.0148±0.003a (+17.73)
50	8±3b (+33.33)	6±2bc (+20.0)	0.0112±0.001b (+41.77)
75	7±1b (+16.66)	3±1d (-40.0)	0.0080±0.001c (-1.26)
100	7±2b (+16.66)	2±1d (-60.0)	0.0050±0.003c (-36.70)
LSD			
5%	4.91	1.90	0.0007

neutralizes soil acidity, can increase ion exchange capacity and pore size, which may be enhance plant growth and yield of the high toxicity of both essential and nonessential element (Woolhouse, 1983).

Maximum nodulation is at low level of coal ash because of the availability of optimum amount of micronutrient for various physiological processes. Toxicity produce coal ash at high level might be due to toxic high level of micronutrients and heavy metals so as it is preferable to use coal ash at low concentration for the productivity. Use of coal ash in agriculture may reduce the menace of ash and its utilization as an organic fertilizer.

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Fig. 1 Impact of coal ash on growth, biomass and yield of Lentil

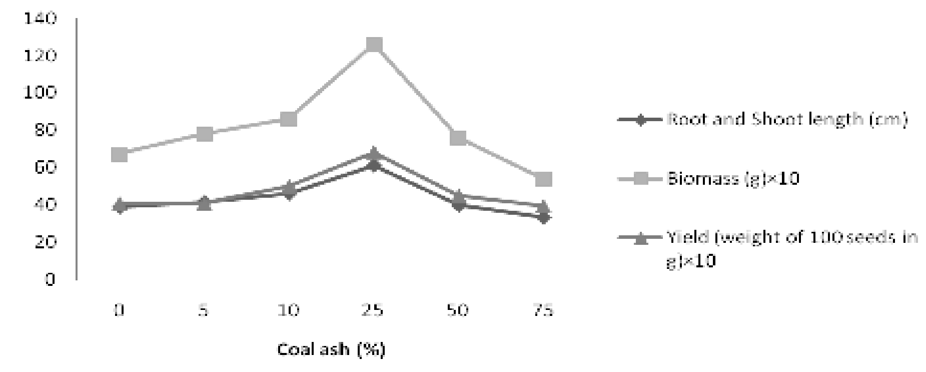
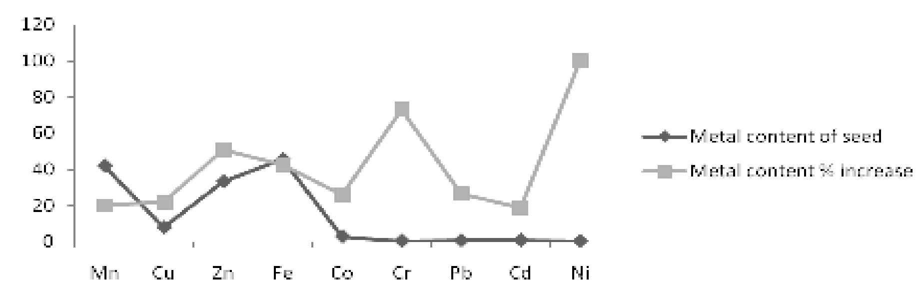


Fig. 2 Metal content (ppm) of lentil seeds and percent increase over control at 25% fly ash level



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