Amelioration of Acidic Soil by Fly Ash for Trace Elements Uptake and Better Crop Yield and Increased Protein Contents in Chick Pea (*Cicer arietinum*)

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The present paper deals with the study of pot experiments on acidic soil of Rehar Basin (major irrigation project) after mixing fly ash in different proportions for better crop yield of chick pea (*Cicer arietinum*).

Tropics are very diverse in both climate and soil resources. Pulses, like cow peas, pigeon peas, chick peas and beans are well known for their protein contents. Molybdenum is needed in the least amount of all the essential micronutrients. It is involved in several enzyme systems[1]. Its major role is in nitrogen fixation[2]. Molybdenum deficiency results in reduced chlorophyll concentration in leaves[3]. Increased use of 'N' fertilizer increases the need for Mo[4]. Zinc deficiency results in an overall reduction in photosynthetic efficiency and disrupted metabolism[5]. Mn helps splitting of water by photolysis in photosystem[6].

In the present experiment it was demonstrated that fly ash neutralises acidic soil, which is an optimum condition for trace elements uptake not only from soil but also from fly ash itself.

EXPERIMENTAL

Fly ash from NTPC Korba and soil from Rehar basin major irrigation project were collected. These were analysed separately for physico-chemical properties and are displayed in Table-1.

Soil and fly ash were mixed in different proportions and homogenised by grinding and sieving and filled in 5 kg pots as mentioned below:

(i) Control—Contained soil only.
(ii) Control + NPK (300 : 400 : 200 : mg)
(iii) Control 90% + Fly ash 10% + NPK (300 : 400 : 200 mg)
(iv) Control 80% + Fly ash 20% + NPK (300 : 400 : 200 mg)
(v) Control 70% + Fly ash 30% + NPK (300 : 400 : 200 mg)
(vi) Control 60% + Fly ash 40% + NPK (300 : 400 : 200 mg)
(vii) Control 50% + Fly ash 50% + NPK (300 : 400 : 200 mg)

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TABLE-1
CHEMICAL PROPERTIES OF FLY ASH AND ORIGINAL SOIL

S. No.	Compositions	Fly ash (%)	Original soil from Rehar Basin (%)
1.	SiO_2	62.10	78.99
2.	Al_2O_3	18.87	8.54
3.	Fe_2O_3	7.85	5.69
4.	P_2O_5	0.18	0.15
5.	SO_3	0.25	0.28
6.	CaO	1.38	1.20
7.	Alkalis by difference	1.45	0.98

For every combination (soil + fly ash) pH, conductivity and water holding capacity were determined by methods suggested by Hesse[7], and are presented in Table-2. Trace elements were analysed spectrophotometrically. Compounds estimations were done gravimetrically. 'N' was estimated by reported method[8] are shown in Table 3.

TABLE-2
PROPERTIES OF DIFFERENT COMBINATIONS

S. No.	Fly ash, soil and their different combinations	pH	Electrical conductivity (in m-mhos/cm.)	Water holding capacity (in %)
1.	Fly ash	8,81	0.217	2.60
2.	Soil	6.54	0.082	1.70
3.	Soil + NPK	6.55	0.091	1.75
4.	90% soil + 10% fly ash + NPK	6.58	0.106	1.82
5.	80% soil + 20% fly ash + NPK	6.62	0.118	1.90
6.	70% soil + 30% fly ash + NPK	7.32	0.131	1.99
7.	60% soil + 40% fly ash + NPK	7.35	0.154	2.05
8.	50% soil + 50% fly ash + NPK	7.39	0.191	2.17

TABLE-3 (a)
CONCENTRATION OF COMPOUNDS IN FLY ASH, SOIL AND THEIR DIFFERENT COMBINATIONS

S. No.	Details of Combination	Compounds concentration (in %)					
		SiO_2	Al_2O_3	P_2O_5	SO_3	CaO	N
1.	Control (Plain soil)	78.99	8.54	0.15	0.28	1.20	0.008
2.	Soil + NPK	62.10	18.87	0.18	0.25	1.58	0.001
3.	Soil 90% + 10% fly ash + NPK	76.55	8.82	0.17	0.25	1.20	0.007
4.	Soil 80% + 20% fly ash + NPK	74.00	9.70	0.16	0.26	1.21	0.006
5.	Soil 70% + 30% fly ash + NPK	72.80	10.83	0.16	0.25	1.25	0.006
6.	Soil 60% + 40% fly ash + NPK	71.06	11.25	0.16	0.24	1.29	0.005
7.	Soil 50% + 50% fly ash + NPK	69.90	12.41	0.16	0.24	1.33	0.004

TABLE-3 (b)
TRACE ELEMENTS AND TOXIC ELEMENTS IN FLY ASH AND THEIR DIFFERENT COMBINATION

S. No.	Details of Combination	Concentration of element (in ppm)					
		Trace elements				Toxic elements	
		Mn	Zn	Mo	B	Cd	Pb
1.	Control (Plain soil)	48.54	55	4.60	0.21	0.45	30
2.	Soil + NPK	49.35	63	51	1.12	3.52	87
3.	Soil 90% + 10% Fly ash + NPK	50.33	56.2	9.41	0.69	0.65	35
4.	Soil 80% + 20% Fly ash + NPK	51.40	56.5	14.05	0.31	1.02	32
5.	Soil 70% + 30% Fly ash + NPK	52.04	57.3	15.35	0.39	1.30	40
6.	Soil 60% + 40% Fly ash + NPK	53.43	59.5	20.00	0.45	1.53	46.
7.	Soil 50% + 50% Fly ash + NPK	54.55	62.33	25.51	0.52	1.64	51

The seeds of chick pea (*Cicer arietinum*) were sown in the experimental pots. Every pot experiment was done in triplicate. Plant growth parameters were recorded and described in Table-4.

TABLE-4
PLANT GROWTH PARAMETERS IN POT EXPERIMENTS

S. No.	Treatments	Percentage germination (%)	In full grown plants			
			Root length (cm.)	Plant height (cm.)	Leaf area in cm^2 of compound leaf	Chlorophyll content (a)
1.	Control (plain soil)	60	9.20	27	3.68	0.201
2.	Control + NPK	62	10.50	27.5	3.69	0.440
3.	90% Control + NPK + 10% fly ash	67	10.87	28	4.06	0.500
4.	80% Control + NPK + 20% fly ash	70	10.96	28.6	5.15	0.686
5.	70% Control + NPK + 30% fly ash	73	11.34	29	5.50	0.795
6.	60% Control + NPK + 40% fly ash	72	12.42	30	5.55	0.889
7.	50% Control + NPK + 50% fly ash	80	14.03	32	6.25	0.955

TABLE-4
(Contd.)

S. No.	Treatments	Percentage germination (%)	In full grown plants			
			Cholophyll content (b)	Weight of 100 seeds (g)	Amount of N in mg.	Amount of protein (%)
1.	Control (Plain soil)	60	1.099	31.26	3.00	18.75
2.	Control + NPK	62	1.894	33.35	3.21	20.07
3.	90% Control + NPK + 10% fly ash	67	1.916	40.23	4.02	25.15
4.	80% Control + NPK + 20% fly ash	70	2.071	41.25	4.13	25.95
5.	70% Control + NPK + 30% fly ash	73	2.304	42.37	4.23	26.50
6.	60% Control + NPK + 40% fly ash	72	3.208	43.47	4.25	26.85
7.	50% Control + NPK + 50% fly ash	80	4.570	44.57	4.87	30.53

RESULTS AND DISCUSSION

Pot experiments were carried out to find:

(1) Solution to the disposal problem of fly ash

(2) As per Table-2, it is observed that the pH and conductivity increases with increase of fly ash proportions. It is found to be almost neutral in 50% soil + 50% fly ash + NPK proportion and maximum conductivity (pH 7.39 and conductivity 0.191).

(3) As per Table-4, it is observed that each and every parameter goes on increasing with increased fly ash proportions and all are found to be maximum in 50% soil + 50% fly ash + NPK.

(4) As per Tables 3 and 5 it is observed that the concentrations of toxic and trace elements in 50% soil + 50% fly ash + NPK are within the permissible limits as recommended by World Health Organisation.

TABLE-5
CONCENTRATION OF ELEMENTS IN IDEAL COMBINATION

Combination	Concentration of elements (in ppm)						WHO limits (in mg/week)	
	Trace elements				Toxic elements			
	Mn	Zn	Mo	B	Pb	Cd	Pb	Cd
50% soil + 50% fly ash + NPK	54.55	62.33	25.51	0.52	51	1.64	3.0	(0.4–0.5)

The concentrations of trace and toxic elements were estimated in different combinations. The combination of 50% soil + 50% fly ash + NPK was ideal for trace elements uptake, chlorophyll contents (a) and (b) and protein content.

Soil of Rehar Basin (Irrigation Project) is very acidic and is deficient in Mo and Zn. These deficiencies were well supplemented by fly ash application and

also the acidic nature of soil changes to almost neutral (pH = 7.39), which helped the plants in trace elements uptake, required for better crop yield and protein contents[9–11].

Conclusion

The pot emperiments reflect that the plants cannot take essential trace elements from soil at lower pH (acidic soil). Fly ash is basic in nature; it ameliorates the acidic soil resulting in better crop yields and higher protein contents Fly ash, otherwise a health hazard, is useful in two ways:

(1) Fly ash is a disposal problem, it can be used in agricultural land. Toxic elements like Cd and Pb have been found within permissible limits.

(2) In the present study, fly ash has neutralised acidic soil and helped nutrient uptake of Fe, Cu, Zn and Mo. The concentrations of Pb and Cd are below the threshold value in the seeds.

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