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Lime Effectiveness of Crab Shell Powder in Acid Spodosols

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This study was carried out in order to determine the effects of increasing crab shell powder on some macro and trace elements content of acid soils. For this purpose, 5 acid Spodosols were used according to US Taxonomy. The incubation experiment was done under laboratory conditions with 3 replications. Four different doses of crab shell powder (0, 5000, 10000 and 15000 kg ha^{-1}) were applied to each pot and incubated for 2 and 4 months. According to the results, pH value, available P content and exchangeable Ca and Mg contents of soils increased with increasing of crab shell powder application and time. But, organic matter amount, exchangeable K content and available trace element (Fe, Cu, Zn and Mn) contents of acid soils decreased with increasing of crab shell powder application and time. All these increases and decreases, except Zn content, were statistically significant at the confidence level of 1 %.

Key Words: Crab shell powder, Acid soil, Organic fertilizer, Lime, Spodosols, Trace elements.

INTRODUCTION

There is a strong relationship between fertility and chemical properties of soils. The main chemical characteristic of soil is pH value. The pH value directly affects the plant nutrient availability in soil. The decrease and increase of pH value cause the deficiency and toxicities of some mineral nutrients. The decrease of pH value makes acid soils[1].

The low soil pH value is associated with a number of soil chemical and biological characteristics that manifest themselves as the components of the problem acid soil syndrome. These components may adversely affect plant growth. These specific problems in acid soil conditions as: Al toxicity, Mn toxicity, Mo deficiency, legume nodulation failures, increase in plant disease and Ca and Mg deficiency. Hydrogen ion toxicity decreased phosphorus availability and toxicities of some other trace elements and heavy metals have also been reported[2]. Nitrogen, P, Ca and Mg contents of hazelnut plant and pH value and available P content of acid soil increased with increasing different organic amendments to acid soil[3].

Hermo *et al.*[4] investigated the effect of granitic powder application on some macro and trace elements content of acid soils. They found that N, P, Ca and Mg contents of acid soil increased with granitic powder application, while K, Fe, Cu, Zn and Mn contents decreased.

Nyamangara *et al.*[5] investigated the effect of some organic amendments application on some macro elements content of acid soils. They found that N, P, Ca and Mg contents of acid soils increased with organic amendments application, but K content of acid soil decreased with this application. Naramabuye and Haynes[6] investigated the effect of five organic manures (poultry manure, pig manure, cattle manure, soybean residues and sewage sludge) application on some chemical properties of acid soils. They found that pH value, available P contents of acid soils increased with organic manure application, on the other hand, available Fe, Cu, Zn and Mn contents and Al concentration decreased with this application. Kant *et al.*[7] conducted experiment to investigate the effect of different liming material on some soil properties, plant growth and mineral composition of acid soils. They reported that all liming materials increased plant growth and pH value, exchangeable Ca and Mg content, available P content of acid soils, but decreased available Fe, Mn, Zn and Cu contents and exchangeable K contents of acid soils.

The effect of increasing rates of crab shell powder (CSP) application to acid soils on some chemical properties of these soils was investigated in this study.

EXPERIMENTAL

Acid spodosol soils were used is this research according to US soil taxonomy. Five soil samples were taken from hazelnut plantation[8] and prepared for necessary analysis in laboratory[9]. Soil samples were analyzed for pH[10]; organic matter[11]; available phosphorus[12]; exchangeable potassium[13]; exchangeable calcium and magnesium[14]; available iron, copper, zinc and manganese[15] and texture[16].

Crab shells collected from Black Sea were washed thoroughly with tap water and then steamed. The solid material obtained was dried, milled and sieved to powder with diameters of < 0.149 mm (mesh no. 100, USA). Crab shell powder (CSP) was analyzed for pH, organic matter, carbonate, phosphorus, potassium, calcium, magnesium, iron, copper, zinc and manganese according to suitable methods.

The incubation experiment was conducted in a split-split plot experimental design under greenhouse conditions with 3 replications. For this purpose, soil samples were sieved through 2 mm (mesh no: 10, USA), then packed into 500 g pots and 0; 5000; 10000 and 15000 kg ha^{-1} crab shell powder (CSP) were thoroughly mixed with soil samples then incubated for 2 and 4 months. The soil samples were moistened to 60 % field capacity (FC) during the incubation periods. Soil samples were analyzed for pH; available P; exchangeable K, Ca and Mg; available Fe, Cu, Zn and Mn at the end of each period (after 2 and 4 months). The results of soil analysis were evaluated statistically[17].

The analysis of the crab shell powder (CSP) used in this experiment are presented in Table-1.

TABLE-1
SOME PROPERTIES AND ELEMENTAL COMPOSITION OF CRAB SHELL POWDER (CSP)

Parameter	Crab shell powder	Parameter	Crab shell powder
pH (1:2.5 water extract)	8.16	Mg (g kg^{-1})	13.00
$CaCO_3$ (%)	27.10	Fe (mg kg^{-1})	780.00
Organic matter (%)	62.40	Cu (mg kg^{-1})	420.00
P (g kg^{-1})	30.00	Zn (mg kg^{-1})	870.00
K (g kg^{-1})	0.80	Mn (mg kg^{-1})	660.00
Ca (g kg^{-1})	234.00	–	–

RESULTS AND DISCUSSION

Some physical and chemical properties of the soils are given in Table-2. The pH values, organic matter amount, available P, exchangeable K, Ca and Mg, available Fe, Cu, Zn and Mn content of soil samples were between 4.55-4.83 %; 4.75-6.88 %; 6.55-14.77 mg kg^{-1}; 156- 217 mg kg^{-1}; 4.25- 5.20 me 100 g^{-1}; 0.76-0.92 me 100 g^{-1}; 15.96- 70.57 mg kg^{-1}; 0.86-3.57 mg kg^{-1}; 0.53-1.06 mg kg^{-1}; 32.90-62.20 mg kg^{-1}, respectively.

TABLE-2
SOME PHYSICAL AND CHEMICAL PROPERTIES OF ACID SPODOSOLS*

Soil no.	pH	Org. matter (%)	Avail. P (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Exchangeable Ca (me 100 g^{-1})	Exchangeable Mg (me 100 g^{-1})	Available (mg kg^{-1}) Fe	Cu	Zn	Mn	Texture
1	4.55	4.75	14.77	217	5.03	0.90	16.87	1.33	0.53	52.40	CL
2	4.62	6.88	9.64	175	5.16	0.83	15.96	0.96	0.85	53.43	CL
3	4.69	6.01	8.86	162	4.25	0.80	23.27	0.86	0.77	40.80	L
4	4.70	6.73	7.17	162	4.85	0.92	18.26	2.46	0.60	32.90	L
5	4.83	6.11	6.55	156	5.20	0.76	70.57	3.57	1.06	62.20	CL

*Values are average of 3 replications.

The effect of increasing crab shell powder (CSP) application on pH, organic matter amount, available P and exchangeable K, Ca and Mg contents of soils are given in Table-3. Table-3 shows that soil pH increases with CSP application. The effect of CSP application on pH value of soil was found to be statistically significant at the confidence level of 1 %. Previous researchers also found that increasing rates of some organic Ca compounds application to acid soils increased pH values of these soils[3-5,18,19]. Organic matter amount of the soil samples decreased with CSP application (Table-3), which was significant statistically at the confidence level of 1 %. This is probably because of increasing of microbial activity with calcium compounds application to acid soil. Consequently, organic matter mineralization increased under acid soil conditions[1,20].

TABLE-3
EFFECT OF INCREASING RATES CRAB SHELL POWDER (CSP) APPLICATION ON SOME CHEMICAL PROPERTIES OF ACID SPODOSOLS*,**

Soil no.	Treatment CSP (kg ha^{-1})	Months	pH	Organic matter (%)	Available P (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Exchangeable Ca (me 100 g^{-1})	Exchangeable Mg (me 100 g^{-1})
1	0	2	4.55a	4.75d	14.77a	217d	5.03a	0.90a
		4	4.55a	4.62d	14.32a	215d	5.01a	0.90a
	5000	2	4.80b	4.52c	15.63b	197c	5.20b	1.02b
		4	4.92b	4.40c	15.87b	180c	5.32b	1.10b
	10000	2	5.20c	4.11b	16.30c	162b	5.52c	1.20c
		4	5.37c	4.00b	16.46c	158b	5.60c	1.22c
	15000	2	5.80d	3.88a	16.75d	132a	5.87d	1.36d
		4	6.37d	3.80a	16.97d	120a	5.96d	1.39d
2	0	2	4.62a	6.88d	9.64a	175d	5.16a	0.83a
		4	4.62a	6.82d	10.71a	146d	5.02a	0.76a
	5000	2	4.76b	6.52c	13.20b	132c	5.16a	0.85a
		4	4.93b	6.37c	13.46b	124c	5.27b	0.97b
	10000	2	5.40c	5.86b	14.10c	116b	5.38c	0.98b
		4	5.90d	5.77b	14.26c	114b	5.46c	1.01c
	15000	2	6.22e	5.42a	14.80d	102a	5.60d	1.15d
		4	6.58e	5.38a	14.96d	98a	5.68d	1.22d
3	0	2	4.69a	6.01d	8.86a	162d	4.25a	0.80a
		4	4.69a	5.87cd	9.36b	132d	4.26a	0.79a
	5000	2	4.97b	5.80c	9.48cb	120c	4.26b	0.82a
		4	5.13b	5.69c	9.76c	112c	4.38b	0.95b
	10000	2	5.92c	5.40b	10.27d	95b	4.46c	0.99b
		4	6.27c	5.36b	10.36d	92b	4.63c	1.10c
	15000	2	6.38cd	5.27a	11.05e	87b	4.76d	1.22d
		4	6.76d	5.22a	11.16e	63a	4.83d	1.27d
4	0	2	4.70a	6.73d	7.17a	162d	4.85a	0.92a
		4	4.70a	6.52cd	10.20ab	160cd	4.77a	0.89a
	5000	2	4.87b	6.48c	10.48b	152c	4.87a	0.93ab
		4	5.12c	6.36c	10.90c	140c	4.98b	0.98b
	10000	2	5.72d	6.12b	11.20c	120b	5.16c	1.17c
		4	5.96d	6.10b	11.32cd	112b	5.22d	1.25c
	15000	2	6.34e	5.90a	11.48d	101a	5.37e	1.42d
		4	6.59e	5.73a	11.50d	97a	5.46e	1.43d
5	0	2	4.83a	6.11d	6.55a	156e	5.20a	0.76a
		4	4.83a	5.96d	7.62b	158e	5.12a	0.72a
	5000	2	5.15b	5.79c	7.65b	138d	5.22a	0.80a
		4	5.27b	5.62c	7.92c	126c	5.36b	0.92b
	10000	2	6.52c	5.42b	8.30d	112b	5.62c	1.20c
		4	6.76c	5.38b	8.40d	101a	5.76c	1.22c
	15000	2	6.82d	5.20a	9.05e	101a	5.87d	1.25cd
		4	7.05d	5.14a	9.20e	92a	5.95d	1.32d

*Soils and properties of soils are evaluated individually and same letter signs no statistically significant differences between them at the confidence level of 0.01.
**Values are average of 3 replications,

TABLE-4
EFFECT OF INCREASING RATES CRAB SHELL POWDER (CSP) APPLICATION ON SOME TRACE ELEMENT CONTENTS OF ACID SPODOSOLS*

N	Treatment CSP (kg ha^{-1})	Months	Some trace elements** (mg kg^{-1})			
			Fe	Cu	Zn	Mn
1	0	2	16.87d	1.33d	0.53a	52.40d
		4	16.80d	1.33d	0.53a	52.34d
	5000	2	13.20c	1.28c	0.52a	41.16c
		4	12.05c	1.27c	0.51a	37.27c
	10000	2	9.16b	1.16b	0.52a	29.65b
		4	8.50b	1.13b	0.50a	22.18b
	15000	2	6.90a	0.97a	0.49a	17.15a
		4	6.02a	0.93a	0.47a	12.67a
2	0	2	15.96d	0.96d	0.85a	53.43d
		4	15.89d	0.96d	0.86a	53.43d
	5000	2	13.52c	0.80c	0.83a	42.27c
		4	11.05c	0.72bc	0.84a	38.72c
	10000	2	9.12bc	0.64b	0.81a	30.16b
		4	8.19b	0.60b	0.80a	25.27b
	15000	2	7.05b	0.48a	0.79a	16.40a
		4	5.80a	0.40a	0.78a	12.43a
3	0	2	23.27d	0.86d	0.77a	40.80d
		4	23.28d	0.82d	0.77a	40.80d
	5000	2	20.60c	0.74c	0.75a	32.62c
		4	18.42c	0.70c	0.74a	29.90c
	10000	2	15.40b	0.58b	0.72a	23.17b
		4	12.64b	0.56b	0.70a	19.66b
	15000	2	9.20a	0.43a	0.69a	12.20a
		4	8.60a	0.38a	0.71a	9.80a
4	0	2	18.26d	2.46d	0.60a	32.90d
		4	18.24d	2.46d	0.60a	32.90d
	5000	2	15.37c	2.30c	0.58a	26.40c
		4	14.02c	2.16c	0.56a	22.17c
	10000	2	10.45b	2.04b	0.54a	15.23b
		4	9.87b	1.99b	0.52a	12.16b
	15000	2	7.45a	1.76a	0.50a	7.40a
		4	6.42a	1.71a	0.50a	5.73a
5	0	2	70.57d	3.57d	1.06a	62.20d
		4	70.60d	3.57d	1.06a	62.18d
	5000	2	68.40cd	3.38c	0.98a	53.40c
		4	60.52c	3.26bc	0.96a	48.26c
	10000	2	49.11b	3.19b	0.94a	39.16b
		4	38.20b	3.05ab	0.94a	30.02b
	15000	2	26.34a	2.91a	0.90a	22.82a
		4	20.18a	2.79a	0.91a	19.63a

*Soils and trace elements are evaluated individually and same letter signs no statistically significant differences between them at the confidence level of 0.01.
**Values are average of 3 replications.

Similar results reported by some earlier researchers under different organic fertilizer application conditions[21-23].

Available P content of acid soils increased with CSP application (Table-3). This increasing was found to be statistically significant at the confidence level of 1 %. Acid soil pH increased with CSP application; therefore phosphorus availability was affected positively by this situation[24,25]. Exchangeable K content of acid soils decreased with CSP application. The effect of CSP application on exchangeable K content of acid soils was found to be statistically significant at the confidence level of 1 %. The same observation was also obtained by some earlier researchers. Decrease in K content of different soils by organic manure application was also found by some earlier researchers[1,21,26].

Exchangeable Ca content of acid Spodosols increased with CSP application (Table-3) which was found to be significant statistically at the confidence level of 1 %. When Ca compound was applied to acid soil, Ca deficiency was hindered and Ca availability increased under acid soil conditions[17,18].

Exchangeable Mg content of acid soils increased with increasing rates of CSP application. The increase was significant statistically at the confidence level of 1 % (Table-3). Same results were observed by previous researchers[17,19,24].

The effect of increasing CSP application on available Fe, Cu, Zn and Mn contents of acid Spodosols are given in Table-4, which shows that Fe content of acid soils decreases with CSP application. The effect of CSP application on Fe content of the soils was found to be statistically significant at the confidence level of 1 %. This may be attributable to high Ca content of CSP. The copper content of the soils decreased with CSP application. This decrease was found to be significant statistically at the level of 1 % (Table-4). Zinc content of the soils decreased with CSP application. But, this was not statistically significant (Table-4). This is probably because Zn content of CSP is high and therefore CSP application is not affected by Zn content of the soils, statistically. Similarly manganese content of the soils was negatively affected by CSP application (Table-4).

The present trace element results are consistent with the earlier observations under different acid soil conditions with different organic soil amendments applications[17,19,21].

Conclusion

According to the results of this experiment, pH value, available P, exchangeable Ca and Mg contents of the soils increased whereas organic matter amount and exchangeable K content of the soils decreased with increasing rates of crab shell powder (CSP) application to acid soils. Also, trace element (Fe, Cu, Zn, Mn) contents of the acid spodosols decreased with CSP application to these soils. Acid soil fertility increased with CSP application in this research. These results are important for acid soil conditions. Because, P deficiency, Fe, Cu, Zn, Mn, Al and H toxicities, hindering of N and organic matter mineralization and poor microbial activity are seen frequently in these soils. In conclusion, CSP, a new organic fertilizer and amendment, is suggested for acid soils to increase the fertility and plant nutrition and nutrient balance.

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