Amelioration of saline-sodic and high calcareous soils through Cotton Acid Delinting Process Residues

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Abstract

The influence of different amount of residues of cotton acid delinting process in improving the physicochemical properties of high salinity (HS) and high calcium (HC) content soils and their productivity for moderately tolerant crops (lettuce and wheat) were studied in greenhouse pots. A pH reduce of 0.5 units between the lowest and highest residue dose over the experimental period for the HS-soils was observed, while the pH returned to its initial value after two months for HC-soils. The $CaCO_3$ content was reduced by 6.0-10.0% (HC-soils) and only 2% (HS-soils). Addition of 1.62 g/kg residues in HS-soils improved both the soil physicochemical and the plant nutritional conditions. The weight of the lettuce plants increased by up to 58% compared with the control. In HC-soils addition of 2.16 g/kg residues increased the height and weight of the lettuce plant, but the greatest increase in the plant biomass achieved with an application rate of 1.62g/kg. In the case of wheat only the highest treatment gave an increase in the plant height (13-19%), the weight of the wheat ears (75-103%) and the number of seeds (95-171%). However, in all treatments, the weight of the plant and seeds were smaller than that of the control.

Introduction

Cotton-seed acid delinting products may be used under specific conditions as organic soil amendments due to their adverse effects on cotton pathogens (Gravanis et al., 2005). A good knowledge of the effect of these organic residues on soil properties is a primordial factor for a successful amendment of soil without risks (Heckman and Kluchinski, 1996). The aim of this study was to determine the influence of residues of seed cotton acid delinting process in improving the physical and chemical properties of high salinity and high calcium content soils. In addition, the productivity of treated soils for the cultivation of wheat and lettuce was studied.

Materials and methods

Soil samples were collected from two different areas of Greece with high-salinity and high calcium content respectively. Lettuce and wheat were grown, under greenhouse conditions, in pots filled with the two soil types and different amounts of cotton acid delinting process residues. Lettuce was cultivated with six levels of residues (control, 1.08, 1.62, 2.16, 5.40 and 10.8 g/kg) and wheat was cultivated with five different amounts of the residue (0.0 (control), 0.54, 27.0, 54.0 and 108.0 g/kg of soil). Plastic pots without drainage holes were used with 2.5 kg of soil substrate. The pots were watered daily with the correct amount of water to maintain each soil at 100% water capacity for the duration of the experiment. Fertilizer was applied to each pot as follows: 0.15g P_2O_5 as (0-20-0), 0.15g K_2O and 0.033g N as (21-0-0). In addition, 0.066g N as (34.5-0-0) was added to the surface of each pot to give a total of 0.1g N/kg soil. Samples of soils and residues were taken before and after cultivation for the determination of their physicochemical properties. In addition, the amounts of N, P, K, Ca, Mg, Cu, Mn, Zn, and Fe were determined in the lettuce leaves and the ears of wheat.

Results

The residue of the cotton acid delinting process was very rich in organic matter and iron (Table 1).

Table 1: Physicochemical properties of cotton acid delinting process residues

N	P	K	SO_4	S	O.M.	Ca	Mg	Cu	Zn	Mn	Fe
%								mg kg^{-1}			
0.45	0.91	1.4	24.7	8.2	95.8	0.21	0.19	2.7	8.9	14.2	432

For salty soil, where *lettuce* was grown, application of the highest dose of cotton residue mainly increased moisture equivalent, permanent wilting percentage, and K_{exc} in comparison to controls (Table 2), while decreased EC, $CaCO_3$ and Na_{exc} being of 16 and 40% respectively of the controls.

Table2. Physicochemical properties of soils with lettuce cultivation

Soil type	Treatments	S.P.(%)	Moist. eq. (%)	PWP (%)	E.C. (mS/cm)	pH	$CaCO_3$ (%)	O.M.(%)	N (mg/100g)	P Olsen (mg kg^{-1})	Exchang.		DTPA			
											K	Na	Cu	Mn	Fe	Zn
											meq/100g		mg kg^{-1}			
Salty	control	77	33	21	4.5	8.0	5	1.7	75	16	0.7	2.1	2.9	9.1	17.7	1.5
	108 g kg^{-1}	85	40	22	9.6	7.6	4	6.0	90	39	2.1	0.8	4.1	25.1	32.3	1.7
Calcare-	control	78	44	23	2.5	7.6	60	4.3	235	6	0.4	0.1	0.8	6.7	27.9	1.1
ous	108 g kg^{-1}	92	47	23	6.8	7.3	57	6.7	350	41	3.2	0.2	0.8	11.4	40.9	1.9

For calcareous soil, at the highest rate of residue, E.C and K_{exc} was considerably increased by 21 and 54 % respectively compared to control. For salty soil, where *wheat* was cultivated, application of the highest amount of cotton residue increased the most of the physicochemical soil properties in relation to controls and particularly E.C, organic matter, P-Olsen, K_{exc}, and EDTA extractable micronutrients(Table 3)

Table 3.Physicochemical properties of soils with wheat cultivation

Soil type	Treatments	S.P.(%)	Moist. eq. (%)	PWP (%)	E.C. (mS/cm)	pH	$CaCO_3$ (%)	O.M.(%)	N (mg/100g)	P Olsen (mg kg^{-1})	Exchang.		DTPA			
											K	Na	Cu	Mn	Fe	Zn
											meq/100g		mg Kg^{-1}			
Salty	control	82	32	19	6.1	7.7	3	1.2	110	31	0.6	2.3	2.4	10.1	15.7	1.2
	108 g kg^{-1}	82	36	22	5.2	7.7	1	1.7	120	32	0.8	1.4	3.3	10.6	14.8	1.4
Calcar.	control	78	43	21	4.7	7.4	64	4.2	310	56	0.5	0.1	0.7	6.2	22.6	5.4
	108 g kg^{-1}	83	44	20	5.7	7.5	60	4.6	345	55	0.8	0.1	0.7	6.7	21.9	3.3

A marked reduction of Na_{exc} , being 65 % of the control, was also found. At the highest rate of residue, E.C, and K_{exc} was considerably increased by 21, and 54 % respectively when compared to control. Similar results were found for calcareous soil except the reduction of C.E.C and the absence of any substantial treatment effect on Na_{exc}.

At all treatment levels, dry weight of lettuce was higher in calcareous soil than in salty soil (Table 4), which may ascribed to differences in certain physico-chemicals properties between the two soil types (water regime, E.C and nitrogen status). For salty soil, at 2.16g kg^{-1} residue the above dry weight was markedly increased by 60% compared to control and that for calcareous soil the increase was not significant, being 30% of the control. Higher application rates decreased dry weights. The decline was stronger for plants grown on salty soils.

Table 4. Above dry weight (g) of lettuce

Treatments	Soil type			
	Salty		Calcareous	
control	20.96	ab	31.89	ab
1.08 g kg^{-1}	29.66	bc	23.77	a
1.62 g kg^{-1}	33.08	c	41.31	b
2.16 g kg^{-1}	24.20	abc	35.96	ab
5.40 g kg^{-1}	19.10	ab	27.29	a
10.80 g kg^{-1}	16.00	a	29.83	ab

Growth analysis indicated that in both soil types application rates were significantly and positively related to plant height, weight of ear and number of seeds and negatively to plant and seed weight (Table 5).

Table 5. Growth parameters of wheat

Treatments	height		weight of plant		number of ears	
	Salty soil	Calcareous soil	Salty soil	Calcareous soil	Salty soil	Calcareous soil
control	12.3 *a*	13.13 *a*	12.78 *c*	19.42 *d*	15.8 *a*	16.8 *b*
0.54 g kg^{-1}	12.9 *b*	14.3 *b*	12.54 *c*	19.28 *d*	16.0 *a*	16.5 *ab*
27 g kg^{-1}	13.2 *b*	14.7 *c*	9.9 *b*	13.8 *c*	15.5 *a*	15.0 *a*
54 g kg^{-1}	13.8 *c*	15.15 *d*	8.5 *a*	11.41 *b*	15.0 *a*	15.0 *a*
108 g kg^{-1}	14.4 *d*	15.63 *e*	7.8 *a*	9.4 *a*	15.0 *a*	15.8 *ab*
Treatments	weight of ear		number of seeds		seed weight	
	Salty soil	Calcareous soil	Salty soil	Calcareous soil	Salty soil	Calcareous soil
control	4.5 *a*	5.9 *a*	102 *a*	110 *a*	5.3 *b*	8.05 *e*
0.54 g kg^{-1}	5.1 *b*	7.2 *b*	120 *b*	133 *a*	5.0 *b*	8.05 *d*
27 g kg^{-1}	5.8 *c*	8.8 *c*	134 *b*	165 *b*	3.9 *a*	6.62 *c*
54 g kg^{-1}	7.0 *d*	10.6 *d*	166 *c*	250 *c*	3.5 *a*	5.0 *b*
108 g kg^{-1}	7.9 *e*	11.9 *e*	200 *d*	298 *c*	3.4 *a*	4.0 *a*

Plants grown with excess amount of residue 108g kg^{-1}, achieved the highest values of the following growth parameters among treatments: height, weight of ear, seed number. Regarding the rest of parameters (plant weight, number and seed weight), maximum values obtained in control plants Plant nutrient concentrations corresponding to maximum growth (Tables 6 and 7) varied within the optimum nutrient range. It is postulated, that under the current experimental conditions, the cotton-seed acid delinting residue can used as an improvement for salty soils.

Table 6. Leaf nutrient concentration of lettuce

Treatments		Leaf nutrient concentration								
		N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
		(%, d.w.)					(mg kg^{-1}, d.w.)			
Salty soil	control	5.6	0.74	6.2	0.86	0.43	10.4	55.1	54.5	195
	1.08 g kg^{-1}	4.5	0.56	5.9	0.87	0.33	7.6	55.6	66.0	239
	1.62 g kg^{-1}	5.6	0.82	6.2	1.07	0.45	6.6	63.5	87.2	186
	2.16 g kg^{-1}	5.3	0.65	6.4	0.77	0.38	3.7	51.9	74.9	194
	5.4 g kg^{-1}	4.9	0.71	6.4	0.97	0.40	5.9	63.1	69.5	63.1
Calcareous soil	control	4.1	0.43	6.1	0.91	0.33	4.0	59.2	52.4	59.2
	5.4 g kg^{-1}	5.6	0.81	6.2	1.00	0.43	<0.13	21.7	65.2	21.7

Table 7. Nutrient concentration in ears

Treatments		nutrient concentration								
		N	P	K	Ca	Mg	Cu	Mn	Zn	Fe
		(%. d.w.)					(mg kg^{-1}. d.w.)			
Salty soil	control	0.60	0.043	1.2	0.37	0.12	33.1	12.3	9.5	75.9
	0.54 g kg^{-1}	0.67	0.042	1.1	0.38	0.12	70.9	8.9	17.2	71.5
	27 g kg^{-1}	0.47	0.024	0.9	0.36	0.14	41.3	13.5	7.8	75.6
	54 g kg^{-1}	0.42	0.030	1.8	0.59	0.21	21.0	26.8	7.4	49.0
	108 g kg^{-1}	0.32	0.024	1.0	0.36	0.21	12.3	17.3	3.5	52.0
Calcareous soil	control	0.85	0.040	2.4	0.68	0.12	11.6	3.8	6.8	49.1
	0.54 g kg^{-1}	0.82	0.044	2.6	0.78	0.12	29.5	5.8	11.9	80.5

References

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