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Anthropogenic Impact of Fertilization on Gypsiferous Soils

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Abstract: A greenhouse pot experiment had been conducted in order to investigate the effect of fertilization on plant growth in gypsiferous soils. The selected soils were different in their gypsum, calcium carbonate and soluble salts contents. The experiment design comprised control and fertilization treatments. Maize and barley were the crop indicators and the germination percentages, dry weight, nitrogen, phosphorus and potassium contents of the harvested plants were the measurable parameters of the current study.The obtained results revealed clearly that the germination percentages, dry weight and NPK contents were increased due to fertilization of the gypsiferous soils. The improvement of the plant growth could be attributed to the improvement of some soil physiochemical properties. Gypsiferous soils exhibited inhibition of plant germination due to their high content of soluble salts, gypsum and calcium carbonate contents. However, the effect of gypsum depends not only on its content but also on its form.

Key words: Gypsiferous soils % Fertilization % Maize % Barley

INTRODUCTION

Gypsiferous soils are, generally, characterized by low fertility. Kovda [1], considered that the accumulation of gypsum in soils results in very low fertility and consequently their productivity remains low under irrigation even with applications of fertilizers and organic manures. Sayegh [2], pointed out that the soils in the Middle East are deficient mostly in nitrogen, phosphorus as well as micronutrients and to some extent in potassium.

Generally, most of the gypsiferous soils have relatively low organic matter content. Rincon *et al*. [3], got significant increments of pine growth in gypsiferous soil due to the amendment with urban waste. They also found that most of the nutrients analyzed in the needles were in higher amounts in plants grown in non amended soil, except nitrogen that was higher in the plants grown in the amended soil.

In their experiment on highly degraded gypsiferous semiarid soil in Madrid, Spain, Roman *et al.* [4], found that treatment with composted urban waste (400 t/ha) increased the hydraulic conductivity of the topsoil and the 10 - 20 cm layer. The parameters showing the most significant changes versus the control plot were C:N ratio, the humic acid to fulvic acid ratio and the lipd content, all of which decreased; the concentration of available Mn, Zn and Cu increased and paralleled aggregate formation.

Under irrigated agriculture on gypsiferous soils with low organic matter and total nitrogen, the regular application of nitrogen fertilizers is essential to secure adequate yields of most crops. The need for phosphorus applications to crops grown in gypsiferous soils is higher than in non-gypsiferous soils because there are more calcium ions in the soil solution. The application of potassium fertilizers is necessary for gypsiferous soils, especially where the plants are intensively cropped [5].

A pot experiment had been conducted in the greenhouse of the National Research Centre using different soils in order to investigate the impact of fertilization on plant growth in gypsiferous soils. They had various contents of gypsum, calcium carbonate and soluble salts. The used soil samples for the current experiment were treated with both manure and chemical fertilizers and were sowed with maize followed by barley.

MATERIALS AND METHODS

Five soils profiles were selected from various regions in Egypt. A soil profile was dug at each location to the hard rock or water table. The soil profiles were then thoroughly examined, morphologically described and the physiographic features of the location were identified according to FAO Guidelines for Soil Description [6].

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Eight soil samples were chosen, air-dried, sieved throw 2 mm sieve and undergone various laboratorial analyses to determine the main physicochemical properties as follows:

- Electrical conductivity (EC) was determined following Page *et al*. [7].
- Total carbonates were estimated using the Schreiber's Calcimeter after Nelson [8].
- Gypsum content was determined following Page *et al*. [7].
- Particle size distribution was conducted according to Vieillefon [9].

The greenhouse pot experiment design comprised the used 8 soil samples in triplicates and two groups of pots. The first group was used without any treatment as a control. The soil of the second group of pots was treated with both manure and chemical fertilizers. Chicken manure was mixed with the soil one week before sowing at a rate of 2%; (60 g/ 3 kg soil). The chemical NPK fertilizers were applied to the pots after 21 days of planting. All pots were sowed with maize followed by barley where they grew for 40 days. Observations were recorded on germination percentage and dry weight, nitrogen, phosphorus as well as potassium contents of the grown plants. The LSD analysis at 0.05 level was carried out using CoStat software [10], for the comparison between different soils and treatments.

RESULTS AND DISCUSSION

Soil Characterization: The currently used soil samples were characterized by different contents of gypsum, calcium carbonate and total soluble salt concentrations. Table 1 showed that the soils N°s 1, 2, 3, 7 and 8 had high gypsum content varied from 17.2 to 86.0%, whereas the soils N°s 4, 5 and 6 had low gypsum content ranged between 2.8 and 5.5%. The soils N°s 1, 4, 7 and 8 were very saline where the EC of the soil paste extract ranged from 21.3 to 116.5 dS/m. The soils N°s 2, 3, 5 and 6 were moderately saline as the EC values fluctuated between 3.9 and 5.6 dS/m. Soil N° 6 was the only one had high calcium carbonate content (14.8%). The soil texture varied from loam to loamy sand.

Greenhouse Pot Experiment: Data in Table 2 show that germination percentages of maize in the soils N°s 1, 2, 3, 5 and 6 ranged between 43 and 90% under control treatment and between 45 and 90% under fertilization treatment. The high values of germination percentages of the control treatment could be due to that some of the selected samples were taken from gypsiferous soils which were under cultivation long time ago. While, the germination was absent in the soils N°s 4, 7 and 8 under both control and fertilization treatments. The dry weight of the harvested plants was between 4.24 and 7.56 g/pot in the case of control treatment and it

Table 1: Location, classification and main characteristics of the soil profiles

Soil profile									
N°	Location	Land use	Classification	Layer N°	Soil sampleN°	ECdS/m	$CaCO_3$%	Ca_2SO_4%	Texture class
1	El-Ismaillia	Non cultivated	Petrogypsic Haplosalids	1	1	21.3	2.0	86.0	LS
2	El-Ismaillia	Cultivated	Gypsic Haplosalids	1	2	5.6	2.3	17.2	LS
				2	3	5.2	1.3	17.3	L
3	Wadi El Natroun	Non cultivated	Typic Haplosalids	1	4	59.1	0.8	2.8	LS
4	North of Tahrir	Cultivated	Typic Haplosalids	1	5	3.9	3.0	3.4	LS
				2	6	4.3	14.8	5.5	SL
5	El Fayoum	Non cultivated	Gypsic Haplosalids	1	7	116.5	2.5	24.1	LS
				2	8	86.6	1.8	60.2	LS

Table 2: Average values for Maize experiment.

Soil	EC (dS/m)		Germ. (%)		Dw (g/pot)		N g/pot		P g/pot		K g/pot	
N°	C	F	C	F	C	F	C	F	C	F	C	F
1	20.6	19.40	43	45	4.24	5.55	0.49	1.43	0.26	0.21	0.20	1.25
2	4.4	4.10	80	88	6.39	12.06	0.63	2.29	0.46	0.58	1.53	1.79
3	3.5	2.50	83	90	6.83	13.38	0.86	2.31	0.36	0.69	1.55	1.93
4	27.5	24.90	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	2.5	1.85	87	87	5.70	11.40	0.73	1.99	0.41	0.44	1.23	1.73
6	1.4	1.35	90	82	7.56	9.92	0.66	1.62	0.28	0.26	1.15	1.50
7	108.2	74.40	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	82.6	64.60	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Germ. = Germination, Dw. = Dry weight, N = Nitrogen content, P= Phosphorus content
K= Potassium content C= Control treatment F= Fertilization treatment

Table 3: Average values for Barley experiment

Soil	EC (dS/m)		Germ. (%)		Dw (g/pot)		N g/pot		P g/pot		K g/pot	
N°	C	F	C	F	C	F	C	F	C	F	C	F
1	15.7	10.5	50	52	4.20	4.53	0.73	1.53	0.20	0.37	0.20	1.53
2	3.7	4.5	85	93	6.10	16.80	0.75	2.73	0.30	0.89	1.11	1.91
3	3.2	2.1	90	96	6.43	16.91	0.77	2.86	0.31	0.90	0.90	1.94
4	25.4	22.9	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.4	1.4	93	93	6.77	16.17	0.87	2.39	0.47	0.87	0.85	1.85
6	1.3	1.2	90	90	6.39	16.16	0.66	2.36	0.26	0.24	0.66	1.81
7	66.9	61.7	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	42.8	40.4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

III.LSD analysis

Table 4: Ranking of the soils according to the significant difference of the studied parameters

Maize						Barley					
Soil N°	Germ.	Dw.	N	P	K	Soil N°	Germ.	Dw.	N	P	K
1	d	d	d	c	d	1	d	d	d	b	c
2	b	b	a	a	b	2	b	b	b	a	a
3	a	a	a	a	a	3	a	a	a	a	a
4	e	e	e	d	e	4	e	e	e	d	d
5	b	b	b	b	b	5	c	c	c	a	b
6	c	c	c	c	c	6	c	c	c	c	b
7	e	e	e	d	e	7	e	e	e	d	d
8	e	e	e	d	e	8	e	e	e	d	d
LSD 0.05	1.224	0.793	0.056	0.113	0.088	LSD 0.05	1.060	0.104	0.099	0.050	0.035

became between 5.55 and 13.38 g/pot under fertilization treatment.

Plants nitrogen content was found to be increased by fertilizing the gypsiferous soils. The obtained results showed that the nitrogen content of maize under the control treatment, ranged between 0.49 and 0.86 g/pot, while it reached between 1.43 and 2.31 g/pot under the fertilization treatment.

Phosphorus content of maize fluctuated between 0.26 and 0.46 g/pot under the control treatment. It showed comparative levels for the plants grown under fertilization treatment, where it was amounted to 0.21 and 0.69 g/pot.

The potassium content exhibited higher values for maize grown under fertilization treatment than those of the control treatment. It was between 0.20 and 1.55 g/pot for the plants of the control treatment, whereas it recorded values between 1.25 to 1.93 g/pot for the plants of the fertilization treatment.

These results revealed that fertilizer application in gypsiferous soils had positive impact on the plant growth and the NPK contents of the plants.

Concerning the second crop, barley, the results expressed more improvement of the plant growth as the soil was fertilized, however the germination remained absent in the soils N°s 4, 7 and 8 under both control and fertilization treatment.

Table 3 contains the data average of the experiment, which showed higher germination percentages of barley than the values of maize experiment. The germination percentages of barley varied between 50 to 93% under the control treatment and from 52 to 96% under fertilization treatment.

The dry weight values also exhibited an increase for barley than maize. They were found to be within the range of 4.20–6.77 g/pot under the control treatment and of 4.53–19.91 g/pot under the fertilization treatment.

Barley nitrogen content was ranging between 0.66 and 0.86 g/pot for the plants under the control treatment and between 1.53 and 2.86 g/pot for those under fertilization treatment. These data were also higher than those obtained for maize plants.

Phosphorus content of barley plants was amounted to the range 0.24–0.90 g/pot under the control treatment and 0.24–0.90 g/pot under fertilization treatment. These results exhibited more phosphorus contents of barley than maize.

Potassium content of the barley plants was found to be higher under fertilization treatment than under the control treatment. It recorded 0.20 to 1.11 g/pot under the control treatment and 1.53 to 1.94 g/pot under fertilization treatment. These values were comparative with those obtained for maize.

These results could be attributed to the different gypsum contents and crystal forms as well as their distribution in the soil fabric.

The statistical analysis was performed using CoStat software, [10]. The LSD results (Tables 4), revealed that there was a clear distinction between two groups of the soils, despite of the variability of the soils under investigation. The first group comprised the soils N°s 4, 7 and 8 which were characterized by highest soluble salts accumulation. This distinction was reflected on the missing of maize and barley germination for those soils under both control and fertilization treatments. The other group which comprised the soils N°s 1, 2, 3, 5 and 6 showed different germination percentages according to variation of their soil characteristics.

The improvement of the results of the fertilization treatment, as they were compared with those of the control treatment, was in agreement with those obtained by Mardoud [11], who studied the fertilization and irrigation impacts on main crops grown on gypsiferous soils of Euphrates basin.

Soils N°s 2 and 3 showed the highest ranking for maize and barley germination, dry weight and NPK contents among the other soils. They had low soluble salts and calcium carbonate contents but high gypsum content accounted for about 17% which did not inhibit the plant growth.

The soils N°s 5 and 6 showed similar potentiality for supporting plant growth and came in the second rank. However, the only difference was the high content of calcium carbonate of soil N° 6 that affect the germination percentage and the phosphorus content.

Although the soil N° 1 that had initially high soluble salts up to 21.3 dS/m and very high gypsum content amounted to 86%, was ranked in the fourth place as it supported, to a certain extent, the germination of both maize and barley under control and fertilization treatments. Similar results were obtained by Aziz [12], who recorded germination percentages accounted for 32.2 and 42.2% of wheat and barley, respectively, grown in a soil that had 81.7% gypsum. It could be attributed to the gypsum form [12, 13].

The soils N°s 4, 7 and 8 were ranked in the last place as they did not show any germination of both maize and barley even under fertilization treatment. Most probably that was due to high soluble salts content and high to very high gypsum contents.

CONCLUSION

Gypsiferous soils exhibited inhibition of plant germination due to their high content of soluble salts, gypsum and calcium carbonate contents. However, the effect of gypsum could depend not only on its content but also on its form.

The fertilization had an impact on improving the agricultural potentiality of the gypsiferous soils. The germination percentages, dry weight and NPK contents were increased due to fertilization.

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