INTERACTION OF PHOSPHOGYPSUM AND SUPERPHOSPHATE IN GAZA SOIL AS RELATED TO QUALITY OF IRRIGATION WATER

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ABSTRACT

Two phosphorus carriers; Phosphogypsum (PG) and Superphosphate (SP)) were added to loamy soil at 4 levels (0, 15, 30 and 45 ppm phosphorus). Two experiments were conducted; a wetting and drying experiment up to 20 cycles using fresh and saline water (EC = 1.55 and 3.2 dS/m respectively, and a pot experiment where corn seedlings (*Hybrid sweet corn*) were grown and irrigated with fresh and saline water. Chemical properties of soil were determined in both experiments. Dry weight, average length and P-concentration in plants were determined. In wetting and drying experiment, EC increased markedly with increasing the number of cycles and was more pronounced on samples treated with saline water. Concentrations of water soluble– and available–P were reduced steady with increasing number of of wetting and drying cycles in all treatments, but slight increase was noticed by superphosphate treated samples. Dry weight of plants irrigated with fresh water were higher than those irrigated with saline water. Phosphorus concentration in plant tissue was relatively higher in the superphosphate treatments than phosphogypsum.

Key words: Phosphogypsum, superphosphate, irrigation, fresh water, saline water, corn.

INTRODUCTION

Phosphogypsum (PG) is a by-product of the phosphate industry. It is produced through the manufacture of phosphoric acid and superphosphate fertilizers by wet process. Each ton of P_2O_5 in the acid form is associated with the production of 3.5–5.5 tonnes of phosphogypsum (Ferguson, 1988 and Mays & Morvedt, 1986). The phosphoric acid component of phosphogypsum is of direct benefit as a phosphate fertilizer in addition to its beneficial acidic effect particularly in calcareous soils (Oster, 1982). It was found to be efficient as soil conditioner for saline-sodic soil. The major concern however, in using PG is that it may contain trace elements, particularly metalls, carried over from primary processing, and which release may contaminate soil and ground water (Mays & Morvedt, 1986 and Liang et al.,1995). Phosphogypsum was more effective than mined gypsum in preventing crust formation, because of its higher rate of dissolution, which is as much as 10 folds more soluble than gypsum (Keren & Shainberg, 1981). The primary salt that limits plant growth on irrigated land in arid and semi–arid regions is sodium chloride (Staples & Toennissen, 1984).

In the Mediterranean area, where the fresh water resources for agricultural use are rather limited, the extension of irrigated agriculture is mainly possible by using saline water. Two factors contribute to the increasing interest in the use of saline water, namely, the worldwide increasing water requirements and competition between human, industrial and agricultural use (Van Hoorn et al., 1997). Only few crop plants can grow under high levels of salts that may accumulate due to fertilizers practices or the use of saline water for irrigation (Shannon, 1985). The deterious effect of saline water on the soil properties may be prevented by application of phosphogypsum with the irrigation water or on the soil surface. (Agassi et al., 1986).

The objective of the present work is to study the interaction between phosphogypsum and superphosphate as two different phosphorus carriers with Gaza soil and their relation to the quality of the applied irrigation water under different conditions.

MATERIALS AND METHODS

Experimental Conditions :

Two types of irrigation water were used; fresh water (EC=1.55 dS/m) from local well at University farm and saline water (EC=3.2 dS/m) brought from Ministry of Agriculture experimental farm in Gaza City, their chemical compositions are shown in Table 1. The soil used was taken from the top layer (0-20 cm) of agricultural soil from middle area of Gaza Strip. The soil was air-dried and passed through 2mm sieve for the laboratory investigations and through a 5mm screen for the pot experiment. Two phosphorus carriers; superphosphate (25% P_2O_5) and phosphogypsum (1% P_2O_5) brought from Abo-Zabel near Cairo/ Egypt were thourghly mixed with the soil at 4-similar rates: control (no P carriers were added) 15, 30, 45 mg P/ kg soil and named, P0, P_1, P_2 and P_3, respectively.

Table (1): Composition of soil and irrigation water used for experiment

Type	PH	EC dS/m	Na me/l	Ca me/l	Mg me/l	Cl^- me/l	$CaCO_3$ %	SAR
Sandy loam soil	7.8	2.1	5.9	11.2	6.6	12.4	4.7	1.98
Fresh water	—	1.55	5.47	3.82	3.86	6.7	—	2.79
Saline water	—	3.2	21.3	4.45	4.42	19.8	—	10.1

Wetting And Drying Experiment

The treated P soil was filled in plastic cups (240 gm soil /cup) and divided into two main treatments; the first was wetted with fresh water and the second with saline water. The cups were first saturated with irrigation water and were dried in open area. The process was repeated for 5,10 and 20 wetting and drying cycles. Each cycle durated 4 days, beginning with addition of irrigation water at field capacity rate until the soil began to crack. At the end of each wetting and drying cycle, soil samples were air-dried. EC-and pH-values in (1:1) soil-water extract were measured using EC- and pH- meters. Sodium was measured by flame photometer method. Available–P was extracted using 0.5 M $NaHCO_3$ adjusted at pH=8.5 (Olsen et al. 1954). Available–and water-soluble–P were determined by spectrophometer using ammonium molybdate blue method at 880 nm (LUFA, 1997).

Pot Experiment

Two seedlings of corn (*hybird sweet corn, merit Asgrow* Co. Idaho, USA) were grown in 3 liters pots having free drainage holes and filled with the same soil used in the wetting and drying experiment. All corn seedlings were first irrigated with fresh water for two weeks, then divided into two main treatments.The firist was irrigated with fresh and the second with saline water.Each treatment had 3 replicates .The two main treatments were the addition of 0, 15, 30,and 45 mg P/kg soil as superphosphate or phosphogypsum P carriers. Ammonium sulfate and potassium sulfate were added to all pots at ordinary recommended doses. The whole plants (vegetative parts and roots) were harvested after 40 days, washed, air dried and then oven dried at 65 ^{0}C. The average length of vegetative and root parts and dry weight were measured. Plant samples were ashed in a muffle furnace at 550 ^{0}C and acid treated using (1:3) HNO_3 and HCl acids and prepared for P-determination as vanadate–molybdate yellow color (Hohenheim, 1999). Soil samples were taken after harvesting from pots to analyse EC, pH and Na as above mentioned procedures.

RESULTS AND DISCUSSION

The used saline water (3.2dS/m) has high SAR-value (10.1), reflecting high sodium ions and is considered as moderately saline water according to Doorenbos and Pruitt (1992). Fresh water (FW) has low EC (1.55 ads/m) as well as SAR (2.79).

Data presented in Tables 2 and 3 show soil composition of wetting and drying experiment using fresh water and saline water respectively. Application of either PG or SP had decreased soil pH. The extend of reduction is related to the nature of added P carrier materials. For instance pH value of soil control was 8.1, it decreased to 7.9,7.73, and 7.63 at P1, P2, and P3 levels with PG after one wetting and drying cycle. The corresponding values with SP were 8.02, 8.01, and 7.97. It seems that PG material is more effective in reducing soil pH as compared to SP. Such pH decreases were diminished upon further cycles and pH become closer to the control treatment. In case of saline water (Table 3) soil pH reduction was more pronounced with both PG and SP treatments and had similar trend with wetting and drying cycles i.e. pH increased as wetting and drying increased.

Table (2): Soil properties of wetting and drying experiment using fresh water.

Treatment	pH (1:1)		EC (dS/m)		Na (me/l)		Water soln.-P (mg/l)		Available-P (mg/kg)	
	PG	SP	PG	SP	PG	SP	PG	SP	PG	SP
	1 Cycle (C_1)									
P_0	8.10		1.25		10.1		0.82		23.65	
P_1	7.79	8.02	2.39	0.99	9.1	8.6	0.59	1.28	29.30	30.45
P_2	7.73	8.01	2.78	0.90	9.2	7.4	0.84	1.65	30.70	32.30
P_3	7.63	7.97	3.33	0.94	10.2	7.1	1.09	2.26	35.05	41.15
	5 Cycles (C_5)									
P_0	8.07		1.63		11.6		0.34		17.40	
P_1	7.88	8.05	2.96	1.73	13.9	10.8	0.29	0.56	18.55	19.60
P_2	7.86	8.03	3.51	1.71	14.7	11.8	0.34	0.65	21.10	20.15
P_3	7.79	7.99	3.41	2.01	12.7	11.5	0.41	0.94	23.25	24.70
	10 Cycles (C_{10})									
P_0	7.97		2.52		15.7		0.25		13.30	
P_1	7.97	8.05	3.12	2.22	16.4	14.7	0.20	0.29	15.45	15.56
P_2	7.86	8.03	3.38	2.31	16.6	14.4	0.19	0.37	16.20	17.60
P_3	7.78	8.03	3.82	2.34	16.2	15.0	0.22	0.43	17.05	18.45
	20 Cycles (C_{20})									
P_0	7.94		4.53		25.7		0.12		12.85	
P_1	7.90	7.95	4.70	4.18	25.1	23.8	0.09	0.15	13.45	13.15
P_2	7.86	7.95	5.43	4.43	24.8	24.2	0.08	0.17	12.95	14.10
P_3	7.85	8.09	5.67	4.86	25.4	23.6	0.09	0.24	11.80	14.10

Table (3): Soil properties of wetting and drying experiment using saline water.

Treat.	pH (1:1)		EC (dS/m)		Na (me/l)		Water soln- P (mg/l)		Available- P (mg/kg)	
	PG	SP	PG	SP	PG	SP	PG	SP	PG	SP
1 Cycle (C_1)										
P_0	7.84		1.42		9.6		0.81		23.35	
P_1	7.61	7.77	2.65	1.41	10.8	9.2	0.57	1.01	28.40	25.40
P_2	7.56	7.81	3.13	1.40	11.4	9.4	0.79	1.39	33.00	33.75
P_3	7.51	7.80	3.16	1.49	10.6	10.5	1.08	1.30	33.70	43.75
5 Cycles (C_5)										
P_0	7.85		3.53		18.3		0.314		17.40	
P_1	7.74	7.98	4.77	3.52	19.4	18.4	0.28	0.39	18.20	18.75
P_2	7.74	7.86	7.65	3.47	19.1	17.5	0.32	0.49	24.45	27.45
P_3	7.72	7.86	5.25	3.90	22.6	19.6	0.40	0.72	26.90	28.95
10 Cycles (C_{10})										
P_0	7.92		5.70		23.2		0.18		12.25	
P_1	7.85	7.95	6.21	5.91	27.8	27.2	0.11	0.23	14.60	15.95
P_2	7.76	7.90	6.65	5.96	29.9	30.8	0.16	0.31	20.50	21.55
P_3	7.80	7.96	6.11	5.21	26.3	25.7	0.22	0.32	22.00	23.95
20 Cycles (C_{20})										
P_0	7.93		11.52		53.3		0.08		11.80	
P_1	7.76	7.87	12.50	8.93	54.4	47.1	0.07	0.08	12.15	15.35
P_2	7.86	8.03	11.72	10.45	54.5	47.7	0.06	0.11	13.55	16.20
P_3	7.92	7.83	11.59	11.27	51.1	50.6	0.07	0.12	16.00	17.65

As expected soil EC increased in case of salin treatments and EC values increased with increasing the number of wetting and drying cycles in the two types of irrigation water, due to continuous salt accumulations. These values were lower with supper-phosphate treated samples compared with the phosphogypusum treated samples. Na concentration in the PG treated soil is higher in most cases than in SP treated soil and increased with increasing numbers of wetting and drying cycles irrespective to the type of irrigation water; this can be attributed to the successive amount of applied water with time. It is also noticed that Na accumulation is markedly higher in the case of saline water treatments.

Behavior of both PG and SP are not much varied at P1 and P2 levels, since water-soluble P as well as available P showed slight increase with SP fertilizer. I n addition, reactivity of these materials in the used soil had slight P variations when FW and SW were used as a reaction medium. Magnitude of P variations are commenced at P3 level, with FW and SW .For instance, available P was 23.35 mg/kg soil, it increased to 33.7 and 43.75 mg P/kg at P3 level. In general, water soluble P and available P decreased with increasing direct contact of P compounds and soil components through further increase of wetting and drying cycles. Such P decrease may be attributed to continuous transformations of the precipitated P compounds to more basic and slight soluble compounds (Larsen, 1976 and Amer et al, 1980.) In general, fresh water treated samples show an increase in water soluble-P concentration than the saline treated samples.

Data presented in Table 4 showed that the average length of corn plants treated with PG and irrigated with fresh water are relatively higher than those irrigated with saline water. Saline water has decreased dry weight of corn plants as compared to fresh treatments .Dry weight of PG treated soil was higher than that of SP treatments, this was true with fresh water treatments but not with saline water. Phosphorus concentration in plants was relatively higher for the superphosphate treatment than for the phosphogypsum ones on the two types of irrigation water, but such increase did not reach level of significance .On the other hand, P-concentration in the plant increased with increasing phosphate applied to soil, this was expected effect. This is in agreement with Mallarino (1996) who reported that nutrient concentration of young plants has been used to evaluate fertilization **effects on nutrient concentration** or uptake and to evaluate nutrient status of crops.

Table (4): Length, dry weight and P– concentration in corn plants

Treatment	Length of plant (cm)		Weight of plants (gm)		P %	
	PG	SP	PG	SP	PG	SP
	Fresh water treatment					
P_0	53		8.1		0.32 (0.02)	
P_1	69	61	14.4	9.8	0.31 (0.01)	0.32 (0.03)
P_2	71	61.7	14.4	11.9	0.31 (0.01)	0.37 (0.01)
P_3	70.6	64.6	14.6	13.9	0.36 (0.03)	0.38 (0.03)
	Saline water treatment					
P_0	49.7		5.1		0.25 (0.02)	
P_1	61	60	9.4	9.1	0.29 (0.02)	0.31 (0.02)
P_2	58	61.7	8.5	8.8	0.34 (0.01)	0.36 (0.02)
P_3	62.3	66	9.9	12.3	0.35 (0.01)	0.40 (0.01)

Soil characteristics for the pots experiment using fresh and saline irrigation water are summerized in Table 5. It is noticed that pH values were slight higher in the case of superphosphate treated samples. EC and Na were significantly ($p<0.05$) lower for superphosphate treated samples than for phosphogypsum treated ones with the two types of irrigation water and within the different phosphate treatments. In general, EC and Na values were significantly higher in the case of saline water treatment. Application of phosphogypsum and superphosphate were found effective in decreasing the Na concentration in soil with most cases, especially with the saline water irrigated soil. This is in agreement with Khan et al., 1992. The statistical analysis showed no differences in pH and EC but slight decrease in Na due to the rate of phosphorus applied to soil. Water soluble and available-P increased with increasing the applied phosphorus after corn plants had been harvested. These were observed with the two phosphorus sources and varied irrigation water. Also, it is found that water soluble–P is significantly ($p<0.05$) higher for the superphosphate treatment than for the phosphogypsum treatment in the case of the types of applied irrigation water.

Table (5): Soil characteristics for pots experiment after harvest .

Treat.	pH (1:1)		EC (dS/m)		Na (me/l)		Water Sol.-P (mg/l)		Available- P (mg/kg)	
	PG	SP	PG	SP	PG	SP	PG	SP	PG	SP
					Fresh water treatment					
P_0	7.77		5.21		13.7		0.30		17.95	
P_1	7.67	7.81	8.92	4.89	18.4	14.8	0.19	0.48	20.15	21.05
P_2	7.63	7.77	8.14	6.09	16.6	14.2	0.25	0.59	23.10	22.05
P_3	7.65	7.80	8.35	5.86	16.1	13.5	0.29	0.69	25.40	24.55
					Saline water treatment					
P_0	7.66		9.21		23.8		0.33		16.65	
P_1	7.65	7.73	10.42	9.08	22.9	18.7	0.35	0.54	17.05	18.85
P_2	7.56	7.69	10.38	9.12	20.6	17.1	0.38	0.64	20.40	20.25
P_3	7.58	7.71	10.83	9.78	18.9	17.3	0.41	0.68	21.35	21.90

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REFERENCES

Agassi, M, Shainberg, I. and T. Morin (1986). Effect of powdered phosphogypsum on the infiltration rate of sodic soils. *Irrig. Sci.* 7:53-61.

Amer, F; M.S.Shams, K.M.Awad, and M.A.Khalil.1980. Immobilization of dominium phosphate and monocalcium phosphate in calcareous soils. Soil Sic. Sos. Am. J. 44:1174-1178.

Armstrong, A. S. B. and T. W. Tanon (1992). Gypsum application to aggregated saline–sodic clay topsoil. *J. of Soil Sci.* 43: 249-260.

Ferguson, F. (1988). Phosphogypsum: An overview. P. 117-130. In: *Proc. Of the 2nd Intern. Symposium On Phosphogypsum.* Vol. 1 FIPR-Publ. No. 01-037-055.

Hohenheim (1999). Analysis of minerals in plant materials: *Labsblatt. Institut of Plant Nutrition. Hohenheim University*, Germany.

Khan, H. R.; Faiz, M. A.; Islam, M. N.; Adachi, T. and I. V. Ahmed (1992). Effects of salinity, gypsum and Zn on mineral nutrition of rice. *Intern. J. Trop. Agric.* Vol. , Pp 147-156.

Keren, R. And I. Shainberg (1981). Effect of dissolution rate on the efficiency and mined gypsum in providing infiltration of a sodic soil. *Soil Sci. Soc. Am. J.* 45:103.

Larsen, S. (1967). Soil phosphorus. *Adv. in Agron.*19, 131 – 206.

LUFA (1997). Bestimmung des Wasserloeslichen Phosphorus. In: *VDLUFA Methodenbuch, Band1.* Landwirtschaftliche Untersuchungs- und Forschungsanstalt. Hameln. Germany.

Mallarino, A. P. (1996). Evaluation of optimum and above-optimum phosphorus supplies for corn by analsis of plant parts. *Agron. J.* 88: 370-380.

May, D. A., and J. J. Mortvedt (1986). Crop response to soil application of phosphogypsum. *J. Evivron. Qual.* 15: 78 – 81.

Liang, J.; Karamanso R. E. and N. E. Moir. The influence of brine contamination and phosphogypsum amendments on soil chemical properties and plant response. Commun. *Soil Sci. Plant Anal.* 26 (7) 1033 – 1057.

Olsen, S.R., Cole, C.V., Watenebe, F.S. and C.A. Dean (1954). Estimation of available P in soil by extraction with sodium bicarbonate. *U.S. Dept. Agric.* No. 939, 19.

Orlov, D. S., Luganskaya. I. A. and I. N. lozanovskaya (1989). Chemical reclamation of saline–sodic soils of the lower Don floodplain by some industrial wastes. *Sovit . Soil Sci.* 21.3 (78 – 89)

Oster, J.A. (1982). Gypsum usage in irrigated agriculture, a review. *Ferlilizer Research* 3 : 73 – 89 .

Scheffer, F.; Ulrich, B., and T. H. Benzler (1960). (G) Bestimung von Phosphosauere und Kieselsauere als Molybdaenblau. *Landw. Forschung* 13: 191-201.

Shannon , M. C. (1985). Principles and strategies in breeding for higher salt tolerance, *Plant and Soil* 89 : 227 – 241.

Staples, R. C. and G. H. Toennissen (1984). Salinity tolerance of plants. *Wiley and sons,* N. Y., U.S.A.

Van Hoorn J.W.; Katerji, N. and A. Hamdy (1997). Long-term salinity development in a lysimeter experiment. *Agricultural Water Management* 34 : 47-55.

تفاعلات فسفوالجبس والسوبرفوسفات مع تربة غزة وعلاقتها بنوعية ميـــــاه الــــــري

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ص.ب ١٢٧٧ – غزة فلسطين

ملخص

تم إضافة فسفوالجبس والسوبرفوسفات كمصادر للفوسفور إلى تربة لومية بأربعــة معــدلات (٠، ١٥ ، ٣٠ و٤٥ جزء من المليون) . تم إجراء نوعين من الــتجارب ، الأولي عبارة عن تجربة تجفيف وابتلال لعدد من الدورات يصل إلى ٢٠ دورة باستخدام نوعين مــن مياه الري (١,٥٥ و ٣,٢ ديسي سيمنز/م) . وفــي الثانــية تم زراعة شتلات الذرة *(Hybrid sweet corn)* في أصص زراعية وتم ريهــا أيضــاً بمياه عذبة ومياه مالحة . تم تقدير الصفات الكيميائية للتربة في كلتا التجربتيــن كمــا تم قياس الأوزان الجافة للنباتات وأطوالها وتركيز الفوسفور في النــبات . لوحــظ زيــادة درجة التوصيل الكهربي مع زيادة عدد دورات التجفيف والابتلال وكان ذلك أكثر وضوحاً في العينات المعاملة بالمياه المالحة ، كما وجد أن الفسفور الذائب والمتيسر للنبات قد انخفض تدريجياً ومعنوياً مع زيادة عدد الدورات ولكــن لوحــظ زيادة بسيطة في العينات المعاملة بالسوبرفوسفات . وجد أن أوزان النــباتات الجافــة كانــت أعلى في حالة العينات المروية بالمياه العذبة وأن تركيز الفوسفور كان أعلى نسبياً في النباتات المعاملة بالسوبرفوسفات مقارنة بالفسفوجبس .