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Interactive Effects of Saline Irrigation Water and N-P Applications on Wheat Plants Grown on a Calcareous Soil

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ABSTRACT. A pot experiment was conducted on calcareous soil to study the interactive effects of saline irrigation water and N-P application rates on growth, yield, N and P content in grains of wheat variety Giza 157. A poitive response in plant height, number of tillers, grain yield, N and P content was obtained for the added N and/or P rates. The degree of response varied considerably from one trait to another at the variable N and P rates. On average, the reductions obtained at the optimum N and P levels due to increasing salinity were subsequently 9.4, 27.6, 18.5, 4.4 and 15.1 % for the above-mentioned traits.

The interaction effect of N×P treatments was clearly pronounced on the number of tillers, grain yield and its P content. The differences between N treatments along P rates varied among the measured parameters.

Number of tillers was linearly and quadratically increased with increasing N rates under both salinity treatments. By increasing the level of salinity, number of tillers was decreased along N rates, but the degree of reduction was, however, greater at the highest N level.

Phosphorus × salinity interaction, only influenced the grain yield and its P content. Increasing salinity produced a greater reduction in yield at the higher P rates than the lower ones. A greater reduction in P content was detected between P_2 and P_3 due to increasing salinity.

Since the grain yield was not drastically reduced under saline treatment, it was concluded that application rates of 150 kg N/ha and 75 kg P_2O_5/ha were effective for increasing yield under saline and non-saline conditions.

Optimizing the yield of different crops in saline soils is still receiving considerable attention from research workers. Reports published by Abdul-Kadir and Paulsen (1982), Carpenter *et al.* (1979), Khalil *et al.* (1967), Langdale and Thomas (1971), Papadopoulos and Rending (1983), Soliman *et al.* (1981) and Thomas and Langdale (1980) indicated considerable variation among species in their salt tolerance. The plant response to fertilizer applications in salt-affected soil is contradictory. Abd-Elnaim *et al.* (1976), Foli (1958) and Garg *et al.* (1982)

reported a marked yield increase in wheat with increasing N and P fertilizers. On the other hand, Schwarz (1957) showed that the yield of barley was increased by an increase in N rate and decreased by increasing P applications. Additional data presented by Savost (1956) confirmed the negative effect of P on maize yield. The results of Bernstein *et al.* (1974) suggested that the effect of salinity and fertility on both grain and several vegetable species were independent and additive when either nutrient deficiency or salinity was moderate and yields were moderately depressed. He added that strongly inhibitory salinity levels or nutrient deficiencies tended to control yield regardless of the level of the other.

The study reported herein was carried out to examine the interactive effects of saline irrigation water and N-P applications on growth and yield of wheat plants grown on a calcareous soil and on the N and P content of the grains.

Material and Methods

A pot experiment was conducted in a greenhouse using the top 30 cm of a calcareous soil collected from the Northern part of Tharir region. The soil had a pH of 8.4; Olsen's P, 7.1; N, 152 ppm; $CaCO_3$, 30.2% and had a silty clay loam texture. The pots (23 cm diameter and 40 cm deep) were filled with a soil, having an electrical conductivity of 0.3 dS/m in the saturation extract.

The seeds of wheat variety Giza 157 were planted and thinned to 4 seedlings/pot after 2 weeks. Thirty-two treatments, consisting of 4 levels of N, *viz.*, 75 (N_1), 150 (N_2) and 225 (N_3) kg/ha as urea, 4 levels of P_2O_5, *viz.*, 0 (P_0), 37.5 (P_1), 75 (P_2) and 112.5 (P_3) kg/ha as superphosphate and 2 levels of saline irrigation water, *viz.*, tap water control 250 ppm, (S_0) and water containing 6000 ppm (S_1) of commercial NaCl + $CaCl_2$ at a ratio of 1:1 by weight, were factorially combined in a complete-block design with three replications. Phosphorus fertilizer was broadcasted and mixed with the upper soil surface prior to planting. Nitrogen treatments were added at 5 intervals, every two weeks to minimize the loss of N. The first dose of N was applied 15 days after planting. Potassium as K_2SO_4 was also applied to all pots at a rate of 60 kg K_2O/ha. Tap water as well as saline water was applied weekly in amounts exceeding 25% of the field capacity of the soil.

At maturity, plant height, number of tillers and grain yield per pot were recorded. Nitrogen and P content of grains were determined by Kjeldahl and vanadomolybdate methods, respectively (Black 1965).

Results and Discussion

1. Plant Growth and Yield

a. Plant Height

The results presented in tables 1 and 2 illustrate the main effects of saline irrigation water, N and P applications on plant height. All were significant at the

Table 1. Effect of salinity of irrigation water, N and P applications on plant height (cm).

Sal. level ppm	N rate kg/ha	P_2O_5 rate, kg/ha				
		P_0	P_1	P_2	P_3	Mean
S_0	N_1	84.3	86.3	87.7	84.0	85.6
	N_2	90.0	90.7	91.3	88.3	90.1
	N_3	90.0	90.3	93.7	90.3	91.1
Mean		88.1	89.1	90.9	87.5	88.9
S_1	N_1	80.0	81.0	83.2	80.3	81.1
	N_2	82.0	85.7	88.3	83.7	84.9
	N_3	83.0	84.7	87.3	83.3	84.6
Mean		81.7	83.8	86.3	82.4	83.5
L.S.D. (0.05), S = 1.66, N = 2.03, P = 2.35 cm						

Table 2. Analysis of variance, with linear (L), quadratic (Q) and cubic (C) contrasts, for the different measured parameters.

S.O.V.	d.f.	F				
		Plant height	No. tillers	Grain yield	N%	P%
P_L	1	0.43	33.51*	625.21*	95.07*	343.05*
P_Q	1	9.77*	0.02	32.88*	0.75	0.51
P_C	1	2.90	0.49	44.00*	0.90	1.82
N_L	1	19.62*	516.28*	336.28*	36.63*	6.65*
N_Q	1	4.78*	0.12	111.65*	0.27	0.04
S_L	1	42.30*	318.38*	185.16*	81.29*	113.47*
$P_L \times N_L$	1	0.05	7.05*	25.69*	1.30	5.43*
$P_L \times N_Q$	1	0.02	17.06*	21.04*	0.07	0.35
$P_Q \times N_L$	1	0.00	0.46	4.41*	0.63	0.40
$P_Q \times N_Q$	1	0.13	1.58	0.54	0.24	1.20
$P_C \times N_L$	1	0.14	0.02	2.59	0.05	0.80
$P_C \times N_Q$	1	0.08	0.55	4.44*	0.19	1.61
$P_L \times S_L$	1	0.40	0.98	21.52*	2.97	40.49*
$P_Q \times S_L$	1	0.23	0.02	2.39	0.03	6.88*
$P_C \times S_L$	1	0.01	0.01	1.67	0.11	1.29
$N_L \times S_L$	1	1.02	10.48*	0.07	1.36	0.00
$N_Q \times S_L$	1	0.03	6.51*	0.88	3.97	0.04
P × N × S	6	0.21	1.83	0.66	0.88	1.52
Error, (M.S.)	48	12.2697	3.3424	7.6379	0.0030	0.0009

* significant at 5% level.

5% level of probability, while the interactions were not significant. Increasing N rates produced a stimulating effect over the control treatment at both salinity levels. The maximum increase in plant height was recorded at N_3 and N_2, respectively. The differences in plant height between N_2 and N_3 were not significant. Phosphorus applications, only at P_2 rate, increased plant height over the control at both saline conditions. The other P rates did not show any significant differences over the control. Increasing salinity had a small depressing effect on plant height. On average, the mean reduction was 9.4%. Similar findings were also reported by Carpenter *et al.* (1979) and Sharma and Lal (1975).

b. Number of Tillers

The main effects of salinity, N and P and N×P and N×S interactions were significant at the 5% level (Tables 2 and 3). Irrespective of salinity, progressive increase in N and/or P rates stimulated tillering. At N_2 and N_3 rates, the number of tillers increased to 1.2 and 1.6 times the plant tillering of N_1 under non-saline conditions. The corresponding increases in salt-treated pots were 1.4 and 1.7, respectively. On average, the salinity treatment reduced tillering by 27.6%. The experimental results of Lal and Singh (1973) and Soliman *et al.* (1978) showed a similar trend. The rate of increase in tillering due to P application rates was relatively lower than to N rates across salinity levels.

Table 3. Effect of salinity of irrigation water, N and P applications on number of tillers per pot.

Sal. level ppm	N rate kg/ha	P_2O_5 rate, kg/ha				
		P_0	P_1	P_2	P_3	Mean
S_0	N_1	19.3	21.0	23.3	23.3	21.7
	N_2	25.7	26.0	29.0	27.3	27.0
	N_3	33.0	34.0	35.0	38.0	35.0
Mean		26.0	27.0	29.1	29.5	27.9
S_1	N_1	13.7	14.2	15.0	16.0	14.7
	N_2	21.7	21.7	20.7	19.4	20.9
	N_3	21.0	23.0	27.0	29.0	25.0
Mean		18.8	19.6	20.9	21.5	20.2

L.S.D. (0.05), S = 0.87, N = 1.06, P = 1.22
N × P = 2.12 & N × S = 1.50

The effect of N×P interaction on number of tillers is presented in table 2 and Fig. 1a. All P rates enhanced tillering at N_1 and N_3. At N_2, the number of tillers was increased up to P_2 and thereafter decreased at the highest P rate, but the difference was not significant. Number of tillers was linearly and quadratically increased with increasing N rates under both salinity treatments (Table 2 and Fig. 1b). By increasing the level of salinity, the number of tillers was decreased along N rates, but the rate of decline was greater at the highest N rate. Bernstein *et al.* (1974) showed that when inhibition by fertility and salinity are in approximate balance, the effects of both increased fertility and decreased salinity may approximately equal.

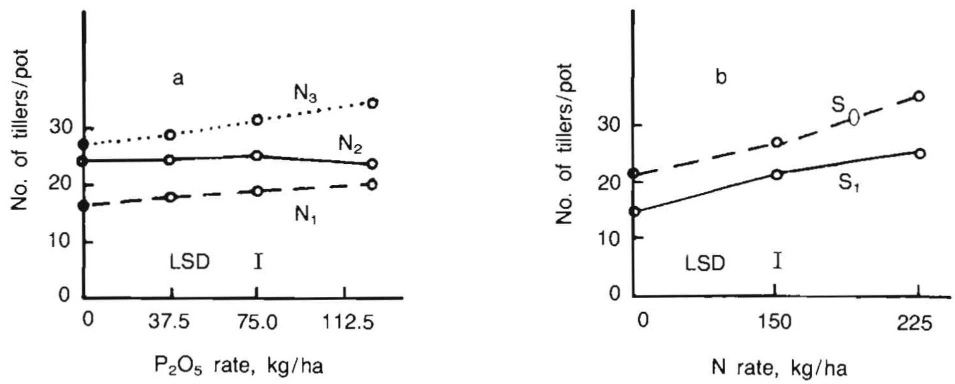

Fig. 1. Number of tillers as related to NxP and PxS interactions.

C. Grain Yield

A marked increase in grain yield was detected for each added increment of N and/or P fertilizer up to N_2 and P_2 rates under non-saline conditions (Table 4). Grain yield tended to increase up to the maximum N and P rates under saline conditions. Yield differences between N_2 and N_3 and/or P_2 and P_3 were not significant. On average, salinity treatment reduced grain yield by 18.5%, which was above the critical level of yield reduction (50%) as defined by Rhoades and Bernstein (1971).

The results given in Table 2 and Fig. 2a show the interaction effect of N and P treatments on grain yield. The differences in grain yield between N_2 and N_3 were not significant along P rates. Yield differences obtained between N_1 and N_2 or N_3 tended to increase up to P_2 rate. Yield did not longer increase at N_2 or N_3 with the

Table 4. Effect of salinity of irrigation water, N and P applications on grain yield (g/pot).

Sal. level ppm	N rate kg/ha	P_2O_5 rate, kg/ha				
		P_0	P_1	P_2	P_3	Mean
S_0	N_1	29.6	34.5	43.9	44.1	38.0
	N_2	35.5	45.5	67.0	65.5	53.4
	N_3	36.7	48.1	63.8	62.9	52.9
Mean		33.9	42.7	58.2	57.5	48.1
S_1	N_1	23.8	27.8	33.0	34.7	29.8
	N_2	32.4	38.4	52.0	51.8	43.7
	N_3	33.0	39.7	52.7	51.5	44.2
Mean		29.7	35.3	45.9	46.0	39.2
L.S.D. (0.05), S = 1.31, N = 1.60, P = 1.85, N × P = 3.21 & P × S = 2.62 g/pot						

highest P rate. Grain yield was linearly increased with increasing P rates under both salinity treatments (Table 2 and Fig. 2b). Differences between yield obtained at P_2 and P_3 were not significant. Increasing salinity exhibited a greater reduction in yield at the higher P levels than the lower ones. In this respect, Bernstein *et al.* (1974) indicated that when ambient salinity is the dominant limiting factor, increasing fertility will be relatively ineffective compared to decreasing salinity. Since the grain yield was not drastically reduced under the saline treatment, it was concluded that application rates of 150 kg N/ha and 75 kg P_2O_5/ha were effective for increasing yield under saline and non-saline conditions.

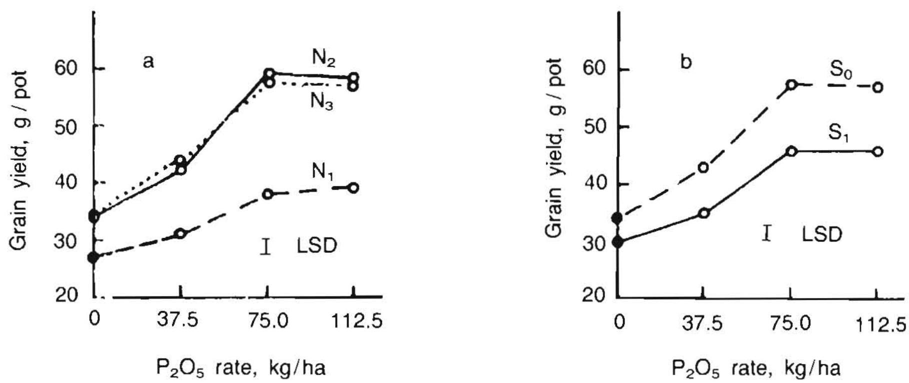

Fig. 2. Grain yield as related to NxP and PxS interactions.

2. Nitrogen and Phosphorus Content in Grains.

a. Nitrogen

The data given in Tables 2 and 5 show the main effects of saline irrigation water, N and P applications on N content in grains. All were significant at the 5% level, while the interactions were not significant. Increasing N and/or P rates increased N content under saline and non-saline conditions. Nitrogen content ranged between 2.44 to 2.55% at N_1 and N_3 for the control pots and from 2.36 to 2.44% for the salt-treated pots. Increasing salinity had a small depressing effect on N content. On average, the reduction was 4.4%. Disruption of plant nitrogen metabolism by salinity was attributed to decreased nitrate uptake (Abdul Kadir and Paulsen 1982) and slowed protein synthesis (Helal and Mengel 1979). Phosphorus application, only at higher rates, significantly increased N content over the control under both salinity treatments.

Table 5. Effect of salinity of irrigation water, N and P applications on N content of grains (%).

Sal. level ppm	N rate kg/ha	P_2O_5 rate, kg/ha				
		P_0	P_1	P_2	P_3	Mean
S_0	N_1	2.36	2.40	2.48	2.52	2.44
	N_2	2.42	2.46	2.55	2.65	2.52
	N_3	2.48	2.50	2.60	2.64	2.55
Mean		2.42	2.45	2.54	2.60	2.50
S_1	N_1	2.30	2.35	2.38	2.41	2.36
	N_2	2.32	2.32	2.40	2.42	2.37
	N_3	2.35	2.39	2.46	2.55	2.44
Mean		2.32	2.35	2.41	2.46	2.39
L.S.D. (0.05), S = 0.03, N = 0.03, & P = 0.04 %						

b. Phosphorus

Similar to N, increasing rates of N and/or P stimulated P content in grains (Table 6). At the two salinity levels, P content in grains was increased by 57.5 and 22.5% over the control at P_3. The mean reduction due to salinity was 15.1%. The reduction in P content under saline conditions was also found in barley and in some of the vegetables (Bernstein *et al.* 1974). They indicated that apart from the effects of salinity on root growth, salinity may have other effects on P availability. They suggested that high calcium concentrations in the saline solution probably caused P precipitation. Nitrogen applications, only at the highest rate, significantly increased P content over the control under both salinity levels.

Table 6. Effect of salinity of irrigation water, N and P applications on P content of grains (%).

Sal. level ppm	N rate kg/ha	P_2O_5 rate, kg/ha				
		P_0	P_1	P_2	P_3	Mean
S_0	N_1	0.40	0.52	0.55	0.60	0.52
	N_2	0.40	0.46	0.59	0.64	0.52
	N_3	0.40	0.49	0.62	0.64	0.54
Mean		0.40	0.49	0.59	0.63	0.53
S_1	N_1	0.41	0.41	0.45	0.50	0.44
	N_2	0.41	0.42	0.47	0.51	0.45
	N_3	0.39	0.45	0.48	0.53	0.46
Mean		0.40	0.43	0.47	0.51	0.45
L.S.D. (0.05), S = 0.01, N = 0.02, P = 0.02, N × P = 0.03 & P × S = 0.03 %						

The effect of N×P interaction on P content in grains is shown in Table 2 and Fig. 3a. Phosphorus content was linearly and quadratically increased with increasing P rates at all N levels. Increasing N rates increased P content especially at the higher P rates. Significant differences in P content were detected only

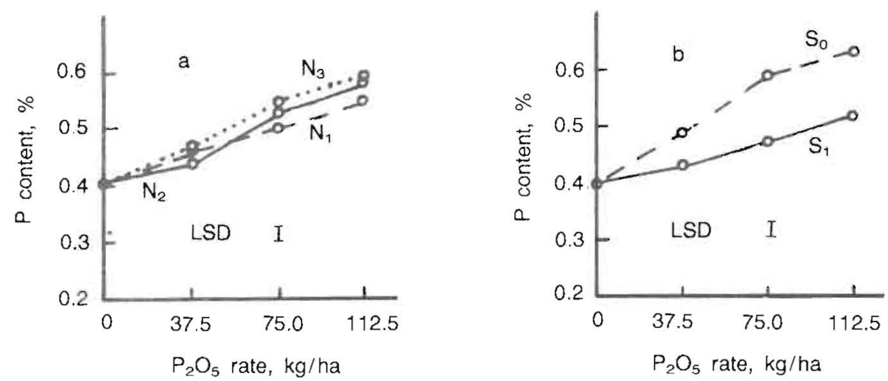

Fig. 3. Phosphorus content in grains as related to NxP and PxS interactions.

between N_1 and N_3 at P_2 and P_3. Linear and quadratic relations were existed between P content and P rates at the two salinity levels (Table 2 and Fig. 3b). Increasing salinity exhibited a pronounced reduction in P content between P_2 and P_3.

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التأثير المتداخل لملوحة مياه الريّ مع إضافة النتروجين والفوسفور على نباتات القمح النامية في أرض حيوية

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مركز البحوث الزراعية - الإسكندرية - مصر

نفذ هذا البحث في تجربة احصى لدراسة التأثير المتداخل لملوحة مياه الريّ عند إضافات مختلفة من النتروجين والفوسفور على النمو من المحصول ومحتوى الحبوب من النتروجين والفوسفور لنباتات القمح النامية في أرض جيرية. كان هناك إستجابة موجبة في إرتفاع النباتات، عدد التفريعات، المحصول ومحتوى الحبوب من النتروجين والفوسفور مع معدلات النتروجين والفوسفور المضافة. اختلف مقدار الإستجابة من مكون إلى آخر على حسب معدلات النتروجين والفوسفور المضافة. أحدثت الزيادة في الملوحة نقصاً تراوح في المتوسط من ٩,٤، ٢٧,٦، ١٨,٥، ٤,٤ و١٥,١٪ من الصفات المدروسة والتي سبق ذكرها على الترتيب.

التأثير المتداخل لمعاملات النتروجين والفوسفور كانت أكثر وضوحاً في عدد التفريعات، محصول الحبوب ومحتواه من الفوسفور. إختلفت الفروق في الصفات المدروسة بين معاملات النتروجين والفوسفور. زيادة معدلات النتروجين أحدثت زيادة في عدد التفريعات من الدرجة الأولى والثانية تحت كلا من معاملتي الملوحة. إنخفض عدد التفريعات بزيادة مستوى الملوحة على إمتداد معدلات النتروجين، إلا أن

مقدار الإنخفاض كان أكبر عند أعلى مستوى نتروجين.

كان هناك تأثير متداخل بين الفوسفور والملوحة على محصول الحبوب ومحتواه من الفوسفور. زيادة الملوحة أحدثت إنخفاض أكبر من المحصول عند معدلات الفوسفور العالية عن المعدلات المنخفضة. ظهر أكبر إنخفاض في محتوى الحبوب من الفوسفور بين معدلي الفوسفور الثاني والثالث نتيجة لزيادة الملوحة نظراً أن محصول الحبوب لم يتأثر بشدة تحت معاملات الملوحة، أمكن الاستنتاج أن معدلات إضافة قدرها ١٥٠ كجم N /هكتار، ٧٥ كجم P_2O_5 هكتار كانت فعّالة في زيادة المحصول تحت كلا من الظروف الملحية والغير ملحية.