Yield Performance, Phosphorus Use and Uptake Efficiency in wheat as Influenced by P-Zn Interactions under Salt-Stressed Conditions

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ABSTRACT

A greenhouse experiment was carried out in bituminous cemented plots to evaluate the single and combined effects of salinity, P and Zn variables on growth, yield components, P use and uptake efficiency (PUE & Pu_pE) of wheat plants. Treatment variables, including 3-P fertilizer rates (0, 15 and 30 kg P_2O_5/fed.), 2 - Zn application methods (foliar and soil treatments) and 2 saline irrigation waters (tap water, as control and 5000 ppm) were replicated three times in a factorial arrangement. The plants were seeded in plots and irrigated with saline irrigation water to the maturity stage. At the harvest, straw and grain (SY, GY) yields, number of tillers and the weight of spikes/plot and 100 grain weight were recorded. Phosphorus use and uptake efficiency (PUE & Pu_pE) associated with first and second P increments were calculated. The results have shown that growth indices were significantly increased at 15 and 30 kg P_2O_5/fed. The salt-treated plants produced greater SY and number of tillers/plot than the control treatment. Superior growth associated with higher yield potentials were noted with Zn-foliar than Zn-soil application. Similar trend was detected for the P effects on yield component. On the contrary to the SY trend, salt stress induced marked reductions on GY, spike weight/plot and harvest index (H.I), amounted by 18.3, 24.0 and 24.3% compared with the control, respectively. The effects of Zn-foliar at variable P rates were prominent on all measured parameters than the Zn-soil application. The combined salinity-P and salinity-Zn interactions proved that although growth indices were significantly increased at the higher salinity level over the control, opposite results were recorded on the yield components. Based on the positive response of wheat-stressed plants to P treatments, attention is being forward to apply 30 kg P_2O_5/fed. On average, the PUE associated with 1st and 2nd P increments was doubled under Zn-foliar compared with Zn-soil application. On the other hand, the salt stress was found to stimulate the PUE by 40%. Reported data on Pu_pE imposed similar trend as for PUE, but the values were relatively lower.

Key words: wheat; yield component; P-use and uptake efficiency; P, Zn and Salinity interactions.

INTRODUCTION

The growing increase of salt-affected soils in Egypt needs substantial investigations to identify the optimal fertilizer programs that could be applied to minimize the advisable effects of salinity on yield crops. In spite of the fact that P utilization by the growing plants in soils is usually limited (Jungk et al., 1993) and did not exceed 10% (Schenk and Barber,1979), increasing P fertilization has been intensively practiced to stimulate yield potentials and to alleviate growth inhibition under salt-stressed condition. However, the economic application rates are still questionable, depending on the response rate of plant species and cultivars (Greenway and Munns, 1980, and Duvick et al., 1981) and on salinity-fertility interaction. The inefficient P use was, however, reasoned to the rapid change of the applied P to unavailable form and to P immobilization in soil rhizosphere, as a consequence of low P diffusion coefficient (Mackay and Barber,1985).

Reported data on the salinity-phosphorus interaction have shown that P fertilization in salt- affected soils may be beneficial in reducing the depressing effects on yield as long as the salinity level is low or in medium range (Bermstein et al. 1974). In this respect, Patel and Wallace (1976) noted that increased P levels were effective to induce positive interaction with moderate salinity in several field crops. Unlike, at higher levels, the yields were decreased progressively as P rate increased (Cerda et al., 1977). It was postulated that the decrease in P utilization by rooting system at higher salinity level was ascribed to the damage of cell membrane that controls intracellular concentration of orthophosphate, acting for P toxicity (Nieman and Clark, 1976).

Restriction of Zn uptake and translocation within plant parts is well documented and were attributed to plant and soil limitation. Previous studies have shown that in soils of pH above 7 and that containing high $CaCO_3$ contents are not operative to supply the plants with Zn needs, due to the immobilization processes (Chaudry et al., 1977), P-Zn interaction (Safaya, 1976, Loneragan et al., 1979, Farah and Soliman,1986) and ion competition (Chaudhry and Loneragan, 1972). In all cases whereas Zn is incorporated to the soil, the soluble Zn is hardly utilized by plants, acting for marked significant effects on yield. Based on these facts, the present study was undertaken to quantify the single and combined effects of salinity, P and Zn application on yield performance and P use and uptake efficiency by wheat.

MATERIALS AND METHODS

A greenhouse experiment was carried out at the Soil Salinity Laboratory, whereas wheat cultivar " Sakha 69" was seeded in bituminous cemented plots of 1.0m length X 0.7m width X 0.7m depth, containing a sandy loam soil. The chemical analysis showed that the soil was low in available $NaHCO_3$-extractable P, 3.6 mg Kg^{-1}soil(Olsen and Sommers, 1982) and poor in the DTPA-extractable Zn, 0.92 mg Kg^{-1} soil (Lindsay and Norvell, 1978). The initial soil pH was 7.6 (1:2.5, soil: water ratio) and contained 0.47% organic matter (Mckeague, 1979), 5.4% $CaCO_3$ and 1000 mg l^{-1} of total soluble salts (EC= 1.56 dSm^{-1}). A 3x2x2 factorial experiment was carried out to study the single and combined effects of salinity, P fertilization and Zn application on yield performance and phosphorus use and uptake efficiency. Basically, the involved treatments were considered to include: 1- Three P application rates, i.e., 0, 15 and 30 kg P_2O_5/fed, as orthophosphoric acid. 2. Two different saline water exposures, i.e. control (tap water) and 5000 ppm, established by diluting sea water. 3. Two different methods of Zn applications, foliar (0.5% $ZnSO_4$) and soil application (4kg $ZnSO_4$/fed). All variables were replicated three times in a complete randomized block design. The seeds were planted during the winter season 2000/2001 and the seedlings were adjusted, keeping a constant population density of 100 plants per plot. The plants were supplied with 30 kg

N/fed, as urea and 45 kg K_2O/fed, as K_2SO_4 fertilizers. To minimize the fertilizer losses by irrigation, N and K doses were equally splited and added during the vegetative and early tillering growth stages. Besides, P and Zn treatments were applied as for the N timing, just before the initiation of booting stage. All plots were regularly irrigated every week with saline water treatments during the course of vegetative stage and according to soil moisture depletion in the later stage. In all cases, an additional irrigation water, amounted by 25% over the F.C. was applied to reduce the salt accumulation in soil rhizosphere. At Maturity, growth index, expressed by straw yield data (SY) and number of tillers/plot, and yield components, including grain yield (GY), spike weight/plot and the weight of 100 grain were recorded for each individual plot. Random grain samples for each replicate were oven-dried (70 C^{o}), ground, digested with $HNO_3/HCLO_4$ (5:1, v/v) acid mixture and analyzed for grain P content by vanadomolybdate method (Jackson, 1958). The agronomic data were statistically analyzed and L.S.D values were calculated to test the significance of the single and combined treatments (Steel and Torrie, 1980). In addition, regression/correlation analyses were also performed for quantitative evaluations. Similar to Fan and Mackenzie (1994), phosphorus use efficiency associated with the first (PUE_{01}) and second (PUE_{02}) P unit increment was calculated using the proposed following formula:

$$PUE_{01} = (GY_{01}-GY_{00})\text{x } 100/P_{01}$$
$$PUE_{02} = (GY_{02}-GY_{01})\text{x } 100/P_{01}$$

Where

GY_{00} = grain yield per plant for the control treatment
GY_{01} = grain yield per plant at rate of 15 kg P_2O_5/fed.
GY_{02} = grain yield per plant at rate of 30 kg P_2O_5/fed.
P_{01} = amount of P added per plant calculated at the rate of 15 kg P_2O_5/fed.

Similarly, phosphorus uptake efficiency associated with the first (PU_pE_{01}) and the second (PU_pE_{02}) P unit increment was calculated, using the following formula:

$$PU_pE_{01} = (GY_{01}\text{ X }C_{01}-GY_{00}\text{ X }C_{00})\text{x } 100/P_{01}$$
$$PU_pE_{02} = (GY_{02}\text{ X }C_{02}-GY_{01}\text{ X }C_{01})\text{x } 100/P_{01}$$

Whereas, C_{00}, C_{01}, and C_{02} represent grain P content for the unfertilized, 15 and 30 Kg P_2O_5/fed.-treated plants, respectively.

RESULTS AND DISCUSSION

1. Main Effect:

1.1. Growth Index

Significant differences on growth index were detected due to P, salinity and Zn treatments (Tables 1). Superior growth was generally observed at the maximum P rate. The advantages in SY yield potentials were, 16.7 and 35.3% at 15 and 30 Kg P_2O_5/fed, respectively. Similar trend was recorded on the number of tillers/plot, but the rate of increases were relatively lower, giving 11.3

and 27.8% at the respective P rates compared with the control. Similarly, wheat plants exposed to saline irrigation water of 5000 ppm exhibited higher SY and reproduced greater number of tillers than the control (Table 1). The stimulatory effects were , however, outlined by 7.9 and 17.0%, respectively. The data proved that Zn-foliar was more conspicuous than Zn-soil treatment, acting for marked increments, amounted by 16.5 and 20.5 % on SY and number of tillers/plot, respectively.

1.2 Yield Components and Harvest Index

In accordance to the pattern of SY trend, the GY data revealed subsequent significant increases with increasing P rates (Table1). Quantitatively, the progressive responses in GY at 15 and 30 kg P_2O_5/fed amounted 19.6 and 41.3%, respectively, over the control treatment. Although the weight of 100 grains and spike weight/plot did not appear any significant performance at 15 kg P_2O_5/fed (Table1), the effects were, only, manifested at the highest P application rate, accounting for 8.6 and 20.7%, over the unfertilized wheat plant, for the respective traits. The data of harvest index (H.I), that describes the relationship between GY and SY yield, showed slight variations across the P application rates (Table1).

Regarding to the effects of salt stress, wheat plants subjected to 5000 ppm of saline irrigation water were seriously affected, as revealed from the yield component data (Table 1). Compared with the control, salt stress induced considerable reductions, amounted by 18.3, 5.0 and 24.0%, for GY, weight of 100 grains and spike weight/plot, respectively. The overall effect of salinity on GY and SY yield production exhibited a reduction of 25.1% on the harvest index, (Table 1). These results agree with the data reported by Soliman (1986) on the salt stressed wheat cultivar " Giza 157" whereas the number of tillers and GY were decreased by 27.6 and 18.5 %, respectively. Additional data (Maas and Poos,1989 and Maas and Grieve,1990) indicated that wheat plants exposed to salt stress prior to and during spikelet development (booting stage) significantly decreased the yield potential, due to the reduction in the number of tillers/plant and kernel weight/spikes. The inverse relationship between GY and each of SY or number of spike/plot under saline environment could be explained on the basis of the changes in morphological and physiological criteria associated with salt imposition on wheat plants. According to Strogonov (1962) and Vaisel (1972), salt stress may induce structural changes, including an increase in thickening of cuticle and earlier occurrence of lignifications and inhibition of organ differentiation, in terms of increasing stem diameter and number of xylem vessels. However, these alteration in plant development may explain the disorder in SY/GY data under salt-stressed conditions. On the other hand, since the ion uptake and transport through cell membrane is partially an active process, requiring energy, it seems possibly that high energy is apparently consumed for osmoregulation, lacking less available energy for metabolic pathway. This might explain the yield depression due to incomplete seed formation, despite of increasing number of tiller/plot.

Table (1) Phosphorus, salinity and Zn effects on growth index, yield component, harvest index and grain P content of wheat.

Treatment	Growth index		Yield component			H.I %	Grain P content g kg^{-1}
	SY g/plot	No. of tillers	GY g/plot	w100 grain, g	spike w., g/plot		
P rate kg P_2O_5/fed.							
P0	382.3	139.4	189.0	4.77	328.5	49.4	4.57
P15	446.0	155.2	226.0	4.74	340.1	50.7	4.97
P30	517.1	178.1	267.0	5.18	396.6	51.6	5.33
L.S.D	13.4	6.8	7.1	0.32	20.4		
Salinity level, ppm							
S0	431.3	145.2	250.2	5.02	403.4	58.0	7.42
S5000	465.6	169.9	204.4	4.77	306.7	43.9	7.46
L.S.D	10.9	5.59	5.8	0.22	16.7		
Zn applied							
F	462.7	172.2	244.9	5.19	384.5	50.7	5.34
s	414.2	142.9	209.7	4.6	325.6	50.6	4.58
L.S.D	10.94	5.59	5.8	0.26	16.7		
P	**	**	**	**	**	*	*
Salinity	**	**	**	**	**	**	n.s
Zn	**	**	**	**	**	n.s	**
P x Salinity	**	**	**	n.s	**	**	*
P x Zn	**	**	**	**	**	n.s	**
Salinity x Zn	*	*	**	**	**	**	*

* Significant at the 5% of probability..
** Highly significant at the 1 % of probability
F = foliar s = Zn-soil application
H.I = (Grain yield / Straw yield) X 100.
n.s = not significant at the 5% of probability
S = salinity level

The relative comparison between Zn treatments showed that greater advantages were clearly manifested on the all measured agronomic data when Zn was introduced as a foliar application. The impressive effects of Zn-foliar treatment averaged 16.8, 12.8 and 18.1 % on GY, weight of 100 grains and spikes weight/plot, respectively. On the other hand, as far Zn-foliar treatment exerted parallel stimulatory effects on both grain and SY yield data, no remarkable variation was detected on the harvest index (Table 1).

2. Interaction effect:

2.1. Phosphorus- Zinc Interaction

The results presented in figure 1 indicated that increasing P rates induced progressive positive effects on all the recorded data when Zn was applied but the performance was, however, more evident for the foliar than the soil application. To assess the degree of variability between the two proposed methods of Zn applications along the applied P rates, the regression coefficients of each trait were quantitatively compared. The relative comparison of regression equations proved that Zn-foliar application was more efficient to increase the straw yield and number of tillers 2.31 times the comparable Zn-soil treatment (Fig. 1a and 1b) . Similarly, the stimulatory effects of Zn foliar application along P rates on grain yield and the spike weight/plot were 2.02 and 3.55 times the Zn-soil application(Fig. 1c and 1d), respectively. In all cases, the yield differences between Zn treatments were more confident at the highest P rates rather than the lower ones (Fig. 1). These results would suggest that by Zn-soil application method, the soluble Zn was immobilized and converted, partially, to non-available in the alkaline pH range, due to the increased adsorption of Zn on the solid-phase carbonate (Moore and Loeppert,1990 and Tadross, 1997) or precipitated, as insoluble amorphous Zn-compounds (Tisdale et al., 1993 and Karimian, 1995) with limited solubility product or complexes with P forming insoluble Zn-phosphate compounds (Fahmi, 2001, Safaya, 1976 and Robson, 1993).

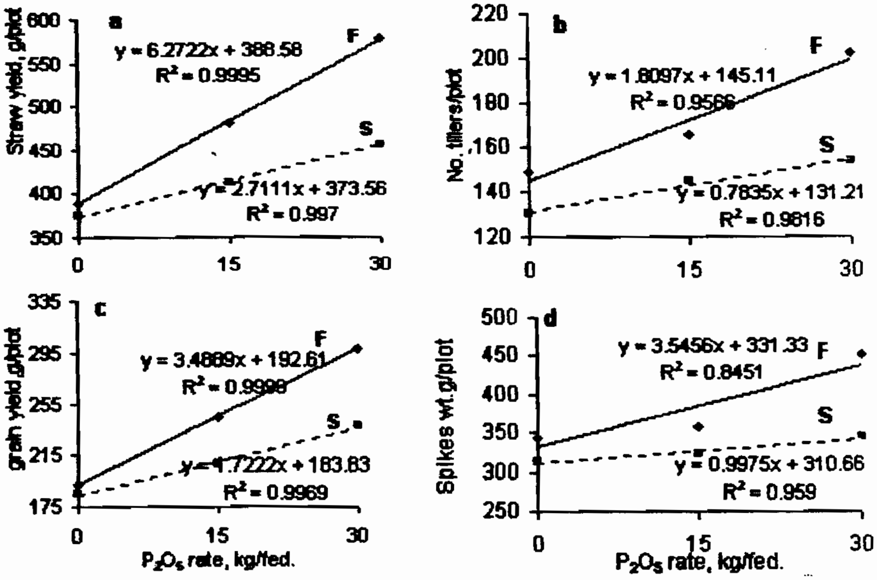

Fig. 1. The growth index (a,b) and yield components (c,d) as influenced by P-Zn interactions. (Zn: F= foliar, S= soil application)

2.2. Salinity – Phosphorus Interaction

The combined effects of salinity and P variables on growth indices and yield components of wheat are illustrated in figure 2. At the all applied P rates, plants exposed to salt stress yielded greater straw yield than those grown under non-stressed condition (Fig. 2a). The differences in SY between salt-treated and non-treated plants were more apparent in the absence of the applied P and decreased significantly as the P rate increased (Fig. 2a). Similar trend was also detected for the number of tillers/plot, but the difference between the salt-treated and untreated plants were relatively greater at the lower P rates (Fig. 2b). These results would suggest that P fertilization was, partially, beneficial to lessen the harmful effects of salinity on plant growth. On the contrary, the GY at the all P rates was significantly decreased under salinity stress compared with the control (Fig. 2c). However, the grain yield response to the applied P for the salt- treated plants was 1.42 times the response rate of the control treatment (Fig. 2c). The positive results detected, under our experimental conditions, are evidently impressive to increase GY potential under saline environment whenever wheat is provided with 30 kg P_2O_5/fed. The spike weight data (Fig. 2d) followed up the same pattern of GY, with greater inhibitory effects at the higher P rates. Relative to the P_0 treatment, the salt exposure at P_{30} acted to induce a limited stimulation (6.2%) on the spike development. This is may be in accordance with the non significant effect of the salinity-P interaction on the weight of 100 grain (Table 1).

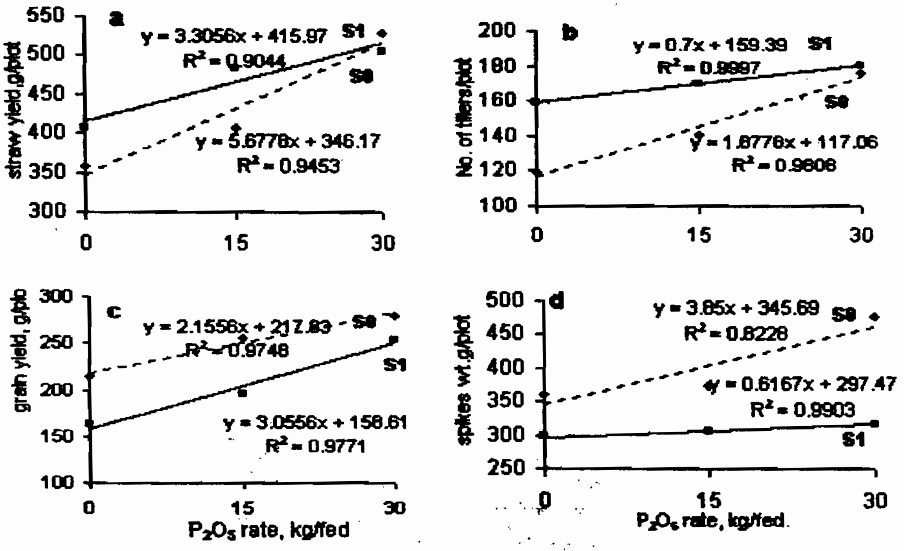

Fig. 2. The growth index (a,b) and yield components (c,d) as influenced by salinity-P interactions. (S0=tap water, S1=5000ppm)

2.3. Salinity - Zinc Interaction

The results given in figure 3 illustrated that the all measured parameters showed greater advantage for the Zn-foliar than the Zn-soil applications in salt-free and salt-treated plants, but the effects varied considerably from one component to another. The SY and the number of tillers/plot exhibited relatively greater values at the high salt treatment than the control for both Zn applications. However, significant differences on both growth index criteria between Zn applications were detected across the salt treatments (Fig. 3a and 3b). Opposite results were noted on the spike weight/plot and GY data (Fig. 3c and 3d), with greater performance of Zn-foliar than Zn-soil treatment. As far as Zn plays an important role as a component of many dehydrogenises enzymes (Hewitt and Smith, 1974) that are enrolled in the protein synthesis (Vallee,1976), it seems possibly that the low grain yield response in the presence of Zn-soil application under saline conditions reflects clearly the inefficient Zn supply to meet the plant needs. Evidences have shown that protein synthesis in wheat was impaired under saline conditions, during the grain filling stage (Helal and Mengel, 1979 and Abdul Kadir and Paulsen, 1982). This fact holds true, because the available Zn in soil rhizosphere may be restricted or bounded due to the interaction with counter ions in the soil solution. The work of Chaudhry and Loneragan (1972) on Zn uptake in wheat seedling proved that cations, including Ca, Mg, K and Na at low levels can drastically reduce Zn uptake.

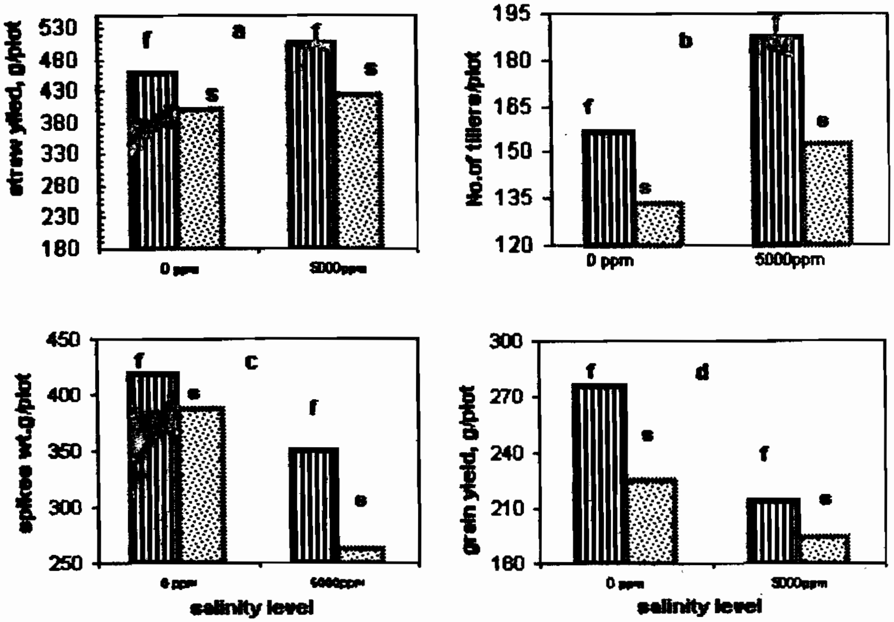

Fig. 3. The growth index (a,b) and yield components (c,d) as influenced by salinity-Zn interactions. (Zn: f =foliar, s =soil application)

3.Phosphorus use and uptake Efficiencies (PUE, PU$_p$E).

Based on the proposed equations for estimating the PUE, the results have shown that the values of PUE at each unit of P increment, were relatively higher for Zn-foliar than soil-Zn treatment (Table 2).

Table 2: The calculated values of Phosphorus use efficiency (PUE,%) as influenced by the main effects of P, Zn and salinity and their interactions.

Treatment	P increment		Mean
	1st unit	2nd unit	
	Zn- P interaction		
Zn application			
Foliar	46.79	49.54	48.16
soil	21.10	25.69	23.39
Mean	33.94	37.61	
	Salinity -P interaction		
Salinity			
Control	37.61	22.02	29.81
5000 ppm	30.27	53.21	41.74
Mean	33.94	37.61	

The relative comparisons between the applied Zn treatments demonstrated that PUE associated with the first and second phosphorus increments for Zn foliar were 2.22 and 1.93 fold the corresponding value for Zn-soil treatment. On average, the advantage of Zn-foliar treatment on promoting PUE was 2.06 times the stimulatory effect of Zn-soil application. This fact may be due to the interaction effects of soil variables on Zn and P mobilization, as previously discussed.

The data also indicated that the rate of change in PUE for each unit of P addition, under saline conditions, were relatively lower at the first P increment than the second subsequent one. Under non-saline condition, opposite results were detected. The PUE at the second P increment was markedly increased by 76% for the salt-treated plants, compared with an abrupt reduction amounted by 41.5% for the control treatment. These results would indicate that salt stress conditions were conductive to stimulate PUE by 40%. To great extent, the higher values detected for PUE under saline condition are coincided with the trend of growth index parameters rather than the data of grain yield components, supporting the view of high energy consumed for mineral nutrition processes in the salt-affected soil (Strogonov,1962 and Vaisel,1972).

The results presented in table 3 indicated that the uptake efficiency (PU$_p$E) of each P unit increment at the variable Zn and salinity treatments followed up the same trend of PUE data. In all cases, the values of PU_pE were relatively lower than the calculated PUE, revealing that P uptake may be partially restricted during the translocation processes within the plant parts, acting for less P accumulation in grains.

Table 3: The calculated values of phosphorus uptake efficiency (PU_pE,%) as influenced by the main effects of P, Zn and salinity and their interactions.

Treatment	P increments 1st unit	 2nd unit	Mean
	Zn- P interaction		
Zn application			
Foliar	36.07	43.25	39.66
soil	13.17	13.66	13.39
Mean	24.61	28.46	
	Salinity -P interaction		
Salinity			
Control	30.29	16.57	23.43
5000 ppm	21.46	37.99	29.73
Mean	25.88	27.28	

Evidences have shown that P-Zn interaction at the root-site interface were associated with translocation problems to the aerial parts (Khan and Zende, 1977 and Murphy et al., 1981). On the other hand, it should be emphasized that the higher predicted values of PUE are basically derived, only, from grain yield data, that takes into account all the involved limiting factors, which is not the case for PU_pE assessment. Accordingly, it seems possibly that beside the main determinal effect of grain P content on PU_pE, some-additive factors should be considered for estimating the PUE.

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الملخص العربى

علاقة إنتاجية محصول القمح وكفاءة استخدام الفوسفور وامتصاصه بالتداخل بين الفوسفور والزنك تحت ظروف الشد الملحي

عبد المنعم مبارك داود و نادى شوقي ناشد

قسم بحوث الأراضي الملحية والقلوية – معهد بحوث الأراضي والمياه والبيئة. مركز البحوث الزراعية باكوس الإسكندرية.

أجريت هذه التجربة في أحواض أسمنتية لتقييم التأثير الرئيسي والمتداخل لمعاملات الملوحة والفوسفور والزنك على النمو ومكونات المحصول وكفاءة استخدام الفوسفور المضاف وامتصاصه بواسطة نباتات القمح. تضمنت معاملات الدراسة ثلاثة مستويات من الفوسفور المضاف (صفر ، ١٥ ، ٣٠ كجم فو٢أ٥ /فدان) و طريقتان للزنك المضاف (رش ورقى و إضافات أرضيه) ومعاملتين من ملوحة مياه الري (ماء الصنبور كمقارنة و ٥٠٠٠ جزء فى المليون من تخفيف ماء البحر) وقد كررت هذه المعاملات ثلاث مرات فى تجربه ذات نظام عشوائي كامل. حيث زرعت حبوب القمح صنف سخا ٦٩ فى الأحواض الأسمنتية ورويت بمعاملات المياه الملحية حتى مرحله النضج. عند الحصاد سجل محصول القش (SY) ومحصول الحبوب (GY) و عدد التفريعات لكل حوض و وزن ١٠٠ حبه . كما حسبت كفاءه استخدام الفوسفور (PUE) وامتصاصه (PUpE) المرتبطة بإضافات الكمية الأولى والثانية من الفوسفور. وقد أوضحت النتائج ما يلي:

- أدت الزيادة التدريجية في إضافات الفوسفور الى زيادة معنوية فى محلولات النمو ومكونات المحصول. فقد زاد وزن القش الى ٣٥,٣ % وكذا زادت عدد التفريعات الى ٢٧,٨ % ومحصول الحبوب زاد ٤١,٣ % ووزن ١٠٠ حبه ٨,٦ % وكذا وزن السنبلة ٢٠,٧ % عند مستوى ٣٠ كجم فو٢أ٥/فدان مقارنة بمعامله الكنترول. وجد ايضا وأن هناك زيادة معنوية بالنباتات التي عوملت بماء ملحي تركيزه ٥٠٠٠ جزء فى المليون حيث زاد وزن القش وعدد التفريعات/ حوض بمقدار ٧,٩ ، ١٧ % على التوالي وانخفاض واضح فى محصول الحبوب ١٨,٣% ووزن ١٠٠ حبه ٢٤% وكذا دليل الحصاد ٢٥,١ % مقارنه بالنباتات التي رويت بمياه الصنبور. كما أظهرت النتائج أيضا ان افضل نمو كان مرتبطا باضافه الزنك رشا مقارنه بالاضافه الأرضية حيث زاد وزن القش بمقدار١٦,٥ % وزادت عدد التفريعات الى ٢٠,٥ %، ومحصول الحبوب زاد ١٦,٨% ووزن ١٠٠ حبه ١٢,٨% وكذا وزن السنبلة ١٨,١ % مقارنه بالكنترول.
- كما تشير التداخلات بين المعاملات إلى انه في حاله إضافة الفوسفور والزنك معا ، ازداد وزن القش وعدد التفريعات وكذلك محصول الحبوب و وزن السنبلة. وقد تحققت أعلى استجابة عند إضافة الزنك رشا في وجود معدل من الفوسفور مضاف مقداره ٣٠ كجم فو٢أ٥/فدان . ومن جهة أخرى أظهرت نتائج التداخل بين إضافة الفوسفور والملوحة الى زيادة معنوية فى محصول الحبوب حيث زاد ١,٤٢ مره تحت ظروف الري بالماء الملحي في وجود ٣٠ كجم فو٢أ٥/فدان رغم ان وزن السنبلة لم يتأثر كثيرا.

- بناء على النتائج الإيجابية المتحصل عليها من استجابة القمح للفوسفور المضاف تحت ظروف الشد الملحي ، يجب توجيه النظر إلى ضرورة إضافة ٣٠كجم فو$_٢$أ$_٥$/فدان.
- أما من حيث تداخل الزنك مع الأملاح فقد أظهرت النتائج أن أعلى زياد في محصول القش وكذا عدد التفريعات قد تحققت عندما أضيف الزنك رشا تحت ظروف الرى بالماء المالح إذا ما قورنت بماء الصنبور بينما كانت النتائج سلبيه بالنسبة لوزن السنابل ومحصول الحبوب.
- تضــاعفت كفاءة استخدام الفوسفور PUE في حاله إضافة الزنك رشا مقارنه بالمضاف إلى الأرض عند كل كميه فوسفور مضافة على حدى. كما أظهرت النتائج ان كفاءه استخدام الفوسفورPUE تحت الظروف المالحة قد ازدادت بمقدار ٧٦ % بزيادة الفوسفور من الكمية الأولى الى الثانية.
- أما من حيث كفاءه امتصاص الفوسفور PU$_p$E تحت جميع معاملات الزنك والملوحة المستخدمة فقد أوضحت النتائج أنها سلكت اتجاه مشابها لنتائج كفاءة استخدام الفوسفور PŨE إلا أن القيم كانت اقل نسبيا . مما يفسر وجود قيود فى عمليات انتقال الفوسفور داخل النبات ومن ثم نقصه داخل الحبوب.