J. Agric. Sci. Mansoura Univ., 32 (10): 8817 - 8829, 2007

INTERACTION EFFECTS OF SALINITY AND PHOSPHORUS ON GROWTH OF RICE PLANTS.

Abou-Zeid, S. T.
Soils Dept., Fac. of Agric., Cairo Univ., Giza.

ABSTRACT

The interaction between salinity and phosphorus nutrition is particularly complex. Plant responses can vary according to many factors. The role of phosphorus application on the growth and mineral composition of rice under saline conditions was studied in a solution culture. In this experiment, the effect of inorganic phosphate (Pi) on the growth and ionic relations of five rice varieties, varying in salt tolerance and phosphorus use efficiency, grown in nutrient solution with and without 50 mol m^{-3} NaCl was measured in a four week trial. The growth of all rice varieties was affected to different degrees due to external Pi in the presence or absence of salt. External Pi concentration up to 100 µM in the presence of NaCl caused stimulation of some growth parameters (shoot and root dry weight), above this concentration of Pi had an inhibitory effect. Increasing the supply of phosphorus (from 1 to 100 µMPi) to the saline medium tended to decrease the concentrations of Na^+ and Cl^- in all varieties. Shoot concentrations of these saline ions much were lower in Sakha 101 and Sakha 103 varieties, than in Sakha 102 variety. Shoot P and Zn concentrations showed an increasing trend in the presence of external Pi and NaCl salt in the rooting medium although P/Zn ratio was lower in some varieties such as Sakha 101 and Giza 178. Significantly higher concentrations of Na^+ and Cl^-, and lower concentration of Zn, were observed in the shoot of Sakha 102, Giza 176 and Giza 178 cultivars when exposed to salt stress in the presence of Pi in the external solution. Our results illustrate the complex relationship that exists between NaCl salinity and phosphorus. We conclude that a low supply of Pi (1-10 µM) to rooting medium is beneficial in improving growth while higher external Pi (more than 100 µM) is not beneficial.
Keywords: Rice varieties, Salinity, Pi.

INTRODUCTION

Soil salinity affects, globally, about 6 per cent of the land surface of the world, but much higher proportions of land in some countries, especially those where irrigated agriculture is practiced. These environments expose plants to a number of constraints on production of biomass and even on survival. (Flowers and Yeo, 1997).

(Oryza sativa L.) is a salt sensitive crop species which is relatively ineffective in controlling the influx of sodium and chloride ions to the shoot. Nonetheless, there is considerable varietal and individual variability in salinity resistance (Yeo and Flowers,1982). The adverse effect of salinity on rice yield has been reported by various workers (Akbar and ponnoamperuma, 1982 and Abou-zeid, 1996) studing the effect of salt concentration at various stages of rice crop development. Environments high in Cl^- and Na may affect plants by reduced transport of solutes. Presence of certain ions might inhibit or stimulate uptake of other ions by plants. These interactions between different inorganic ions are, conceivably, not confined to ion uptake by the plant or the cell, as a whole (Greenway, 1973).

Interaction between salinity and mineral nutrition affecting yields and nutrient uptake has been reported for several crops (Bernstein *et al.*, 1974). The combined effects of salinity and phosphorus nutrition are perhaps as complex than that between salinity and nitrogen. The interaction is highly dependent upon the plant species, plant developmental age, the composition and level of salinity and the concentration of P in the substrate.

As increase in the salt tolerance of some crops was reported when phosphorus level was a raised under saline conditions (Zaiter and Saade, 1993). In the presence of high sodium and calcium, accompanied by high pH, the forms of phosphate are either sparingly soluble or require more energy to be absorbed by plant roots (Yoshida, 1981). High levels of chloride could influence phosphate utilization as soil salinity led to increased chloride concentration in rice (Akbar, 1975). Rice growth at high NaCl salinity increased with increasing external P concentration up to 100 µM. Significant improvement in paddy yield by applying phosphorus to pots with salty soil was also observed (Aslam *et al.*, 1996).

Since phosphorus is a major plant nutrient and our knowledge of its availability in salt affected soils and improving salt tolerance of rice plant is limited, solution culture study was carried out with the aim of investigating the effects of salinity in presence of phosphorus on the growth of rice plant.

MATERIALS AND METHODS

Primary experiment (solution culture study)

Before the initiation of the main experiment one preliminary experiment with (50 mol m^{-3}) and without NaCl conducted on one rice cultivar (Sakha 101) to select a suitable range of phosphorus Pi concentration in culture solution for the salt × P interaction study.

Growth conditions

Plants were grown in a big net house without any environmental control, having glass covered roof, sides open, having only wire gauze and no problem of sunlight. During the time of the experiment and inside the net house, average of maximum temperature 32-40 c, minimum temperature 20-27, relative humidity 60-75 % and bright sunlight, with active photoperiod of 12-14 hours.

Experimental procedure:

Seeds of five rice varieties (Giza 176, 178 and Sakha 101,102,103) were surface-sterilized with 0.1 % HgCl for 5 minutes, washed and then soaked for 24 h in water at 20-25 ºC. the seeds were germinated in Petri dished over three layers of cotton saturated with distilled water. The dishes were then covered and left in the incubator for 48 h at 28-30 ºC. the germinated rice seeds were raised on nylon seedbed floating in phosphorus -free culture solution (From Yoshida *et al.*,1976). The five rice varieties were grown at (control) and 50 mol m^{-3} NaCl salinity and phosphorus concentrations of 1, 10 100 µM (five varieties, two NaCl salinity and three phosphorus levels). Ten-day-old seedlings of similar size were selected and transplanted to 3L plastic containers with phosphorus free nutrient solution. Each container was used for a single variety having sixteen seedlings held with cotton plugs through plastic lids with equidistant holes. The pH of the nutrient solution was adjusted daily by NaOH or H_2SO_4 to (5.5-6). Five days after transplanting, phosphorus solution (KH_2PO_4) of respective concentration (1,10,100 µM) was add. Later, within one day respective containers were salinized with NaCl to a concentration of 50 mol m^{-3} in two increments each of 25 mol m^{-3}. After the imposition of salt stress, the substrate solutions were changed daily and the pH adjusted to (5.5-6).

Plants were allowed to grow 28 days after salinization. After harvest, plants were rinsed with distilled water, separated to shoot and root and blotted between filter papers. Dry weight of shoot and root were recorded after drying at 70 ºC in a forced-air oven.

Plant analysis: oven-dried plant material was ground in a rotary grinder. Samples of finely ground of shoots were digested with concentrated sulphuric and perchloric acids until the mixture becomes colourless (Jsckson, 1973). The following determinations were carried out:

Phosphorus was determined by using molybdenum blue method described by El-Hineidy and Agiza (1959). Potassium and sodium were determined by using flame photometer apparatus according to Jackson (1973). Chloride was extracted from plant materials in boiling water for one hour, then chloride content of the filtrate was determined by silver nitrate using chromate as indicator, Greenway (1963). Zinc was determined using atomic absorption spectrophotometer according to Yoshida *et al.*, (1976).

RESULTS AND DISCUSSION

Plant growth:-

In general, plants exposed to high salinity treatments were small compared with those grown in soil with low salinity level. Crops (mostly glycophytic) are comparatively salt sensitive, salinity causing osmotic and ion-specific effects leading to reduction in growth and yield.

Primary experiment:

The preliminary experiment was conducted on Sakha 101 variety to determine its response to inorganic phosphorus (Pi) in the culture solution with (50 mol m^{-3}) and without NaCl salinity. Some growth characteristics, such as shoot and root weights, increased with increasing level of Pi in the absence of salt in the rooting medium (Fig.1); the increase in shoot and root was of a much higher from 0.1-100 µM P than with and without salinity. The effect of higher concentration of Pi (from 100-900 µM) in the presence of NaCl salinity was adverse (Fig. 1). In conclusion, a low supply of phosphorus to the root medium with and without salinity is beneficial in improving growth while higher external phosphorus concentration (more than 100 µM) is not beneficial.

Main experiment:

Results of the main study presented in Table 1 show the effects of salinity- Pi interaction on the shoot, root dry weight and shoot/root ratio of five rice varieties. Data show that increasing the concentration of Pi in culture solution increased significantly shoot and root growth of all the five varieties.

Dry weights of shoot and root of all the five rice were markedly enhanced by Pi application to the culture solution. As compared to 1 µM Pi, the average increase in shoot dry weight being 93,170 and 35 and 51% in root at 10 and 100 µM Pi, respectively.

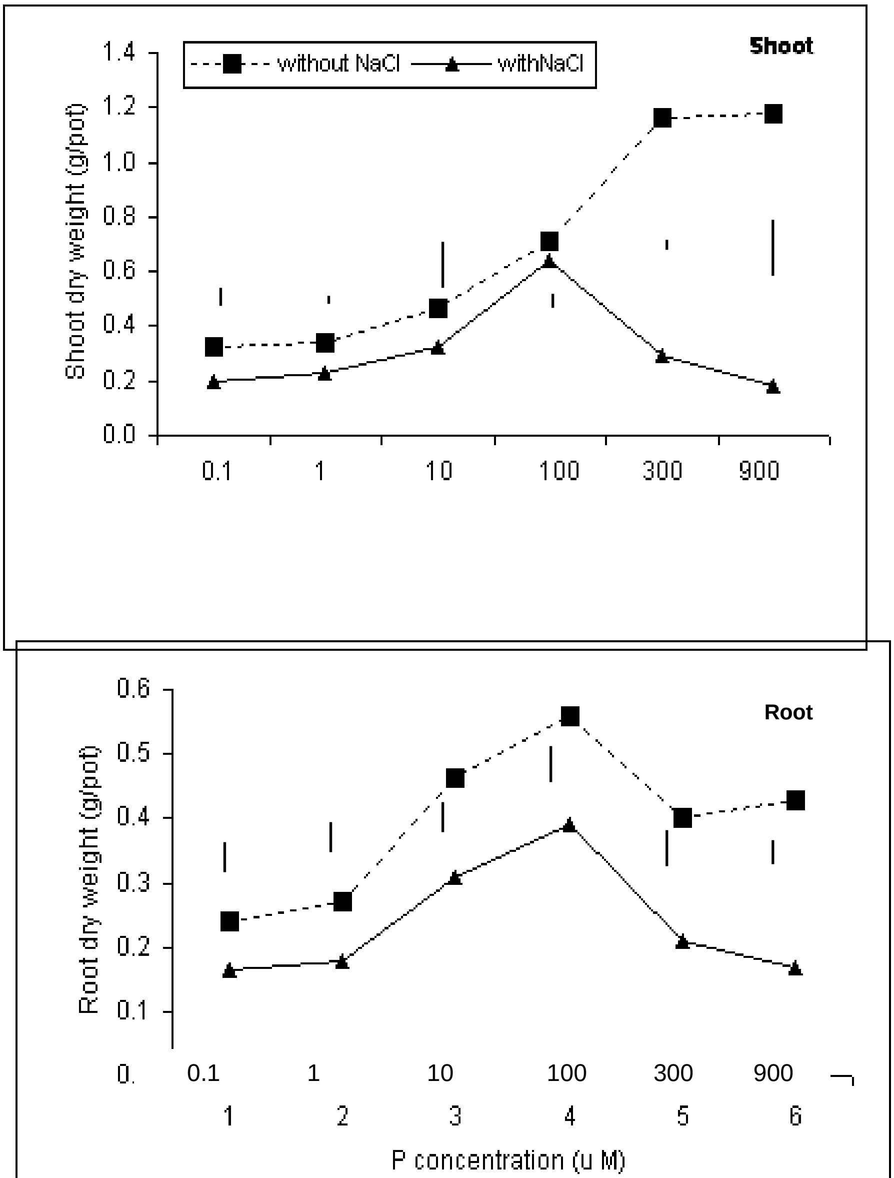

Fig. (1) Effect of phosphorus supply on shoot and root dry weight of Sakha 101 grown with (50 mol m^{-3}) and without NaCl salinity.

The addition of NaCl (50 mol m^{-3}) in the root zone caused a reduction in shoot and root growth of all rice varieties. The average percent of reduction were 56 % in shoot and 44 % in root. These results illustrate that the hazard effect of salinity was more marked on shoot than root. The more sever depression in rice growth with salinity has been reported by Abou-Zeid (1987) and Aslam *et al.*, (1996). A plant growing on a saline solution must reduce the osmotic potential of all its cells, by about the potential of the solution to a void dehydration. This process is called osmotic adjustment (Berntein, 1961). Besides this, low osmotic potential press, and reduced phosphorylatiion state of cells, impaired phloem transport and carbohydrate and protein metabolism (Mass and Nieman, 1978) may have also account for this reduction in dry matter under higher salinity levels.

Table 1: Effect of phosphorus supply and NaCl salinity on growth of five rice varieties.

	NaCl salinity *(S)* (*mol* m^{-3}) 0				50			
	P concentration *(P)* (*uM*)				P concentration *(P)* (*uM*)			
Varieties *(V)*	**1**	**10**	**100**	**Mean**	**1**	**10**	**100**	**Mean**
Shoot dry weight (*g/pot*)								
Giza 176	0.56	0.94	1.3	**0.93**	0.22	0.41	0.49	**0.37**
Giza 178	0.49	1.21	1.4	**1.03**	0.22	0.33	0.48	**0.34**
Sakha 101	0.34	0.46	0.71	**0.50**	0.23	0.33	0.64	**0.40**
Sakha 102	0.65	1.15	1.66	**1.15**	0.27	0.43	0.55	**0.42**
Sakha 103	0.42	0.97	1.52	**0.97**	0.22	0.46	0.65	**0.44**
Mean	**0.49**	**0.95**	**1.32**	**0.92**	**0.23**	**0.39**	**0.56**	**0.40**
L.S.D. for treatments at 1 %		***V*** *0.05*	***P*** *0.04*	***S*** *0.03*	***V*P*** *0.09*	***V*S*** *0.07*	***P*S*** *0.05*	***V*P*S*** *0.17*
Root dry weight (*g/pot*)								
Giza 176	0.43	0.47	0.53	**0.48**	0.17	0.22	0.36	**0.25**
Giza 178	0.44	0.60	0.65	**0.56**	0.19	0.24	0.37	**0.27**
Sakha 101	0.27	0.46	0.56	**0.43**	0.18	0.31	0.39	**0.29**
Sakha 102	0.48	0.63	0.66	**0.59**	0.22	0.28	0.35	**0.28**
Sakha 103	0.31	0.49	0.54	**0.45**	0.20	0.34	0.40	**0.31**
Mean	**0.39**	**0.53**	**0.59**	**0.50**	**0.19**	**0.28**	**0.37**	**0.28**
L.S.D. for treatments at 1 %		***V*** *0.02*	***P*** *0.01*	***S*** *0.01*	***V*P*** *0.03*	***V*S*** *0.03*	***P*S*** *0.02*	***V*P*S*** *0.04*
Shoot/Root Ratio								
Giza 176	1.30	2.00	2.45	**1.92**	2.12	2.16	2.07	**2.12**
Giza 178	1.11	2.02	2.15	**1.76**	1.98	1.96	1.90	**1.95**
Sakha 101	1.26	1.00	1.27	**1.18**	1.15	1.20	1.17	**1.17**
Sakha 102	1.35	1.83	2.52	**1.90**	2.08	2.16	2.05	**2.10**
Sakha 103	1.35	1.98	2.81	**2.05**	2.28	2.38	2.24	**2.30**
Mean	**1.28**	**1.76**	**2.24**	**1.76**	**1.92**	**1.97**	**1.89**	**1.93**
L.S.D. for treatments at 1 %		***V*** *0.11*	***P*** *0.08*	***S*** *0.07*	***V*P*** *0.19*	***V*S*** *0.15*	***P*S*** *0.12*	***V*P*S*** *0.27*

Increasing Pi supply in the presence of NaCl improved shoot and root growth to a different degree in various rice varieties (Fig. 2). Phosphorus had a significant effect to reduce the adverse effects of salinity on shoot and root dry weight. As phosphorus increased up to 100 µM, the reduction in shoot and root dry weight with 50 mol m^{-3} NaCl were less than those at lower Pi (1µM) (Table 1).

The five rice varieties showed differential responses to external Pi concentration for growth in the presence of salinity in the rooting medium. Cultivar Sakha 103 had the highest shoot and root dry weight. However, Giza 178 had the lowest one. There is a considerable variation in salinity resistance both between and within cultivars (Akbar *et al.*, 1972, Flowers and Yeo 1981, Abou-Zeid, 1987).

Growth of all cultivars improved due to the addition of Pi in the external medium, but with NaCl the rate of improvement in growth (measured as percentage improvement over the minimum Pi concentration) was much more pronounced in Sakha 103 and 101 (Fig.2) than other cultivars.

Shoot / root ratio :-

Irrespective of phosphorus supply to culture solution, it is clear that shoot/root ratio of all rice cultivars except Sakha 101 treated with NaCl salts significantly increased with 50 mol m^{-3} NaCl compared to those without salinity. As regards Pi effect, although shoot/root ratio was not affected by P application, yet this ratio was markedly enhanced under without salinity. Shoot/root ratio of all rice cultivars showed variable responses to Pi supply under with and without salinity. The cultivar Sakha 103 had highest shoot/root ratio, while Sakha 101 had the lowest.

Ion concentration in shoots:

The simultaneous presence of salts and nutrient elements in the root zone can influence ion uptake by plants and affect their chemical composition. Synergistic and antagonistic effects can increase or decrease the intensity of these processes. Specific ion effects, nutritional disorders, may be created or corrected, depending on the specific conditions. The level of soil fertility may affect salinity tolerance through its effect on root growth and activity (Feign, 1985).

Sodium:

It is generally accepted that Na^+ disturbed the nutrient balance and causes specific toxicity. Shoot concentration of Na^+ showed marked increases with the concentration of NaCl in the external medium. The percent increasing in Na^+ concentration at 50 mol m^{-3} being 125 % over without salinity. Irrespective of salinity level, as the level of phosphorus applied was increased the Na^+ percent of shoot decreased. Raising the Pi in the external solution from 1 to 100 µM decreased the Na^+ concentration. At each Pi level in the presence of 50 mol m^{-3} NaCl. Na^+ concentrations in Sakha 101 was the lowest and those of Sakha 102 was the highest. The relative interactive effect of Pi (100 µM) and NaCl salinity (50 mol m^{-3}) was found beneficial in promoting vigour (particularly in Sakha 101 and Sakha 103) and reduced accumulation of Na^+ (dilution effect). In this respect, Rogers *et al.* (2003) reported that more sever increasing in Na and Cl concentration in Lucerne plants with increasing NaCl.

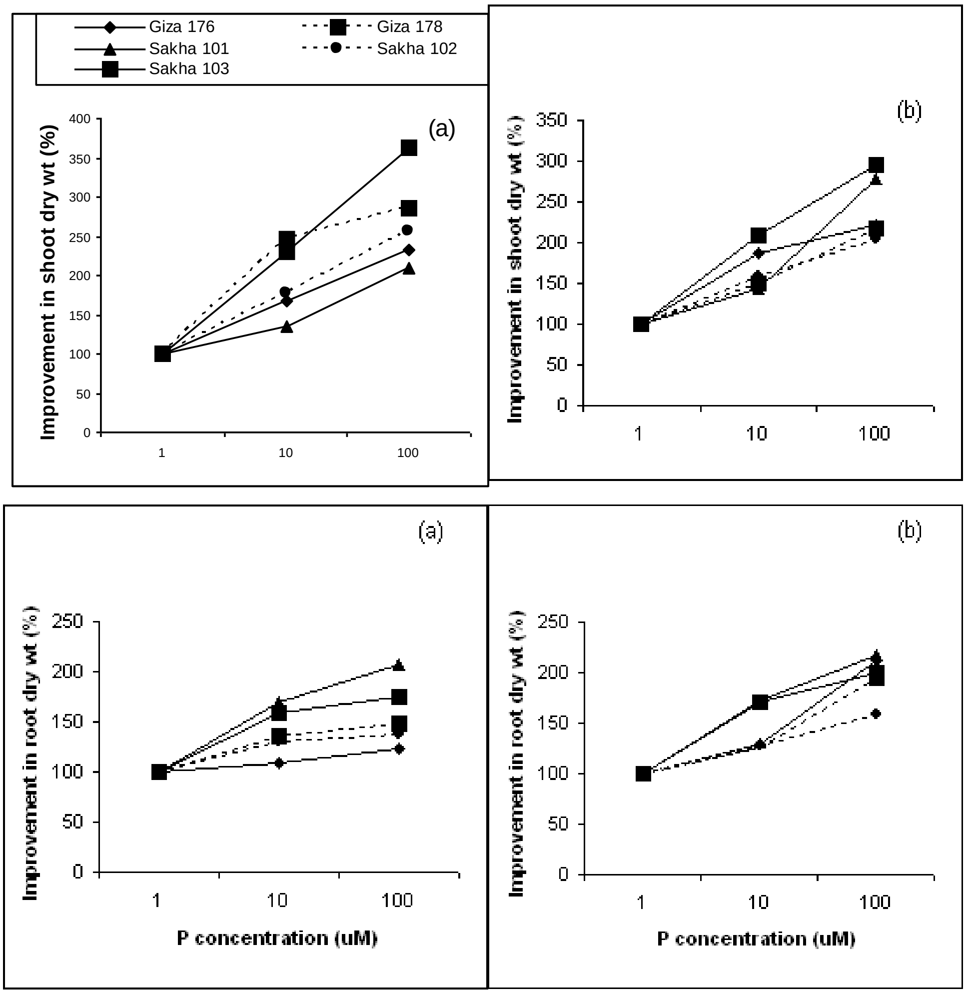

Fig.(2): Improvement in shoot and root dry weight without NaCl (a) and with 50 mol m^{-3} NaCl (b)of five rice varieties due to substantial increase of phosphorus supply over its minimum concentration.

Chloride:-

Chloride is a more sensitive indicator of salt damage than Na, since , generally, more Cl than Na is stored in plant. Moreover, sodium and chloride are so highly correlated (Yeo and Flowers 1982) that their effects are not distinguishable. The chloride concentration in the shoot of the five rice varieties decreased consistently with increasing external Pi in the presence or absence of NaCl salt (Table 2). The reduction of Cl concentration with Pi application may be due to a dilution effect caused by greater dry matter production and the antagonistic relationship between chloride and phosphorus anions (Aslam,1996). With regard to the effect of salinity on the Cl^- content, the data in Table (2) indicated that the concentration of Cl was nearly seven folds as the salinity increased from 0 to 50 mol m^{-3} NaCl. At each Pi level, in the presence of 50 mol m^{-3} NaCl, Cl concentration in Sakha 102 was the highest and those of Sakha 101 was the lowest. The concentration of Cl^- at 100 µM P with salt decreased sharply in Sakha 101 as compared to the other rice varieties. Salt tolerance in rice is closely associated with the exclusion of Na^+ and Cl^- from the shoot (Akita and cabuslay, 1990).

Table 2: Concentration of Na,K,Cl and K/Na ratio in the shoot of five rice varieties as affected by phosphorus supply and NaCl salinity.

	NaCl salinity *(S)* (*mol m⁻³*) 0				50			
	P concentration *(P)* (*uM*)				P concentration *(P)* (*uM*)			
Varieties *(V)*	**1**	**10**	**100**	**Mean**	**1**	**10**	**100**	**Mean**
				Na^+ %				
Giza 176	0.65	0.61	0.60	**0.62**	5.53	5.03	4.17	**4.91**
Giza 178	0.62	0.60	0.56	**0.59**	6.13	5.23	4.37	**5.24**
Sakha 101	0.67	0.65	0.60	**0.64**	3.88	3.50	3.07	**3.48**
Sakha 102	0.58	0.55	0.53	**0.55**	7.10	6.53	6.10	**6.58**
Sakha 103	0.56	0.55	0.53	**0.55**	4.60	4.17	3.60	**4.12**
Mean	**0.62**	**0.59**	**0.56**	**0.59**	**5.45**	**4.89**	**4.26**	**4.87**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*0.09*	*0.07*	*0.06*	*0.15*	*0.12*	*0.10*	*0.21*	
				K^+ %				
Giza 176	3.28	3.58	4.10	**3.65**	2.34	2.63	3.30	**2.76**
Giza 178	3.14	3.52	4.08	**3.58**	2.20	2.74	3.45	**2.80**
Sakha 101	3.01	3.54	4.34	**3.63**	2.17	2.88	3.66	**2.90**
Sakha 102	3.01	3.33	3.79	**3.38**	2.11	2.74	3.43	**2.76**
Sakha 103	3.47	3.70	4.06	**3.74**	2.36	2.95	3.62	**2.98**
Mean	**3.18**	**3.53**	**4.07**	**3.60**	**2.24**	**2.79**	**3.49**	**2.84**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*0.11*	*0.09*	*0.07*	*0.19*	*0.16*	*0.12*	*0.27*	
				Cl^- %				
Giza 176	1.20	0.91	0.86	**0.99**	8.03	7.17	6.52	**7.24**
Giza 178	1.08	0.94	0.91	**0.98**	8.47	7.37	6.23	**7.36**
Sakha 101	1.13	1.03	0.91	**1.02**	6.32	5.79	5.26	**5.79**
Sakha 102	1.33	1.13	0.94	**1.13**	8.80	8.39	7.37	**8.19**
Sakha 103	1.30	1.04	0.92	**1.09**	7.07	6.40	5.50	**6.32**
Mean	**1.21**	**1.01**	**0.91**	**1.04**	**7.74**	**7.02**	**6.18**	**6.98**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*0.15*	*0.11*	*0.09*	*0.25*	*0.21*	*0.16*	*0.36*	
				K^+ / Na^+ Ratio				
Giza 176	5.05	5.87	6.83	**5.92**	0.42	0.52	0.79	**0.58**
Giza 178	5.06	5.87	7.29	**6.07**	0.36	0.52	0.79	**0.56**
Sakha 101	4.49	5.45	7.23	**5.72**	0.56	0.82	1.19	**0.86**
Sakha 102	5.19	6.05	7.15	**6.13**	0.30	0.42	0.56	**0.43**
Sakha 103	6.20	6.73	7.66	**6.86**	0.51	0.71	1.01	**0.74**
Mean	**5.20**	**5.99**	**7.23**	**6.14**	**0.43**	**0.60**	**0.87**	**0.63**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*0.18*	*0.14*	*0.11*	*0.31*	*0.26*	*0.20*	*0.44*	

Potassium:

Potassium is the metallic element needed by plants in the largest amounts. Since potassium must be absorbed from saline environments, which invariably have a large excess of Na and Cl over K, a capability to selectively absorb K is also a requisite for plants growing in saline conditions (Omielan *et al.*, 1991). Concentration of K^+ in the shoot of five rices increased consistently with increasing Pi in the presence or absence of NaCl salt. The average value of K concentration for the different levels of Pi was 3.18, 3.53 and 4.07 at without salinity, while at 50 mol m^{-3} NaCl was 2.24, 2.79 and 3.49 at 1, 10 and 100 µM Pi, respectively. Irrespective of Pi, K concentration of the five rice varieties decreased significantly by at higher external NaCl concentration (Table 2). The percent reduction at 50 mol m^{-3} NaCl was 21 % compared to without salinity. Among the rice varieties Sakha 101 and Sakha 103 had higher K^+ concentration in shoot in descending order as compared to the other rice varieties followed by Giza 178, Sakha 102 and Giza 176.

K^+/Na^+ ratio:

The calculated values of K/Na ratio decreased markedly in all the five rice varieties as the NaCl salt in the external solution increased. It decreased from 6.14 (without NaCl) to 0.63 under 50 mol m^{-3} NaCl. Such decrease in K/Na ratio brought about a disorder in the nutritional status of the plant due to an inability of roots to maintain a high selectivity of K versus Na in the presence of large amounts of NaCl. Results of similar nature were obtained by Yeo and Flowers (1984). K/Na ratio in the shoot of all the rice varieties consistently increased with increasing external Pi under without and with NaCl salinity. Among the five rice varieties Sakha 101 having the highest K/Na ratio in the shoot and Sakha 102 having the lowest.

Phosphorus concentration in shoot:

Data presented in Table (3) show the effects of salinity-Pi interaction on the concentration of phosphorus in shoot. As regards the salinity effect, increasing salinity significantly increased P concentration of shoot. With the increase of NaCl salinity from 0 to 50 mol m^{-3}, there was an increase in P concentration from 0.13 to 0.16. This indicates that although salinity decreased dry weight, yet phosphorus absorption by rice plants continued even in a saline growth medium, hence phosphorus concentration increased. These results were in agreement with those obtained by Abou-Zeid (1996) and (Kaya, *et al.*, (2001). Higher salinity improves P availability in flooded soil because it decreases pH and Eh (Neu and Zhu, 1990). Adding salt and increasing the supply of Pi in the culture solution resulted in an increase P concentration of the shoot of all the five rice varieties. Raising the phosphorus dose from 1 to 100 µM increased the phosphorus concentration from 0.08 to 0.23 % in shoot. It was interesting to notice that the rice variety Sakha 101 accumulated much more P in the shoot compared to the other varieties at 10 and 100 µM P levels in the presence of NaCl salt. In this respect, Aslam *et al.* (1996) reported that Low supply of phosphorus to salt-affected soils is beneficial in improving growth and yield while higher external phosphorus concentration is not beneficial because it proves toxic. The extent of P toxicity varies due to the cultivar and the concentration of salt in the rooting medium.

Table (3): Concentration of P,Zn and P/Zn ratio in the shoot of five rice varieties as affected by phosphorus supply and NaCl salinity.

	NaCl salinity *(S)* (*mol m*$^{-3}$) 0				50			
	P concentration *(P)* (*uM*)				P concentration *(P)* (*uM*)			
Varieties *(V)*	**1**	**10**	**100**	**Mean**	**1**	**10**	**100**	**Mean**
				P %				
Giza 176	0.06	0.12	0.18	**0.12**	0.07	0.18	0.22	**0.16**
Giza 178	0.06	0.13	0.19	**0.13**	0.08	0.17	0.22	**0.16**
Sakha 101	0.08	0.15	0.21	**0.15**	0.07	0.18	0.24	**0.16**
Sakha 102	0.06	0.11	0.16	**0.11**	0.07	0.16	0.21	**0.15**
Sakha 103	0.07	0.14	0.18	**0.13**	0.09	0.20	0.25	**0.18**
Mean	**0.07**	**0.13**	**0.18**	**0.13**	**0.08**	**0.18**	**0.23**	**0.16**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*0.01*	*0.01*	*0.01*	*0.02*	*0.02*	*0.01*	*0.03*	
				Zn ppm				
Giza 176	20.00	30.00	36.00	**28.67**	27.67	37.00	44.67	**36.45**
Giza 178	17.67	26.67	34.00	**26.11**	30.00	38.67	43.67	**37.45**
Sakha 101	21.00	32.00	34.67	**29.22**	33.00	44.00	51.67	**42.89**
Sakha 102	18.67	30.33	37.00	**28.67**	27.00	36.67	40.00	**34.56**
Sakha 103	23.67	34.33	38.33	**32.11**	30.00	42.00	50.33	**40.78**
Mean	**20.20**	**30.67**	**36.00**	**28.96**	**29.53**	**39.67**	**46.07**	**38.42**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*1.30*	*1.00*	*0.82*	*2.24*	*1.83*	*1.42*	*3.17*	
				P / Zn Ratio				
Giza 176	30.00	40.00	50.00	**40.00**	25.30	48.65	49.25	**41.07**
Giza 178	33.96	48.74	55.88	**46.19**	26.67	43.96	50.38	**40.34**
Sakha 101	38.10	46.88	60.57	**48.51**	21.21	40.91	46.45	**36.19**
Sakha 102	32.14	36.27	43.24	**37.22**	25.93	43.63	52.50	**40.69**
Sakha 103	29.57	40.78	46.96	**39.10**	30.00	47.62	49.67	**42.43**
Mean	**32.75**	**42.53**	**51.33**	**42.21**	**25.82**	**44.95**	**49.65**	**40.14**
L.S.D. for treatments	***V***	***P***	***S***	***V*P***	***V*S***	***P*S***	***V*P*S***	
at 1 %	*4.20*	*3.25*	*2.66*	*7.28*	*5.94*	*4.60*	*10.29*	

Zinc concentration in shoot:

Data presented in Table (3) show that concentration of Zn in shoot of the five rice varieties increased significantly with increasing NaCl and Pi concentration of the external medium. This may be due to the consequences of the poor rate of growth and less vigour in the presence of NaCl salinity (Aslam, *et al.*, 1991 and Abou-Zeid, 1996). With the increase of NaCl salinity from 0 to 50 mol m^{-3}, there was an increase in Zn concentration by 32 %. Raising the Pi in the external medium from 1 to 100 µM increased Zn concentration. Under without salinity the percent of increase at 10 and 100 µM in comparison to 1 µM were 50 and 80 %, while at NaCl salinity, the percent of increase were 34 and 58 %. These results are in agreement with that obtained by Aslam *et al.* (1996) who found that concentration of zinc in shoot of all the rices increased in NaCl salinity and Pi concentration of the external medium. Zinc concentration varied between rice varieties. At 50 mol m^{-3} NaCl salinity, Sakha 101 had the highest while Sakha 102 had the lowest concentration of Zn in shoot. The order of Zn concentration in the shoot at the highest Pi concentration in the presence of salt was Sakha 101 > Sakha 103 > Giza 176 >Giza 178 > Sakha 102.

P : Zn ratio:

This ratio increased in all the cultivars with increasing Pi concentration in the culture solution; however, increasing salt stress to 50 mol m^{-3} NaCl decreased P/Zn ratio in the case of Giza 178 and Sakha 101 in contrast to Giza 176, Sakha 102 and Sakha 103 (Table 3). Among the rice cultivars, Sakha 103 had the highest while Sakha 101 had the lowest P/Zn ratio, indicating a high P accumulating tendency by the Sakha 103 cultivar. A high P/Zn ratio affects phosphorus metabolism in roots (Laughman *et al.* 1982) and increases the permeability of plasma membrane of root cells to phosphorus, and also to chloride (Welch *et al.*1982). It is well documented that Zn stabilizers biomembranes presumably reacting with sulfhydryl group (R-SH) of membrane protein (Chvapil,1973),and this has an important role in membrane integrity (Welch *et al.* 1982).

REFERENCES

Abou-Zeid, S. T. (1987). Mechanisms of salt tolerance in rice plant . Ph. D. Thesis, Faculty of Agric, University of Cairo.

Abou-Zeid, S. T. (1996). Interaction effects of salinity and nitrogen application on rice plants. J. Agric. Sci. Mansoura Univ. 21(1):441-454.

Akbar, M. (1975). Water and chloride absorption in rice seedlings. J. Agri. Res. 13,341-348.

Akbar, M. and Ponnamperuma, F. N. (1982). Saline soils of south and southeast Asia as potential rice lands. In: Rice research strategies for the future. IRRI, Los Banos, Philippines.

Akbar, M., Yabuno, T. and Nakao, S. (1972). Breeding for saline-resistant varieties of rice. I. Variability for salt tolerance among some rice varieties. Jpn. J. of Breeding 22:277-284.

Akita, S., and Cabuslay, G. S. (1990). Physiological basis of differential response to salinity in rice cultivars. Plant and Soil 123,277-294.

Aslam, M.; Flowers, T. J. ; Qureshi, R. H. and Yeo, A. R. (1996). Interaction of phosphate and salinity on the growth and yield of rice (Oryza sativa L.) J. Agronomy & crop Science 176,249-258.

Aslam, M.; Qureshi, R. H.; Ahmad, N. and Kausar, M. A. (1991). Relative growth rate and ion transport in rice grown under saline environment. Pak. J. Bot.23:3-10.

Bernstein, L. (1961). Osmotic adjustment of plants to saline media. 1-Steady state. Am. J. Bot. 48:909-918.

Bernstein, L; Francios, L. E. and clark, R. A. (1974). Interaction effects of salinity and fertility on yield of grains and vegetables. Agron. J. 66:412-421.

Chvapil, M. (1973). New aspects in biological role of zinc : Astabilizer of macromalecules and biological membranes. Life Sci.13,1041-1049.

El-Hineidy, M. I. and Agiza, A. H. (1959). Calorimetric method for determination of micro amounts of phosphorus. Cairo Univ., Fac. Agric. Bull.121.

Feigin, A. (1985). Fertilization management of crops irrigated with saline water. Plant and Soil 89:285-299.

Flowers, T. J. and Yeo, A. R. (1981). Variability in the resistance of sodium chloride salinity within rice (Oryza sativa L.) varieties. New phytol. 88:363-373.

Flowers, T. J. and Yeo, A. R. (1997).Breeding for salt resistance in plants. In: Strategies for improving salt tolerance in higher plants. (Jaiwal, P. and Singh, R., eds) p248-262.

Greenway, H. (1963). Plant response to saline substances. 111-Effect of nutrient concentration on the growth and ion uptake of Hordium valgare during NaCl stress-Aust. J. Biol. Sci. 16:616-628.

Greenway, H. (1973). Salinity, plant growth, and metabolism. J. Australian Inst. Agric. Sc., 39:24-34.

Jackson, M. L. (1973). "Soil chemical Analysis" Prentice-Hall. Inc. Englewood cliffs, N. J. USA.

Kaya, C.; Higgs, D. and Kirmak, H. (2001). The effects of high salinity (NaCl) and supplementary phosphorus and potassium on physiology and nutrition development of spinach. Bulg. J. plant physiol., 27 :(3-4), 47-59.

Loughman, B. C. ; Webb, M. J. and Loneragan, J. F. (1982). Zinc and ultilization of phosphorus in wheat plants. In : A. Scaife (ed), proceedings of the ninth plant nutrition colloquium. Warwick. England pp. 335-340.

Mass, E. V. and Nieman, R. M. (1978). Physiology of plant tolerance to salinity. In: Crop tolerance to subtropical land conditions, ASA, Special publication. No:32:277-299.

Neue, H. U. and Zhu, Z. L. (1990). Chemistry of adverse flooded soils. Phosphorus requirement for sustainable agriculture in Asia and Oceania. Proceedings of asymposium, 6-10 March 1989. 225-242.

Omielan, J. A.; Epstein, E. and Dvorak, J. (1991). Salt tolerance and ionic relations of wheat as affected by individual chromosomes of salt-tolerant Lophopyrum elongatum. Genome 34:961-974.

Roger, M. E., Griever, C. M. and Shannon, M. C. (2003). Plant growth and ion relations in Lucerne (Medicugo Sativa L.) in response to the combined effects of NaCl and P. Plant and Soil 253:187-194.

Welh, R. M.; Webb, M.; and Loneragen, J. F. (1982). Zinc in membrane function and its role in phosphorus toxicity. In ; A. scaife (ed). Proceedings of the ninth plant nutrition colloquiums. Warwick England pp 710-715.

Yeo, A. R. and Flowers, T. J. (1982). Accumulation and localization of sodium ions within the shoots of rice (Oriza sativa) varieties differing in salinity resistance, Physiol. Plant. 56:343-348.

Yeo, A. R. and Flowers, T. J. (1984). Mechanisms of salinity resistance in rice and their role as physiological criteria in plant breeding. In : Salinity tolerance in plants: Strategis for crop improvement (stuples, C. and Toennissen, H., eds.) p. 151-170.
Yoshida, S. (1981). Fundamentals of rice crop science. IRRI, los Banos, philippiens, 269 pp.
Yoshida, S.; D. A. Forno; J. H. cock and K. A. Gomez (1976). Laboratory manual for physiological studies of rice. IRRI, Los Banos, Philippines.
Zaiter, H. Z. and Saade, M. (1993). Interaction effects of salinity and phosphorus nutrition on trpary and common been cultivars. Commun. Soil Sci. Plant Anal. 24,109 -123.

التأثير المشترك للملوحة والفوسفور على نمو نبات الأرز

سيد طه أبو زيد
قسم الاراضى – كلية الزراعة – جامعة القاهرة.

أن التأثير المشترك بين الملوحة والتغذية بالفوسفور معقد، وتختلف استجابة النبات لذلك تبعا لعوامل متعددة. وقد تم دراسة دور الفوسفور المضاف تحت ظروف التمليح فى مزرعة مائية على النمو والتركيب المعدنى لنبات الأرز. فى هذه التجربة ، تم دراسة تأثير الفوسفور الغير عضوى على النمو والتركيب الايونى لخمسة أصناف من الأرز المختلفة فى تحملها للملوحة وكذا فى كفاءة استخدامها للفوسفور والتى نميت فى محلول مغذى يحتوى أو لا يحتوى على 50 ملليمول/ م^3 كلوريد صوديوم لمدة أربعة أسابيع. تأثر نمو جميع الأصناف المنزرعة بدرجات مختلفة نتيجة إضافة الفوسفور الغير عضوى فى وجود او عدم وجود كلوريد الصوديوم. اضافة الفوسفور الغير عضوى حتى 100 ميكرومول فى وجود كلوريد الصوديوم أدى إلى تحسن فى بعض خواص النمو (الوزن الجاف للمجموع الخضرى والجذور) ، ولكن التركيز الأعلى من ذلك للفوسفور كان له تأثير مثبط. زيادة الإمداد بالفوسفور (من 1 الى 100 ميكرومول فوسفور غير عضوى) إلى بيئة النمو المالحة أدى إلى نقص تركيز كل من الصوديوم والكلوريد فى جميع الأصناف. تركيز هذه الايونات فى المجموع الخضرى كان أكثر انخفاض فى أصناف سخا 101 ، 103 بينما كان أعلى فى صنف سخا 102. أظهرت تركيزات كل من الفوسفور والزنك فى المجموع الخضرى ميلا للزيادة عند تواجد الفوسفور الغير عضوى فى بيئة النمو المالحة. وقد لوحظ أن نسبة الفوسفور إلى الزنك كانت منخفضة فى بعض الأصناف مثل سخا 101 ، وجيزة 178. وكانت هناك زيادة معنوية فى تركيزات الصوديوم والكلوريد وانخفاض فى تركيز الزنك فى المجموع الخضرى لأصناف سخا 102، جيزة 176 وجيزة 178 عندما نميت فى بيئة ملحية تحتوى على فوسفور غير عضوى.

أوضحت نتائج هذه الدراسة وجود علاقة معقدة بين الملوحة بكلوريد الصوديوم والفوسفور ويتلخص ذلك فى أن الإمداد المنخفض بالفوسفور الغير عضوى فى بيئة نمو الجذور يكون له فائدة فى تحسين النمو بينما التركيز العالى يعتبر غير مفيد.