THE ROLE OF PHOSPHOROUS MANAGEMENT IN SALINITY TOLERANCE ALLEVIATION IN RICE CROP

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Abstract

Integrating crop management of rice is the main strategy for maximizing rice productivity in Egypt under saline soils. Exogenous application of some nutrients such as phosphorous application will ensure high salt tolerance and productivity of rice under saline soil. Two field experiments were conducted in seasons of 2010 and 2011 seasons at The Farm of El Sirw Agricultural Research Station, Dammietta Governorate, Egypt. The soil texture was clayey. Salinity levels were 7.5 and 6.5dS/m during 2010 and 2011 seasons, respectively. The response of Giza 178 rice variety to various treatments of phosphorous management was studied under saline soil namely; control(1), basal application of recommended phosphorous for rice under saline soil i.e.60 kg P_2O_5 ha^{-1} (2), diammonium phosphate (DAP) spray with the concentration of 2 % at mid tillering stage(MT) (3), potassium tri-phosphate(KTP) spray at MT 2% (4), basal application of recommended phosphorous+ 2%of DAP at MT(5), basal application of recommended phosphorous+ 2%of KTP at MT(6), DAP spray 2% at panicle initiation(PI) (7), KTP 2% at panicle initiation(PI) (8), basal application of recommended phosphorous+ 2%of DAP at PI(9), basal application of recommended phosphorous + 2%of KTP at PI (10), DAP spray 2% at booting stage (BT) (11), KTP 2% at booting stage (BT) (12), basal application of recommended phosphorous + 2%of DAP at BT(13) and basal application of recommended phosphorous+ 2%of KTP at BT(14).

Phosphorous application either basal or foliar and their combination at various growth stages significantly increased nutrient leaf content (NPK and Fe), while decreased Zn and Na^+ as well as Na^+/K^+ ratio. Also, phosphorous application significantly improved flag leaf characteristics and growth parameters at heading date viz; LAI, dry matter production, tillers numbers/hill and plant height. Phosphorous application significantly shortened the period from sowing date to heading. Yield components and rice grain yield were significantly improved by phosphorous application involving basal, foliar application and their combinations at various growth stages particularly at booting growth sage. The most and significant effective phosphorous treatments are basal application of recommended phosphorous+ 2%of DAP at BT and basal application of recommended phosphorous+ 2%of KTP at BT, whereas they were comparable regarding all above mentioned traits and recorded the maximum values of them. From economic point of view, the treatment of basal application of recommended phosphorous+ 2%of DAP at BT was the best and it could be recommended under similar conditions.

Key words: saline soil, p management, rice crop

INTRODUCTION

The application of essential plant nutrients, particularly major and micronutrients in optimum quantity and right proportion, through correct method and time of application, is the key to increased and sustained crop production as well as alleviate the harmfully effect of environmental stresses such as salinity stress. Salinity is a major environmental constraint for crop production throughout the world (Munns *et. al*.., 2006). Salt-affected soils occupy more than 7% of the earth land surface (FAO, 2008).

It is well known that salt stress causes a number of undesired effects on plants such as osmotic effects, ion toxicity, hormonal imbalance, generation of reactive oxygen species and nutritional imbalance (Flowers and Flowers, 2005). Different strategies have been listed by various plant scientists to improve crop salt tolerance that will result into enhanced productivity of salt affected soils. On the bases of these strategies it has been suggested that salt induced nutritional disorders can be alleviated by the addition of mineral nutrients in the growth medium. In view of these reports, it is suggested that high level of macro-nutrients can be supplied exogenously so as to alleviate the adverse effects of salt stress on plant growth. Among various approaches in relevance to increase salt tolerance, application of plant nutrients to maintain nutritional imbalance has a great significance (Aslam et. a.., 1996).

Phosphorous (P) is the second major nutrient for plant growth as it is an integral part of different bio-chemicals like nucleic acids, nucleotides, phospholipids and phosphoproteins. Phosphate compounds ATP act as "energy currency" within plants (Tisdale et. al., 1985). Plant-available P deficiency is common in most of our soils which hinders crop production. In relation to plant growth, sufficient P nutrition improves several plant processes that include photosynthesis, nitrogen fixation, flowering, fruiting, seed formation, root development, and crop maturation (Memon, 1996).

Most of the studies that show salinity-reduced P concentrations in plant tissues were conducted in soils. Phosphate availability is reduced in saline soils not only because of ionic strength effects that reduce the activity of phosphate but also because phosphate concentrations in soil solution are tightly controlled by sorption processes and by the low-solubility of Ca±P minerals. Therefore, it is understandable that phosphate concentrations in field-grown agronomic crops decreased as salinity (NaCl + CaCl2) increased (Sharpley *et. al.,* 1992). Champagnol (1979) concluded that it is unlikely that Cl- and H2PO4 ions are competitive.

Rice (Oryza sativa L.) is the second most important crop in the world and Egypt too after wheat, and currently supported nearly one half of the world population.(Mishra, 2004). It is a salt-sensitive crop, but it is the only cereal that has been recommended as a desalinization crop because of its ability to grow well under flooded conditions, and because the standing water in rice fields can help to leach the salts from the topsoil to a level low enough for subsequent crops. In Egypt, about 400,000-500,000 acres of salt affected soils are under rice cultivation with low productivity (Zayed et. al.., 2010).

It has already been observed that P fertilization reduced the concentration of Na+ in shoots, resulting in better survival, growth and yield of rice (Qadar, 1998, Naheed el. al., 2008 and Zayed et. al., 2010). Annadurai and palaniappan (1998) found that application 19 kg P2O5 /ha + spray of 2%diammonium phosphate (DAP) at boot leaf +50% flowering + gave the highest rice grain yield and yield components, panicle number, filled grains, 1000-grain weight as well higher return, but didn't effect the panicle length. Maibangsa et. al., (1999), Basker et. al. (2002) and Elayaraja and Angayarkanni (2007) stated that foliar spray of 2% DAP at boot leaf+ 50% flowering significantly increased leaf area index (LAI), chlorophyll accumulation, dry matter production and rice grain yield as well as main yield components such as filled grain and panicle weight. Furthermore, Kalyanasundaram and Surrndirakumar (2003) reported that among different treatment, NPK+12.5 t FYM /ha+Azosperillum+ foliar spray of 2% DAP and 1% KCL at panicle initiation and booting stage recorded the highest number of tillers, leaf area index, dry matter production and at harvest, number of panicles, number of filled grains, grain yield and net return. Sivakumar *et. al.* (2007) and Reddy et. al. (2009) revealed that foliar spray of nutrient, viz, 2% DAP + 1% KCl+ 1% Zn SO4 combination at panicle initiation + boot leaf significantly gave the highest values of growth attributes, dry matter, chlorophyll content, yield attributes, productive tillers, filled grain, panicle weight and grain and straw yields but, produced the lowest value of sterility %. Ramanathan et. al. (2002) found that spraying mono potassium phosphate at the concentration of 1% at tillering stage, panicle initiation stage, booting stage and flowering stage significantly surpassed the foliar spray of DAP and basal application of potassium and phosphorous in enhancing rice grain yield and yield components.

In view the concept of effective role of P as well effective P management under salt stress, the present study was conducted to observe whether P alleviates the adverse effects of salinity on rice plants particularly in relation to mineral nutrients of rice.

MATERIALS AND METHODS

The current trial was carried out in 2010 and 2011 seasons at the Experimental Farm of El-Sirw Agriculture Research Station, Dammietta governorate, at the northern part of Delta, Egypt. The soil was clayey and the soil chemical analysis is listed in Table (1). To find out the response of Giza 178 rice variety to various combinations of phosphorous treatments under saline soil, the following treatments were performed, namely; control (1), basal application of recommended phosphorous for rice under saline soil i.e.60 kg P2O5 ha-1 (2), diammonium phosphate (DAP) spray at the concentration of 2% at mid tillering stage (MT) (3), 2% of potassium triphosphate spray at MT (4), basal application of recommended phosphorous+ 2%of DAP at MT (5), basal application of recommended phosphorous+ 2% of KTP at MT (6), DAP spray 2% at panicle initiation (PI) (7), 2% of KTP at (PI) (8), basal application of recommended phosphorous+ 2% of DAP at PI (9), basal application of recommended phosphorous+ 2%of KTP at PI (10), 2% of DAP spray at booting stage (BT) (11), 2% of KTP at booting stage (BT) (12), basal application of recommended phosphorous+ 2%of DAP at BT (13) and basal application of recommended phosphorous+ 2%of KTP at BT (14). Diammonium phosphate (DAP) compound contains 47% of P2O5 and 18% N while; potassium tri-phosphate (KTP) contains 34% K2O and 47% of P2O5. The amount of water for each plot for dissolving the above mentioned compound was calculated as based on 500 L water/ha. The spraying was done before sun set for avoiding leaf burin and losses. The experiment was laid out in a randomized complete block design, with four replications. Seedlings of 30 days old of Giza 178 rice variety were transplanted with 3 seedlings hill-1, spaced at 20 x 20 cm. Transplanting was done on April, 20th, and harvesting on September1st. Nitrogen fertilizer was added in 4 equal doses 15 days after transplanting (DAT), maximum tillering stage, panicle initiation, and mid of booting stages as recommended under saline soil. All plots received 165 kg N ha-1and 48 K2O ha-1 in the form of urea and potassium sulphate. Plot area was adjusted to 10 m2.

Table 1. Soil chemical analysis at the experimental sites during 2010 and 2011seasons.

season	pH	EC dS m^{-1}	Cations meq L^{-1}			Anions Meq L^{-1}		
			Ca^{++} + Mg^{++}	Na^{+}	K^{+}	$SO^{=}_4$	Cl^{-}	HCO^{-}_3
2010	8.3	7.5	20.0	58.0	0.32	26.5	45.3	8.0
2011	8.2	6.5	18.0	57.0	0.31	20.0	46.0	7.0

Available nutrients mg kg^{-1}							
	N	P	K	Zn	S	Fe	Cu
2010	28.0	9.12	245.0	1.22	10.7	5.00	6.2
2011	26.0	9.35	280.0	1.16	10.5	5.13	6.0

At heading stages, ten hills from each plot were taken to estimate flag leaf area, flag leaf dry weight, chlorophyll content of flag leaf (SPAD value), leaf are index (LAI) and dry mater content (the dry samples were weighed and dry matter of plant in g m^{-2} was computed). The dried leaves were grinded and kept to determine the N, P, K, Fe, Zn and Na leaf contents as well as Na / K ratio according to Yoshida et. al. 1968. Phosphorus recovery and uptake as well as days to heading were determined.

At harvest, panicles of ten guarded hills for each plot were counted to determine the number of panicles m-2 and also, plant height (cm) was measured. Ten main panicles from each subplot were used to determine panicle length (cm), number of filled and unfilled grains panicle -1, panicle and 1000-grain weights. The plants of the six inner rows of each subplot were harvested, dried, threshed, then grain and straw yields were determined at 14 % moisture content and converted into t ha-1.

All data collected were subjected to standard statistical analysis of variance following the methods described by Gomez and Gomez (1984) using the computer program (IRRISTAT). The treatment means were compared using Duncan's multiple range test (Duncan, 1955). * and ** symbol used in all Tables indicate the significant at 5% and 1% levels of probability, respectively, while NS means not significant.

RESULTS AND DISCUSSION

1- Nutrient contents in rice leaves

Interestingly, phosphorous sources application involving single application as foliar or basal and their combination significantly increased measured nutrient contents in rice leaves (NPK and Fe) except, Na and Zn (Tables 2, 3 and 4). Regarding N% in leaf the treatment of basal application plus diammonium phosphate (DAP) spray at booting stage gave the highest values of nitrogen leaf content in both seasons. The lowest values of nitrogen leaf content were shown by control treatment in both seasons. Concerning P% in leaves, the effect of studied phosphorous application alternates showed the same trend of N% of rice leaves. Certainly, phosphorous application as basal or foliar spray and their combination was beneficial in enhancing K leaf content and resulted in reducing Na/K ratio in rice leaves under salt stress that might be contributed to increase the salt tolerance of rice. The increase in K uptake might be due to higher energy in roots because of the continuous supplemental phosphorous as essential element for biosynthesis of energetic compounds inside the plant. On the other hand, phosphorous application with different alternative significantly reduced Zn leaf content rather than of control treatment because the soil was rich in the Zn (Table1). The highest values of Zn leaf content were produced by control treatment. It is interesting to mention here the concentration of Zn in rice leaf under phosphorous application is still within the acceptable limits. Also it was found that DAP or KTP spray alone did not affect much the Zn leaf content as compared with the other treatments.

As for Fe % in rice leaf .Data in Table 3 clarify that phosphorus basal application + DAP spray at booting stage significantly gave the highest values of Fe leaf content in both seasons without any significant differences with those obtained by phosphorous basal application + KTP foliar spray at booting stage.

Phosphorus recovery% recoded its highest values when rice plants were sprayed by DAP at booting stage in the first season and KTP in the second season (Table 4). On the other hand, the lowest values of P recovery were produced by P basal application in both seasons. At the same time, the highest values of P uptake were given by DAP spray at BT + Basal application of recommended phosphorous in both seasons. It seems that foliar spray at late growth stage might improve the P recovery and P uptake by increasing the efficiency of rice plant in nutrient uptake and avoiding nutrient uptake problem happened under saline soil. The desired effect of P application might be mainly due to some possibilities; phosphorus application had positive effect on soil reclamation resulted in improving its physical proprieties leading to increase nutrients availability (Qadar, 1998 and Naheed et. al. 2008), Phosphorous application either basal or foliar spray encourage rice growth involving shoot and root systems resulted in high capability for nutrient uptake and foliar spray of P increased its content in leaf and thus avoiding the problem happened under saline soil. Furthermore, using DAP which has two molecules of NH_4 enhanced the growth of plant and increase the uptake of P (accompanied ionic effect) that increase the energetic compound such as ATP, NADPH and FADP consequently increase root power and photosynthesis in above -ground parts of rice plants under salt stress and phosphorous as accompanied ion with K^+ in KTP increase the uptake of K against Na that minimize the Na/K ration. Similar data has bean reported by Qadar, (1998), Naheed *et. al.* (2008) and Zayed *et. al.* (2010).

Table 2. Concentration of N, P and K in rice leaf of as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons

Treatment	N%		P%		K ppm	
	2010	2011	2010	2011	2010	2011
Control	1.72d	1.70c	0.193e	0.190e	666i	676i
Basal application(B)	2.58abc	2.44ab	0.288b	0.283b	804 f	812fg
DAP spray at MT	2.26c	2.28b	0.215de	0.213de	718.5h	735h
KTP spray at MT	2.20c	2.21b	0.213de	0.214de	765g	772gh
B+DAP spray at MT	2.55abc	2.46ab	0.313abc	0.288b	770g	762h
B+KTP spray at MT	2.50abc	2.43ab	0.303ab	0.30ab	820ef	830ef
DAP spray at PI	2.62abc	2.51ab	0.228de	0.218cd	845e	857e
KTP spray at PI	2.54abc	2.50ab	0.225de	0.213cd	888 d	857e
B+DAP spray at PI	2.64a	2.62ab	0.323ab	0.318ab	902d	902d
B+KTP spray at PI	2.59ab	2.57ab	0.307ab	0.295b	953c	908d
DAP spray at BT	2.50abc	2.51ab	0.225de	0.220cd	954c	960c
KTP spray BT	2.48abc	2.45ab	0.224de	0.219cd	1054b	964c
B+DAP spray at BT	2.86a	2.79a	0.336a	0.335a	1025a	1061b
B+KTP spray at BT	2.78a	2.70a	0.333a	0.334a	1165a	1169a
F test	**	**	**	**	**	**
LSD0.0	0.45	0.35	0.040	0.037	30.322	42.9466

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

Table 3. Concentration of Zn, Fe and Na in rice leaf as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons.

Treatment	Zn ppm		Fe ppm		Na ppm	
	2010	2011	2010	2011	2010	2011
Control	5.93a	4.62a	290.8e	296.3g	447.1a	440.8a
Basal application(B)	3.83f	3.23de	343.0de	345.7d-g	314.2de	298.8cd
DAP spray at MT	3.75bc	3.91a-d	312.0e	323.4e	367.3b	354.8b
KTP spray at MT	3.78bc	3.94a-d	316.0ab	321.7ab	357.0bc	350.0b
B+DAP spray at MT	3.08def	3.22de	323.8de	323.6efg	297.3df	289.8de
B+KTP spray at MT	4.30b	4.24abc	360.8cd	353.8fg	272.0fg	267.0ef
DAP spray at PI	4.00bc	4.16abc	335.3de	311.8efg	335.5cd	327.8bc
KTP spray at PI	3.75bcd	3.76b-e	361.5cd	377.0bcd	317.7de	316.8cd
B+DAP spray at PI	4.15bc	4.33ab	381.3bc	374.6cd	267.8g	260.5f
B+KTP spray at PI	3.76cde	3.62b-e	362.3cd	355.7de	273.3fg	266.0ef
DAP spray at BT	3.98bc	4.1abc	314.3e	317.2efg	255.5gh	225.0g
KTP spray BT	3.78bc	3.75b-e	334.3de	343.0def	212.0i	204.5gh
B+DAP spray at BT	3.67dcd	3.89a-d	426.1a	451.75a	232.0hi	209.2gh
B+KTP spray at BT	3.55cde	3.46cde	412.0ab	428.2abc	205.3i	194.0h
F test	**	**	**	**	**	**
LSD0.05	0.67	0.82	42.9	67.3	27.56	29.19

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

Table 4. Ratio of Na/K and P uptake and recovery % in rice as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons.

Treatment	Na/K ratio		P uptake kg /ha		P recovery%	
	2010	2011	2010	2011	2009	2010
Control	0.65a	0.67a	18.73e	18.60e	-	-
Basal application(B)	0.37de	0.39d	32.1ab	30.39bc	22.3	19.7
DAP spray at MT	0.50b	0.51b	22.30de	22.1de	71.4	70.0
KTP spray at MT	0.45c	0.47c	22.1de	22.2de	67.4	72.0
B+DAP spray at MT	0.38d	0.39d	36.35ab	33.8b	27.1	23.4
B+KTP spray at MT	0.32ef	0.33ef	35.24ab	34.52ab	25.4	24.5
DAP spray at PI	0.38ef	0.40d	23.5de	22.6de	95.4	80.0
KTP spray at PI	0.35de	0.36de	23.1de	22.5de	87.4	78.0
B+DAP spray at PI	0.29f	0.30fg	35.32ab	37.11ab	25.5	28.3
B+KTP spray at PI	0.28fg	0.29g	35.85ab	35.1abc	26.3	25.4
DAP spray at BT	0.23gh	0.27gh	23.6de	22.7cd	97.4	82
KTP spray BT	0.19hi	0.20ij	23.4de	22.8cd	93.4	84
B+DAP spray at BT	0.20hi	0.23hi	37.13a	38.681a	28.3	30.9
B+KTP spray at BT	0.17i	0.18j	35.24ab	36.41ab	25.3	27.4
F test	**	**	**	**	-	-
LSD0.05	0.024	0.027	4.82	4.39	-	-

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

2-Flag leaf characteristics

It is well known that flag leaf had great role in rice grain yield formation and its maximization, not only in normal soil but also under saline soil. Keeping flag leaf healthy under salt stress is effective to increase rice salt tolerance and subsequently higher grain yield. Thereby, data in Table 5 revealed that phosphorous application either as basal or foliar spray or in combination at various critical growth stages significantly improved flag leaf characteristics, namely; flag leaf area, flag leaf dray weight and chlorophyll content. The improved previously mentioned traits reach to their maximum values when rice plants were fertilized by phosphorous as basal + spray KTP or DAP at booting stage.

Phosphorous application *via* root media might promote and accelerate early rice growth as well as enhance rice vigor under current salt stress. Phosphorous application using calcium super phosphate might induce improvement in soil physical and chemical properities by reducing Na^{+} content of current soil via Ca^{+2}subisttution. Furthermore, spraying P at late booting stage might increase some biochemical compounds such as RNA and DNA as well as the energetic compound i.e. NADP, FADP ATP result in cell division and elongation and leading to for heavy and large flag leaf. Both large leaf area and heavy weight of flag leaf with higher chlorophyll consequently the greatest amount of photosynthetic metabolism stream which is directly transformed to spikelet.

Phosphorous application either as basal or spray particularly at booting stage markedly increased the nutrient content and chlorophyll content in the rice and contribute to high photosynthetic rate. Moreover, phosphorous application could reduce Na/ K ratio in the terms of keeping the vital role of flag leaf. Improving flag leaf characteristics might increase its photosynthetic rate might improve grain filling leading to reduction in sterility % in rice grains under saline soil. Zayed *et. al.*(2011) mentioned that the most critical yield component criteria under salt stress is panicle sterilely or fertility % in which any improvement in panicle fertility will ensure considerable grain yield of rice crop under saline soil.

In General, the lowest values of flag leaf characteristics were recorded by control treatment. The data are in accordance with those reported by Reddy *et. al.* (2009) and Zayed *et. al.* (2010).

Table 5. Flag leaf area (cm^2), flag leaf dry weight (g) and chlorophyll content in flag leaf of rice as affected by various phosphorous treatments under saline soil condition during 2010 and 2011 seasons.

Treatment	Flag leaf area (cm^2)		Flag leaf dry weight (g)		Chlorophyll flag leaf SPAD Value	
	2010	2011	2010	2011	2010	2011
Control	30.35e	30.65i	0.1448e	0.146d	40.53 e	39.98f
Basal application(B)	33.55bc	33.9ef	0.180bcd	0.188abc	42.63 c	42.7cd
DAP spray at MT	32.7cd	32.75gh	0.181a-d	0.184abc	43.33 abc	43.53abc
KTP spray at MT	32.05d	32.35h	0.166d0.	0.173bc	41.84 d	40.55ef
B+DAP spray at MT	34.865a	35.05abc	0.186abc	0.191ab	41.93 d	42.325cd
B+KTP spray at MT	34.95a	35.2ab	0.182a-d	0.189ab	43.9 ab	43.625cd
DAP spray at PI	33.4c	33.35fg	0.174cd	0.183abc	44.25a	44.4a
KTP spray at PI	32.7cd	32.9gh	0.179bcd	0.186ab	41.88 d	42.275cd
B+DAP spray at PI	34.25ab	34.5b-e	0.181bcd	0.181abc	41.87 d	41.85de
B+KTP spray at PI	34.85a	34.75a-d	0.182a-d	0.180abc	42.73 bcd	43.00bcd
DAP spray at BT	33.3c	34.4cde	0.180bcd	0.160cd	42.15cd	42.53cd
KTP spray BT	33.35c	34.0de	0.190abc	0.183abc	42.99 ab	43.08a-d
B+DAP spray at BT	34.7a	35.05abc	0.194ab	0.199ab	44.28 a	43.23abc
B+KTP spray at BT	34.95a	35.4a	0.199a	0.203a	44.20 a	44.25ab
F test	**	**	**	**	**	**
LSD0.05	0.864	0.771	0.018	0.026	1.30	1.374

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

3- Growth parameters at heading

Data presented in Tables 6 and 7 indicated that phosphorus application as basal and foliar as well as in combination at different critical growth stages significantly and positively affected growth parameters i.e. leaf area index (LAI), dry matter of plant g m^{-2}, heading date, plant height and tillers number m^{-2} as well as heading in both seasons. The largest leaf area index was produced by phosphorus application as basal +KTP 2% sprayed at booting stage without any significant difference with those obtained by B application +DAP spray at BT. Meanwhile, the lowest values of LAI were produced by control treatment in both seasons. The highest values of dry matter of plant were recorded by phosphorus application as basal +DAP2% at MT without any significant difference with basal application only or in combination with KTP or DAP at PI and BT stages in both seasons. The lowest values of dry matter production were recorded when rice plants did not receive any phosphorus fertilizer in both seasons.

Regarding heading date, phosphorus application particularly basal application shortened the period from sowing to heading. Interestingly, phosphorous application pronounced improved leaf area indices in both years of study and that was true with all methods of application at various growth stages. Under saline soil, the antagonistic effect among the nutrient elements minimizes the soil fertility. Moreover, the toxicity of Na^+ and Cl^- and the other toxic ions restrict the biosynthesis of phytochrom and hormones consequently decrease the date of heading. The application of phosphorous counteracts the salinity harmful effect in rice plant (Giza 178 rice variety) under current study.

The tested phosphorous treatments significantly affected plant height in both seasons. Basal phosphorus application +KTP spray at mid tillering stage gave the tallest plant while control treatment i.e. no of P application gave the shortest plant (Table7). The treatments of P basal alone or basal application + foliar spray with either DAP or KTP at various growth stages (MT, PI and BI) and a part were at a par in plant height. As for tiller number, the tested phosphorus application treatments at different growth stages significantly affected tillers number $hill^{-1}$ in the both seasons.

The treatments of phosphorus application as basal + KTP foliar spray gave the highest number of tillers $hill^{-1}$ in both seasons. The treatments of phosphorus basal application +KTP or DAP as foliar spry at MT, and DAP spray at BT were a comparable effect regarding tillers number. The non application of phosphorus treatment produced the lowest number of tillers hill^{-1} in the both seasons. As previously mentioned in Tables 2 and 3 the phosphorous application either through soil or foliar and their combination significantly improved nutrient availability and contents as well as reducing lowered Na^{+}/ K^{+} ratio. That might relief salinity hazard on rice growth resulted in more active node which emerge more tillers, especially effective tillers. These results are in a harmony with those reported by Kalyanasundaram and Surrndirakumar (2003), Elayaraja and Angayarkanni (2007), and Reddy *et. al. (*2009) and Zayed *et. al.*.(2010).

Table 6. Leaf area index (LAI), Dry mater production and heading date of rice as affected by various phosphorous treatments under saline soil condition during 2010 and 2011 seasons.

Treatment	LAI		Dry matter g m^{-2}		Heading date (day)	
	2010	2011	2010	2011	2010	2011
Control	4.72 f	4.92 g	974 e	979.4c	99.3 a	99 a
Basal application(B)	5.35 cd	5.43 c-f	1137.5ab	1572 ab	96.1 ef	96.5 b-e
DAP spray at MT	4.98 ef	5.11 fg	1041.3 d	1032.bc	98.5 ab	98 ab
KTP spray at MT	5.31 cde	5.41 c-f	1036d	1036bc	95.8 ef	96.5 b-e
B+DAP spray at MT	5.40 cd	5.54 b-e	1165.6a	1177.0a	97.5 bc	98 ab
B+KTP spray at MT	5.48 bcd	5.63 b-e	1165.0 a	1151.4a	95.3 fg	96.5 b-e
DAP spray at PI	5.19 de	5.34 def	1030.8 d	1034.4b	96.3 def	98 ab
KTP spray at PI	5.29 cde	5.27 efg	1027.5 d	1034b	96.8 cde	97.3 a-d
B+DAP spray at PI	5.59 bc	5.70 bcd	1161.5 a	1169.3a	95.3 fg	95.5 cde
B+KTP spray at PI	5.52 bcd	5.79 abc	1167.8 a	1168.5a	97.4 bcd	97.8 ab
DAP spray at BT	5.45 bcd	5.53 b-e	1051.5cd	1031.8b	96.3 c-f	96.8 a-e
KTP spray BT	5.53 bcd	5.60 b-e	1043.8cd	1039b	94.4 gh	95 de
B+DAP spray at BT	5.75 ab	5.85 ab	1124.3ab	1155.8a	95.5 fg	96..5 b-e
B+KTP spray at BT	6.03 a	6.11 a	1127 ab	1155a	94 h	94.5 e
F test	**	**	**	**	**	**
LSD0.05	0.34	0.41	47.98	63.27	1.23	2.48

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

Table 7. Plant height (cm), tiller and panicle number hill-1of rice as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons.

Treatment	Plant height		Tiller numbers hill^{-1}		Panicle numbers hill^{-1}	
	2010	2011	2010	2011	2010	2011
Control	92.0 b	90.0 d	16.5 f	17.0g	15.4 f	13.5 e
Basal application(B)	98.9 a	98.6 ab	19.9 ab	20.9 ab	19.0 ab	18.3 ab
DAP spray at MT	92.9 b	93.6 c	18.1 de	18.8 ef	17.3 e	16.4 d
KTP spray at MT	93.5 b	94.1 c	18.6 cde	19.0 def	17.5 de	17.35 bc
B+DAP spray at MT	98.5 ab	98.5 ab	19.9 ab	21.0 ab	18.8 abc	18.25 ab
B+KTP spray at MT	100.3 a	100.4 ab	20.5 a	21.7 a	19.3 ab	18.1 ab
DAP spray at PI	93.4 b	94.1 cd	17.9 e	18.7 ef	16.9 e	16.8 cd
KTP spray at PI	93.4 b	93.0d	18.0 e	18.5 f	16.9 e	17.3 bcd
B+DAP spray at PI	99.0 a	98.4 ab	18.9 b-e	19.5 c-f	19.5 a	18.6 a
B+KTP spray at PI	99.5 a	98.9 ab	19.5 abc	20.0 b-e	19.0 ab	18.0 ab
DAP spray at BT	93.0 b	92.7 d	18.6 cde	19.5 c-f	17.6 de	16.5 d
KTP spray BT	93.6 b	92.5 d	18.8 b-e	20.0 b-e	17.8 cde	16.5 d
B+DAP spray at BT	99.5 a	99.4 ab	19.4 abc	20.9 ab	18.5 bcd	17.9 bc
B+KTP spray at BT	100.5 a	99.4 a	19.3 bcd	20.3 bcd	18.5 bcd	17.8 bc
F test	**	**	**	**	**	**
LSD0.05	2.4	3.3	1.16	1.45	1.02	1.19

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

4-Yield Attributes

Data in Tables 7, 8 and 9 revealed that phosphorus application significantly influenced yield components of rice. It is hold true with all phosphorus treatments in the both seasons. Basal application + foliar spray of DAP at PI produced the maximum values of panicles number hill^{-1}without any significant differences with those produced by phosphorus as basal application alone or with spraying DAP or KTP at MT and PI. Data in Table 8 demonstrated that the treatments of phosphorus as basal application plus DAP and KTP spray at booting stage significantly surpassed other phosphorus treatments. Basal application plus DAP or KTP spray at booting stage gave the maximum values of filled grains panicle^{-1}, 1000-grain weight and panicle weight while the greatest panicle length was obtained by Basal application +DAP or KTP spray at BT without significant differences with those obtained by B+KTP at MT in 2010 season, DAP or KTP at PI or BT and B+DAP or KTP at BT. At the same time, the treatments of B+ DAP or KTP spray at BT gave the lowest values of number of unfilled grains panicle^{-1}. The control treatment i.e. non phosphorus fertilizer recorded the lowest values of yield components except, unfilled grains number/ panicle.

It could be concluded that both root media of phosphorus application and foliar application starting from panicle initiation growth stage upto booting stage are essential for high yield components under saline soil conditions.

Root media phosphorous application might be acting as saline alleviator, soil chemical remedy for saline soil resulting in the improvement both of physical and chemical properties of soil and leading to improve growth of rice under saline conditions. Phosphorus application in combination as basal or foliar spray might increase nutrients availability and contents as well as uptake as mentioned previously resulted in encourage growth of rice and photosynthesis. Furthermore, increasing K^+ uptake and reducing Na^+ resulted in lower Na^+/K^+ ratio in rice plant and soil root media improved rice growth, and salt tolerance and increased P content in leaf at growth stage particularly during reproductive and active grain filling stages improving current photosynthetic rate reaching to its maximum value and translocation of metabolism stream will be higher giving ultimately high sink capacity, yield components and grain yield.

The late foliar phosphorous application might improved grain filling processes resulting in higher value of filled grains, lower value of unfilled grains panicle^{-1}, heaviest panicle and 1000-grain weight and encouraged rice plant to produce more bearing tillers. Similar findings are reported by Kalyanasundaram and Surrndirakumar (2003), Elayaraja and Angayarkanni (2007), and Reddy *et. al.*(2009) and Zayed *et. al.* 2010).

Table 8. Panicle length (cm), number of filled and unfilled grains /panicle of rice as affected by various phosphorous under saline soil conditions during 2010 and 2011 seasons.

Treatment	Panicle length (cm)		Filled grains panicle^{-1}		Unfilled grainspanicle^{-1}	
	2010	2011	2010	2011	2010	2011
Control	18.33 d	18.40f	108.5f	109.3f	24.5a	21.3a
Basal application(B)	19.80 bc	19.30ef	121.8e	121.0e	18.0b	16.8b
DAP spray at MT	19.70 bc	19.45de	118.3e	118.3e	17.5b	16.5b
KTP spray at MT	19.43 c	19.48cde	118.5e	117.3f	17.0bc	16.8bcd
B+DAP spray at MT	20.00 bc	20.15a-e	120.3e	128.8cd	16.5bcd	14.3b-e
B+KTP spray at MT	20.48 ab	20.33a-d	121.3e	129.0cd	15.0cde	14.0bcd
DAP spray at PI	20.28abc	20.00a-e	126.3d	127.8d	15.3cde	14.5bcd
KTP spray at PI	20.25abc	20.20a-e	126.5d	127.0d	14.0ef	15.0bc
B+DAP spray at PI	20.60 ab	20.45abc	129.0cd	1305bcd	14.8def	11.8de
B+KTP spray at PI	20.10abc	19.95a-e	131.3bc	130.0b-d	12.8fg	13.0cde
DAP spray at BT	20.15abc	20.05a-e	133.5bc	133.0bc	11.3g	11.3ef
KTP spray BT	20.28abc	20.40a	133.5b	134.5b	11.0gh	12.0de
B+DAP spray at BT	20.95 a	20.95a	142.3a	142.8a	10.8gh	8.5f
B+KTP spray at BT	21.30 a	21.40a	143.0a	143.3a	9.0h	8.5f
F test	**	**	**	**	**	**
LSD0.05	0.911	0.994	3.9	4.74	2.08	2.9

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

Table 9. Panicle weight, 1000-grain weight and grain yield of rice as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons.

Treatment	Panicle weight (g)		1000 grain weight (g)		Grain yield t ha^{-1}	
	2010	2011	2010	2011 g	2010	2011
Control	2.20f	2.41 de	19.15 f	18.86def	5.14 i	5.20 e
Basal application(B)	2.52 b-e	2.55 cd	20.23 cd	19.93 f	6.60 b	6.40 cb
DAP spray at MT	2.33 f	2.39 e	19.63 e	19.50 ef	5.60 h	5.50 de
KTP spray at MT	2.38 def	2.39 e	19.65 e	19.85 cd	5.60 h	5.45 de
B+DAP spray at MT	2.33 f	2.36 e	20.2 cd	20.4 cd	6.46 ef	6.56 cb
B+KTP spray at MT	2.43 c-f	2.48 cde	20.2 cd	20.38cde	6.62 de	6.50 cb
DAP spray at PI	2.47 c-f	2.52 cde	19.9 de	20.18 bc	5.50 h	5.90 d
KTP spray at PI	2.34 ef	2.41 de	20.38 bc	20.60 b	5.60 h	5.70 de
B+DAP spray at PI	2.53 bcd	2.61 bcd	20.45 bc	20.90 bc	6.69 b	6.70 b
B+KTP spray at PI	2.57 bc	2.63 abc	20.7 b	20.60 bc	6.70 b	6.80 b
DAP spray at BT	2.50 b-f	2.51 cde	20.38 bc	20.60 bc	5.86 bc	5.93 d
KTP spray BT	2.48 c-f	2.51 cde	20.55 a	20.48 bc	5.80 bc	5.80 de
B+DAP spray at BT	2.75 ab	2.79 a	21.33 a	21.43 a	7.13 a	7.25 a
B+KTP spray at BT	2.98 a	2.84 a	21.45 b	21.45 a	7.15 a	7.27 a
F test	**	**	**	**	**	**
LSD0.05	0.199	0.21	0.41	0.48	0.39	0.50

MT= mid- tillering, PI= panicle initiation, BT= the beginning of booting stage.

5- ice grain yield and economic evaluation

Data presented in Table 9 indicated that rice gain yield was significantly improved by various phosphorus application alternatives at different growth stages against zero phosphorus application. Marked increase in rice grain has been detected as a result of phosphorus application for rice root medium plus foliage application at late growth stage i.e. booting stage. Phosphorous as basal application+ KTP spray at booting stage recorded the highest values of grain yield in the both seasons of study (Table 9). Meanwhile, the lowest values of rice grain yield were produced when no phosphorous was applied.

It could be concluded that both of early phosphorous application via root medium and late phosphorous application via foliage were effective for considerable rice yield under saline soil.

Basal P application might improve soil properties and root power ensuring continues nutrient supply to plant canopy led to optimum LAI, high dry matter production accumulation as a result of high photosynthesis during post –head stage which transferee to rice sink consequently producing high yield under saline soil. Late phosphorus application assures healthy growth for active leaves, particularly flag leaves resulted in increase current photosynthesis and translocation to rice grain improving panicle improving panicle characteristics and leading to higher grain yield.

Table 10. Economic values of rice as affected by various phosphorous treatments under saline soil condition during 2010 and 2011 seasons.

Treatment	Yield increase over control t ha^{-1}		Production of yield increase over control L.E ha^{-1}		Cost of applied phosphorous LE ha^{-1}	
	2010	2011	2010	2011	2010	2011
Control	-	-	-	-		
Basal application(B)	1.46	1.20	2920	2400	320	320
DAP spray at MT	0.46	0.30	920	600	50	60
KTP spray at MT	0.46	0.35	920	700	120	130
B+DAP spray at MT	1.32	1.36	2640	2720	370	380
B+KTP spray at MT	1.48	1.30	2960	2600	440	450
DAP spray at PI	0.36	0.70	720	1400	50	60
KTP spray at PI	0.46	0.50	920	1000	120	130
B+DAP spray at PI	1.55	1.50	3100	3000	370	380
B+KTP spray at PI	1.56	1.60	3120	3200	440	450
DAP spray at BT	0.72	0.73	1440	1460	50	60
KTP spray BT	0.66	0.60	1320	1200	120	130
B+DAP spray at BT	1.99	2.05	3980	4100	370	380
B+KTP spray at BT	2.01	2.07	4020	4100	440	450

Average paddy rice price from Oct 2010 to Oct 2011= 2000LE/metric tone. 5-6 ,12-13L.E./ one kg of DAP and for DAP and KTP in 2010 and 2011 seasons, respectively.

Table 11. Economic values of rice as affected by various phosphorous treatments under saline soil conditions during 2010 and 2011 seasons.

Treatment	Value cost ratio		Net return LE ha^{-1}	
	2010	2011	2010	2011
Control			-	-
Basal application(B)	9.12	7.5	2600	2080
DAP spray at MT	18.4	10	870	540
KTP spray at MT	7.66	5.38	800	570
B+DAP spray at MT	7.13	7.15	2270	2340
B+KTP spray at MT	6.72	5.77	2520	2150
DAP spray at PI	14.4	23.3	670	1340
KTP spray at PI	7.66	7.69	800	870
B+DAP spray at PI	8.37	7.89	2730	2620
B+KTP spray at PI	7.09	7.11	2680	2750
DAP spray at BT	28.8	24.3	1390	1400
KTP spray BT	11	9.3	1200	1070
B+DAP spray at BT	10.7	10.8	3610	3720
B+KTP spray at BT	9.13	9.91	3580	3650

From data presented in Tables 10 and 11 , the most economic and applicable one is basal application of recommended phosphorous+ 2%of DAP at BT(13) which gave the highest value of net return LE ha^{-1}, medium rate of value cost ratio and almost the highest value of yield increase over control. The highest mean of value cost ratio was produced by 2 % DAP spray at booting stage (Table 11). By the way, foliar application of phosphorus at late growth stage combined with early application *via* rooting medium as basal is more effective, economically and fruitful under saline soil conditions from the point view of yield and economy as well as salinity hazardous effect alleviation. Similar data had been reported by Ramanathan *et. al.*(2002) Kalyanasundaram and Surrndirakumar (2003), Elayaraja and Angayarkanni (2007), and Reddy *et. al.* (2009) and Zayed *et. al.* (2010).

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دور ادارة الفسفور فى تخفيف الآثار الناتجة عن الملوحة فى الأرز

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مركز البحوث والتدريب فى الأرز- سخا – معهد بحوث المحاصيل الحقليه – مركز البحوث الزراعيه – الجيزه – مصر

ادارة المحصول المتكامله للأرز هي الاستراتجيه الرئيسيه لتعظيم إنتاجية المحصول فى مصر تحت ظروف الأراضى الملحيه ومن ثم فان إضافة بعض العناصر الغذائيه للنبات مثل الفسفور سوف تساهم فى زيادة تحمل النبات للملوحه وزيادة انتاجيته تحت ظروف الأراضى الملحيه.

أقيمت تجربتان حقليتان فى موسمي 2010, 2011 بالمزرعه البحثيه لمحطة بحوث السرو الزراعيه بدمياط وذلك بتربه طينية ملوحتها هي 7.5 و 6.5 بموسمي الدراسة علي التوالي .وصممت المعاملات لدارسة استجابة الصنف جيزة 178 لتبايل مختلفه من اضافة الفوسفور تحت ظروف الأراضى الملحيه وذلك بغرض رفع إنتاجيته وزيادة تخمله للملوحه, وكانت المعاملات هى المعامله الكنترول بدون اى اضافات و اضافة الموصي بة مخلوط بالتربه, رش النباتلت بفوسفات الأمونيوم الثنائيه بنسبة 2% فى مرحلة التفريع المتوسط, الرش بـ 2 % بوتاسيوم ثلاثى الفوسفات عند مرحلة التفريع المتوسط و الرش بفوسفات الأمونيوم الثنائيه + الإضافه أرضى عند مرحلة التفريع المتوسط و2 % بوتاسيوم ثلاثى الفوسفات + الإضافه أرضى عند مرحلة التفريع المتوسط و 2 % فوسفات الأمونيوم الثنائيه عند مرحلة بداية تكوين السنبله و 2 % رشاً ببوتاسيوم ثلاثى الفوسفات عند مرحلة بداية تكوين السنبله و الرش بـ 2 % فوسفات الأمونيوم الثنائيه عند مرحلة بداية تكوين السنبله + الإضافه أرضى , الرش 2 % ببوتاسيوم ثلاثى الفوسفات + الإضافه أرضى و الرش بـ 2% فوسفات الأمونيوم الثنائيه عند مرحلة بدايه طور الحنبله والرش 2 % ببوتاسيوم ثلاثى الفوسفات عند مرحلة بدايه طور الحنبله و الرش بكل منهما عند نفس الطور+ الإضافه الأرضى. وكانت أهم النتائج كالتالى:

أثرت المعاملات معنويا على محتوى الأوراق من العناصر المعدنيه خصوصا النيتروجين, الفوسفور, البوتاسيوم, الحديد ولكنها قللت من كل من الزنك بدرجه خفيفه والصوديوم, ونسبة الصوديوم/ البوتاسيوم.

نجحت معاملات إضافة الفوسفور سواء أرضى أو رشاً أو هما معاً عند المراحل المختلفه فى تحسين صفات ورقة العلم والنمو وكذلك كل الصفات المساهمه فى تكوين المحصول ومحصول الحبوب, حيث وجد ان اعلى القيم للمحصول ومكوناته وكذلك صفات النمو المقاسه فى مرحلة الطرد وصفات ورقه العلم سجلت عند رش النباتات بفوسفات الأمونيوم الثنائيه أو بوتاسيوم ثلاثى الفوسفات عند مرحلة بدايه الحنبله + الإضافة الأرضى بدون فرق معنوى.

ومن الناحيه الإقتصاديه فان المعامله الرش بــ فوسفات الأمونيوم الثنائيه + الإضافه أرضى للفوسفور الموصى بها حيث أعطت أعلى صافى ربح وعليه يمكن التوصيه بهذه المعامله تحت الظروف المماثله من ظروف الملوحه.