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Response of Rice Crop to Phosphorus and Sulfur Fertilizers Under Saline Soil Conditions

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ABSTRACT

A field experiment was conducted during 2014 and 2015 seasons at El-Sirw Agricultural Research Station, Damietta, Egypt. The present study was conducted to identify the response of rice cultivar Giza 179 to phosphorus (P) and sulfur (S) fertilizers application under saline soil conditions. The average of salinity levels of experimental site were 7.9 and 7.5 dS m^{-1} in 2014 and 2015 seasons, respectively. Split plot design with four replications was used. The treatments comprised the response of rice cultivar Giza 179 to four phosphorous rates namely; 0, 36, 54 and 72 kg P_2O_5 ha^{-1} and four sulfur rates viz; 0, 120, 240 and 360 kg S ha^{-1}. Some growth characteristics, grain yield and yield components of rice were estimated. However, the economic evaluation was assessed. The main results could be summarized as follows; the P and S treatments significantly improved rice growth criteria i.e. leaf area index, chlorophyll content, dry matter production, number of tillers $hill^{-1}$, plant height, yield components; number of panicles $hill^{-1}$, panicle length, panicle weight, number of filled grains $panicle^{-1}$ and 1000-grain weight, grain and straw yields and harvest index compared to control treatment. The treatment of 54 kg P_2O_5 ha^{-1} gave the highest values of all above mentioned traits and also, the treatment of 240 kg S ha^{-1} gave the highest values of them without any significant difference with 120 kg S ha^{-1}. The interaction between P and S significantly affected LAI, plant height, number of panicles $hill^{-1}$, grain and straw yields especially with the combination of 54 kg P_2O_5 ha^{-1} and 240 kg S ha^{-1}. From economic evaluation, the highest grain yield increase over control (t ha^{-1}), profitability (LE ha^{-1}) and net return were obtained with the treatment of 54 kg P_2O_5 ha^{-1} and 120 kg S ha^{-1}. It sum up that application of 54 kg P_2O_5 ha^{-1} and 120 kg S ha^{-1} is enough to obtain higher grain yield and economic return under the present study and similar conditions.

Keywords: *Oryza sativa L., P, S, Fertilizer, Salinity*

INTRODUCTION

Soil salinization is a serious problem in the entire world and it has grown substantially causing loss in crop productivity (FAO, 2006). It is a major constraint for agricultural production on nearly 20 % of the cultivated and irrigated area worldwide (Zheng et al., 2001). The major inhibitory effect of salinity on plant growth and development has been attributed to osmotic inhibition of water uptake and ions toxicity. Nutritional imbalance caused by such ions leads to reduction in photosynthetic and other physiological disorders (Yeo and Flowers, 1983; Yeo et al., 1990 and Khan et al., 2000).

Rice (*Oriza sativa* L.) is the second important crop in all over the world after wheat, and currently supported nearly one half of the world population (Mishra, 2004). According to the classification of crop tolerance to salinity, the rice crop is with the sensitive division from 0 to 8 dS m^{-1} (Maas et al., 1986). It is the only the cereal crop that has been recommended as a desalinization crop because of its ability to grow well under flooding conditions and this help to leach the salts from the surface layer of soil to enough low level for subsequent crops. In Egypt, about 400.000 – 500.000 Feddan of salt affected soils are under rice cultivation with low productivity (Zayed et al., 2010a).

Phosphorous (p) is the second major nutrient for plant growth as it is an integral part of different bio-chemicals like nucleic acid, nucleotides, phospholipids and phosphoproteins. Sufficient p nutrition improves several plant processes such as; photosynthesis, nitrogen fixation, flowering, fruiting, seed formation, root development and crop maturation (Memon, 1996). It has been observed that P fertilization reduced the concentration of Na^{+} in shoots, resulting in better survival, growth and yield of rice (Naheed *et al*., 2008; Zayed *et al*., 2010b and Zayed, 2012b).

Sulfur is found to be absorbed by rice crop in amounts equal to phosphorus and is considered essential for attainment of 90 percent of the optimum rice yield (Aulakh and Chhibba, 1992). Also, they observed that synergistic effect of P and S on the uptake of both when the nutrients were supplied at low rates. Nair (1995) reported that the higher P levels had an antagonistic effect on S uptake in rice. Rahman *et al*. (2007) claimed that sulfur fertilizer significantly increased grain yield of cereal crop including rice by significant improvement in all yield attributes and rice growth traits such as leaf area index and dry matter production.

This study was conducted to identify the response of rice cultivar Giza 179 to P and S fertilizers application under saline soil conditions.

MATERIALS AND METHODS

The present study was carried out in the two seasons of 2014 and 2015 at the Experimental Farm of El-Sirw Agricultural Research Station, Damietta Governorate, Egypt. The soil was salty clayey in both seasons. The chemical analysis are presented in Table 1.

Table 1.Chemical analysis of the experimental sites during 2014 and 2015 seasons.

Seasons	ECe (dS m^{-1})	pH	Na^{+1}	Ca^{+2} +Mg^{+2}	K^{+1}	HCo^{-}	Cl^{-1}	So_4^{-2}	N %	Available ppm	
					meg l^{-1}					P	K
2014	7.9	8.3	48	31	0.32	8.0	43	23.5	0.028	12	240
2015	7.5	8.2	45	29	0.31	6.7	33	25.6	0.026	14	250

The treatments comprised the response of rice cultivar Giza 179 to four phosphorous rates viz; 0, 36, 54 and 72 kg P_2O_5 ha^{-1} and four sulfur rates namely; 0, 120, 240 and 360 kg S ha^{-1} as a basal application. The experiment was laid out in split plot design, with four replications. P rates were randomly assigned to the main plots and S rates in the sub-plots. The plot size was 10 m^2.

Seed of rice cultivar Giza 179 was sowing on April 25th and harvested on August 27th. The nursery seedbed preparation was well performed as recommended under saline soil. Thirty days old seedlings were transplanted at the rate of 2-3 seedlings $hill^{-1}$ with spacing of 20×20 cm, which were sown with 2-3 cm of standing water in the land. The nitrogen at the rate of 165 kg N ha^{-1} in the form of urea (46 % N) was applied into three splits; 1/3 at tillering stage (45 days) + 1/3 at maximum tillering stage (60 days) +1/3 at the booting stage (75 days). Potassium sulphate (48% K_2O) was applied at the rate of 57 kg K_2O ha^{-1} into two equal doses as basal application and at maximum tillering stage. The rest of cultural practices of rice under saline soil were followed according to the recommendation of national campaign of rice, Ministry of Agriculture.

At heading (89 days), five hills were randomly taken and transferred to Lab to determine the following traits; leaf area index (LAI), chlorophyll content (SPAD value), dry matter production (g $hill^{-1}$), and number of tillers $hill^{-1}$, heading date (day) and plant height (cm). At harvest, panicles of ten hills were randomly taken from the second inner row of each sub-plot to estimate the following characteristics; number of panicles $hill^{-1}$, panicle length (cm), panicle weight (g), number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, 1000-grain weight (g). The plants of the six inner rows of each subplot were harvested, dried, threshed, then grain and straw yields were determined based on 14% moisture content and converted to (t ha^{-1}), however, harvest index (HI) was determined.

All data collected were subjected to standard statistical analysis according to 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 that the significant at 0.05 and 0.01 levels probability, respectively, while NS means not significant.

RESULTS AND DISCUSSION

A. Growth parameters:

Data in Table 2 indicated that the investigated phosphorous rates significantly influenced growth parameters; leaf area index, chlorophyll content and dry matter production except, heading date in both studied seasons. Increasing rate of phosphorous fertilizer significantly increased the leaf area index up to 72 kg $P_2O_5ha^{-1}$ without any significant differences with those produced by 54 kg P_2 O_5 ha^{-1} in both seasons. Chlorophyll content and dry matter responded to phosphorous fertilizer up to 54 kg P_2O_5 ha^{-1} in 2014 and 2015 seasons. Applying phosphorous for rice under salt stress might be improved rooting system formation at early growth stage increased rice salinity tolerance, pushed early growth and fasted growth with large leaf area against terrestrial soil giving large leaf area index. Furthermore, applying phosphorous at optimum rate apparently increased the phosphorous of leaf tissue that ensured high energy content resulted in higher content of leaf pigments in the terms of chlorophyll content producing more dry matter. The current findings are in a good conformity with those reported by Zayed *et al*. (2010b) and Zayed (2012b).

Table 2. Some growth characteristics of rice cultivar Giza 179 as affected by P and S rates in 2014 and 2015 seasons.

Characters / Treatments	LAI 2014	LAI 2015	Chlorophyll content (SPAD value) 2014	Chlorophyll content (SPAD value) 2015	Dry matter production (g $hill^{-1}$) 2014	Dry matter production (g $hill^{-1}$) 2015	Heading date (day) 2014	Heading date (day) 2015
Kg P_2O_5 ha^{-1}								
0	3.73c	4.18c	41.8b	41.4c	27.3b	34.1c	87.9	89.1
36	4.31b	4.86b	41.9b	42.8b	33.6a	37..4b	88.0	89.4
54	4.77a	5.09a	43.3a	43.3a	37.2a	40..1a	88.1	88.9
72	4.87a	5.11a	42.5ab	42.8b	37.1a	39.5a	87.9	89.0
F- test	**	**	*	**	**	**	NS	NS
Kg S ha^{-1}								
0	4.25b	4.64c	41.1b	42.1b	31.9b	35.8c	87.9	89.1
120	4.47ab	4.86b	42.9a	42.7a	33.2ab	38.4b	88.0	89.1
240	4.63a	4.93a	43.2a	42.9a	35.1a	39.3a	88.0	89.2
360	4.34b	4.83b	42.3a	42.7a	34.9a	37.7b	87.9	89.1
F- test	*	**	**	**	*	**	NS	NS
Interaction	*	**	NS	NS	NS	NS	NS	NS

***, ** and NS indicate P ≤ 0.05, P ≤ 0.01 and not significant, respectively. Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).**

Regarding the effect of sulfur rates fertilizer, sulfur rates had significant effect on studied growth characteristics, except heading date in couple study seasons (Table 2). Leaf area index, chlorophyll content and dry matter production showed significant response to sulfur rate until 240 kg S ha^{-1} in the first and second seasons (Table 2). An increasing sulfur rate beyond the previous mentioned rate did not gave significant increase in previous traits in both seasons of study. The lowest values of growth traits were produced under zero sulfur in both seasons, while 240 kg S ha^{-1} gave the highest value of growth parameters in 2014 and 2015 seasons. Sulfur element might be played vital role in growth and development of rice plants because their activation role in plant metabolic processes. Sulphur performs many physiological functions like synthesis of sulphur containing amino acids (cysteine, cystine and methionine), synthesis of vitamins, and metabolism of carbohydrates and proteins. Plants deficient in sulphur are reported to be small and spindly with short and slender stalks, their growth is retarded. The increasing in dry matter production due to the high rate in protein synthesis and enhanced photosynthetic activity of the plant with increased pigments synthesis (Naresh and Jangra, 2007). The findings related to rice growth in this attempt are in a good harmony with those reported by Aulakh and Chhibba (1992), Rahman *et al*. (2007), Amaraweera (2009), Shehata *et al*. (2009), Zayed *et al*. (2010a) and Zayed (2012a).

The interaction effect of studied treatment had significant effect on leaf area index in both seasons (Table 2). The results of interaction corresponding to leaf area index provided that leaf area index reached its maximum values when rice plants were fertilized with both of phosphorous and sulfur at the rates of 54 kg P_2O_5 ha^{-1} and 240 kg s ha^{-1}, respectively (Table 3).

Table 3. Leaf area index of rice cultivar Giza 179 as affected by the interaction between P and S rates in 2014 and 2015 seasons.

		Kg S ha^{-1}							
	Kg P_2O_5 ha^{-1}	2014				2015			
		0	120	240	360	0	120	240	360
Leaf area index (LAI)	0	3.62f	3.63f	4.01ef	3.68f	4.00h	4.20g	4.30g	4.23g
	36	3.94ef	4.34cde	4.68a-d	4.30de	4.60f	4.90de	5.00cd	4.95d
	54	4.29de	4.79a-d	5.19a	4.84abc	4.80e	5.13b	5.30a	5.15b
	72	5.17ab	5.11ab	4.66bcd	4.54cd	5.15b	5.20ab	5.10bc	5.00cd

Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).

B. Yield attributes:

As for the effect of phosphorous rates, number of tillers $hill^{-1}$ and number of panicles $hill^{-1}$, plant height and panicle length were significantly affected by various investigated phosphorous levels in both seasons (Table 4). It is being that the phosphorous rate of 54 kg P_2O_5 ha^{-1} exhibited good effect on above mentioned yield attributes, since it gave the highest values of them. The couple phosphorous rates of 54 and 72 kg P_2O_5 ha^{-1} were at a par regarding the mentioned traits. It is mentioning here that the panicle length only responded to phosphorous fertilizer at the rate of 36 kg P_2O_5 ha^{-1} in both seasons (Table 4).

Continuously, the phosphorous level had significant effect on filled grain, unfilled grains, and panicles and 1000-grain weights in both seasons (Table 5). The rate of 54 kg P_2O_5 ha^{-1} continued to exert the optimum panicle characteristics. The latter rate gave the highest values of filled grains and heaviest panicle and 1000 grain weights in both seasons. Any increasing in P beyond the 54 kg P_2O_5 ha^{-1} is not favorable considering the panicle characteristics. The lowest values of unfilled grain were produced when rice plant was fertilized by 72 kg P_2O_5 ha^{-1} without any significant differences with those produced by 54 kg P_2O_5 ha^{-1} (Table 5). The advantages impact of P might be attributed to increment of N and P uptake and optimized dry matter translocation to sink, raising synthesis of ATP and RNA and enhanced the efficiency of PSII photochemistry compound in rice plants resulted in high dry production content, high assimilates rate, particularly developed from current photosynthesis (Saleque *et al*., 2002 and Xu *et al*., 2007). Furthermore, P fertilizer might be induced the vigorous growth superficial roots, increased growth, photosynthesis and its partitioning as well as delaying leaf senescence under salt stress as increasing nitrogen leaf content leading to high yield attributes. P supplementary might be talked the hazard effects of salt stresses on rice plant biomass (Kaya *et al*., 2003).

Table 4. Some yield attributes of rice cultivar Giza 179 as affected by P and S rates in 2014 and 2015 seasons.

Characters	No. of tillers $hill^{-1}$		No. of panicles $hill^{-1}$		Plant height (cm)		Panicle length (cm)	
Treatments	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Kg P_2O_5 ha^{-1}								
0	20.2c	20.3b	17.2b	18.2c	78.7c	87.1b	16.6b	18.7b
36	21.1bc	21.7ab	18.3a	18.9b	83.5b	91.0a	17.0ab	18.8ab
54	22.5a	22.9a	18.7a	20.2a	85.0a	92.1a	17.3a	19.4a
72	21.7ab	21.8ab	18.5a	19.8a	84.2ab	91.4a	17.1ab	19.0ab
F- test	**	*	**	**	**	**	*	*
Kg S ha^{-1}								
0	20.2b	20.4b	17.7b	18.7b	80.2c	89.1c	16.7b	18.7b
120	21.7a	22.0a	18.4a	19.6a	83.0b	90.5b	17.3a	19.1a
240	22.0a	22.6a	18.5a	19.6a	84.7a	91.3a	17.0ab	19.1a
360	21.6a	21.7a	18.1a	19.2ab	83.5b	90.7ab	16.9b	19.1a
F-test	**	**	**	*	**	**	*	*
Interaction	NS	NS	**	*	**	**	NS	NS

***, ** and NS indicate $P \leq 0.05$, $P \leq 0.01$ and not significant, respectively. Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).**

Data in Tables 4 and 5 referred that the sulfur fertilizer significantly affected all yield attributes; tiller number, panicle numbers, plant height, panicle length, filled and unfilled grains numbers, and 1000-grain weight in both seasons. Panicle weight did not respond to sulfur rates in both seasons (Table 5). All yields attributes significantly responded to sulfur levels up to 120 kg S ha^{-1}, except plant height continued to response to sulfur fertilizer up to 240 kg S ha^{-1} in both seasons (Table 4). The highest values of above mentioned traits were obtained when 120 kg S ha^{-1} was applied except for plant height. On the other hand, the lowest values of yield attributes were obtained when rice plants received zero sulfur in both seasons (Tables 4 and 5). The main advantages of sulfur application that owing to improving soil proprieties by reducing pH of saline soil, drainage improvement, encouraging aggregates formation and raising nutrient availability reflecting on plant growth and salinity tolerance of rice (Farook and Khan, 2010 and Chien *et al*., 2011).

The apparent improvement in studied yield attributes was owing to higher assimilation and translocation of carbohydrates to panicle induced by sulfur. The sulfur also could stimulate synthesis of chloroplast protein resulting in greater photosynthetic efficiency which in turn resulted in increased yield (Biswas and Tewatia, 1992). Similar findings were reported by Aulakh and Chhibba (1992), Rahman *et al*. (2007), Amaraweera (2009), Shehata *et al*. (2009), Zayed *et al*. (2010a) and Zayed (2012a).

Table 5. Some yield components of rice cultivar Giza 179 as affected by P and S rates in 2014 and 2015 seasons.

Characters / Treatments	No. of filled grains $panicle^{-1}$ 2014	2015	No. of unfilled grains $panicle^{-1}$ 2014	2015	Panicle weight (g) 2014	2015	1000-grain weight (g) 2014	2015
Kg P_2O_5 ha^{-1}								
0	76.4c	82.7c	18.6a	17.9a	1.92b	2.49c	18.5c	19.9c
36	86.3b	88.1b	17.4ab	16.5ab	2.01b	2.63bc	19.6b	20.9b
54	89.7a	97.4a	16.6b	15.6b	2.25a	2.96a	20.5a	21.3a
72	86.3b	86.6b	16.1b	15.5b	2.09ab	2.78ab	20.0ab	20.8b
F- test	**	**	*	*	*	*	**	**
Kg S ha^{-1}								
0	82.4b	86.8b	18.4a	17.0a	2.02	2.51	19.3b	20.5b
120	85.8a	88.7ab	16.6b	16.3ab	2.12	2.78	19.7a	20.9a
240	85.9a	91.3a	16.1b	15.3b	2.10	2.78	19.9a	20.9a
360	84.6ab	88.0ab	17.6ab	16.9ab	2.04	2.78	19.7a	20.6b
F-test	*	*	*	*	NS	NS	*	**
Interaction	NS	NS	NS	NS	NS	NS	**	**

***, ** and NS indicate $P \leq 0.05$, $P \leq 0.01$ and not significant, respectively. Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).**

The interaction between phosphorous and sulfur rates had significant effect on number of panicles $hill^{-1}$, plant height and 1000-grain weight in both seasons (Tables 6 and 7). Interestingly, the combination of 54 kg P_2O_5 ha^{-1} and 240 kg S ha^{-1} produced the highest values of panicle numbers without significant differences with those produced by 120 kg S with the same above-mentioned level of P. Data in Table 6 confirmed that 120 kg S ha^{-1} with 54 kg P_2O_5 ha^{-1} is needed for rice growing under salt stress. Regarding the plant height, the combination of 54 kg P_2O_5 ha^{-1} and 240 kg S ha^{-1} produced the tallest plants in both seasons providing the superiority of this combination (Table 6). For the 1000-grain weight, data in table 7 showed that the combination of 54 kg P_2O_5 ha^{-1} and 240 kg S ha^{-1} continued to fix its efficient and produced the heaviest 1000-grain weight in both seasons.

Table 6. Number of panicles and plant height of rice cultivar Giza 179 as affected by the interaction between P and S rates in 2014 and 2015 seasons.

P*S	Kg P_2O_5 ha^{-1}	Kg S ha^{-1} 2014: 0	120	240	360	2015: 0	120	240	360
No. of panicles $hill^{-1}$	0	16.8gh	17.7def	17.5efg	16.6h	16.9g	18.4ef	18.8c-f	18.7def
	36	17.2fgh	18.2cde	19.0ab	19.0ab	18.0fg	19.0c-f	19.6a-d	18.9c-f
	54	18.4abc	19.0ab	19.1a	18.3bcd	20.4ab	20.3ab	20.6a	19.4a-e
	72	18.2cde	18.6abc	18.3cd	18.8abc	19.5a-e	20.6a	19.4b-e	19.9abc
Plant height cm^{-1}	0	75.9i	78.0h	80.0fg	81.0ef	83.8h	87.1g	87.8g	89.8ef
	36	79.0gh	84.0cd	86.0ab	85.0bc	89.4f	90.4def	92.4ab	91.9bc
	54	82.8de	85.0bc	87.0a	85.0bc	91.0cde	92.5ab	93.3a	91.6bcd
	72	83.0d	85.0bc	85.8abc	83.1d	92.3abc	92.1abc	91.8bc	89.4f

Means of each column designated by the same letters in a column are not significantly different at 0,05 level using Duncan's Multiple Range Test (DMRT).

Table 7. 1000-grain weight of rice cultivar Giza 179 as affected by the interaction between P and S rates in 2014 and 2015 seasons.

1000-grain weight (g)	Kg P_2O_5 ha^{-1}	Kg S ha^{-1} 2014: 0	120	240	360	2015: 0	120	240	360
	0	17.5g	18.4f	19.1e	19.1e	19.2i	20.1gh	20.4fgh	20.0h
	36	19.5de	19.7cde	19.8b-e	19.7cde	20.8def	21.0b-e	21.0b-e	20.6efg
	54	20.4ab	20.6a	20.6a	20.3abc	20.9cde	21.5a	21.3abc	21.4ab
	72	20.0a-d	20.1a-d	20.2abc	19.8b-e	21.0b-e	21.1a-d	20.8def	20.3gh

Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).

C. Yields:

Data listed in Table 8 revealed that phosphorous rates significantly affected grain and straw yields, and harvest index in both seasons. In first season, rice grain yield significantly responded to phosphorous fertilizer up to 54 kg P_2O_5 ha^{-1}, while in the second season, it responded to phosphorous fertilizer up to only 36 kg P_2O_5 ha^{-1}. Regarding straw yield, it showed the opposite pattern of grain yield in both seasons. Harvest index of rice significantly responded to phosphorous fertilizer up to 36 kg P_2O_5 ha^{-1}. The difference in grain yield response to P fertilizer in the two seasons might be mainly due to the available phosphorous in the soil (Table1). As previously mentioned the P fertilizer might be improved soil proprieties, increased salt tolerance, improved rice growth and enhanced yield components led to high grain yield, particularly at optimum rate. The current findings are in a good agreement with those reported by Aslam *et al*. (1996), Saleque *et al*. (2002), Ali and Ansari (2006), Zayed *et al*. (2010b) and Zayed, (2012b).

With respect to the effect of sulfur fertilizer, grain and straw yields, and harvest index significantly responded to sulfur fertilizer in both seasons (Table 8). By the way, the grain, straw yields and harvest index significantly responded to sulfur fertilizer up to 120 kg S ha^{-1} in both seasons (Table 8). Sulfur fertilizer showed ability to produce more grain against straw resulted in higher harvest index comparing to non-sulfur fertilizer. At the same time, sulfur fertilizer keep high dry matter production under salt stress giving reasonable grain yield.

To sum up, the favorable effect of sulphur on rice yield under salt stress was apparent because of its vital role in synthesis of proteins and pigments as well as soil reclamation. Also, application of sulfur might be remediated soil salt and soil proprieties including soil physical and chemical under current saline soil with high pH which, in turn, resulted in improving nutrients availability, low PH and bulk density leading to increase rice salt tolerance, improve rice growth, proper yield components and subsequently high yield. As seen in the current data ammonium sulphate exhibited other sulfur sources and showed its superiority in most of studied traits in both seasons that can be attributed to the readily soluble nature of the former. The current findings are in a good agreement with those reported by Amaraweera (2009), Shehata *et al*. (2009), Zayed *et al*. (2010a) and Zayed (2012a).

Table 8. Grain and straw yields and harvest index of rice cultivar Giza as affected P and S rates in 2014 and 2015 seasons.

Characters / Treatments	Grain yield (t ha^{-1}) 2014	Grain yield (t ha^{-1}) 2015	Straw yield (t ha^{-1}) 2014	Straw yield (t ha^{-1}) 2015	HI 2014	HI 2015
Kg P_2O_5 ha^{-1}						
0	4.35c	4.73c	6.98c	7.65c	0.39b	0.38c
36	5.04b	5.96a	7.33ab	7.96b	0.41a	0.43a
54	5.46a	6.04a	7.56a	8.39a	0.42a	0.42ab
72	5.18b	5.36b	7.18bc	8.01b	0.42a	0.40bc
F- test	**	**	**	**	**	**
Kg S ha^{-1}						
0	4.56c	5.06b	6.83b	7.60b	0.40b	0.40b
120	5.16ab	5.67a	7.44a	8.17a	0.41a	0.41a
240	5.25a	5.75a	7.47a	8.22a	0.41a	0.41a
360	5.06c	5.62a	7.31a	8.02a	0.41a	0.41a
F- test	**	*	**	**	*	*
Interaction	*	*	*	*	NS	NS

***, ** and NS indicate $P \leq 0.05$, $P \leq 0.01$ and not significant, respectively. Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).**

The interaction between phosphorous and sulfur had significant effect on rice grain and straw yields in both seasons (Table 8). This interaction data related to grain yield came to confirm the superiority combination of 54 kg P_2O_5 ha^{-1} and 120 kg S ha^{-1} (Table 9).

It could be concluded that high rice grain yield could be obtained under saline soil by application of combination of phosphorous and sulfur at the rate of 54 kg P_2O_5 and 120 kg S ha^{-1}, respectively. The current findings are in a good agreement with those reported by Aslam *et al*. (1996).

Table 9. Grain and straw yields of rice cultivar Giza 179 as affected by the interaction between P and S rates in 2014 and 2015 seasons.

P*S	Kg P_2O_5 ha^{-1}	Kg S ha^{-1} 2014: 0	120	240	360	2015: 0	120	240	360
Grain yield (t ha^{-1})	0	4.18h	4.38gh	4.48fgh	4.38gh	4.38e	4.73de	4.78de	5.05de
	36	4.50fg	5.15cd	5.25bc	5.25bc	5.15de	6.15abc	6.28ab	6.28ab
	54	4.85de	5.65a	5.75a	5.60a	5.28cde	6.23abc	6.5a	6.15abc
	72	4.70ef	5.48ab	5.53ab	5.00cd	5.43bcd	5.58a-d	5.45bcd	5.0de
Straw yield (t ha^{-1})	0	6.31f	7.24bcd	7.43ab	6.94cde	7.25h	7.70e-h	7.89c-f	7.65fgh
	36	6.88de	7.36abc	7.55ab	7.55ab	7.35gh	8.01c-f	8.19b-e	8.38abc
	54	7.38abc	7.74a	7.55ab	7.56ab	7.85d-g	8.65ab	8.85a	8.21b-e
	72	6.75ef	7.43ab	7.34abc	7.2b-e	7.95c-f	8.31bcd	7.95c-f	7.83d-g

Means of each column designated by the same letters in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).

D. Economic evaluation:

Data in Table 10 indicated that the treatment of 54 kg P_2O_5 ha^{-1} gave the highest values of grain yield increase over control, profitability (LE ha^{-1}), net return (LE ha^{-1}) in the two seasons of study and the highest mean value of cost ratio in 2014 season. However, the treatment of 120 kg S ha^{-1} gave the highest values of all above mentioned economic items in both seasons of study compared with the rest treatments. Similar data had been reported by Kalyanasundaram and Surrndirakumar (2003), Amaraweera (2009), Zayed (2012a) and Zayed (2012b).

Table 10. Some economic parameters of rice cultivar Giza 179 as affected by P and S rates in 2014 and 2015 seasons.

Characters	Grain yield increase over control (t ha^{-1})		Profitability (LE ha^{-1})		Cost of fertilizer (LE ha^{-1})		Value cost ratio		Net return (LE ha^{-1})	
Treatments	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Kg P_2O_5 ha^{-1}										
0	-	-	-	-	-	-	-	-	-	-
36	0.69	1.23	1380	2460	196	196	7.04	12.6	1184	2264
54	1.11	1.31	2220	2620	294	294	7.55	8.91	1926	2326
72	0.83	0.63	1660	1260	391	391	4.25	3.22	1269	869
Kg S ha^{-1}										
0	-	-	-	-	-	-	-	-	-	-
120	0.60	0.61	1200	1220	240	240	5.00	5.08	960	980
240	0.69	0.69	1380	1380	480	480	2.88	2.88	900	900
360	0.50	0.56	1000	1120	720	720	1.39	1.56	280	400

The price of rice and fertilizer was as average in black market and governmental price, average price of paddy rice = 2000 LE ton^{-1}, 2 LE kg^{-1} as S and 42 LE 50 kg^{-1} as calcium super phosphate 15.5% P_2O_5.

CONCLUSION

From point view of economic evaluation and yield, phosphorous at the rate of 54 kg P_2O_5 ha^{-1} and sulfur at the rate of 120 kg S ha^{-1} could be recommended under Salt stress.

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استجابة محصول الأرز للتسميد الفوسفاتي والكبريتي تحت ظروف الأرض الملحية

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أقيمت تجربتان حقليتان في موسمى ٢٠١٤ ، ٢٠١٥ م بالمزرعة البحثية لمحطة بحوث السرو الزراعية بدمياط ، مصر، وكان الهدف من هذه التجربة هو معرفة استجابة الصنف جيزة ١٧٩ للتسميد بالفسفور والكبريت تحت ظروف الأرض الملحية. كان متوسط مستوى الملوحة ٧.٩ و ٧.٥ ديسيسيمنز م-١ في كلا موسمى الدراسة على التوالي. أستخدم تصميم القطع المنشقة مرة واحدة مع أربعة مكررات في هذه التجربة حيث وضعت مستويات الفوسفور (٠ ، ٣٦ ، ٥٤ و ٧٢ كجم فو٢أ٥ للهكتار) في القطع الرئيسية ومستويات الكبريت في القطع المنشقة (٠ ، ١٢٠ ، ٢٤٠ و٣٦٠ كجم كبريت معدنى للهكتار). وقد تم تقدير صفات النمو والمحصول ومكونات المحصول لصنف الأرز جيزة ١٧٩ بالإضافة لعمل تقييم اقتصادى للمحصول. أوضحت النتائج أن صفات النمو (دليل مساحة الأوراق ، محتوى الكلوروفيل ، المادة الجافة المتكونة ، وعدد الفروع وطول النبات) وصفات المحصول (عدد السنابل ، طول السنبلة ، وزن السنبلة ، عدد الحبوب الممتلئة ووزن الألف حبة) ومحصول الحبوب والقش ودليل الحصاد تأثرت معنويا بإضافة الفسفور والكبريت حيث أعطى المعدل ٥٤ كجم فو٢أ٥ للهكتار أعلى القيم من هذه الصفات وبالنسبة للكبريت أعطى المعدل ٢٤٠ كجم كبريت معدنى بدون اى فرق معنوى عن المعاملة بـ ١٢٠ كجم كبريت للهكتار أعلى القيم من هذه الصفات. وكان هناك تفاعل معنوى بين المعدلات المختلفة من السماد الفوسفاتى والكبريتى على صفات دليل مساحة الأوراق ، طول النبات ، عدد السنابل ومحصول الحبوب والقش حيث وجدت أعلى القيم من هذه الصفات عند إضافة ٥٤ كجم فو٢أ٥ للهكتار و ٢٤٠ كجم كبريت للهكتار. وأشار التقييم الاقتصادى إلى ان أعلى زيادة في محصول الحبوب عن المعاملة الكنترول وأعلى عائد وأعلى صافى ربح تحقق مع إضافة ٥٤ كجم فو٢أ٥ للهكتار و ١٢٠ كجم كبريت للهكتار. ولذلك توصى هذه الدراسة بإضافة ٥٤ كجم فو٢أ٥ للهكتار مع ١٢٠ كجم كبريت للهكتار للحصول على أعلى محصول وأعلى صافى ربح من صنف الأرز جيزة ١٧٩ تحت ظروف هذه التجربة أو ما يماثلها من أراضى متأثرة بالأملاح.