EFFICIENCY OF DIFFERENT SULFUR FERTILIZER SOURCES IN INCREASING HYBRID RICE PRODUCTIVITY UNDER SALINE SOIL CONDITIONS

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Abstract

Two field experiments were conducted during 2010 and 2011 seasons at El -Sirw Agricultural Research Station, Dammitta, Egypt. The study aimed to point out the most favorable source of sulfur fertilizer along with urea fertilizer for increasing rice productivity and farmer income under saline soil conditions. The average of salinity levels of experimental site were 6.3 and 6.0 dS/m in both seasons, respectively. The studied treatments were control treatment without any fertilizer application, urea alone in the rate of 165 kg N ha-1 , urea+ 24 kg Zn SO4 ha-1, urea + elemental sulfur (ES) applied as basal in the rate of 95 ES kg ha-1., urea+ calcium super phosphate (60 kg P2O5 ha-1), urea+ gypsum at the rate of 476 kg ha-1., urea + potassium sulfate at the rate of 57 kg K2O ha-1., and ammonium sulphate (AS)alone at the rate of 165 kg N ha-1. The growth, nutrient contents in rice leaf, yield grain and its components of the hybrid rice variety EHR1 were estimated. The economic evaluation was also, considered. It is mentioning that the study aimed to answer the question, Is the sulfur present in some main fertilizer is enough for hybrid rice growing under saline soil comparing to elemental sulfur application irrespective sulfur rate?

The main results could be summarized as following, the tested treatments significantly improved rice growth criteria i.e. Leaf area index (LAI), dry matter production, chlorophyll content of leaf, heading date and plant height, yield components(As well as, panicle number, panicle length, filled grains, fertility, panicle weight, 1000 grain weight and rice grain yield) against control treatment. Furthermore, the tested treatments significantly boosted the nutrient contents except, Na leaf content. The treatment of urea + gypsum showed certain decrease in Na+ and gave the lowest value of Na+ leaf content followed by urea+ potassium sulphate. Urea application alone was significantly less efficient as compared to the rest of treatments irrespective control treatment. Ammonium sulphate as the source of N and sulfur significantly gave the highest values of mentioned traits and the highest economic values followed by urea+ gypsum and, then, urea+ potassium sulfate. The treatments of urea+ Zn SO4, urea + CSP two and booting stage, urea + agricultural sulfur as well as Urea + potassium sulfate were at a par.

Generally, it could be concluded that urea application alone is not enough to give considerable yield. The blended fertilizer or urea + other sources for sulfur have to be applied for obtaining high productivity of hybrid rice. Ammonium sulphate as source for N and S was the best under current experiment and it is enough as sulfur fertilizer source.

Key words: Rice, hybrid, saline soil, sulfur fertilizer sources

INTRODUCTION

Sulphur (S) is one of the essential elements required for the normal growth of plants and concentration of S in plants is lower than that of nitrogen, however, it similar to that of phosphorus fertilizer . Sulphur plays an important role as a constituent of many plant processes, as plant metabolism, depends on S and a deficiency of this nutrient will cause basic metabolic impairment, which will not only reduce crop yield but also the quality of the product. For many years, little attention was paid to sulphur as a plant nutrient mainly because it has been applied to soil in incidental inputs in rainfall and volcanic emissions, and as a component of nitrogen, phosphorus and potassium fertilizers (Naresh and Jangra, 2007). The awareness of sulphur deficiency is increasing, as is the development of S deficiency in previously S sufficient areas in many parts of the world. The intensification of agricultural production per unit area, coupled with an expanding use of high-analysis, sulphur-free fertilizers or low-sulphur fertilizers, such as urea and ammoniated phosphates, is causing sulphur deficiencies. The problem could be exacerbated further as sulphur dioxide emissions are increasingly controlled. If this problem is neglected, the inevitable consequences will decrease yields and reduced efficiency of other inputs, which will, in turn, result in higher production costs. Under saline soil or soil with high pH is acting as nutrient fertilizer and chemical remediation. Shehata *et al.* (2009) and Zayed *et al.* (2010) found that sulfur fertilizer at the rate of 50 kg S/fed in the form of elemental S significantly increased rice growth, yield and yield components as well as it had apparent positive effect on soil properties. Tripathi and Sharma (1994) reported that application of sulphur at 40 kg per ha gave significant higher uptake of nutrients (N, P, K, S, and Fe of rice. Both the sources of sulphur (gypsum and pyrite) were equally effective in increasing the uptake by Indian mustard and succeeding rice.

Mercy *et al.*(2006) stated that sulfur signal super phosphate as source for sulfur significantly surpassed the elemental sulfur as sources for sulfur in rice grain yield, effective tillers number and harvest index, while the maximum test weight and protein content was found with the application of elemental sulphur. Khan *et al.* (2007) reported that the application of sulfidic materials (SM) at the rate of 75 kg S /ha for sulfur deficient soils had no negative effect on soil pH, nutrient status in the soils and sunflower production. They suggested that the application of SM was not only effective as sulfur fertilizer but also enriched the organic matter in the soils. Bhuvaneswari *et al.* (2007) studied the effect of farmyard manure (FYM) and four levels of sulphur applied through gypsum on the growth and yield of rice variety ADT 43. Results of the experiment revealed that application of 40 kg sulphur per ha in combination with FYM (12.5 tonnes per ha) significantly increased physiological characters of crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI) over the control. CGR, RGR, NAR and LAI were least which did not receive sulphur and FYM. Naw *et al.* (2007) reported a significant effect of sulphur application on N, P, K and S uptake in rice. Amaraweera (2009) found that the elemental sulfur significantly exhibited the highest values of NPKZn, growth, yield and yield components as well as grain quality characteristics and economic parameters than those obtained by gypsum as sulphate sulfur. Farook and Khan (2010) found that the best growth and yield performance were recorded by sulfidic materials SM45 treatment as compared to gypsum treatments as S sources regarding yield weight. The application of gypsum at the highest rate of G45 was not as effective as even the lowest dose of SM15 in both soils. Almost similar and significant effects were observed for the panicle length, number of tillers, plant height, 1000 grain weight, and harvest index of rice grown in both soils. The applied SM increased the average of organic matter and available sulfur contents in the soils by 46 to 78% and 194 to 208% increase over control respectively, while the increments were 5 to 19% and 132 to 145 % for gypsum treatments, indicating that the SM is potentially more effective than gypsum as a source of sulfur fertilizer and can also enrich the fertility and productivity of the soils. Moreover, the use of SM treatment did not show any harmful effect on the growth and yield parameters of rice.

Li *et al.* (2010) found that elemental sulfur significantly surpassed the sulfur (SO4-S) presented in calcium super phosphate resulted in the highest grain yield and its components. Chien *et al .* (2011) stated that ammonium sulfate is more effective than granulated elemental S (ES) or ES-enriched NP fertilizers to provide S nutrient because AS is water soluble, whereas ES requires S oxidation to SO_4-S which rice growth and yield were recorded the highest values under ammonium sulfate as a source for S and N nutrients.

The current study aimed to find out the efficiency of various sources of sulfur fertilizer involving sulfur and sulphate combined with urea fertilizer on EHR1 (hybrid rice one) productivity and behaviors under saline soil conditions. Also, It is mentioning that the study amid to answer the following question, is sulfur present in some main fertilizer is enough for hybrid rice growing under saline soil comparing to elemental sulfur application irrespective the rate?

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, to find out the response of Egyptian hybrid one (EHR1) rice variety to various sulfur sources combined with urea. The fertilizer treatments were control treatment without any fertilizer application, urea alone in the rate of 165 kg N ha^{-1} , urea + 24 kg Zn SO_4 ha^{-1}, urea + elemental sulfur (ES) applied as basal in the rate of 95 ES kg ha^{-1}, urea + calcium super phosphate (CSP) at the rate of 60 kg P_2O_5 ha^{-1} , urea + gypsum at the rate of 476 kg ha^{-1}, urea + potassium sulfate at the rate of 57 kg K_2O ha^{-1}, and ammonium sulphate alone at the rate of 165 kg N ha^{-1}. The experiment was laid out in a randomized complete block design, with four replications. Seedlings, 30 days old of EHR1 rice variety were transplanted with 3-4 seedlings $hill^{-1}$ at 20 x 20 cm, between hills and rows. Transplanting was done on April, 20th, and harvesting on September1st in both seasons. Nitrogen fertilizer was added as recommended under saline soil in three equal doses, 15 days after transplanting (DAT), maximum tillering and panicle initiation stages. Plot area was adjusted to 10 m^2. The soil was clayey and the soil chemical analysis is listed in Table (1).

Table 1. soil chemical analysis (0-30 cm soil depth) for 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	8.4	6.3	15.0	43.0	0.30	23.5	39.3	6.0
2011	8.3	6.0	14.0	41.0	0.29	20.0	36.0	5.0

Available nutrients mg kg^{-1}							
	N	P	K	Zn	S	Fe	Cu
2010	28.0	11.12	275.0	1.22	10.7	5.00	6.2
2011	26.0	12.35	287.0	1.16	10.5	5.13	6.0

Table 2. The S % of used sulfur sources in this study.

Fertilizer	S%	Others for main fertilizers
$(NH_4)_2SO_4$	24	N20.6%
K_2SO_4	18	K_2O 50%
$2H_2O.CaSO_4$	18	CaO 32%
$2CaSO_4.Ca(H_2PO_4)_2$	16	CaO20%,P2O5 15%
ZnSO4	18	Zn 48%
Elemental sulfur	98	-

These sources as previously mentioned were recommended under saline soil irrespective S rates. At heading stage, ten hills from each plot were taken to estimate leaf area 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). 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 plot were used to determine panicle length (cm), number of filled and unfilled grains panicle $^{-1}$, and panicle and 1000-grain weights. The plants of the six inner rows of each plot were harvested, dried, threshed, and then grain and straw yields were determined at 14 % moisture content and converted into t ha^{-1}. The economic evaluation was estimated based on grain yield increase over control due to tested treatments comparing to the price of tested fertilizer.

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

Data collected on rice growth indicated that leaf area index and dry matter (g /m^2) significantly affected by the tested treatments in both seasons (Table 3). Furthermore, the treatments involving any of sulfur sources otherwise sulphate or sulfur significantly exhibited higher growth parameters than those exerted by urea application alone. The highest values of LAI were produced by ammonium sulphate, as source for N and S in both seasons. The treatments of urea + elemental sulfur, urea+ CSP, Urea + gypsum and urea + K_2SO_4 came in the second rank, with the same level of significance in both seasons. While, urea plus zinc sulphate thirdly ranked as for leaf area index . The urea application without any sulfur source came in the fourth order among the fertilizer treatments. On the other hand, the control treatment gave the lowest values of leaf area index in both seasons (Table3). Regarding dry matter production, the same trend of leaf area index had been detected in both seasons (Table3). The highest values of dry matter were produced by the treatment of ammonium sulphate followed by urea+ gypsum without any significant differences between them. The lowest values of dry matter production were produced by control treatment without any fertilizer application. With respect to heading date, the longest period from sowing to heading was recorded by urea+ potassium sulphate while, the shortest period exerted by control treatment, because the double stresses of salinity and nutrient deficiency. Assimilated sulphur might have played vital role in growth and development of rice plants because of their active 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. Increase in dry matter production due to sulphur may be because of high rate in protein synthesis and enhanced photosynthetic activity of the plant with increased chlorophyll

synthesis (Naresh and Jangra, 2007). The results related to rice growth in this study are consonance with the findings Sreedevi *et al.* (2006) and Bhuvaneswari *et al.* (2007).

Table 3. Leaf area index(LAI), dry matter and heading date of EHR1 as affected by various sulfur sources during 2010 and 2011 seasons.

Traits / Treatments	LAI		Dry matter gm^{-2}		Heading date(days)	
	2010	2011	2010	2011	2010	2011
Control	4.65 e	4.7 e	619 e	725 e	92.3 b	92.3 d
Urea	5.8 d	5.9 d	842 d	874 d	94.8 a	95.9 ab
Urea+ Zn So4	6.27c	6.26 c	1096 b	1086 c	94.3 a	96.3 a
Urea+ ES	6.43 b	6.4 bc	970 c	1034 c	94.8 a	95.7 ab
Urea + CSP	6.49 b	6.4 bc	1098 b	1095 bc	95.3 a	95.6 abc
Urea + Gypsum	6.58 b	6.59 ab	1203 a	1215 a	94.3 a	95.8 ab
Urea + K_2 So4	6.67 a	6.54 b	1103 b	1159 ab	95.9 a	96.2 a
Ammonium sulphate	6.79 a	6.7 a	1225 a	1220 a	94.5 a	94.9 c
F test	**	**	**	**	*	**
LSD0.05	0.16	0.19	60.85	71.43	1.77	0.75

ES= elemental sulfur, CSP calcium super phosphate.

Regarding yield components, data listed in Tables (4, 5 and 6) showed that the estimated traits were significantly affected by various treatments in both seasons. Interestingly, the application of various sulfur sources, including elemental sulfur or sulfur combined fertilizer significantly improved all yield attributing characteristics over urea application alone in both seasons. The treatment of ammonium sulphate as sources for N and S gave the highest values of panicle number, panicle length, panicle weight , number of filled grains panicle^{-1} and 1000- grain weight while, it gave the lowest values of sterility% in both seasons. The treatments of ammonium sulphate, urea + CSP, urea+ ES, urea + gypsum and urea + potassium sulphate were at a par regarding the above mentioned characteristics. Zinc sulphate as source for sulfur is not so much efficient. Urea application alone is not recommend for high yield under saline soil for hybrid rice. The tallest plants under current experiment were recorded by urea +CSP without significant differences with those obtained by other treatments containing sulfur except, Zn SO4 as sulfur source in the first season. The lowest values of yield attributes of EHR1 were recorded by control treatment in both seasons, except, sterility% whereas, it gave the highest values of it.

Regarding rice grain yield, perusal data in Table 6 revealed that rice grain yield of EHR1 significantly differed under various treatments related to varying S sources and control treatments in both seasons. First, sulfur application, including all sources significantly surpassed the none sulfur application in the terms of urea application alone in both seasons of study indication the importance of sulfur application under saline soil(Shehata *et al.,* 2009 and Zayed *et al.,* 2010). The sources of sulfur significantly varied among them in their apparent positive effect on grain yield of EHR1 under current study (Table 6). Interestingly, ammonium sulphate as source for both of nitrogen and sulfur significantly gave the highest values of rice grain yield in both seasons. The treatments of ammonium sulphate, urea+ gypsum and urea+ potassium sulphate were a comparable regarding rice grain yield in both seasons. The rest of sulfur sources were at a par too. The zinc sulphate as sulfur source occupied the last order regarding its efficiency on grain yield of Egyptian hybrid one. The lowest values of rice grain yield were produced by control treatment while the urea application alone intermediated the control treatment and the sulfur sources treatments, as seen in Table 6. By the way, the ammonium sulphate treatment showed apparent significant and positive effect on rice growth and yield components resulted in higher grain yield of rice under current study.

Under present study, increase of yield and yield attributes was due to better assimilation of carbohydrates in panicle and it could be due to its stimulating effect in the synthesis of chloroplast protein resulting in greater photosynthetic efficiency which in turn resulted in increased yield (Biswas and Tewatia, 1992).

Furthermore, the beneficial effect of sulphur on rice yield was possible because of its vital role in synthesis of proteins and vitamins. Also, application of sulfur might be improved 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 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 high soluble nature of ammonium sulphate (AS) as sources of sulfur compared to others might have resulted in high amount of sulphur release during growth in the treatment receiving AS which, consisted of ammonium plus sulphate. Gypsum came in the second rank regarding the order of the superiority of studied sulfur sources because Ca^{++} and S which contributed in saline soil reclamation and reduced Na content in rice leaf resulted in raising rice salinity withstanding and improving rice yield in spite of its low solubility . Potassium sulphate, as sulfur source, had both K and sulphate which, in turn reducing Na accumulation in rice leaf, improve rice growth resulted in high yield under saline soil. At the time, single super phosphate had P, Ca and sulfur which can contribute in saline soil proprieties improving and rice growth and ultimately rice yield. Regarding the elemental sulfur didn't rank advance order for beneficial effect of different sulfur source as compared to the above-mentioned sulfur sources that might be the energy needed to convert it from S to SO_4 as uptake form by plant. The sulfur in the ZnSO4 seems to be not enough for rice growing under current study.

Results of this investigation on efficiency of varying sulphur sources are in consonance with the findings of Sreedevi *et al.* (2006) and Bhuvaneswari *et al.* (2007), Khan *et al.* (2007), Li *et al.*(2010) and Chien *et al*. (2011).

Table 4. Number of panicle hill-1, plant height and panicle length of HER as affected by various sulfur sources during 2010 and 2011 seasons.

Traits / Treatments	No of panicle		Plant height (cm)		Panicle length(cm)	
	2010	2011	2010	2011	2010	2011
Control	16.63 d	15.9 d	91.9 d	91.7 d	18.0 c	18.5 c
Urea	18.8 c	18.7 c	102.4c	103.7 c	19.0b	20.8 b
Urea+ Zn So4	20.1 b	19.9 b	105.3 b	107.9 ab	19.9 a	21.7 ab
Urea+ ES	20.8a b	20.2 ab	105.9 ab	106.5 ab	19.6 a	21.9 ab
Urea + CSP	20.9 ab	20.5 ab	108.3 a	108.8 a	19.3 ab	21.5 ab
Urea + Gypsum	21.6 a	21.0 a	106.1 ab	107.9 ab	20.1 a	22.1 a
Urea + K2 So4	21.06 a	20.9 a	106.2 ab	105.7 b	19.9 ab	22.2 a
Ammonium sulphate	21.70 a	21.30 a	106.5 ab	107.4 ab	20.3a	22.5 a
F test	**	**	**	**	*	**
LSD0.05	1.38	1.09	2.48	3.08	0.7	0.99

ES= elemental sulfur, CSP = calcium super phosphate

Table 5 . Panicle weight, 1000-grain weight and number of filled grain grains panicle-1 of EHR1 as affected by various S sources during 2010 and 2011 seasons.

Traits / Treatments	Panicle weight g		1000-grain weight g		No of filled grains	
	2010	2011	2010	2011	2010	2011
Control	2.10 c	2.34 c	18.4 b	19.2 d	130.9 c	133.0 c
Urea	2.85 b	3.00 b	20.4 a	20.2 c	139.5 b	142.1 b
Urea+ Zn So4	3.02 b	3.15 b	20.9 a	21.3 b	154.7 a	158.4 a
Urea+ ES	3.19 ab	3.26ab	19.7 ab	21.3 b	150.6 a	158.3 a
Urea + CSP	3.48 a	3.32 ab	20.7 a	21.3 b	153.9 a	156.8 a
Urea + Gypsum	3.50a	3.68 a	21.0 a	22.4 a	154.3 a	160.9 a
Urea + K2 So4	3.49 a	3.53 ab	19.5 ab	22.4 a	152.8 a	160.8 a
Ammonium sulphate	3.61 a	3.69 a	21.2 a	22.5 a	156.8 a	161.2 a
F test	*	*	*	**	**	**
LSD0.05	0.44	0.43	1.37	0.72	6.00	4.86

ES= elemental sulfur, CSP= Calcium super phosphate

As for effect of various sulfur sources on leaf nutrients content at heading, the data documented in Tables 6 , 7 and 8 clarified that the nutrients leaf content was significantly affected by the current treatments in both seasons. Irrespective control treatment, the treatments including sulfur sources otherwise sulfur combined fertilizer or elemental sulfur significantly increased nutrients leaf content (NPK Zn and Fe) as compared to urea application alone in both seasons. On the other hand, all treatments significantly reduced Na leaf content rather than obtained by control treatment that might contribute in enhancing rice salinity tolerance. It is worthy to mention that the sources containing Zn or P restricted the leaf content of each other. Ammonium sulphate gave the highest values of N and Fe in both seasons at par with other treatment except urea alone and control treatments while, the lowest values of them were produced by control treatment and irrespective control one, urea application alone gave the lowest values of them comparing to other treatment containing sulfur (Table7).Urea + calcium super phosphate gave the maximum mean of P% of rice leaf in both seasons without significant difference with the rest of treatments except urea+ $ZnSO_4$ .On the other hand, the minimum value of P%, in rice leaf at heading stage were produced by control treatment followed by urea + $ZnSO_4$ (Table7). Interestingly, the highest values of K% in rice leaf were produced by the treatment of urea + potassium sulphate without any significant difference with those obtained by urea+ gypsum and ammonium sulphate as well as urea+ CSP, while, the lowest values of it were recorded when rice plants didn't receive any kind of fertilizer. The lowest values of Na^+, in rice leaf at heading were produced by urea+ gypsum followed by the treatment of urea + potassium sulphate which obviously reduced sodium uptake by rice plants growing under saline soil resulted in proper rice growth and yield under such condition. The highest values of Na^+ in rice leaf were produced by control treatment. Regarding to Zn leaf content, the treatment of urea + zinc sulphate produced the highest values of zinc, in rice leaf, without any significant differences with those produced by ammonium sulphate and urea plus ES. As nitrogen and sulphur are constituents of protein and involved in chlorophyll formation, there is a direct link between nitrogen and sulphur. Phosphorus exhibited a synergistic effect with sulphur application, which enhanced better utilization of nutrients. Also, the application various sources of sulfur might be improved the soil proprieties resulted in increasing nutrients availability and subsequently, nutrients leaf content. Gypsum and potassium significantly reduced Na leaf content because the antagonism between Ca^{++} and K^+ from side and Na^+ from other side. The current finding is in conformity with those reported by Naw *et al.* (2007), Amaraweera (2009) and Zayed *et al.* (2010).

Table 6. Sterility (%) , grain yield t ha-1 and N (%) of EHR1 as affected byvarious S sources during 2010 and 2011 seasons.

Traits / Treatments	Sterility		Grain yield (t/ha)		N %	
	2010	2011	2010	2011	2010	2011
Control	15.8 a	18.8 a	4.62e	4.70d	2.49 d	2.08 f
Urea	9.55 b	12.1 b	6.40d	6.22c	3.34 c	2.83 e
Urea+ Zn So4	6.0 c	5.1 cd	6.98b	7.00b	3.54 b	2.93 de
Urea+ ES	4.7 cd	6.3 c	7.32b	7.26b	3.67 a	3.19 bc
Urea + CSP	4.9 cd	7.4 c	7.30b	7.40b	3.46 b	3.39 ab
Urea + Gypsum	5.2 cd	6.3 c	7.70ab	8.28a	3.65 a	3.54 a
Urea + K2 So4	4.5 cd	4.3 cd	7.67ab	7.76b	3.56 b	3.12 cd
Ammonium sulphate	3.3 d	3.8 d	7.96a	8.36a	3.59 a	3.64 a
F test	**	**	**	**	**	**
LSD0.05	2.28	2.20	0.46	0.63	0.10	0.20

ES= elemental sulfur, CSP= calcium super phosphate

Table 7. P % , K+ and Na+ of EHR1 rice leaves as affected by various S sources

Traits / Treatments	P %		K ppm		Na ppm	
	2010	2011	2010	2011	2010	2011
Control	0.217 c	0.201 c	856 d	902 d	2197 a	2218 a
Urea	0.267 ab	0.277 a	996 c	1081 bc	1429 b	1361 b
Urea+ Zn So4	0.251 b	0.250 b	1010 c	1141 abc	1316 bc	1301 bc
Urea+ ES	0.258 ab	0.282 a	1128 b	1158 abc	1106 c	1069 d
Urea + CSP	0.295 a	0.299 a	1120 b	1092 bc	1125 c	1284 bcd
Urea + Gypsum	0.275 ab	0.289 a	1235 a	1186 a	760 d	1110 cd
Urea + K2 So4	0.287 a	0.292 a	1243 a	1192 a	1174 c	1128 cd
Ammonium sulphate	0.289 a	0.290 a	1079 b	1156 abc	1219 bc	1145 bcd
F test	**	*	**	*	**	**
LSD0.05	0.033	0.032	45.5	93.0	232	221

during 2010 and 2011 seasonsES= elemental sulfur, CSP= calcium super phosphate

Table 8. Zn and Fe of EHR1 rice leaves as affected by various S sources during 2010 and 2011 seasons.

Traits / Treatments	Zn ppm		Fe ppm	
	2010	2011	2010	2011
Control	2.84 c	3.15 d	252 c	254 c
Urea	5.93 a	6.0 b	355 ab	339 ab
Urea+ Zn So4	6.66 a	6.9 a	3o8 ab	345 ab
Urea+ ES	5.28 ab	6.9 a	367 ab	374 a
Urea + CSP	4.98b	5.2 c	384 a	376 a
Urea + Gypsum	5.13 b	5.8 b	263a b	364a b
Urea + K2 So4	6.13 a	6.2 b	357 ab	352 ab
Ammonium sulphate	6.25 a	6.5 a	389 a	381 a
F test	*	**	*	**
LSD0.05	0.9	0.6	80.6	81.7

ES= elemental sulfur, CSP= calcium super phosphate

Regarding economic evaluation, data in Tables 9 and 10 indicate that the treatment of ammonium sulphate gave the highest values of yield increase over control in kg ha^{-1} and in LE ha^{-1} followed by urea+ gypsum treatment in both seasons while the highest cost of fertilizer was recorded by ammonium sulphate treatment followed by urea+ gypsum treatment. Also, the previous mentioned gave the highest values of net return in both seasons as in table 10. Regarding the value of cost ratio, the treatment of urea+ gypsum gave the maximum values of value cost ratio followed by urea+ CSP followed by the treatment of ammonium sulphate. The urea application alone gave the lowest values of the estimated economic parameter under current study. From going discussion it could be concluded that the ammonium sulphate could be recommended under saline soil as sources for N and S. Interestingly, urea + Gypsum came in the second order in this concern. Amaraweera (2009) found similar findings of current results of economic evaluation

Table 9. Yield increase over control kg ha-1, yield increase over control (profitability)LE ha-1 and cost of fertilizer LE ha-1of EHR1 as affected by various S sources during 2010 and 2011 seasons.

Traits / Treatments	Yield increase over control kg ha^{-1}		profitability LE ha^{-1}		Cost of fertilizer LE ha^{-1}	
	2010	2011	2010	2011	2010	2011
Control	-	-				
Urea	1.78	1.60	3560	3200	785	785
Urea+ Zn So4	2.36	2.46	4720	4920	881	881
Urea+ Es	2.70	2.64	5400	5280	1023	1023
Urea + CSP	2.68	2.78	5360	5560	1105	1105
Urea + Gypsum	3.08	3.66	6160	7320	975	975
Urea + K2 So4	2.98	3.14	5960	6280	1380	1380
Ammonium sulphate	3.34	3.74	6680	7480	1142	1142

ES= elemental sulfur, CSP= calcium super phosphate, Average price of paddy rice= 2000 LE/ton,

Table 10. Value cost ratio and net return LE ha-1of EHR1 as affected by various S sources during 2010 and 2011 seasons.

Traits / Treatments	Value cost ratio		net return LE ha^{-1}	
	2010	2011	2010	2011
Control	-	-	-	-
Urea	4.5	4.10	2775	2415
Urea+ Zn So4	5.35	5.58	3839	4039
Urea+ ES	5.30	5.20	4377	4257
Urea + CSP	4.90	5.03	4255	4455
Urea + Gypsum	6.30	7.50	5185	6345
Urea + K2 So4	4.30	4.60	4580	4900
Ammonium sulphate	5.9	6.6	5538	6338

The price of urea fertilizer was as average in black market and governmental price. 4LE/ Kg $ZnSO_4$, 2.5LE /kg ES, 40LE/ 50 kg CSP, 0.4LE / kg gypsium250 LE / 50 kgK2O, 80LE/ 50kg AS

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كفاءة مصادر مختلفة من الأسمدة الكبريتية في زيادة انتاجية الأرز الهجين تحت ظروف الأراضي الملحية

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أقيمت تجربتان حقليتان في موسمي ٢٠١٠، ٢٠١١ بالمزرعه البحثيه لمحطة بحوث السرو الزراعيه بدمياط وذلك بتربه طينيه.وصممت المعاملات لدرسة استجابه صنف الأرز الهجين مصري واحد لمصادر مختلفة من الأسمدة الكبريتية ، وكانت المعاملات كالآتي: المعاملة القياسية بدون اضافة أي سماد، إضافة اليوريا فقط بمعدل١٦٥ كجم نتروجين / هكتار، يوريا+ كبريتات زنك(٢٤ كجم كبريتات زنك/هكتار)، يوريا +كبريت معدني (٩٥ كحم /هكتار)، يوريا+ سوبر فوسفات الأحادي(٦٠ كجم فو٢ا٥ /هكتار)، يوريا + جبس زراعي (٤٧٦ كجم /هكتار)، يوريا+ كبريتات بوتاسيوم(٢٤ كجم / فدان) وسلفات الأمونويوم (بمعدل النتروجين المشار الية في معاملة اليوريا فقط). و كان مستوي الملوحة في السنتين كالأتي ٦،٣ و ٦،٠ ديسيسمنز / م في كلا موسمي الدارسة علي الترتيب. أقيمت التجربة في تصميم القطاعات الكاملة العشوائية في اربعة مكررات . وكان الهدف من الدراسة هو الإجابة علي السؤال التالي هل الكبريت الموجود في بعض الأسمدة الرئيسية يغني النبات عن اضافة السماد المعدني. وتم تقدير محتوي النبات من بعض العناصر عند مرحلة طرد السنابل و كذلك بعض صفات النمو . كما تم تقدير المحصول و مكوناتة و كذلك التقييم الأقتصادي علي اساس الزيادة في المحصول عن المعاملة القياسية مقارنة بتكلفة السماد المضاف.

و كانت أهم النتائج المتحصل عليها كالأتي: أثرت المعاملات تحت الدراسة معنويا علي جميع الصفات المدروسة. وكان هناك تأثير ايجابي و معنوي للمعاملات المحتوية علي الكبريت سواء كان في صورة كبريت(كبريت معدني) او كبريتات الموجود في بعض الأسمدة الرئيسية الأخرى المقيمة في هذة التجربة حيث كان التاثير بالزيادة عما هو متحصل عليه من إضافة اليوريا فقط بغض النظر عن المعاملة الكنترول. في جميع الصفات المدروسة سواء كانت محتوي بعض العناصر و صفات النمو او المحصول و مكوناتة و كذلك التقييم الأقتصادي . لوحظ ان الأسمدة المحتوية علي زنك أو فوسفور أثرت على محتوي الورقة منهما .كما وجد أن إضافة سلفات الأمونيوم كمصدر لكل من النتروجين و الكبريت اعطت اعلي نمو (دليل مساحة الورقة و المادة الجافة) و كذلك المحصول و مكوناتة والنتروجين و الفسفور و وتلها معاملة اليوريا + الجبس ثم اليوريا + البوتاسيوم او سوبر فوسفات الأحادي وكان اقلهم في الكفاءة عندما استخدمت كبريتات الزنك كمصدر للكبريت. اعطت المعاملة يوريا+ سوبر فوسفات اعلي محتوي من الفسفور بينما المعاملة المحتوية علي كبريتات الزنك سجلت اعلي محتوي من الزنك وعلي الجانب الأخر اعطت المعاملة المحتوية علي جبس اقل محتوي من الصوديوم ثم المعاملة المحتوية علي كبريتات بوتاسيوم ثم معاملة السوبر. كما بين التقييم الأقتصادي افضلية معاملة سلفات الأمونيوم و الجبس + يوريا.