J. Plant Production, Mansoura Univ., Vol. 8(11): 1085 - 1092, 2017

Response of Egyptian Hybrid Rice One Cultivar to Zinc Sulphate, Potassium Sulphate and Magnesium Silicate as Foliar Application.

Mariam T. Wissa
Rice Research Department (RRD), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC) , Sakha, Kafr El-Sheikh ,Egypt.

ABSTRACT

The two field experiments were conducted during 2015 and 2016 seasons at the Experimental Farm of Rice Research Department (RRD), Sakha, Kafrelsheikh, Egypt. In order to examine the response of Egyptian hybrid rice one cultivar to foliar application of zinc sulphate, potassium sulphate and magnesium silicate. A randomized complete block design (R.C.B.D.) with four replications was used in the two seasons. The used treatments of foliar applications of zinc sulphate, potassium sulphate and magnesium silicate were used as follows: (T_1), control (without any application of the three tested compounds); (T_2), Zinc sulphate; (T_3), potassium sulphate; (T_4), magnesium silicate; (T_5), Zinc sulphate + potassium sulphate; (T_6),Zinc sulphate + magnesium silicate; (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate. The foliar applications treatments were applied twice with the same concentration 2% at 15 and 30 days after transplanting. The studied characters were; plant height (cm), leaf area index, dry matter accumulation (g/m^2), chlorophyll content in flag leaf (SPAD-Value), number of tillers per m^2, number of panicles per m^2, number of grains per panicle, panicle weight (g), filled grain percentage, thousand grain weight, grain yield(ton/ha) and hulling, milling, head rice and milled grain protein percentages. The results showed that combined foliar application of the three tested compounds caused an increased in the previous studied growth characters, yield, yield attributes and grain quality of the Egyptian hybrid rice one cultivar. While, control treatment (without spraying) resulted maximum thousand grain weight (g) without significant differences between control and combined application of the three tested compounds in this criteria. All the other parameters showed overlapping results of different foliar application treatments. According to the previous results, it could be concluded and that: Using foliar application of zinc sulphate, potassium sulphate and magnesium silicate twice with the same concentration 2.0% at (15 and 30 days after transplanting) was the best treatment for obtaining the greatest grain yield besides improving growth and the grain quality of Egyptian hybrid rice one cultivar. Using of the previous fertilizer compounds as foliar spray saved about more than two thirds from the amount of zinc sulphate and potassium sulphate if applied as basal application which is a result to application of magnesium silicate which caused integration with zinc sulphate and potassium sulphate.

Keywords: Zinc sulphate, potassium sulphate, magnesium silicate, Silicon, Foliar application, Hybrid rice, growth, yield, grain quality and nutrients contents.

INTRODUCTION

Rice is the main foodstuff for more than 90% of the Egyptian population. Rice considered one of the most important cereal crops of the world and the oldest cultivated crops in the earth which grown in a wide range of climatic zones. Improving rice grain yield per unit land area is the only way to achieve the increase of rice production because of the reduction in area devoted to rice production. It must be developed the rice varieties with higher yield potential to enhance the average farm yields of irrigated rice to increase the world's total rice production. Hybrid rice is an important step towards augmentation and maximizing rice grain yield. Hybrid rice cultivar is the product from a cross between two genetically distinct rice parents, so when the parents are selected right, the hybrid will have both greater seedling vigor and grain yield than either of the parents (Xie *et al.,* 2007). Consequently, hybrid rice cultivar is considered the only way to improve and maximize rice grain yield by exploiting the heterosis in the F_1 hybrid rice cultivars (Abo Youssef *et al.,* 2005). Integrated nutrients management (INM) for hybrid rice cultivar is the most common approach to maximize grain yield production (Bhowmick and Nayak, 2000). Zinc as a micronutrient is essential element for all plants especially rice plants and being absorbed in the form of Zn^2 ions. Zinc play co active (co catalytic), catalytic and structural roles in a large number of enzymes and it is involved in the catabolism and biosynthesis of proteins, nucleic acids, carbohydrates and lipids these results reported by Marschner (1996) and Pedas *et al.* (2009). The deficiency of the zinc decreased the levels of flowering and seed development, reduced amount of protein and decreased the number of starch grains, (Singh *et al.,* 2005). Zinc is indispensable for the stability and integrity of plasma membranes consequently protects proteins and membrane lipids against oxidative damage (Zhao *et al.,* 2005). Consequently zinc application to plants may have a vital role in nutrient uptake and homeostasis. More than half of the agricultural soils in the world are under zinc deficiency (Cakmak, 2002). Also, zinc malnutrition is one of the most common mineral disorders in cereal crops (Cakmak *et al.,* 1999). Excess zinc may have negative consequential effects on plant growth as it may result in deficiency of other nutrients such as magnesium, iron and phosphorus. Increased oxidative stress after plant exposure to excess zinc has been reported by several investigators (Sharma *et al.,* 1986 and Wang *et al.,* 2009). Rice grain is the most important dietary source of many minerals like zinc. In addition to yield reduction, zinc deficiency may decrease rice grain quality due to low zinc content in the grains. Zinc deficiency is a widespread problem in rice production under waterlogged conditions which caused a yield reduction and decreased quality of the rice grains (Impa *et al.,* 2013). Potassium is linked with all phenomena of plant photosynthesis, respiration, metabolism of fats, carbohydrates and nitrogenous compounds, enzyme activation, cell elongation and water efficiency, so it is considered the key element in hybrid rice nutrition for improving root growth and plant vigor, helping prevent lodging and enhancing rice resistance to pests and diseases (Krishnakumar *et al.,* 2005). Using of potassium nutrition, with hybrid rice behaving physiological advantage in nutrient uptake and use efficiency than inbred rice to achieve higher grain yield potential (Liu and Liu, 1997 and Hu and Wang, 2003 and 2004). Hybrid rice produce 15-20% yield over inbred cultivars (Tu *et al.,* 2000 and Yuan, 2004). Hybrid rice cultivars needs more potassium due to a well-developed root system and vigorous growth than do the ordinary rice varieties (Xu and Bao, 1995). Potassium is a macronutrient which involved in many plant processes critical for optimum growth, yield and quality of crops. Potassium plays a number of indispensable roles in a wide range of functions: photosynthesis, translocation assimilates, enzyme activation, osmotic potential, protein synthesis and as a counter ion to inorganic ions and organic biopolymers. The application of potassium sulphate as foliar results in fast potassium absorption and has advantage of quickly correcting deficiencies. Potassium is involved in sugar translocation (assimilates) and is an important counter-anion for nitrate transport in the xylem. The transport rate of solutes in the phloem depends on the plant potassium concentration (Marschner, 1996). Silicate nutrition considered as an agronomically essential element for increasing and sustaining rice production (Takahashi and Miyake, 1977 and Yoshida, 1981). Magnesium silicate improves the membrane functioning of the plant cell and integrity consequently increases the uptake and transportation of the nutrients (Neumann and Nieden, 2001 and Gong *et al.,* 2006). Use silicon as foliar application to rice leads to its normal growth. The resistance to lodging and erectness of leaves improved by magnesium silicate application and allows better light transmittance through plant canopies and consequently improves whole plant photosynthesis, thus, increased markedly rice grain yield (Tamai and Ma, 2008). Magnesium silicate mitigates Zn toxicity in rice (Song *et al.,* 2011 and Gu *et al.,* 2012). Accordingly, this study was carried out to obtain the response of Egyptian hybrid rice one cultivar to zinc sulphate, potassium sulphate and magnesium silicate as foliar application on growth, yield and grains quality.

MATERIALS AND METHODS

The field experiments were conducted at the Experimental Farm of Rice Research Department (RRD), Sakha, Kafrelsheikh, Egypt during 2015 and 2016 rice seasons. The main objective of this investigation was aimed to study the response of Egyptian hybrid rice one cultivar to foliar application of zinc sulphate, potassium sulphate and magnesium silicate. Barley was the previous crop during the both seasons of the study. The soil samples representative were taken from the experimental site at the depth of 0 to 30 cm from the soil surface and both of some chemical and physical analyses were done. To procedure the soil analysis followed the methods described by (Black *et al.,* 1965). Soil chemical and physical analysis of the experimental site during 2015 and 2016 seasons showed that Soil texture was clayey with Clay % 57.00 and 54.00, Sand % 11.00 and 11.00, Silt % 32.00 and 35.00, pH (1: 2.5 water suspension) 8.05 and 8.2, EC (dS/m) 2.0 and 2.05, Organic matter 1.65 and 1.50, Available Phosphorus mg / Kg 14.00 and 12.00, Available NH_4 mg/ Kg 13.5 and 12.60, Available NO_3 mg /Kg 10.0 and 11.80, Available K mg /Kg 366 and 350, Cations (meq/L.); Ca^{++} 7.20 and 6.00, Mg^{++} 2.60 and 1.50, Na^{+} 12.00 and 13.00, K^{+} 0.50 and 0.50, Anions (meq /L.); $HCO3^{-}$ 5.60 and 5.00, Cl^{-} 14.00 and 14.00, $SO4^{--}$ 2.70 and 2.00, $CO3^{--}$0.00 and 0.00 , Available micronutrients mg kg^{-1} ; Fe^{++} 6.2 and 6.0, Zn^{++} 1.1 and 0.9, and Mn^{++} 3.6 and 3.5 respectively.

The experimental design:

The experimental design was randomized complete block design (R.C.B.D) with four replications. The assigned eight foliar application treatments i.e., Zinc as {zinc sulphate (22% Zn) } , potassium as {potassium sulphate (48% K_2O)} and silicate as {magnesium silicate (25% Sio_2)} used in this study were arranged as follows: (T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate, (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate . The foliar application of the nutrients with the same concentration at the rate of 2% applied twice at 15 and 30 days after transplanting.

Nursery and preparation:

The nursery area was identified, ploughed and well dry leveled then, 4 kg calcium super phosphate (15.5% P_2O_5/175 m^2 land area) before ploughing, 3 kg urea (46.5% N/175 m^2 land area) was added after ploughing. The seeds of hybrid rice, at the rate of 24 kg ha^{-1}, were soaked in fresh water for 24 hrs. and incubated for another 48 hrs. to hasten early germination. Pre-germinated seeds were broadcasted in the nursery with 2 to 3 cm water depth on May 19th in 2015 and 2016 seasons. Weeds were chemically controlled in nursery land using Saturn 50% at the rate of 5 liters/ha (85 cm^3 / 175 m^2 land area) mixed with enough sand to make it easy for homogenous distribution and it was applied at seven days after sowing into 3 cm water depth. The other cultural practices were applied as recommended for the nursery.

The permanent field

The experimental site was identified and prepared by plowing twice and harrowing then, well dry leveling was done and wet light leveling was carefully made. Each plot of the experimental site was fertilized by 36 kg P_2O_5 per ha in the form of calcium super phosphate (15.5% P_2O_5) during the preparation of the soil. Nitrogen fertilizer was added according to the recommendation as urea form (46.5% N) at the rate of 165 kg N/ha as recommended in two split doses (2/3 as basal, 1/3 top dressing at 30 days after transplanting). Seedling were pulled and transferred at twenty five days old to the permanent field then, transplanted regularly at 20*20 cm distances between hills and rows(25hills m^{-2}). Two seedlings per hill in all plots were transplanted in both studied seasons. The plot size was 12 m^2 (3 × 4). Weeds were chemically controlled using Saturn 50% at the rate of 5 L/ ha. It was mixed with enough sand to make it easy for homogenous distribution. It was applied four days after transplanting into 3 cm water depth and kept without either flushing or irrigation until all the water in the field reach to the saturation to increase the efficiency of the herbicide to control weeds. The other usual cultural practices for Egyptian hybrid rice one cultivation were conducted in growing rice fields as the recommendation of Rice Research and Training Center (R. R.D., 2010).

Studied characters:

Growth characters were; Leaf area index (LAI), Dry matter accumulation (g per m^2):at booting period, Plant height (cm) at 5 days before harvest, Chlorophyll content of flag leaf (SPAD- value) at booting period and No. of tillers per m^2 at 5 days before harvest Yield and its attributes: No. of panicles per m^2 at 5 days before harvest, No. of grains per panicle, Panicle weight (g), Filled grains percentage, Thousand grain weight (g) and Grain yield (t/ha).

Grain quality characters: Hulling, milling and head rice percentage were estimated according to the methods reported by Adair (1952) and Grain protein percentage in milled grains was determined according to standard Kjeldahl method, then, crude protein was calculated by multiplying nitrogen percent by a factor of 5.95.

Statistical analysis:

The data were subjected to analyses of variance which described by Gomez K. and A. Gomez (1984) and all statistical analysis was performed by using “MSTATC” computer software package according to Russell F. (1986). The treatment means were compared by using Duncan’s Multiple Range Test which described by Duncan D. (1955).

RESULTS AND DISCUSSION

A-Growth characters:

Means of leaf area index, dry matter accumulation (g/m^2) at booting period and plant height (cm) at 5 days before harvest of Egyptian hybrid rice one cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate in 2015 and 2016 are presented in Table 1. Data demonstrated that sprayed each of the used fertilizers caused an increase in leaf area index, dry matter accumulation and plant height as compared with the control treatment which didn’t receive any of the tested compounds. The greatest values of the previously studied growth characters were obtained from the three tested compounds combined and sprayed together (T_8 treatment), followed by the combination between zinc sulphate and magnesium silicate (T_6 treatment) in the two studied seasons, respectively. While the lowest values of the three previously mentioned growth characters were observed with control (T_1 treatment). This increase may be due to the favorable effect of zinc on cell division and elongation of internodes and the role of Zn as a co-factor in the enzymatic reactions of the anabolic pathways which led to increase the uptake of nutrients as well as the improving the activation of various types of enzymes, such as those required for the CO_2 assimilation pathway and chlorophyll synthesis. These results reported by, Mawardi et al. (1980) and Sakal and Singh (1983). The superiority of the potassium when applied as foliar spray could mainly be due to its role for increase the potassium supply viability of rice leaves and delayed leaf senescence specially flag leaf as the result of the increase in both protein and chlorophyll synthesis with the reduction in abcisic acid (ABA), also, potassium improve the activity of the enzymes related to biosynthesis of auxinex and growth substances in plants which improve the plant growth consequently the increase in photosynthesis and its products (assimilates) resulted in increased the dry matter accumulation (Randall *et al.,* 2003). Magnesium silicate improves the architecture of rice plants by increasing the light penetration through the leaves of the plants, which generates an increase of both leaf area index and photosynthetic rate. The increases of photosynthetic rate causes an increase in NADP, NADPH reducing power, and consequently higher nitrogen assimilation capacity and more dry matter accumulation (Taiz and Zeiger, 2010). Interesting silica had favorable effect on rice growth, since it improve photosynthesis, reducing respiration and increased cell division and elongation turn in good canopy resulted in high LAI. Similar findings had been reported by Singh and Singh (2006) and Singh *et al.* (2006).

Table 1. Leaf area index, dry matter accumulation g/m^2 at booting period and Plant height (cm) at 5 days before harvest of Egyptian hybrid rice 1 cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate treatments in 2015 and 2016 seasons.

Character	LAI		Dry matter(g / m^2)		Plant height(cm)	
Treatments	2015	2016	2015	2016	2015	2016
T_1	5. 792 c	5.809 c	889.96 h	895.19 h	107.12 h	107.67 h
T_2	6.985 bc	6.992 bc	907.21 g	911.18 g	108.76 g	109.19 g
T_3	7.087abc	7.097 abc	924.28 f	929.73 f	110.26 f	110.98 f
T_4	7.252abc	7.261 abc	941.94 e	944.19 e	111.56 e	112.07 e
T_5	7.350abc	7.357 abc	953.89 d	957.23 d	112.69 d	113.42 d
T_6	7.739 a	7.750 a	982.99 b	986.79 b	114.97 b	115.89 b
T_7	7.557 ab	7.562 ab	967.51 c	971.49 c	113.59 c	114.01 c
T_8	7.829 a	7.843 a	1000.39 a	1003.87 a	115.92 a	117.00 a

(T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate , (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate

Chlorophyll content (SPAD-value) and number of tillers /m^2 of Egyptian hybrid rice 1 cultivar as influenced by zinc sulphate, potassium sulphate and magnesium silicate applied as foliar spray in 2015 and 2016 seasons are presented in table 2. Data revealed that the application of the previous compounds as either single or combinations caused a significant increase in both chlorophyll content and number of tillers/m^2 as compared with control (T_1 treatment). The highest values of the previously mentioned characters were found when the three tested compounds were combined together and applied to the tested cultivar as foliar spray, followed by (T_6 treatment) which had zinc sulphate and magnesium silicate. On the other hand the lowest values of both chlorophyll content and number of tillers/m^2 were observed under control treatment. These results were hold true in the two studied seasons. This increase might be due to the favorable effect of zinc on tillers stimulation in tillering stage. Application of potassium resulted in increasing leaf K content, which considered co-activator of enzymes related to chlorophyll biosynthesis formation process present in chloroplasts and photosynthetic reactions (Pan *et al.,* 2004 and Taiz and Zeiger, 2010). The application of magnesium silicate resulted in a smaller opening of the leaf angle of rice plants. This effect madeing the plant leaves more erect and reduced the self-shading of lower leaves of the canopy (Deren *et al.,* 1994), which made the plants more photosynthetically efficient and better able to exploit the space available to intercept solar radiation and also increasing their leaves and viability longevity . Improving rice growth as a result of magnesium silicate application that might be attributed to enhancing early growth, increasing nutrient availability and uptake and improving of cell nodes and bud division, turn in more developing tillers. The results are in agreement with those reported by Ali *et al.* (2012) and Ahmad *et al.* (2013).

Table 2. Chlorophyll content (SPAD-value) in flag leaf at booting period and number of tillers/m^2 at 5 days before harvest of Egyptian hybrid rice 1 cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate treatments in 2015 and 2016 seasons.

Character	Chlorophyll content Spad-value		number of tillers/m^2	
Treatments	2015	2016	2015	2016
T_1	39.92 f	39.98 f	511.98 h	519.11 h
T_2	40.46 ef	40.58 ef	527.71 g	530.74 g
T_3	40.86 de	40.99 de	540.32 f	541.97 f
T_4	41.08 de	41.17 de	551.28 e	549.99 e
T_5	41.47 cd	41.50 cd	560.42 d	563.82 d
T_6	42.29 b	42.37 b	583 19 b	589.26 b
T_7	41.93 bc	41.98 bc	571.13 c	577.61 c
T_8	43.57 a	43.68 a	596.54 a	600.81 a

(T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate , (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate

B- Yield and its attributes:

Data associated with number of panicles/m^2, number of grains/panicle and panicle weights (g) of Egyptian hybrid rice cultivar as influenced by foliar application of zinc sulphate, potassium sulphate and magnesium silicate in the studied seasons are listed in Table 3. In the two seasons the application of each of the tested fertilizers or their combinations caused a significant increase in number of panicles/m^2, number of grains per panicle and panicle weight as compared with control treatment. The lowest values of these characters were found when the tested cultivar didn't receive any of the fertilizer treatments (control). The greatest values of the three previously mentioned characters were recorded when the tested rice cultivar sprayed by the combination of the three fertilizer compounds together, followed by treatment which received zinc sulphate plus magnesium silicate. Under severe zinc deficiency, tillering decreases and may stop completely. So, zinc application increase number of panicles per m^2 especially productive tillers and the weight of panicle as a result of number of grains per panicle and filled grains percentage. The effect of zinc on these characters might be due to the increase in metabolites translated from source to sink. These results are in hold true with those reported by Das (1986), Dutta *et al.* (1987) and Abdel-Whab *et al.* (1992). The superiority of potassium application could mainly be due to their capability on produce more effective tillers (number of panicles) as a result to enhancement the nods and buds to emerge early tillers that mostly productive tillers or number of panicles and the buds emerge leaves. The increase in both productive tillers and leaves led to increase the canopy of the tested rice cultivar consequently increase the photosynthesis and its products. In this case potassium as a cofactors in most of the transferring enzymes cause improving in the activity of these enzymes consequently increase in the translocation of metabolites from source (especially flag leaf) to the sink (panicles and spikelets) that increase the filling rate and percentage resulted in increase the weight of panicles and number of filled grains. Such results were observed by Ebaid and Ghanem (2001) and Omer (2002). Adding magnesium silicate as foliar sprays ensures and promotes panicle differentiation and primordia formation resulted high panicles number. The favorable impact of magnesium silicate application might be attributed to increase leaf water potential, bioavailability of nutrient, increasing antioxidant, elevated growth hormones and regulators, reducing transpiration rate, increasing photosynthesis rate, improving cell membrane stability, increasing energy compound and encourage cell division and elongation. Furthermore, silica contractors the abundant of ABA release which inhibited panicle exertion by reducing panicle peduncle elongation and division. Applying silica might increase IAA and GA3 formation that reduce ABA formation. The current findings are in a good agreement with those reported by Arab *et al.* (2011) and Dastan *et al.* (2011). Application of magnesium silicate improved photosynthesis, fasten and proper zed assimilates production and translocation, optimizing current photosynthesis and maximizing catabolism against anabolism. The current findings are in a good agreement with those reported by Singh and Singh (2006) and Singh *et al.,* (2006).

Table 3: Number of panicles/m², number of grains/panicle and panicle weight (g) of Egyptian hybrid rice 1 cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate treatments in 2015 and 2016 seasons.

Treatments	Number of panicles/m²		number of grains/panicle		panicle weight (g)	
	2015	2016	2015	2016	2015	2016
T_1	507.88 h	510.21 h	194.98 h	200.17 h	4.133 c	4.147 c
T_2	526.10 g	530.18 g	206.27 g	210.81 g	4.300 bc	4.330 bc
T_3	531.29 f	536.55 f	211.89 f	217.27 f	4.406 abc	4.415 abc
T_4	544.17 e	548.66 e	230.91 e	229.65 e	4.415 abc	4.583 abc
T_5	555.38 d	561.40 d	235.86 d	237.63 d	4.717 abc	4.717 abc
T_6	580.08 b	583.25 b	250.46 b	251.97 b	5.008 ab	5.013 ab
T_7	570.29 c	572.13 c	241.51 c	244.40 c	4.894 abc	4.901 abc
T_8	591.83 a	597.75 a	255.66 a	259.62 a	5.173 a	5.184 a

(T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate , (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate

As for filled grains percentage, thousand grain weight (g) and grain yield (ton/ha) data in Table 4 documented that the application of each eight tested fertilizer treatments or their combinations caused an increase in the previously mentioned characters as compared with control except thousand grain weight which reached to the maximum value under control treatment also, the lowest filled grain percentage and grain yield were found with control treatment. The greatest values of both filling grains percentage and grain yield were obtained when the three fertilizer compounds were combined together and applied as foliar spray two times of the tested cultivar. The combination of zinc sulphate and magnesium silicate came in the second rank after the (T_8 treatment) in the two studied seasons. Grain yield, in fact, is the out-product of its main components. The increase in most of these components will reflect in the increase in grain yield. Therefore, the increase in grain yield due to applying zinc was the logical resultant due to the achieving increased in its components, i.e. the number of panicles per m², filled grains percentage and the number of grain per panicle. Similar trend was found by Abdel-Whab et al. (1992).These increases of grain yield might be owing to the foliar of potassium to the rice which is more beneficial and increase the amount and translocation of carbohydrates from stems, leaf sheathes and other storage organs to grain, leading to high sink capacity and subsequently, higher grain yield as a result to the role of potassium for enhancing the activity of enzymes related to the biosynthesis of carbohydrate. The results confirm the findings of Nagarathna and Prakasha (2007). Results also revealed that magnesium silicate addition helped plant growth, which might be due to the increased photosynthetic efficiency upon silicate addition, and it was exerted through the numbers of productive tillers, panicle length, the percentage of filling grains. Also, because of the role of silicon in increase the strength of cell wall by precipitate the cuticle layer resulted in more erect leaves which gave the chance of light to penetrate most of the leaves that increase the photosynthesis and its products consequently increase filling rate and percentage which lead to increase grain yield. Effects of silicon on yield are related to the deposition of the element under the leaf epidermis which results a physical mechanism of defense, reduces lodging, increases photosynthesis capacity and decreases transpiration losses (Korndörfer *et al.,* 2004).

Table 4. Filled grains (%), thousand grain weight (g) and grain yield (ton/ha) of Egyptian hybrid rice 1 cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate treatments in 2015 and 2016 seasons.

Treatments	Filled grains (%)		Thousand grain weight (g)		grain yield (ton/ha)	
	2015	2016	2015	2016	2015	2016
T_1	93.003 h	93.011 h	25.68 a	25.89 a	9.52 e	9.70 d
T_2	93.249 g	93.287 g	24.04 f	24.00 f	11.71 d	11.89 c
T_3	93.584 f	93.599 f	24.39 ef	24.27 ef	11.93 cd	12.01 c
T_4	93.891 e	93.902 e	24.80def	24.59def	12.14 bcd	12.29 bc
T_5	94.153 d	94.156 d	25.17cde	24.84cde	12.30 abcd	12.44 abc
T_6	94696 b	94.755 b	25.40abc	25.32abc	12.67 ab	12.78 ab
T_7	94.400 c	94.419 c	25.29bcd	25.01bcd	12.49 abc	12.60 ab
T_8	95.073 a	95.100 a	25.51 ab	25.60 ab	12.84 a	12.91 a

(T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate , (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate.

C: grains quality characters

Hulling, milling, head rice and milled grain protein content percentages values of Egyptian hybrid rice one cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate fertilizers during the two growing seasons 2015 and 2016 are presented in Table 5. Data indicated that the application of each of the fertilizer compounds or their combinations caused an increase in the percentage of hulling, milling, head rice and protein in milled rice as compared with control. The lowest values of the previously mentioned grain quality and protein percentage were observed when the tested rice cultivar didn't receive any of the tested fertilizer compounds in the two studied seasons. While the highest values of these characters were obtained when the tested rice cultivar was sprayed by the combinations of the three used fertilizer compounds (T_8 treatment), followed by the treatment which had zinc sulphate plus magnesium silicate (T_6 treatment). Both zinc and potassium as a co-activator for high number of enzymes improve and enhance the activity of these enzymes which increase the biosynthesis of protein, carbohydrates and lipids as well as the metabolic absorption of nutrients by plant. Also, potassium as a co-activator for about 64 enzymes in rice some of them are transferring enzymes. These enzymes responsible for the translocate all the previously mentioned metabolites or assimilates from the source of rice plant to its sink consequently increase the filling processes resulted in increase in filling grains. In this case the starch will be filled the endosperm of grain completely that minimized both vacuoles among the starch layers which led to decrease the broken grains and minimized the weight and thickness of the hull resulted in increased in hulling, milling and head rice percentage consequently improve the grain quality characters. These findings are in close agreement with those reported by Omer (2002) and Bahmaniar and Ranjbar (2007). As, previously mentioned the increases in hulling, milling, head rice and protein percentage under the tested fertilizer treatments could be attributed to the role of silicon in increase the erectness of leaves (small angle between the leaf and culm) which gave the chance for light to penetrate through more number of leaves that that increase the photosynthesis processes resulted in increased in more dry matter accumulation in plant canopy. The current findings are in a same line with those reported by Shashidhar *et al.* (2008) and Ahmad *et al.* (2013).

Table 5. Percentage of hulling, milling, head rice and milled grain protein of Egyptian hybrid rice 1 cultivar as affected by foliar application of zinc sulphate, potassium sulphate and magnesium silicate treatments in 2015 and 2016 seasons.

Treatments	Hulling %		Milling %		Head rice %		Milled grain protein %	
	2015	2016	2015	2016	2015	2016	2015	2016
T_1	79.878 h	79.989 g	67.918 h	68.030 h	60.991 h	61.017 h	6.478 d	6.498 d
T_2	80.319 g	80.383 f	68.317 g	68.397 g	61.338 g	61.499 g	6.681 cd	6.689 cd
T_3	80.521 f	80.703 e	68.490 f	68.580 f	61.636 f	61.794 f	6.789 bc	6.794 bc
T_4	80.692 e	80.761 e	68.660 e	68.772 e	61.863 e	62.101 e	6.900 abc	6.911 abc
T_5	80.840 d	80.926 d	68.856 d	68.961 d	62.100 d	62.242 d	6.970 ab	6.980 ab
T_6	81.209 b	81.280 b	69.154 b	69.260 b	62.546 b	62.707 b	7.093 a	7.100 a
T_7	81.019 c	81.095 c	68.994 c	69.071 c	62.268 c	62.411 c	7.039 ab	7.046 ab
T_8	81.476 a	81.551 a	69.401 a	69.449 a	62.792 a	62.939 a	7.142 a	7.149 a

(T_1), control (without application), (T_2), Zinc sulphate, (T_3), potassium sulphate, (T_4), magnesium silicate, (T_5), Zinc sulphate + potassium sulphate, (T_6),Zinc sulphate+ magnesium silicate , (T_7), potassium sulphate + magnesium silicate and (T_8), Zinc sulphate + potassium sulphate + magnesium silicate.

REFERENCES

Abdel-Wahab, A. E.; S. A. Ghanem and A. O. Bastawisi (1992).

Performance of transplanted rice under different sources and method of zinc application. Egy. J. of Applied Sci., 7(7):27-36.

Abou Youssef, M.; A. Draz and H. El-Mowafi (2005). The effect of sowing date and GA3 doses of the parental lines of SK2058H on hybrid rice seed production under Egyptian conditions. Egy. J. Agric. Res., 83(5B): 323-331.

Adair, C. R. (1952). The McGill Miller method for determining the milled quality of small samples of rice. Rice J., 55(2):21– 23.

Ahmad, A.; M. Afzal; A. U. H. Ahmad and M. Tahir (2013). Effect of foliar application of silicon on yield and quality of rice (Oryza sativa L.). Cercetari Agro. In Moldova, 3 (155): 21 – 28.

Ali, A.; M. A. B. Shahzad; I. Javaid; H. Safdar; M. N. Subhani; S. Muhammad and A. Muhammad (2012). Augmenting the salt tolerance exogenously in wheat (Triticum aestivum, L.) through applied silicon. Afric. J. of Biotech., 11 (3) : 642 – 649.

Arab, R.; S. Dastan; H. R. Mobasser and A. M. Ghanbari (2011). Effect of silicon and cycocel application on yield components and quantity yield of rice (Oryza sativa, L.) in Iran. Proceedings of The 5th International Conference on Silicon in Agriculture Spt, 13 - 18, Beijing, China, pp. 4.

Bahmaniar, M. and G. Ranjbar (2007). Effect of nitrogen and potassium fertilizers on rice (Oryza sativa L.) genotypes processing characteristics. Pakistan J. of Biological Sci., 10(11): 1829-1834.

Bhowmick, N. and R. L. Nayak (2000). Response of hybrid rice (Oryza sativa L) varieties to nitrogen, phosphorus and potassium fertilizers during dry (boro) season in West Bengal. Ind. J. of Agron., 45(2): 323-326.

Black, C. A.; D. D. Evans; L. E. Ensminger and F. E. Clark (1965). Methods of Soil Analysis. Part 2- Chemical and microbiological properties. Americ. Soc. of Agron., Inc., Pub., Madison, Wisconsin, USA.

Cakmak, I. (2002). Plant nutrition research priorities to meet human needs for food in sustainable ways. J. of Plant Soil 247:3–24.

Cakmak, I.; M. Kalayci; H. Ekiz; H.J. Braun and A. Yilmaz (1999). Zinc deficiency as an actual problem in plant and human nutrition in Turkey: a NATO-science for stability project. Field Crop Res., 60:175-188.

Das, D. K. (1986). A study on zinc application to rice. J. of Maharashtra Agric. Univ., 11 (1): 120-121.

Dastan, S.; A. Ghasemi; H. R. Mobasser and M. J. Mirhadi (2011). Silicon and potassium effects on lodging related morphological characteristics and agronomical indices of rice (Oryza sativa, L.) in Iran. Proceedings of the 5th International Conference on Silicon in Agriculture Spt, 13 - 18, Beijing, China, pp. 30-31.

Deren, C. W.; L. E. Datnoff; G. H. Zinder and F. G. Martin (1994). Silicon concentration, disease response and yield components of rice genotypes grown on flooded organic histosols. Crop Sci. 34:733-737.

Duncan, D. B. (1955). Multiple Range and Multiple F. Test. Biometrics. 11: 1-42.

Dutta, R.; K. Muslimuddin and L. Rahman (1987). Yield and flowering of rice in relation to fertilizer Zinc Sulphate. Inter. Rice News., 36(1): 16-22.

Ebaid, R. A. and S. A. Ghanem (2001). Effect of nitrogenous and potash fertilizers on the productivity of Sakha 101 rice cultivar. J. of Agric. Sci. Mansoura Univ., 26(4): 1833-1840.

Gomez, K. and A. Gomez (1984). Statistical Procedures of Agricultural Research. John Wiley and Sons. Inc., New York, U.S.A.

Gong, H. J.; D. P. Randall and T. J. Flowers (2006). Silicon deposition in the root reduces sodium uptake in rice (Oryza sativa L.) seedlings by reducing bypass flow. Plant and Cell Environ., 29:1970-1979.

Gu, H. H.; S. S. Zhan; S. Z. Wang; Y. T. Tang; R. L. Chaney; X. H. Fang; X. D. Cai and R. L. Qiu (2012). Silicon-mediated amelioration of zinc toxicity in rice (Oryza sativa L.) seedlings. Plant Soil, 350:193-204.

Hu, H. and G. H. Wang (2003). Influence of potassium fertilizer on nutrient accumulation and physiological efficiency of hybrid rice. Plant Nutr. Fertilizer Sci., 9 (2):184-189.

Hu, H. and G. H. Wang (2004). Nutrient uptake and use efficiency of irrigated rice in response to potassium application. Pedosphere, 14(1):125-130.

Impa, S. M.; A. Gramlich; S. Tandy; R. Schulin; E. Frossard and S. E. Johnson-Beebout (2013). Internal Zn allocation influences Zn deficiency tolerance and grain Zn loading in rice (Oryza sativa L.). Front Plant Sci., 4: 534.

Kaya, C.; L. Tuna and D. Higgs (2006). Effect of silicon on plant growth and mineral nutrition of maize grown under waterstress conditions. J. of Plant Nutr., 29:1469-1480.

Korndörfer, G. H.; H. S. Pereira and A. Nolla (2004). Silicon analysis in soil, plant and fertilizers. Brazil.

Krishnakumar, S.; R. Nagarajan; S. Natarajan; D. Jawahar and B. Pandian (2005). NPK fertilizers for hybrid rice (Oryza sativa L.) productivity in alfisols of Southern Districts of Tamil Nadu. Asian J. of Plant Sci., 4(6): 574-576.

Liu, G. D. and G. L. Liu (1997). Genotypic differences of potassium contents of rice (Oryza sativa L.) seeds. Chin. J. Rice Sci., 11 (3): 179-182.

Marschner, H. (1996). Mineral nutrition of higher plants. Academic Press, London.

Mawardi, A.; S. chaly; M. A. Z. My and A. A. Razik (1980). Effect of zinc sources, rates and method of application on paddy yield. Agricultural Research Review, 58(5): 165-172.

Nagarathna, T. and H. Prakasha (2007). Synchronization of potassium supply in rice hybrids. Environ. And Ecology, 25(3-4): 967-968.

Neumann, D. and U. Z. Nieden (2001). Silicon and heavy metal tolerance of higher plants. Phytochemistry,56:685–692.

Omer, A. S. A. (2002). Rice fertilizer under saline soil conditions. Ph.D. Agron. Dept., Fac. Agric., Zagazig Univ.

Pan, Y.; J. Hom; J. Jenkins and R. Birdesey (2004). Importance of foliar nitrogen concentration to predict forest productivity in the mid-atlantic region. Forest Sci., 50:279-289.

Pedas, P.; J. K. Schjoerring and S. Husted (2009). Identification and characterization of zinc-starvation-induced ZIP transporters from barley roots. Plant Physiol. Biochem., 47: 377–383.

R.R.D. (2010). Rice Research Department, Proceedings of the 13th Rice Workshop, Annual Report Agronomy, Sakha, Kafrelsheikh, Egypt, pp. 38.

Randall, M.; H. William; C. Kessell and J. Williams (2003). Fertility and crop nutrition. California Rice Production Workshop, 1.

Rusell, F. (1986). MSTAT- A microsoft program for agricultural research. International oat conference, July 1986.

Sakal, R.; B. P. Singh and A. P. Singh (1983). Direct and residual effect of zinc and zinc amended organic manures on the zinc natrition of filed crops. Indian J. of Agric. Res.,19 (2): 93-97.

Sharma, K.; B. A. Krants; A. L. Brown and S. Quick (1986). Interaction of Zn and P in top and root of corn and tomato. Agron. J., 60:453–456.

Shashidhar, H. E.; N. Chandrashekhar; C. Narayanaswamy; A. C. Mehendra and N. B. Prakash (2008). Calcium silicate as silicon source and its interaction with nitrogen in aerobic rice. Silicon in Agriculture: 4th International Conference 26-31 October, South Africa: 93.

Singh, B.; S. K. A. Natesan; B. K. Singh and K. Usha (2005). Improving zinc efficiency of cereals under zinc deficiency. Cur. Sic. Indian, 88:36-44.

Singh, K.; R. Singh; J. P. Singh; Y. Singh and K. K. Singh (2006). Effect of level and time of silicon application on growth , yield and its uptake by rice (Oryza sativa, L.). Indian J. Agric. Sci., 76 (7) : 410 - 413.

Singh, K. K. and K. Singh (2006). Response of nitrogen and silicon levels on growth, yield attributes, and nutrient uptake of rice. Oryza sativa L., 43(3):220-223.

Song, A.; P. Li; Z. Li; F. Fan; M. Nikolic and Y. Liang (2011). The alleviation of zinc toxicity by silicon is related to zinc transport and antioxidative reactions in rice. Plant Soil, 344:319-333.

Taiz, L. and E. Zeiger (2010). Pant physiology, 5nd edn. Sinauer Associates. Sunderland, MA. 782p.

Takahashi, E. and Y. Miyake (1977). In: Proceeding and International Seminar on Environment and Fertility management in Intensive Agriculture (SEFMIA), 603-611. Tokyo, Japan.

Tamai, K. and J. F. Ma (2008). Reexamination of silicon effects on rice growth and production under field conditions using a low silicon mutant. Plant Soil, 307:21-27.

Tu, J.; G. Zhang; K. Datta; C. Xu; Y. He; Q. Zhang; G. S. Khush and S. K. Datta (2000). Field performance of transgenic elite commercial hybrid rice expressing Bacillus thuringiensis d-endotoxin. Nature Biotechnology, 18: 1101–1104.

Wang, C.; S. H. Zhang; P. F. Wang; J. Hou; W. J. Zhang; W. Li and Z. P. Lin (2009). The effect of excess Zn on mineral nutrition and antioxidative response in rapeseed seedlings. Chemosphere, 75:1468–1476

Xie, W.; G. Wang and E. Zhang (2007). Potential production simulation and optimal nutrient management of two hybrid rice variety In Jinhua, Zhejian Province, China. J. Zhejiang Univ. Sci., 8(7): 486-492.

Xu, G. and S. Bao (1995).The relationship between potassium absorption ability and root parameters of different crops. J. Nanjing Agri. Univ. 18, 49–52.

Yoshida, S. (1981). International Rice Research Institute, Los Banos, Laguna. Philippines.

Yuan, L. P. (2004). Hybrid rice technology for food security in the world. Fao Rice Conf., 12-13 Feb., Rome, Italy.

Zhao, Z. Q.; Y. G. Zhu; R. Kneer and S. E. Smith (2005). Effect of zinc on cadmium toxicity induced oxidative stressing winter wheat seedlings. J. Plant Nutr., 28:1947-1959.

استجابة صنف الأرز هجين مصري ١ لاضافة سلفات الزنك و سلفات البوتاسيوم وسيليكات الماغنيسيوم رشا.

مريم طلعت ويصا غبريال
قسم بحوث الأرز – معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية – الجيزة – مصر.

أجريت تجربتان حقليتان خلال موسمي الزراعة ٢٠١٥ و ٢٠١٦ في المزرعة البحثيه بقسم البحوث الأرز، سخا، كفر الشيخ، مصر. من أجل دراسة استجابة صنف الأرز هجين مصري ١ للرش الورقي بأسمدة سلفات الزنك و سلفات البوتاسيوم وماغنيسيوم سيليكات.تم استخدام تصميم القطاعات الكاملة العشوائية في أربعة مكررات في الموسمين. وتم استخدام معاملات الرش الورقي سلفات الزنك و سلفات البوتاسيوم وماغنيسيوم سيليكات على النحو التالي: م١ كنترول و م٢ الرش بسلفات الزنك و م٣ الرش بسلفات البوتاسيوم و م٤ الرش بسيليكات الماغنيسيوم و م٥ الرش بسلفات الزنك وسلفات البوتاسيوم و م٦ الرش بسلفات الزنك و بسيليكات الماغنيسيوم و م٧ الرش بسلفات البوتاسيوم وسيليكات الماغنيسيوم و م٨ الرش بسلفات الزنك وسلفات البوتاسيوم وسيليكات الماغنيسيوم. تم اضافة معاملات الرش الورقي بنفس المحتوى ٢ % مرتين عند ١٥ و ٣٠ يوم من الشتل. وكانت الصفات المدروسة طول النبات , دليل مساحة للاوراق, وتراكم للمادة الجافة, تركيز كلوروفيل في ورقة العلم , وعدد الفروع لل م٢ , عدد السنابل لل م٢ , وزن السنبله,عدد الحبوب الكلية للسنبله, النسنبة المئوية لامتلاء الحبوب ,وزن الالف حبة, محصول الحبوب وايضا النسبه المئويه لتصافي التقشير والتبييض والحبوب الكامله والبروتين في الحبوب المبيضة .واظهرت النتائج ان الدمج بين معاملات الرش الورقي الثلاثه (سلفات الزنك وسلفات البوتاسيوم وسيليكات الماغنيسيوم) ادت ال زيادة النمو الخضري وصفات المحصول ومكونات المحصول وصفات الجودة للحبوب لصنف الارز هجين مصري واحد. ولكن اعطت معاملة الكنترول اعلي وزن للالف حبة بدون اي فروق معنويه بين معاملة الكنتول والدمج بين معاملات الرش الورقي الثلاثه في هذه الصفه. وتتراوح الأختلافات في النتائج بين معاملات الرش الورقي بسلفات الزنك وسلفات البوتاسيوم و سيليكات الماغنيسيوم المختلفه. ووفقا للنتائج السابقة يمكن الاستنتاج انه :إستخدام الرش الورقي بمعاملة الدمج بين الاسمدة الثلاثة (سلفات الزنك وسلفات البوتاسيوم و سيليكات الماغنيسيوم) بنفس المحتوى ٢% وذلك عند ١٥ و ٣٠ يوم من الشتل كانت افضل معاملة ادت الي الحصول علي اعلي محصول حبوب ومكوناته بجانب تحسين النمو الخضري وصفات جودة الحبوب لصنف الارز هجين مصري واحد.إستخدام مركبات التسميد السابق ذكرها كإضافة بالرش ادت الي توفير اكثر من ثلثين كمية السماد المضافة ارضيا من سلفات الزنك وسلفات البوتاسيوم وذلك نتيجة استخدام سيليكات البوتاسيوم حيث يحدث تكامل مع سلفات الزنك وسلفات البوتاسيوم ولذلك توصي الدراسة برش صنف الارز هجين مصري واحد بكلا من سليفات الزنك وسليفات البوتاسيوم وسيليكات الماغنسيوم مرتين عند ١٥ و ٣٠ يوم من الشتل بتركيز ٢%للحصول علي اعلي محصول وجودة للحبوب.