J. Plant Production, Mansoura Univ., Vol. 7(2): 257 - 262 , 2016

RESPONSE OF EGYPTIAN HYBRID RICE VARIETY TO SOIL AND FOLIAR APPLICATION OF POTASSIUM SULFATE FERTILIZER

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ABSTRACT

Use of efficient K dose is an important complementary strategy in improving rice yield, quality and reducing cost of production. The price of K fertilizers is getting higher day by day and becoming unaffordable to farmers. Potassium (K) is an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism of rice.

Field experiments were conducted during 2013 and 2014 seasons at the farm of Sakha Research Station, Sakha, Kafr El-Sheikh, Egypt to compare foliar application of Potassium Sulfate (K_2SO_4) with soil application of Potassium sulfate and their combination on yield of Egyptian hybrid rice 1(EHR1) crop. Five treatments from potassium sulfate as a soil application or a foliar application and their combinations were used. The increase in panicle number/m^2 and panicle weight were a maximum when half dose of recommended potassium as basal (59.5 kg.ha^{-1}) + 2% Potassium sulfate as a foliar application were applied at panicle initiation (P.I). Grain yield of the treatment K_3 (half recommended dose of potassium as basal + 2% potassium sulfate as foliar application at P.I) proved to be superior over all treatments. Among all treatments tested the highest values of potassium uptake was observed in K_3. Our results suggested that foliar application of Potassium sulfate at 2 % concentration 15 days after transplanting and at P.I was active, appropriate and could produce rice yield equal to the yield obtained with soil application of potassium sulfate at the rate of 119 kg ha^{-1}. From the economic point of view side, spraying with Potassium Sulfate at the concentration of 2%, 15 days after transplanting (DAT) plus spray with the same concentration at panicle initiation (PI) was the best treatment to grain more yield with high economic value.

INTRODUCTION

Potassium is an essential element for the growth of rice plant and takes part in various physiological processes (Yoshida 1981). Potassium is considered to be an important mineral nutrient element for the plants after nitrogen which needs to be applied in sufficient amount to produce healthy and productive crop (IRRI 2007). Potassium enhances the translocation of photosynthesis and mobilizes the stored material (Mengal, 1980) and has a beneficial effect on ATP synthesis. With increased use of phosphorous and nitrogen fertilizers and due to intensive cropping system in last decade. Potassium deficiency has been considered to be the most limiting factor for increasing rice yield in many places (Yang *et al*. 2003).

The main function and role of K is working as activation of various enzymes. Deficiency of K has been reported to accumulated soluble carbohydrate, amino acids and reducing sugars. It impairs the synthesis of starch as will as glycogen and block the respiratory substances and decreases the rate of oxidative phosphorylation and photophosphorylation (Baskaran *et al*., 1982). Potassium can easily move to exchange sites on clay colloid, get into the soil solution, diffuse towards plant roots for absorption, move up in the plant system or lead out plant tops and roots back into the soil, be contrasted into exchangeable and non-exchangeable forms or more out of the soil with draining water. Qi and Spalding, 2004 reported that due to high levels of monovalent cations, e.g., Na and NH_4 restrict potassium uptake and eventually results in low potassium content of plants.

Potassium is very expensive so, more farmers cannot buy it. The imbalanced and inadequate application of fertilizers has serious repercussion for efficiency of applied fertilizers. Potassium deficiency is also closely associated with low chlorophyll content, decreased stomatal conductance, poor chloroplast and increased mesophyll resistance (Dong *et al*. 2004).

Development practices to improve the efficiency of nutrients require an understanding of the fact of the applied nutrient and their effect on crop production. Greater opportunities exist for increased crop production by improving rate, timing and management of mineral fertilizers. Foliar feeding of potassium is of great significance for plants because it includes low cost, quick response to plant. Foliar fertilization use only small quantity of nutrients and it provides compensation for lack of soil fixation. For plant demand foliar application of fertilizer may provide plenty of nutrients for plant growth (Pettigrew *et al*., 2000). More information about the effect of rate, timing and method of potassium application on grain yield of Egyptian hybrid rice (EHR1) and nutrient uptake, therefore, some studies were carried out on their aspect. K utilization by plants through foliar application is well recognized and is being practiced in agricultural advanced countries. Hence, there is a need to provide the required K, through foliar application as well.

Therefore, this study was planned to compare different methods of applying potassium sulfate as foliar, basal application and their combinations to obtain optimum paddy yield with minimum cost.

MATERIALS AND METHODS

Two field experiments were conducted in a complete block design with four replications at the farm of Agriculture Research Station during the 2013 and 2014 seasons. Treatments included method, rate and timing of potassium application treatments were: K0:

without potassium (control), K_1: the use of 119 kg potassium sulfate as a basal (Recommended dose), K_2: half dose of the recommended rate was applied as a basal and the rest amount was applied as a topdressing at panicle initiation (PI); K_3: half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at PI; K_4: spray with potassium sulfate at the concentration of 2% at PI and K_5: spray with potassium sulfate at the concentration of 2%, 15 day after transplanting + spray with same concentration at PI.

Soil sample was taken, crushed then grinned to path through 2mm sieve mechanical and chemical analysis were determined according to cottenie *et al*., (1982) and Page *et al*., (1982). The results were presented in Table 1. A common procedure was followed in raising of seedling in seedbed. Seedlings of 30 days old were uprooted from the nursery beds carefully. Seedlings were transplanted in the well puddled experimental plots. Spacing's were given 20 cm X 20 cm. nitrogen as urea at the rate of 165 kg N ha^{-1} was applied for all treatments in two splits, two third as a basal application and incorporated into the soil then immediately the soil was flooded. The rest amount of nitrogen fertilizer was top dressed 25 days after transplanting (DAT). Full dose of phosphorus as a single superphosphate was applied as a basal dose at the time of final land preparation and incorporated well into the soil. All intercultural operations were done carefully.

Table1: Some mechanical and chemical characteristics of the used soil in season 2013 and 2014.

Tested characteristics	Value	
	2013	**2014**
Piratical size distribution		
Sand %	55	27.3
Silt %	31.8	28.64
Clay %	13.2	44.06
Texture class	Clayey	Clayey
PH (1:2.5 soil water suspension)	8.2	8.10
Ec_e (soil paste extracted at 25c $ds.m^{-1}$)	2	1.97
OM (organic matter) %	1.53	1.55
Available potassium (ppm)	290	300
Soluble cations, $meq.l^{-1}$(soil paste):		
Ca^{++}	5.2	5
Mg^{++}	2.1	2
K^{+}	0.7	0.8
Na^{+}	12	11.9
Soluble anoins, $meq.l^{-1}$(soil paste):		
CO_3^{--}	-	-
HCO_3^{--}	3.5	3.6
Cl^{-}	14.7	14.4
SO_4^{--}	1.8	1.7

From transplanting up to 15 days before harvesting, a thin layer of water (3-5cm) was kept on the plots. Water was removed from the plots two weeks before harvesting. The crop of each plot was harvested separately at full maturity. Plant samples were collected from each plot for data collection on plant growth characters and yield components.

Plant samples (grain and straw) were taken at harvest then placed on paper bags and oven dry at $70^{o}c$ for 48 hours. Dried samples were ground to powder and digested. Soil samples were collected at harvest then extracted to determine available potassium. Potassium was determined by the flame photometer as described by Jackson (1967). A guarded area of ten square meters was harvest then left three days for air drying then thrashed. The grain yield was weight in kilogram and adjusted to 14 percent moisture basis, then converted to tons per hectare. Data were analyzed statistically and treatment differences determined using Duncan's multiple range tests (1995).Economic viability evaluation was done using partial budget. Partial budget is a way of calculating total cost that varied (TCV) and the net benefits (NB) of each treatment on farm experiment.

RESULTS AND DISCUSSION

Yield and yield attributes:

Data in table (2) shows that methods of potassium application affected the number of panicle. $hill^{-1}$. It was evident that panicle number per hill influenced significantly by potassium and it was highest when half dose of the recommended rate + spray with potassium sulfate at the concentration of 2% at P.I(K_3) was applied followed by utilization of spray with potassium sulfate at the concentration of 2% 15 days after transplanting plus spray with the same concentration at PI (K_5). This may be due to the continuous supply of potassium to the crop during the growth seasons beside the role of using potassium as foliar that help for increasing fertilizer use efficiency consequently K uptake. These results were also supported by Dwived *et al* (2006).

Application of the potassium sulfate as half of the recommended dose plus spray with potassium sulfate at the concentration of 2% at PI(K_3) produced the heaviest panicle followed by K5 (spray with potassium sulfate at the concentration of 2% 15 days after transplanting + spray with the same concentration at PI). Data also shows there is no any significant difference among the other treatments. the increase in panicle weight with K_3 and K_5 treatments may be due to the continuous supply of potassium that encourage all physiological processes.

Data in Table 2, present values of 1000 grain weight of EHR1 rice variety as affected by the application of different fertilizer treatments. Thousand grain weights showed no constant trend among the different treatments. K3 (half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at PI) in the second season produced the highest value of 1000 grain weight. This mainly due to the increase of seeds. panicle-1. consequently, increase the weight of seeds. These results are in accordance with those obtained by Barnes (1985).

Table (2): Number of panicle/hill, panicle weight (g) and 1000 grain weight (g) as affected by methods and timing of potassium application for Egyptian Hybrid rice during 2013 and 2014 seasons.

Treatments	Number of panicle/hill		Panicle weight (g)		1000 grain weight (g)	
	2013	2014	2013	2014	2013	2014
K_0	20.24e	21.32d	3.8 c	3.9 c	23.61 a	24.02 b
K_1	22.32c	22.64c	3.98 bc	4.01 c	23.71a	24.3 b
K_2	23.04b	23.00c	4.03 bc	4.0bc	24.00 a	24.33 b
K_3	24.88a	26.04a	4.48 a	4.52 a	24.65 a	24.72 a
K_4	20.84d	21.48d	3.73 c	3.96 c	23.64 a	24.36 b
K_5	23.12b	24.60b	4.31 ab	4.41 ab	24.30 a	24.50 b

Table (3) Grain and straw yield of Egyptian hybrid rice ($t.ha^{-1}$) as affected by methods and timing of potassium application for Egyptian Hybrid rice during 2013 and 2014 seasons.

Treatments	Grain Yield		Straw Yield	
	2013	2014	2013	2014
K_0	10.11 b	10.25 c	12.64 c	13.32 b
K_1	11.04ab	11.10 abc	13.91 ab	13.89 ab
K_2	11.33 a	11.39 ab	14.16 a	14.26 ab
K_3	11.45 a	11.64 a	14.31 a	14.56 a
K_4	10.24 b	10.53 bc	12.78 b	13.69 ab
K_5	11.34 a	11.41ab	14.18 a	14.29 ab

Data in table (3) show the grain and straw yield of Egyptian hybrid rice as affected by method and timing of potassium application. Paddy yield was significantly increased by all fertilizer treatments compared with the control. This reduction in paddy yield under control may be due to the shortage of available potassium in the soil. Khan *et al*. (2007) conducted a field experiment to check the potassium effect on yield of wheat and rice crop under wheat-rice cropping system. They found that grain yield of wheat and rice were increased by using potassium to higher level up to 13 % and 50% over control respectively, whereas, number of tillers/m^2, number of spike/m^2, spike length, plant height and 1000 grain weight were much higher using potassium at 60 kg/ha. The highest value of grain yield was obtained when K_3 treatment (half of the recommended dose was applied as a basal + Spray with potassium sulfate at the concentration of 2% at P.I) was applied followed by K_5 (spray with potassium sulfate at the concentration of 2% 15 days after transplanting + spray with same concentration at P.I) whereas, the lowest values of grain yield were found either when only fertilizer potassium was applied as a foliar one time at PI (K_4) or when no potassium was added (K_1). The increase in grain yield with potassium fertilizer application was mainly due to improvement yield components. It is well known fact that K serves a vital role in photosynthesis by directly increasing growth and leaf area index and hence CO2 assimilation enhance outward translocation of more ATP essential for vigorous growth of plants. Many researchers have reported the positive response of K_2SO_4 foliar application to rice and wheat crops as well as higher plants (Ramos *et al*. 1999; Ali *et al*. 2005a, b). Several workers reported significant response grain yield of rice to the application of potassium i.e. Quampah *et al*., (2011) and Pal *et al*., (2000).

Also data show that utilization of fertilizer potassium as a foliar gave a good grain yield and helping to reduce the amount of potassium fertilizer used. About one bag of potassium sulfate fertilizer for one hectare can be saved when treatment No.3 (half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at P.I) was applied and 2 bags of potassium fertilizer can be saved when treatment No.5 (spray with potassium sulfate at the concentration of 2% 15 days after transplanting + spray with same concentration at P.I) will apply. By using both of these treatments (3 and 5) we can help the farmers to save money and subsequently increase income. The highest straw yield also found with K_3 due to the influenced of potassium on vigorous vegetative growth of rice.

Potassium uptake:

Data in table (4) represent the potassium uptake in grain and straw as affected by methods and timing of K application. Data indicate that potassium uptake affected by the method of K application. It is important to notice that utilization of potassium more than one time increased the potassium uptake. The increased potassium uptake of hybrid rice may be due to the continuous supply which was proved more beneficial and increased dry matter resulted to high potassium uptake.

Table (4) Potassium uptake ($kg.ha^{-1}$) at harvest as affected by method and time of potassium application during 2013and 2013 seasons.

Treatments	potassium uptake in grain ($kg.ha^{-1}$)		potassium uptake in Straw ($kg.ha^{-1}$)	
	2013	2014	2013	2014
K_0	15.3 d	17.32 d	89.2 d	92.20 d
K_1	20 b	22 b	99.3 b	102.30 c
K_2	20.٦ ab	22.6 ab	100 b	103 bc
K_3	21.3 a	23.3 a	106.41a	109.41a
K_4	18.1c	20 c	93.2 c	96. 2 d
K_5	20.٧ab	22.9 ab	100.02 b	103.21b

Among all the treatments tested, treatment No.3 (half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at P.I) gave the highest value of potassium uptake followed by treatment No.2 (half dose of the recommended rate was applied as a basal and the rest amount was applied as a top dressing at panicle initiation) and 5(spray with potassium sulfate at the concentration of 2% 15 days after transplanting + spray with same concentration at P.I) compared to the other treatments and control (K_0). It is important to notice that utilization of potassium as a basal at the recommended rate only one time or half of the recommended rate as a basal + the rest amount from the recommended rate as top dressing did not give the highest amount of potassium uptake. This may be due to the leaching of the potassium and the minerals in soil that may affect the availability of K. It may be fixed in the interlayer and on wedge sites of soil clay and is rendered unavailable to growing plants. The amount of K fixed increases with added potassium (Ali *et al*., 2007). Similar findings regarding significant effect of K application have also been obtained by various researchers Arabi *et al*. 2002; Ali et al. 2005a & b).

Economic study

An economic analysis on the combined result using the partial budget technique is appropriate. The results of the partial budget and the economic data used in the development of the partial budget are given in Table 5and 6. Data shows that the highest profit were recorded when half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at P.I(K_3) or spray with potassium sulfate at the concentration of 2% 15 days after transplanting + spray with same concentration at P.I (K_5).

Table 5: Effect of different potassium treatments on farmer profit in season 2013.

Treatments	time	Product	(1) Revenue (product *1800)	(2) Labor (50)	(3) Machine (20)	(4) Potassium (300)	(5) Cost (2+3+4)	Profit (1-5)
Control (without Potassium Sulfate)(K_0)	Grain yield1	10.11	18198	0	0	0	0	18198
119 kg potassium sulfate as a basal (Recommended dose) (K_1)	Grain yield1	11.04	19872	50	0	714	764	19108
half dose of the recommended rate was applied as a basal and the rest amount was applied as a topdressing at panicle initiation (PI) (K_2)	Grain yield1	11.33	20394	100	0	714	814	19580
half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at PI (K_3)	Grain yield1	11.45	20610	50	20	414.12	484.12	20125.9
spray with potassium sulfate at the concentration of 2% at PI (K_4)	Grain yield1	10.24	18432	0	20	57.12	77.12	18354.9
spray with potassium sulfate at the concentration of 2% 15 day after transplanting + spray with same concentration at PI. (K_5)	Grain yield1	11.34	20412	0	40	114.24	154.24	20257.7

***mean one ton of rice equal 1800 LE**

Table 6: Effect of different potassium treatments on farmer profit in season 2014.

Treatments	time	Product	(1) Revenue (product *1800)	(2) Labor (50)	(3) Machine (20)	(4) Potassium (300)	(5) Cost (2+3+4)	Profit (1-5)
Control (without Potassium Sulfate)	Grain yield	10.25	18450	0	0	0	0	18450
119 kg potassium sulfate as a basal (Recommended dose)	Grain yield	11.1	19980	50	0	714	764	19216
half dose of the recommended rate was applied as a basal and the rest amount was applied as a topdressing at panicle initiation (PI)	Grain yield	11.39	20502	100	0	714	714	19688
half of the recommended dose was applied as a basal + spray with potassium sulfate at the concentration of 2% at PI	Grain yield	11.64	20952	50	20	414.1	484.12	20467.8
spray with potassium sulfate at the concentration of 2% at PI	Grain yield	10.53	18954	0	20	57.12	77.12	18876.8
spray with potassium sulfate at the concentration of 2% 15 day after transplanting + spray with same concentration at PI.	Grain yield	11.41	20538	0	40	114.24	154.24	20383.7

***mean one ton of rice equal 1800 LE**

CONCLUSION

Based on the result it may be recommended that potassium should be applied at 59.5 kg potassium sulfate. ha^{-1} + spray with potassium sulfate at the concentration of 2% at P.I or spray with the potassium sulfate at the concentration of 2% at 15 DAT and at P.I to obtain optimum paddy yield with minimum cost.

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إستجابة الأرز الهجين المصرى للاضافة الأرضية والرش من سماد كبريتات البوتاسيوم .

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إجريت تجربتان حقليتان موسمى ٢٠١٣، ٢٠١٤ فى مزرعه الأرز بسخا لدراسة اثر استخدام طرق ومواعيد مختلفة لاضافة كبريتات البوناسيوم علي محصول الارز لصنف هجين مصري ١ .

اوضحت النتائج أن الزياده فى عدد السنابل/جوره ووزن السنابل وصلت أقصاه مع إستخدام نصف كميه البوتاسيوم الموصى بها قبل الزراعه ثم الرش بتركيز ٢% كبريتات البوتاسيوم فى مرحله بدايه تكوين السنبله وكذا عند الرش بكبريتات البوناسيوم مرتبن بعد ١٥ يوم من الشتل وعند مرحلة بداية تكوين السنبلة.

أظهرت النتائج أيضاً أن أعلى كميه للبوتاسيوم الممتص عند الحصاد كانت مع إستخدام نصف كميه البوتاسيوم الموصى بها قبل الزراعه ثم الرش بتركيز ٢% كبريتات البوتاسيوم فى مرحله بدايه تكوين السنبله. وقد أوضحت الدراسة الاقتصادية من خلال الموازنة الجزئية ان أعلي فائده للمزارع ظهرت مع استخدام كبريتات البوتاسيوم فى صوره رش ١٥ يوم بعد الشتل ثم الرش مره إخرى عند بداية تكوين السنبلة ثم استخدام نصف كميه البوتاسيوم الموصى بها قبل الزراعه ثم الرش بتركيز ٢% فى مرحله بدايه تكوين السنبله .

من النتائج يمكن القول انه مع إستخدام البوتاسيوم فى صوره رش ١٥ يوم بعد الشتل ثم الرش مره إخرى عند بداية تكوين السنابل أدى إلى توفير ٢ شيكارة من كبريتات البوتاسيوم. مما أدى إلى زيادة دخل المزارع وتقليل تكاليف الأنتاج.