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PERFORMANCE OF THE RICE VARIETY EGYPTIAN HYBRID-1 UNDER DIFFERENT LEVELS OF PHOSPHORUS FERTILIZER AND ORTHOPHOSPHORIC ACID AS FOLIAR SPRAY

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ABSTRACT

A field experiment was conducted in 2014 and 2015 consecutive seasons at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt to study the performance of the variety rice Egyptian hybrid-1 (EHR1) under different phosphorus fertilizer levels, *i.e.* control (P1), 18 (P2), 36 (P3) and 54 (P4) Kg P_2O_5 ha^{-1} and 2% orthophosphoric acid as foliar spray. The treatments were applied at different periods, namely control (without foliar spray) (F1), foliar spray with 2% of orthophosphoric acid at mid tillering (MT) period (F2), at late booting (LB) period (F3) and at MT + LB periods (F4). The experimental design was split plot where the main plots were arranged in randomized complete blocks with four replications. The phosphorus levels were allocated in the main plots**,** while sub-plots were received foliar applications with 2% orthophosphoric acid (H_3PO_4)**.** The studied characters plant height, number of tillers $hill^{-1}$, panicle length, panicle weight, number of panicles $hill^{-1}$, number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, 1000-grain weight, grain yield t ha^{-1}, straw yield t ha^{-1} and phosphorus uptake kg ha^{-1}. All studied characters increased with all treatment as compared with the control. Application of either 36 or 54 kg P_2O_5 ha^{-1} gave the same highest values of the studied characters except empty grains $panicle^{-1}$ which reached the maximum under the control. A significant increase in each of plant height (cm), number of tillers $hill^{-1}$, number of panicles $hill^{-1}$, panicle weight, panicle length, number of filled grains $panicle^{-1}$, grain and straw yields and P uptake was observed in both seasons. Spray of the tested cultivar with 2% orthophosphoric acid at MT or at MT plus LB gave the greatest values for all studied characters, except the F3 treatment (spray one time at late booting) which gave the least as compared to the other sprayed treatments because the plant had the required amount at this time. The results revealed that the combination of 36 or 54 kg P_2O_5 ha^{-1} along with foliar 2% H_3PO_4 at MT (mid tillering) treatment produced the same greatest values of grain yield and most of growth and yield attributes without any significant difference between them. From economical point of view, the combination of 36 kg P_2O_5 ha^{-1} with 2% H_3PO_4 sprayed at MT was the best combination because it produced the highest grain yield and saved one third of phosphorus fertilizer.

Key words*: Oryza sativa L., phosphorus fertilizer, foliar application*

1. INTRODUCTION

Maximizing and sustaining crop yields are main objectives to enhance yield production. One of the major problems constraining the development of an economically successful agriculture is nutrient deficiency (Fageria and Baligar, 2005). After nitrogen, phosphorus (P) has more widespread influence on both natural and agricultural ecosystems than any other essential plant elements (Brady and Weil, 2002). Higgs *et al*.(2000) reported that 30 to 50% of the increase in world food production since the 1950's is attributable to fertilizer use, including P use. Phosphorus deficiency in crop plants is a widespread problem in various parts of the world, especially in highly weathered soils, as well as calcareous/alkaline soils (Fageria and Baligar, 2001 and Faye *et al*., 2006). Worldwide applications of phosphate fertilizers now exceed over 30 million metric tons annually (Epstein and Bloom, 2005). The deficiency of this element is related to several factors. These factors are low natural level in some soils, high immobile or fixation capacity of soils, and uptake of modern crop cultivars in large amounts, loss by soil erosion, and use of low rate by farmers in developing countries.

Phosphorus is an essential constituent of adenosine triphosphate (ATP), nucleotides, nucleic acids, and phospholipids. Its major functions are in energy storage and transfer and membrane integrity. It is mobile within the plant and promotes tillering, root development, early flowering, and ripening (especially where the temperature is low). It is particularly important in the early growth stages. The addition of mineral P fertilizer is required when rice root system is not yet fully developed and the native soil P supply is little. P is remobilized within the plant during later growth stages if sufficient P has been absorbed during early growth (Doberman and Fairhruse, 2000). The timing of P fertilizer application may need to be changed to maximize crop use of the P fertilizer and avoid possible P deficiency. Knowledge of how rice responds to the P fertilizer application time during the growing season is essential for the development of efficient P fertilizer recommendations (Slaton *et al.*, 2002). Cahyono and Hartati (2013) reported that improving the efficiency of P fertilizer can be reached by providing a quickly dissolving phosphate fertilizer. However, as phosphate forms a reaction with other compounds soon after release from the fertilizer, a proper method of P application, split application, should be applied. Girma *et al*. (2007) reported that foliar application is a visible economic way to supplement the plant nutrients for more efficient fertilization. Foliar application of phosphorus could be used as an efficient phosphorus management tool in cereal crops when applied at appropriate growth stages and rates. Zayed (2012) reported that P application in basal and foliar combination at various growth stages significantly increases nutrient leaf content, plant height, tiller number hill^{-1}, and improves rice grain yield and its components. Barker and Pilbeam (2007) reported that among the various organic and inorganic phosphorus-containing compounds on vegetable crops, foliar spray with orthophosphoric acid was the most effective.

The objectives of the current study were to evaluate the effect of P fertilizer application level and the time of foliar spray applications with 2% orthophosphoric acid at different growth stages and their interaction on grain yield and P uptake of the Egyptian hybrid rice one (EHR1) variety.

2. MATERIALS AND METHODS

A field experiment was conducted during the two consecutive seasons 2014 and 2015 rice growing seasons at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt. The experiment was conducted to study the effect of three times of foliar spray applications with 2% orthophosphoric acid plus control under four phosphorus levels and their interaction on growth and yield and its component of the Egyptian hybrid rice one (EHR1) variety under transplanting method. The preceding crop was barely (*Hordeum Vulgare* L.) in the two seasons. The soil of the experimental site is clayey in texture. The initial soil chemical properties at 0 - to 20 cm soil depth of the experimental site were: pH 8.3, organic matter (OM) 1.5%, total nitrogen 475 mg kg^{-1}, available P 10 mg kg^{-1}, available K 360 mg kg^{-1}, available Zn 0.70mg kg^{-1}, available Fe 5.20 mg kg^{-1} and available Mn 2.9 mg kg^{-1}. The experimental design was split plot in randomized complete blocks arrangement with four replications. The main plots were assigned to four P fertilizer levels (soil application), while the sub-plots were assigned to four foliar application treatments with 2% orthophosphoric acid H_3PO_4 (assay 70 %, density 1.60 g cm^{-3} and P content 354 gm l^{-1}). Phosphorus fertilizer application at four levels *i.e.* control (without any phosphorus fertilizer) (P1), 18 (P2), 36 (P3) and 54 (P4) kg P_2O_5 ha^{-1} in the form of single superphosphate (15% P_2O_5) was used and applied as a basal at the time of final land preparation and merely incorporated into the soil. The four foliar application treatments were: control (without any of orthophosphoric acid) (F1), foliar spray with 2% of orthophosphoric acid at mid tillering (MT) period (F2), foliar spray with 2% of orthophosphoric acid at late booting (LB) (F3), foliar spray with 2% of orthophosphoric acid at MT + LB (F4). The amount of water for each plot for dissolving orthophosphoric acid was calculated based on 500 l water ha^{-1}. Seeds at the rate of 24 kg ha^{-1} were soaked in water for 24 hr, and then incubated for 48 hr to hasten early germination. Pre-germinated seeds were uniformly broadcasted in the nursery on 5th and 9th May of the two seasons, respectively. The permanent field was well prepared, *i.e.* plowed twice followed by good dry leveled and immediately irrigation and slight leveling were done. Seedlings were carefully uprooted from the nursery after 30 days from sowing and distributed through the plots.

Seedlings were manually transplanted into 12 m^2 subplots in 20x20 cm space between rows and hills, with 3 seedlings $hill^{-1}$. Nitrogen fertilizer was applied at the rate of 165 kg N ha^{-1} in the form of Urea (46.5% N). Urea was added in three equal splits (at basal application before transplanting, 30 and 60 days after transplanting). All plots received 48 kg K_2O ha^{-1} as basal dose in the form of Potassium Sulphate. All other agronomic practices were done as recommended. Plant samples (five hills each) were taken randomly from each plot five days before harvest to estimate the plant height (cm), number of tillers $hill^{-1}$ and number of panicles $hill^{-1}$. Ten panicles were collected randomly to estimate the panicle length (cm), panicle weight (g), number of both filled and unfilled grains per panicle, and 1000-grain weight. The crop of central 5 m^2 of each plot was harvested separately at full maturity, dried, threshed, then grain and straw yields were recorded and each of them was converted into t ha^{-1}. The grain yield was adjusted at 14% moisture content. P content in the grain and straw was determined according to the method of Watanabe and Olsen (1965). Total P uptake in biological yield (grain plus straw) was calculated by multiplying P content with their grain and straw yield. The obtained data were subjected to analyses of variance according to Gomez and Gomez (1984) using the computer program (Genstat). The significantly different means were compared using LSD test.

3. RESULTS AND DISCUSSION

3.1. Growth

Means of plant height and number of tillers $hill^{-1}$ of hybrid rice cv. Hybrid 1 as affected by phosphorus levels and time of foliar applications with 2% orthophosphoric acid in 2014 and 2015 are presented in Table (1). Plant height increased with increasing the rate of P fertilizer. Application of 54 kg P_2O_5 ha^{-1} produced the tallest plant and it was statistically at par with 36 kg P_2O_5 ha^{-1}. The control (without phosphorus as basal application (P1)) produced the shortest plants. Increase in plant height due to P application could be attributed to the positive role of P in the stimulation of cell division and elongation. These results are in harmony with those reported by Zayed (2012) and Naeem *et al.* (2016). The data also showed that in both seasons, foliar application with 2% H_3PO_4 at mid tillering (MT) period produced the tallest plants, while the control treatment produced the shortest plants in the two studied seasons.

Table (1): Plant height and tiller number of the Egyptian Hybrid Rice1 variety as affected by phosphorus levels and time of foliar application.

Treatment	Plant height (cm)		No. of tillers $hill^{-1}$	
	2014	2015	2014	2015
P level (basal)				
control (P1)	86.54	87.42	28.38	26.08
18 kg P_2O_5 ha^{-1} (P2)	91.50	91.31	28.96	27.90
36 kg P_2O_5 ha^{-1} (P3)	91.80	92.59	31.58	30.83
54 kg P_2O_5 ha^{-1} (P4)	92.19	92.94	31.95	31.52
LSD 5%	0.79	0.73	0.75	0.77
H_3PO_4 foliar spray				
Without (F1)	89.13	90.44	29.27	28.26
2% at MT(F2)	91.38	91.63	30.96	29.55
2% at LB (F3)	90.29	90.96	29.90	29.05
2% at MT + LB (F4)	91.23	91.23	30.73	29.47
LSD 5%	0.84	0.54	0.38	0.37
Interaction	NS	NS	*	*

LB= late booting MT= mid tillering.

The number of tillers of EHR1 cv. significantly varied due to the different levels of phosphorus as basal application in both seasons (Table 1). Application of 54 kg P_2O_5 ha^{-1} gave the highest number of tillers, but was statistically at par with 36 kg P_2O_5 ha^{-1} in the two studied seasons. Plants grown without phosphorus (control) had the lowest number of tillers $hill^{-1}$. It might be due to the role of P for enhancing the upground nodes to immerge more tillers. These findings are in agreement with those of Matsou *et al*. (1995), who reported that applying much P fertilizers is necessary to help rice plants to accelerate the phosphate absorption for increased tillering. Naeem *et al.* (2016) reported that P application increased the content of phosphorus leaf, which led to high ATP, NAD and NAPH that improve plant metabolism resulting in high relative growth rate and more tillers and bud formation. A similar trend was found by Alam *et al.* (2009) and Metwally *et al.* (2012). Number of tillers $hill^{-1}$ was also significantly affected by application of foliar spray treatments (Table 1). Foliar application with 2% H_3PO_4 at mid tillering (MT) period in the F2 treatment produced the peak number of tillers $hill^{-1}$ without any significant differences with foliar spray with 2% H_3PO_4 at mid tillering (MT) plus late booting (LB) in the treatment F4 in the two studied seasons. The plants untreated with H_3PO_4 foliar spray produced the lowest number of tillers $hill^{-1}$ in both seasons. Interaction between P fertilizer levels and time of foliar spray significantly affected the number of tillers $hill^{-1}$ (Table 2). The treatment of P4 (54 kg P_2O_5

Table (2): Tiller number of the Egyptian Hybrid Rice1 variety as affected by the interaction between phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	**F2**	**F3**	**F4**	**F1**	**F2**	**F3**	**F4**
control (P1)	27.75	28.50	28.17	29.09	26.06	26.25	25.92	26.11
18 (P2)	28.33	29.42	29.00	29.09	27.42	28.22	27.92	28.03
36 (P3)	30.22	32.89	30.89	32.30	29.45	31.50	30.86	31.53
54 (P4)	30.78	33.03	31.53	32.45	30.12	32.25	31.50	32.22
LSD 5 %	0.69				0.95			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

ha^{-1}) combined with F2 treatment (foliar spray with 2 % H_3PO_4 at MT) produced the highest number of tillers $hill^{-1}$ in both seasons which was statistically similar with values of P3F2 and P4F4 in the first season, and with P3F2, P3F4 and P4F4 in the second one. The lowest number of tillers $hill^{-1}$, however, was produced by the treatment P1F1. Doberman and Fairhruse (2000) reported that P is mobile within the plant and promotes tillering, root development, early flowering, and ripening. It is particularly important when P is applied at early growth stages. The addition of mineral P fertilizer is required when the rice root system is not yet fully developed.

3.2. Yield attributes

Means of panicle length, panicle weight and panicle numbers $hill^{-1}$ of EHR1 as affected by phosphorus levels and time of foliar application in 2014 and 2015 are presented in (Table 3).

Phosphorus basal applied caused a significant increase in panicle length as compared with control (Table 3). Application of 54 kg P_2O_5 ha^{-1} produced the longest panicles without significant differences with the application of 36 kg P_2O_5 ha^{-1} in the two studied seasons. These findings are in line with those of Alam *et al*. (2009), who reported that the higher the levels of N, the longer the panicle although panicle increase was not proportional to the increase in the level of P fertilizer. The data also showed that, in both seasons, the untreated control plants (P1) gave the shortest panicle. These results are in agreement with those of Sahar and Burbey (2003), and Metwally *et al.* (2012). Application of foliar spray treatments and their interaction did not show any significant variation in respect of panicle length in both seasons.

The tested P basal treatments significantly affected panicle weight in both seasons under study (Table 3). Plants fertilized with either level of phosphorus fertilizer significantly gave heavier panicle weight than the unfertilized ones. In both seasons, plants fertilized with either 36 or 54 kg P_2O_5 ha^{-1} gave the heaviest panicles. The lightest panicles were obtained in the absence of P application. Application of P fertilizer resulted in ensuring high ATP, which provided high photosynthesis resulted in more assimilates in pre and post heading, which lead to improve panicle filling and consequently increase in weight of panicle. These data are in agreement with those obtained by Sahar and Burbey (2003), Metwally *et al.*, (2012) and Naeem *et al*., (2016).

Significant variation in panicle weight was observed due to application of foliar spray treatments in the first season (Table 3). Spraying the tested variety with 2% H_3PO_4 at MT recorded the heaviest panicles as compared with the other foliar treatments. In the second season, there were no significant differences among all the foliar spray treatments. Interaction between P fertilizer basal applied in dry soil and P applied as foliar spray 2% orthophophoric acid did not show any significant variation in respect of panicle weight in both seasons.

The number of panicles $hill^{-1}$ gradually increased with the increase of phosphorus levels up to 54 kg P_2O_5 ha^{-1} (P4) (Table 3). Application of 54 kg P_2O_5 ha^{-1} produced the maximum number of panicles $hill^{-1}$ followed by the application of 36 kg P_2O_5 ha^{-1} treatment. As for foliar spray and its effect on the number of panicles $hill^{-1}$, data indicated that each of the foliar spray treatments caused an increase in the number of panicles as compared with the control. The highest number of panicles $hill^{-1}$ were found when the tested variety was sprayed at MT (F2) followed by F4 treatment (sprayed at both MT and LB). It could be attributed mainly to P application before planting which, encourage the aboveground nodes to emerge early and effective tillers as well as the role of P for increasing the flowering hormones (phytocrom) which increase the number of panicles during panicle initiation, besides

Table (3): Panicle length, panicle weight and the number of panicle hill^{-1} of the Egyptian Hybrid Rice1 variety as affected by phosphorus levels and the time of foliar application.

Treatment	Panicle length (cm)		Panicle weight (g)		No. of panicles hill^{-1}	
	2014	2015	2014	2015	2014	2015
P level (basal)						
control (P1)	22.90	21.81	3.88	3.98	26.38	24.58
18 kg P_2O_5 ha^{-1} (P2)	23.73	22.30	4.24	4.19	27.46	25.90
36 kg P_2O_5 ha^{-1} (P3)	23.74	23.04	4.47	4.31	29.11	28.58
54 kg P_2O_5 ha^{-1} (P4)	23.77	23.41	4.46	4.34	29.92	28.77
LSD 5%	0.34	0.43	0.13	0.17	0.25	0.77
H_3PO_4 foliar spray						
Without (F1)	22.50	22.61	4.14	4.19	27.33	26.14
2% at MT(F2)	23.78	22.83	4.41	4.26	29.02	27.43
2% at LB (F3)	23.54	22.55	4.25	4.18	27.96	26.92
2% at MT + LB (F4)	23.31	22.58	4.24	4.19	28.55	27.35
LSD 5%	NS	NS	0.14	NS	0.38	0.37
Interaction	NS	NS	NS	NS	*	*

MT=Mid tillering LB= Late booting

improving panicle growth rate including the number of branches and spikelets. A similar trend was found by Sahar and Burbey (2003), Alam *et al*. (2009) and Metwally *et al*.(2012). Significant variation in the number of panicles hill^{-1} of EHR1 was observed due to the interaction between P fertilizer as soil application and foliar spray with 2% H_3PO_4 treatments (Table 4). The combination of P4 with F2 treatments produced the maximum values of number of panicles hill^{-1} which was statistically at par with P3F2 and P4F4 in the first season and with P3F2, P3F4 and P4F4 in the second season. The minimum number of panicles hill^{-1} was recorded when no P fertilizer was added. The combination of P3 with each of F2 and F4 caused a continuous P supply for the tested cultivar through its different stages, that causes an increase in all biological and physiological processes, especially photosynthesis which increase the number of panicles and other components of yield. Doberman and Fairhruse (2000) reported that P is remobilized within the plant during later growth stages if sufficient P has been absorbed during early growth.

The number of filled grains panicle^{-1}, the number of unfilled grains panicle^{-1} and 1000-grain weight as influenced by phosphorus fertilizer as basal application and orthophosphoric acid as foliar spray are presented in Table (5). Data indicated that basal application of phosphorus fertilizer caused a significant increase in filled grains panicle^{-1} as compared with control. The greatest number of grains was found when either 36 or 54 kg P_2O_5 ha^{-1} was applied without any significant difference between them. It might be due to the continuous supply of adequate amount of phosphorus for the tested rice cultivar during its different stages that increases the biological and physiological process such as ATP, NAD, and NADP which enhance and increase the photosynthesis and its assimilates consequently increase the filling process. These results are in agreement with those reported by Sahar and Burbey (2003), Alam *et al*. (2009) and Metwally *et al.* (2012). As for foliar spray with 2% orthophosphoric acid, data revealed that spraying the EHR1 cultivar with 2% orthophosphoric acid at any of the tested periods caused an increase in the number of filled grains as compared with the control. The highest number of filled grains was observed when the plants were sprayed at MT without any significant difference with the spraying at MT plus LB in the first season, while in the second season only spraying at mid tilliring (MT) produced the highest value in this aspect. The decrease in grain filling numbers under spraying by 2% orthophosphoric acid at late booting might be due to the presence of the required amount of phosphorus at filling period, resulting in low response under this treatment (F3).

Data in Table (6) clarified that there was a significant difference among the interaction treatments. The combination of each foliar spray treatments with any level of phosphorus

Table (4): Panicles number hill^{-1} of the Egyptian Hybrid Rice1 variety as affected by the interaction between phosphorus levels and the time of different foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	25.75	26.50	26.17	27.09	24.56	24.75	24.42	24.61
18 (P2)	26.83	27.92	27.50	27.59	25.42	26.22	25.91	26.03
36 (P3)	28.00	30.67	28.67	29.09	27.20	29.25	28.61	29.28
54 (P4)	28.75	31.00	29.50	30.42	27.37	29.50	28.75	29.47
LSD 5 %	0.67				0.73			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

Table (5): Number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and 1000-grain weight of the Egyptian Hybrid Rice1 variety as affected by phosphorus levels and the time of foliar application.

Treatment	Filled grain panicle^{-1}		Unfilled grain panicle^{-1}		1000 grain weight (g)	
	2014	2015	2014	2015	2014	2015
P level (basal)						
control (P1)	151.40	152.16	15.16	13.05	24.20	24.35
18 kg P_2O_5 ha^{-1} (P2)	163.64	159.64	14.14	12.62	24.71	24.93
36 kg P_2O_5 ha^{-1} (P3)	171.93	164.20	13.28	11.93	25.53	25.57
54 kg P_2O_5 ha^{-1} (P4)	172.94	166.42	11.71	10.67	25.50	25.54
LSD 5%	1.46	1.84	0.55	0.31	0.22	0.28
H_3PO_4 foliar spray						
Without (F1)	161.39	157.60	15.19	13.44	24.70	24.81
2% at MT(F2)	167.75	163.92	12.23	11.08	25.26	25.33
2% at LB (F3)	164.33	159.80	14.20	12.61	24.80	24.95
2% at MT + LB (F4)	166.69	161.10	12.67	11.12	25.19	25.30
LSD 5%	1.23	1.49	0.62	0.34	0.26	0.36
Interaction	*	NS	*	*	*	*

MT=Mid tillering LB= Late booting

fertilizer basal applied cased an increase in number of filled grains panicle^{-1} as compared with control. The greatest number of filled grains panicle^{-1} was observed when F2 treatment was combined with either P3 or P4 treatment. For economical point of view, the combination of F2 with P3 treatment was the best combination. The combination of F2 with P3 treatment makes continuous supply of adequate amount of phosphorus to the tested rice hybrid and improves the viability of flag leaf beside the second and third leaves which impact about 75 % from total photosynthesis and its products (assimilates). The assimilates or metabolites stream are translocated directly from flag leaf to the spikelets (from source to sink) and consequently increase the filling rate percentage, resulting in an increase in number of filled grains.

Number of unfilled grains panicle^{-1} of the Egyptian Hybrid Rice1 was significantly affected by basal application of P levels (Table 5). The plants fertilized with 54 kg P_2O_5 ha^{-1} produced the lowest number of unfilled grains in both seasons. While the plants that had no basal P fertilizer gave the highest number of unfilled grains. Tanaka *et al.,* (1995) and Metwally (2007) reported that the effect of P application on unfilled grain is mainly attributed to that P is rapidly deposited in spikelets during the ripening stage. With the progress of ripening, it ultimately accumulates in the form of phytic acid in cellular particles of the aleurone layer. Phytic acid becomes the source of phosphoric acid. Phytic acid function to adjust the concentration of phosphoric acid is utilized for starch synthesis. So, the highest level of phosphorus increases the metabolites stream translocated from source to sink and results in an increase in the maximum number of spikelets and minimizes the number of unfilled grains. The finding of the present

Table (6): Number of filled grains panicle^{-1} of the Egyptian Hybrid Rice1 variety as affected by the interaction between phosphorus levels and the time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014			
	F1	F2	F3	F4
0 (P1)	147.80	153.45	149.40	154.95
18 (P2)	160.45	167.05	161.80	165.25
36 (P3)	166.75	175.70	172.45	172.80
54 (P4)	170.55	174.80	173.65	173.75
LSD 5 %	1.94			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

study is in agreement with that of Alam *et al.* (2009) and Metwally *et al*. (2012).

The data in Table (5) also showed that foliar spray with 2% H_3PO_4 at MT in F2 treatment gave the lowest value of number of unfilled grains which is statistically similar with the value of foliar spray with 2% H_3PO_4 at MT+ LB stages (F4) in both seasons. Interaction of P basal treatments and foliar spray with 2% H_3PO_4 at different time of application significantly affected the number of unfilled grain panicle^{-1} in both seasons (Table 7). Application of 54 kg P_2O_5 ha^{-1} (P4) combined with F2 treatment gave the lowest values of unfilled grain panicle^{-1} in both seasons. The highest values of unfilled grain panicle^{-1}, however, were obtained by the treatment P1F1 (no P fertilizer was added). A similar trend was found by Zayed (2012).

The data in Table (5) also revealed that basal application of phosphorus or as foliar using 2% orthophosphoric acid caused an increase in 1000-grain weight as compared with control treatment. The highest 1000-grain weight was observed either with 36 or 54 kg P_2O_5 ha^{-1} in the two studied seasons. Spraying the tested cultivar with 2% orthophosphoric acid at MT (F2) gave the heaviest 1000-grain weight followed by F4 treatment without any significant difference between them in the two seasons under study. The interaction between P levels (basal application) and 2% orthophosphoric acid sprayed at different periods in 1000-grain weight of EHR1 is presented in Table (8). Data revealed that mostly the combination of F2 with each of P3 and P4 treatments and the combination of F4 with each of P3 and P4 treatments produced the greatest 1000-grain weight, while combination of F1 with P1 gave the least in the two studied seasons. The increase in 1000-grain weight due to the P applied basally with P as foliar spray in different periods could be attributed to improvement of rice growth and increased P content in leaf at growth stages, particularly during reproductive and active grain filling stages, which improves photosynthesis and reaches to maximum assimilates that are translocated rapidly from source to sink and consequently increase the filling of spikelet completely resulted in heavy grains. A similar trend was found by Zayed (2012).

3.3.Grain and straw yields

Grain and straw yields of the hybrid rice variety as influenced by the basal application of phosphorus fertilizer and the foliar application with 2% orthophosphoric acid at different stages are presented in Table (9). Data showed that the application of P either basally or foliar caused an increase in grain yield as compared with control. The greatest value of grain yield was obtained when the cultivar under study was fertilized with 54 kg P_2O_5 ha^{-1} followed by 36 kg P_2O_5 ha^{-1} when the P was applied basally before planting. Shah (2002), Alam *et al.* (2009), Metwally *et al*., (2012) and Naeem *et al.* (2016) also reported a similar response of P application on grain yield. Data also showed that when application of P as foliar spray (2% orthophosphoric acid) at mid tillering (MT) or at both MT + LB (late booting), the grain yield also reached to maximum value as compared with the other spraying treatments. The interaction between phosphorus levels basally and foliar application with 2% orthophosphoric acid at different periods is presented in Table (10). Data revealed that all the combinations of P levels with each of foliar spray treatments significantly increased grain yield as compared with control treatment (P1F1). The highest grain yield was obtained when either F2 or F4 was combined with each of P3 and P4 treatments, without any significant differences among them. The combination of F3 (sprayed at late booting) with any of P levels did not reach to the maximum yield; it might be due to the present of enough amount of phosphorus during filling period and consequently the response of plant at this time to P was very low. The increases of grain yield under P3 and P4 or with combination of either F2 and F3 with both P3 and P4 could be attributed to adequate enough of P as energetic elements that increases the biological processes (ATP, NAD and NADP) which leads to supply all the chemical compounds by energy inside the plant beside the improvement of physiological processes such

Table (7): Number of unfilled grains panicle^{-1} of the Egyptian Hybrid Rice1 variety as affected by interaction between phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	17.20	12.75	16.50	14.17	15.07	11.80	14.52	11.80
18 (P2)	15.85	13.60	13.95	13.15	14.64	11.60	13.05	11.17
36 (P3)	14.90	11.80	14.60	11.80	12.77	10.92	12.03	11.98
54 (P4)	12.80	10.75	11.75	11.55	11.30	9.99	10.87	10.53
LSD 5 %	1.17				0.65			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

Table (8): Weight of 1000-grain the Egyptian Hybrid Rice1 variety as affected by interaction between phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	24.07	24.34	24.11	24.28	24.15	24.45	24.30	24.50
18 (P2)	24.35	24.96	24.47	25.06	24.58	25.12	24.83	25.17
36 (P3)	25.08	26.08	25.28	25.68	25.23	26.02	25.29	25.73
54 (P4)	25.30	25.65	25.32	25.74	25.28	25.72	25.36	25.79
LSD 5 %	0.50				0.64			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

Table (9): Grain, straw yields and phosphorus uptake kg ha^{-1} of the Egyptian Hybrid Rice1 variety as affected by phosphorus levels and time of foliar application.

Treatment	Grain yield t ha^{-1}		Straw yield t ha^{-1}		P uptake kg ha^{-1} by biological yield	
	2014	2015	2014	2015	2014	2015
P level (basal)						
control (P1)	9.75	9.80	12.63	13.53	26.76	27.11
18 kg P_2O_5 ha^{-1} (P2)	10.28	10.55	13.22	13.92	30.05	30.60
36 kg P_2O_5 ha^{-1} (P3)	11.13	11.12	14.48	14.49	35.91	34.54
54 kg P_2O_5 ha^{-1} (P4)	11.40	11.29	14.92	14.86	37.64	36.22
LSD 5%	0.25	0.11	0.33	0.24	0.44	0.30
H_3PO_4 foliar spray						
Without (F1)	10.29	10.12	13.06	13.69	29.92	28.92
2% at MT (F2)	10.92	11.09	14.12	14.38	33.81	33.82
2% at LB (F3)	10.43	10.48	13.71	14.15	31.84	31.27
2% at MT + LB (F4)	10.93	11.07	14.36	14.59	34.77	34.57
LSD 5%	0.22	0.10	0.29	0.27	0.45	0.20
Interaction	*	*	*	*	**	**

MT=Mid tillering LB= Late booting

Table (10): Grain yield t ha^{-1} of the Egyptian Hybrid Rice1 variety as affected by interaction between phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	9.42	9.89	9.64	10.03	9.30	10.10	9.66	10.15
18 (P2)	9.94	10.55	10.06	10.57	10.06	10.88	10.46	10.80
36 (P3)	10.74	11.54	10.84	11.40	10.46	11.57	10.80	11.65
54 (P4)	11.05	11.68	11.18	11.70	10.67	11.79	11.01	11.70
LSD 5 %	0.44				0.32			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

as photosynthesis due to increase in the viability of flag leaf (late the senescence of flag leaf) and second plus third leaf which represent about 75% from the total photosynthesis during filling period. The highest amount of metabolites produced of high photosynthesis, that are directly translocated to the panicles and completely fill the highest number of the spikelets of the large panicle of hybrid rice and consequently increases the number of filled panicles, weight of panicle, number of filled grains resulting in an increase of the grain yield. Choudhury *et al*. (2007) reported that P applied during the tillering stage is most efficiently utilized for grain production. These results are in agreement with Zayed (2012), who reported that both of early P application *via* root medium and P application *via* foliage were effective for considerable rice grain yield. Doberman and Fairhruse (2000) reported that P is remobilized within the plant during later growth stages if sufficient P has been absorbed during early growth.

Straw yield increased linearly with increment of fertilizer levels of phosphorus up to 54 kg P_2O_5 (Table 9). In both seasons, the highest values of straw yield were recoded when the plants were fertilized at the rate of 54 kg P_2O_5 ha^{-1}, while the lowest straw yield was obtained when no P fertilizer as a basal was added. High straw yield with increase levels of P basal application might be due to the increase in growth, *i.e.* plant height and the number of tillers (plant canopy). These findings are in close agreement with Tang and Yu (2002) and Metwally *et al*. (2012), who reported that the increase in straw yield with P fertilizer might be due to the increase in vegetative growth due to enhancement of cell division and elongation in stem internodes. Straw yield of EHR1 was also significantly increased due to application of P as foliar spray at different growth stages (Table 9). Foliar spray with 2% H_3PO_4 at the period of MT+LB (F4) gave the maximum straw yield which was statistically similar with the treatment F2 in both seasons. The lowest straw yield was recorded with control.

Interaction between P basal treatments and foliar spray with 2% H_3PO_4 at different growth stages significantly affected the straw yield in both seasons (Table 11). Application of 54kg P_2O_5 ha^{-1} (P4) coupled with F4 treatment gave the highest value of straw yield which was statistically similar to the values of P3F4 and P4 F2 treatments in the first season and with P2F4 in the second season. The lowest values of straw yield, however, were obtained by the treatment P1 F1 (no P fertilizer was added).

Table (11): Straw yield t ha^{-1} of the Egyptian Hybrid Rice1 variety as affected by interaction between phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	11.93	12.95	12.59	13.05	12.72	13.84	13.62	13.95
18 (P2)	12.63	13.66	12.80	13.79	13.24	14.08	13.92	14.44
36 (P3)	13.61	14.62	14.58	15.13	14.29	14.50	14.38	14.80
54 (P4)	14.10	15.23	14.89	15.46	14.50	15.07	14.67	15.18
LSD 5 %	0.44				0.37			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

3.4.Phosphorus uptake (kg ha^{-1})

Phosphorus uptake by biological yield (grain and straw yields) was differed significantly among P basal application, time of foliar application and their interaction in 2014 and 2015 seasons (Table 9). Phosphorus uptake by biological yield significantly increased as P fertilizer level increased up to 54 kg P_2O_5 ha^{-1}. The greatest P uptake was observed when the tested cultivar received 54 kg P_2O_5 ha^{-1}, while the lowest value was found when the cultivar did not receive any P fertilizer. These results are holding true in the two studied seasons. It could be attributed to presence of high available P in the soil, under the highest level of P fertilizer which caused increases in P uptake by rice plants besides increasing the biological yield by increasing the levels of P basal application as compared with unfertilized treatment. A similar trend was found by Gewaily *et al.* (2011) and Naeem *et al*. (2016). The data in Table (9) also showed that phosphorus uptake by EHR1 cv. was also significantly increased due to application of P as foliar spray at different growth stages. Foliar spray with 2% H_3PO_4 at MT + LB periods in F4 treatment gave the

Table (12): Phosphorus uptake kg ha^{-1} of the Egyptian Hybrid Rice1 variety as affected by phosphorus levels and time of foliar application.

H_3PO_4 foliar / P_2O_5 kg ha^{-1}	2014				2015			
	F1	F2	F3	F4	F1	F2	F3	F4
0 (P1)	25.06	27.37	26.34	28.26	25.14	28.22	26.76	28.74
18 (P2)	28.14	30.91	28.76	32.37	28.10	31.62	30.10	32.61
36 (P3)	32.70	37.84	34.95	38.17	30.65	36.41	33.45	37.64
54 (P4)	33.80	39.11	37.33	40.30	31.79	39.00	34.78	39.30
LSD 5 %	0.34				0.93			

F1= without foliar, F2= foliar 2% H_3PO_4 at MT, F3= foliar 2% H_3PO_4 at LB and F4= foliar 2% H_3PO_4 at MT+LB.

maximum phosphorus uptake in both seasons. The lowest phosphorus uptake was obtained with control. Interaction between P as basal application and foliar spray with 2% H_3PO_4 at different growth periods positively affected the P uptake in both seasons (Table 12). Application of 54 kg P_2O_5 ha^{-1} (P4) coupled with F4 treatment produced the highest values of P uptake in the both seasons. The lowest values of P uptake, however, were obtained by the treatment P1 F1 (no P fertilizer was added). A similar trend was found by Zayed (2012) who reported that P application either as basal or foliar spray encourages rice growth involving shoots and root systems resulting in high capability for P uptake especially under more available P in the soil.

Conclusion

According to the previous results, it could be concluded that

1-The Hybrid Egyptian Rice 1 variety responded to phosphorus fertilizer up to 54 P_2O_5 kg ha^{-1} and produces the greatest yield.

2-Spraying the Egyptian Rice Hybrid 1 variety with 2% orthophosphoric acid at MT period improved the yield and its components.

3-The combination of 2% orthophosphoric acid as foliar spray at MT period with either 54 or 36 P_2O_5 kg ha^{-1} improves most of yield components and produces the same highest grain yield.

4-From the economic point of view, only application of 36 P_2O_5 kg ha^{-1} combined with 2% orthophosphoric acid at MT period was the best treatment which caused an improve in plant growth, yield component and gave the greatest grain yield as well as saving 18 P_2O_5 kg ha^{-1} which equals 120 kg single super phosphate (15% P_2O_5) per ha or 50 kg single super phosphate per fadden. In other words, it saved one third of recommended dose of P fertilizer.

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أداء صنف الأرز هجين مصرى واحد تحت مستويات مختلفة من السماد الفوسفاتى والرش بحامض الارثوفوسفوريك

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ملخص

أجريت هذه الدراسة فى موسمى زراعه الأرز 2014 و2015 بالمزرعه البحثية لمحطة بحوث سخا – كفر الشيخ – مصر وذلك لدراسة سلوك صنف الأرز هجين مصرى واحد تحت مستويات مختلفة من سماد الفوسفات وهى كنترول (بدون أضافه) ، 18، 36 و 54 كجم فو$_2$أ$_5$ للهكتار وكذلك الرش بحامض ارثوفوسفوريك بتركيز 2% . وذلك عند فترات نمو مختلفة من عمر النبات وكانت المعاملات هى كونترول (بدون رش) و الرش ب 2% حامض ارثورفوسفوريك عند فتره التفريع المتوسط ،الرش قبيل طرد السنابل والرش عند مرحله التفريع المتوسط . كان تصميم التجربة هو القطع المنشقة وذلك فى توزيع القطاعات الكاملة العشوائية فى أربع مكررات حيث وضعت مستويات السماد الفوسفاتى بالقطع الرئيسية ووضعت معاملات الرش بحامض الفورسفوريك بالقطع المنشقة. تمت دراسة الصفات الاتيه: طول النبات - عدد الفروع للجورة – طول السنبله – وزن السنبله – عدد السنابل لكل جوره - عدد الحبوب الممتلئه وعدد الحبوب الفارغه لكل سنبلة و وزن 1000– حبه، محصول الحبوب ومحصول القش وكمية الفسوسفور الممتص. وقد أوضحت النتائج الاتى:- زادت كل الصفات المدروسة بتطبيق اى من المعاملات وذلك مقارنه بالكنترول (بدون معامله) كان إستخدام كلا من المستويين 36- 54 كجم فو$_2$أ$_5$ للهكتار قد أعطى اعلى القيم للصفات المدروسة ماعدا عدد الحبوب الفارغه الذى سجل اعلى قيم من الكنترول (بدون معامله) . زادت قيم كلا من طول النبات عدد الفروع - عدد السنابل للجوره - وزن السنبله وطول السنبله عدد الحبوب الممتلئه لكل سنبله ومحصول الحبوب والقش وكذلك الفوسفور الممتص زيادة معنوية بزيادة مستويات السماد الفوسفاتى. أوضحت النتائج أيضا ان الرش بتركيز 2% حامض ارثوسوسفوريك عند فتره التفريع المتوسط او الرش عند التفريع المتوسط بالإضافة إلى الرش قبيل طرد السنابل قد أعطى اعلى القيم لكل الصفات المدروسة بينما الرش قبيل الطرد منفردا قد أعطى اقل القيم مقارنه بمعاملات الرش الأخرى وذلك لحصول النبات على احتياجاته من الفوسفور عند مرحله النمو المبكر. بينت النتائج ان إضافة السماد الفوسفاتى بمعدل 36 او 54 كجم فو$_2$أ$_5$ للهكتار مع الرش عند مرحله التفريع المتوسط قد أعطت أفضل القيم لمحصول الحبوب ولمعظم الصفات المدروسة وبدون وجود اى فروق معنوية بينهما. من وجهه النظر ألاقتصاديه فان استخدام معدل 36 كجم فو$_2$أ$_5$ للهكتار مع الرش بتركيز 2% حامض فوسفوريك عند فتره التفريع المتوسط كان الأفضل حيث أنتج اعلى قيم لمحصول الحبوب و أدى إلى توفير 18كجم فو$_2$أ$_5$ (ثلث الكميه اللازمة لإنتاج اعلى محصول) تحت ظروف الدراسة.

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