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Productivity and Quality of Some Rice (*oryza sativa* l.) Cultivars as Affected by Phosphorus Fertilizer Levels

Mohsen A. Badawi[1], Saleh E. Seadh[1*], El-Sayed S. Naeem[2], Ahmed S.E. El-Iraqi[1]

1. Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt.

2. Rice Research Department in Sakha, Field Crops Research Insatiate, ARC, Giza, Egypt.

Abstract: The field experiment was carried out at the Kafr El-Tayfa Village, Kafr El-Sheikh Center, Kafr El-Sheikh Governorate, during 2015 and 2016 seasons to determine the effect of (5) phosphorus fertilizer levels (0, 12, 24, 36 and 48 kg P_2O_5/ha) on growth, grain yield and its attributes and quality characters of some rice cultivars (Namely, Giza 179, Giza 182 and Misr hybrid 1). The experiment was carried out in strip-plot design with four replications. The vertical plots were assigned to rice cultivars. The horizontal plots were occupied with the phosphorus fertilizer levels. The obtained results showed that Misr hybrid 1 cultivar significantly superior Giza 179 and Giza 182 cultivars in number of days to 50 % heading, total chlorophylls in flag leaf, flag leaf area, plant height, panicle length, number of branches/panicle, number of grains/panicle, phosphorus content, total nitrogen and crude protein percentages in rice grains in both seasons. Whereas, Giza 179 cultivar exceeded Misr hybrid 1 and Giza 182 cultivars and resulted in the highest values of number of panicles/m^2, 1000-grain weight, grain and straw yields/ha in both seasons. While, Giza 182 cultivar recorded the highest values of total carbohydrates percentages in rice grains in both seasons. Application the highest level of phosphorus fertilizer (48 kg P_2O_5/ha) produced the highest values of growth characters, yield and its attributes and grains quality, excluding total carbohydrates percentages in rice grains in both seasons. According to the obtained results from this study, it can be concluded that, fertilizing rice Giza 179 cultivar with kg 48 P_2O_5/ha could be recommend to achieve maximum grain and straw yields per unit area and fertilizing Misr hybrid 1 cultivar with kg 48 P_2O_5/ha to obtained growth and individual yield of plant under the environmental conditions of Kafr El-Sheikh Center, Kafr El-Sheikh Governorate, Egypt.

Key words: Rice (*Oryza sativa* L.), Varieties, Genotypes, Phosphorus fertilizer, Yield and yield components, Quality.

INTRODUCTION

Rice (*Oryza sativa* L.) is a cereal crop and major source of income for a large number of peoples. In Egypt, rice is playing a major role in food security and we need to produce rice with self sufficiency and exported to improve the national income. Increasing rice productivity can be achieved through using high yielding cultivars and optimizing the cultural practices such as phosphorus fertilizer levels.

Crop genotypes play a dominant role in crop production systems. They affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions. Significant varietal differences in grain yield and its attributes and grains quality was observed among rice cultivars by many investigators. In this concern; Ahmadikhah *et al.* (2010) showed that the two studied varieties were significantly differed in their performance and all studied traits, except 1000-grain weight; Salama *et al.* (2011) pointed out that Egyptian hybrid rice 1 cultivar (H_1) significantly surpassed the local cultivar (Giza 178) in number of days from transplanting to 50 % heading, flag leaf area, plant height, number of panicles/m^2, panicle length, number of grains/panicle, weight of grains/panicle, 1000-grain weight, grain and straw yields/ha; Badawi *et al.* (2013) showed that IET 1444 cultivar significantly superior the two local cultivars

*Corresponding author: seseadh04@mans.edu.eg

Giza 177 and Giza 178 and resulted in the highest values of total chlorophyll content, flag leaf area, plant height, number of panicles/m^2, panicle length, number of grains/panicle, 1000-grain weight, grain and straw yields per feddan in both seasons; Tripathi *et al.* (2013) showed that studied varieties were differed in plant height, number of tillers, number of panicles, maturity days and grain yield Hussain *et al.* (2014) reported that Koshihikari was the tallest varieties and Nipponbare the shortest one. Japonica varieties produced higher number of panicles/m^2, ripening ratios and lower nitrogen content in panicle, stem and leaves; NERICA-4 gave higher values of SPAD. The highest straw yield (11.53 t/ha) and paddy yields (6.79 t/ha) were obtained from IR-28; Yuni-Widyastuti and Rumanti (2015) found that grain yield of rice was significantly affected by genotypes. They added that the number of panicles per hill and the number of filled grains per panicle could be used as selection criteria for yield in hybrid rice; Hossain *et al.* (2016) revealed that different rice varieties had significant effect on growth and yield of rice. Effect of varieties found highest for grain (6.38 t/ha) and straw (6.60 t/ha) yields in case of Binadhan-10 variety; Shovon *et al.* (2016) showed that the hybrid varieties exhibited superiority in respect of growth characters and yield attributes viz. effective tillers/m^2 and 1000-grain weight over the inbred. The highest grain yield was achieved from Tia (7.82 t/ha), which was closely followed by Shakti 2 (7.65 t/ha).

Phosphorus is an essential constituent of adenosine triphosphate (ATP), nucleotides, nucleic acids, and phospholipids. Its major functions are in energy storage and transfer within the plant (Dick, 2011). Phosphorus is also a component of other compounds necessary for transfer of genetic material DNA and RNA (Zhang and Raun, 2006). So, the requirement of plants for phosphorus is only next to nitrogen. Phosphorus fertilizer is critical for plant growth, especially in the early jointing stages and for enhancing grain yield and yield components of rice. In this concern, Das *et al.* (2003) reported that increasing phosphorus levels increased both grain and straw yields of rice, thus increased the economic return; Alam *et al.* (2009) reported that application phosphorus fertilizer at the rate of 72 kg/ha produced that highest values of grain yield of rice (7.23 t/ha), while plants grown without phosphorus fertilizer gave the lowest grain yield (4.99 t/ha) ; Slaton *et al.* (2009) reported that phosphorus fertilizer was often needed to maintain soil fertility and/or maximize agronomic yield of rice grown on silt loam soils; Bünemann *et al.* (2011) stated that phosphorus fertilizer application is one of the most important factors for higher crop yields; Sharma *et al.* (2012) found that increasing phosphorus levels up to 45 kg P/ha significantly increased growth parameters (plant height, flag leaf area, dry matter accumulation), yield components (number of panicles/m^2 and number of grains/panicle) and grain and straw yields; Yoseftabar (2013) showed that plant height, stem height, total fertile tillers and rice grain yield significantly increased with increasing phosphorus fertilizer rates up to 90 kg/ha; Dakshina-Murthy *et al.* (2015) found that the increase in phosphorus doses from 100 to 125% (from 60 to 75 kg/ha) significantly improved rice grain yield; Ochwoh *et al.* (2015) reported that application of phosphorus at the rate of 25 kg P_2O_5/ha gave highest and significant effect on grain yield.

Thus, the aim of this study was to determine the effect of phosphorus fertilizer levels on growth, grain yield and its attributes and grains quality characters of some rice cultivars under the environmental conditions of Kafr El-Sheikh Center, Kafr El-Sheikh Governorate during 2015 and 2016 seasons.

MATERIALS AND METHODS

The field experiment was carried out at Kafr El-Tayfa Village, Kafr El-Sheikh Center, Kafr El-Sheikh Governorate, during 2015 and 2016 seasons to determine the effect of phosphorus fertilizer levels on growth, grain yield and its attributes and grains quality characters of some rice cultivars. The experiment was carried out in strip-plot design with four replications. The vertical plots were assigned to the three rice cultivars (Giza 179, Giza 182 and Misr hybrid 1). Summary of the main details of the studied cultivars are shown in Table 1.

Table 1: The pedigree of the studied cultivars.

Name	Pedigree
Giza 179	G2 6293 X G2 1368
Giza 182	[G 181 X IR 39422] X Giza 181
Misr hybrid 1	IR 69625 X Giza 178

The horizontal plots were occupied with the phosphorus fertilizer levels *i.e.* 0, 12, 24, 36 and 48kg P_2O_5/ha. Calcium superphosphate (15.5 % P_2O_5) was added at the aforementioned rates on the dry soil after ploughing and division to experimental plots and before leveling. The experimental plot area was 2.0 m width and 3.0 m length, resulted an area of 6.0 m^2. The preceding winter crop for the nursery and permanent field was bread wheat (*Triticum aestivum* L.) in both seasons. Soil samples were taken at random from the experimental field area to measure the mechanical and chemical soil properties and the corresponding data are presented in Table 2.

Table 2: Mechanical and chemical soil characteristics at the experimental site during the two growing seasons of 2015 and 2016.

Soil analysis		**2015**	**2016**
A: Mechanical properties:			
Fine sand (%)		19.21	19.31
Corse sand (%)		3.82	3.62
Silt (%)		29.27	29.17
Clay (%)		47.70	47.90
Texture class		Clayey	Clayey
B: Chemical analysis			
Soil reaction pH in soil water extraction (1:2.5)		7.82	7.89
EC (ds/m^2) in soil water extraction (1:5) at 25^0C		1.14	1.12
Organic matter (%)		1.49	1.47
Saturation percentage (%)		62.65	62.50
Calcium carbonate (%)		4.12	4.09
	N	55.20	53.80
Available (ppm)	P	5.66	5.76
	K	171.60	172.50

The nursery seedbed preparation was well performed. The nursery land was fertilized with calcium superphosphate (15.5 % P_2O_5) at the rate of 4 kg/175 m^2) on the dry soil before ploughing. Nitrogen in the form of urea (46.0 % N) was added at the rate of 3 kg/175 m^2 after last ploughing before leveling and zinc sulphate (24 % Zn SO_4) at the rate of one kg/175 m^2 was also incorporated with soil after leveling and before sowing. Rice grains at the rate of 60 kg/ha were soaked in water for about 48 hours and incubated for 24 hours. Thereafter, they were broadcasted with 2-3 cm of standing water in the nursery on the first week of May in the first and second seasons. Weeds were chemically controlled with Saturn 50 % at the rate of 2 liters dissolved in 100 liters of water/ha and sprayed using at seven days after sowing using Knapsack Sprayer. The permanent land was prepared as recommended. Calcium superphosphate (15.5 % P_2O_5) was added as formerly mentioned. Twenty five days old seedlings were transplanting at a rate of 4-5 seedlings/hill adopting a spacing of 20 x 20 cm, which were sown regularly with the rate of 25 hills/m^2, with 2-3 cm of the standing water on the land surface. Nitrogen at the recommended rate (60 kg N/ha) in the form urea (46 % N) was added in two equal portions. The first part was added after 4 days from transplanting and the second part was added after 24 days from the first one. Potassium in the form of potassium sulphate (48 % K_2O) was added to soil at the recommended rate (24 kg K_2O/ha) with the first dose of nitrogen fertilizer. The weeds were chemically controlled with Saturn 50 % as mentioned after transplanting with four days. However, the common agricultural practices for growing rice according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

DATA RECORDED:

A. GROWTH CHARACTERS:

1- Number of days from transplanting to 50 % heading.

2- Total chlorophyll content (SPAD).

3- Flag leaf area (cm^2): It was estimated at maximum tillering stage (90 DFS) following the formula reported by Yoshida *et al.* (1976) as follows:

Flag leaf area (cm^2) = K x leaf length (cm) × maximum width (cm).

Where: K (0.75) a correction factor can be used for all growth stages, except the seedling and maturity stages.

B. YIELD AND YIELD COMPONENTS:

4- Plant height (cm).

5- Number of panicles/m^2.

6- Panicle length (cm).

7- Number of branches/panicle.

8- Number of grains/panicle.

9- 1000- grain weight (g).

10- Grain yield (t/ha): The plants in the inner four square meter of each experimental unit were harvested, collected together, labeled and tied. Thereafter, plants were transported to the threshing floor for air drying for five days, threshed and the grains were separated. The grain yield was recorded in kg/4 m^2, and then it was converted to record grain yield in ton per feddan at 14 % moisture content.

11- Straw yield (t/ha): It was estimated using the same steps for grain yield estimation.

C- QUALITY COMPONENTS:

12- Phosphorus content (mg/100 g): It was determined in rice grains colorimetric at spectrophotometer at wave length 640 nm (Jackson, 1967).

13- Crude protein (%): It was calculated by multiplying the total nitrogen values which estimated in rice grains by the improved Kjeldahl – method according to A.O.A.C. method (1990) by 5.57.

14- Total carbohydrates (%): It was determined in rice grains using the anthrone method as described by Sadasivam and Manickam (1996).

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip plot design as mentioned by Gomez and Gomez (1984). Least significant difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

A- Cultivars performance:

The obtained results in Tables 3 and 4 show that the three studied cultivars *i.e.* Giza 179, Giza 182 and Misr hybrid 1 cultivars were significantly differed in growth characters (number of days from transplanting to 50 % heading, total chlorophyll content and flag leaf area), yield and its attributes (plant height, number of panicles/m^2, panicle length, number of branches/panicle, number of grains/panicle, 1000-grain weight, grain and straw yields/ha) and grains quality (phosphorus content, total nitrogen, crude protein and total carbohydrates percentages) in both seasons.

It could be observed that Misr hybrid 1 cultivar significantly superior Giza 179 and Giza 182 cultivars and resulted in the highest values of number of days to 50 % heading, total chlorophylls in flag leaf, flag leaf area, plant height, panicle length, number of branches/panicle, number of grains/panicle, phosphorus content, total nitrogen and crude protein percentages in rice grains in both seasons. This means that Misr hybrid 1 cultivar had greater growth and some yield attributes than Giza 179 and Giza 182 cultivars in the first and second seasons of this study. On the other side, this cultivar resulted in the lowest values of number of panicles/m^2, 1000-grain weight and total carbohydrates percentages in grains.

Whereas, Giza 179 cultivar exceeded Misr hybrid 1 and Giza 182 cultivars and resulted in the highest values of number of panicles/m^2, 1000 - grain weight, grain and straw yields/ha in both seasons. On the other hand, Giza 179 cultivar associated with earliness in heading date, which resulted in the lowest number of days from transplanting to 50 % heading and lowest values of total chlorophylls in flag leaf, flag leaf area, plant height, panicle length, number of branches/panicle and number of grains/panicle in the first and second seasons.
While, Giza 182 cultivar recorded the highest values of total carbohydrates percentages in rice grains and the lowest values of grain and straw yields per feddan, phosphorus content, total nitrogen and crude protein percentages in rice grains in the two growing seasons.
These results might be related to genetic factors which resulted from genetic makeup relations for the varieties. The obtained results of this study are partially agreement with those noticed and discussed by Salama *et al.* (2011), Badawi *et al.* (2013), Tripathi *et al.* (2013), Hussain *et al.* (2014), Yuni-Widyastuti and Rumanti (2015), Hossain *et al.* (2016) and Shovon *et al.* (2016).

B- Effect of phosphorus fertilizer levels:
The obtained data in Tables 3 and 4 revealed that the effect of phosphorus fertilizer levels on growth characters (number of days from transplanting to 50 % heading, total chlorophyll content and flag leaf area), yield and its attributes (plant height, number of panicles/m^2, panicle length, number of branches/panicle, number of grains/panicle, 1000-grain weight, grain and straw yields/ha) and grains quality (phosphorus content, total nitrogen, crude protein and total carbohydrates percentages) was significant in the two growing seasons.
It can be stated that all studied characters significantly increased as a result of increasing phosphorus fertilizer levels from 0 to, 12, 24, 36 and 48 kg P_2O_5/ha and the differences between them were obvious, with exception carbohydrates percentages in rice grains which was decreased by increasing phosphorus fertilizer levels in both seasons. Application the highest level of phosphorus fertilizer (48 kg P_2O_5/ha) produced the highest values of growth characters, yield and its attributes and grains quality, excluding total carbohydrates percentages in rice grains in both seasons. It means that rice plants responded to increasing phosphorus fertilizer level was up to 48 kg P_2O_5/ha.

Table 3: Number of days to 50 % heading, total chlorophyll, fag leaf area, plant height, number of panicles/m^2, panicle length and number of branches/panicle as affected by rice cultivars and phosphorus fertilizer levels as well as their interaction during 2015 and 2016 seasons.

Characters / Treatments	Number of days to 50 % heading		Total chlorophyll (SPAD)		Flag leaf area (cm^2)		Plant height (cm)		Number of panicles/m^2		Panicle length (cm)		Number of branches/ panicle	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
A- Cultivars:														
Giza 179	49.10	50.05	11.14	11.14	34.46	34.71	73.75	74.73	720.6	706.8	19.23	20.19	6.79	7.79
Giza 182	56.70	57.20	13.19	13.19	39.34	40.35	73.86	74.86	553.2	561.2	20.03	21.08	7.32	8.32
Misr hybrid 1	66.85	67.85	17.09	16.78	43.67	44.63	95.79	95.64	445.0	451.2	24.14	25.14	8.86	9.87
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.27	0.19	1.92	1.96	5.65	4.81	4.38	4.08	63.0	74.0	1.94	2.02	0.75	0.74
C- Foliar spraying treatments:														
0 kg P_2O_5/ha	55.25	56.16	12.74	12.74	36.26	37.25	79.34	78.23	546.0	530.2	20.04	21.28	6.93	7.95
5 kg P_2O_5/ha	56.33	57.08	13.09	13.09	38.02	39.04	79.37	79.37	555.1	556.4	20.36	21.36	7.66	8.66
10 kg P_2O_5/ha	57.33	58.33	13.53	13.52	38.85	39.95	81.09	82.09	577.2	578.2	21.19	22.19	7.79	8.79
15 kg P_2O_5/ha	58.66	59.50	14.36	14.36	40.14	41.04	81.37	82.89	582.5	583.5	21.94	22.92	7.90	8.90
20 kg P_2O_5/ha	60.16	60.75	15.31	14.78	42.50	42.20	84.40	86.14	603.9	617.0	22.15	22.94	8.00	9.00
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.36	0.49	1.62	1.73	3.81	3.39	4.22	4.06	75.3	77.2	1.16	1.06	0.75	0.72
D- Interaction (F. test):														
A × B	NS	NS	*	*	*	*	*	*	*	*	*	*	*	*

Table 4: Number of grains/panicle, 1000-grain weight, grain and straw yields/ha, phosphorus content, crude protein and total carbohydrates percentages in grains as affected by rice cultivars and phosphorus fertilizer levels as well as their interaction during 2015 and 2016 seasons.

Characters / Treatments	Number of grains/panicle		1000 - grain weight (g)		Grain yield (t/ha)		Straw yield (t/ha)		P (mg/100g)		Crude protein (%)		Total carbohydrates (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
A- Cultivars:														
Giza 179	78.35	79.15	24.04	24.28	4.434	4.708	8.581	9.551	111.0	112.0	7.34	8.34	80.02	80.99
Giza 182	81.63	82.46	23.70	23.58	3.556	3.591	5.013	5.929	107.2	108.2	7.12	8.12	80.38	81.21
Misr hybrid 1	109.65	109.21	21.97	22.31	3.919	3.943	7.604	8.600	115.8	116.7	7.55	8.55	78.05	80.58
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	11.95	10.86	1.03	1.69	0.321	0.320	0.514	0.614	0.9	0.8	0.06	0.07	0.42	0.39
C- Foliar spraying treatments:														
0 kg P_2O_5/ha	79.75	78.65	21.39	21.47	3.618	3.60	6.257	7.112	88.3	89.2	6.13	7.12	82.40	83.13
5 kg P_2O_5/ha	85.71	84.11	22.82	22.99	3.833	3.894	6.691	7.695	96.7	97.6	6.66	7.66	81.24	82.24
10 kg P_2O_5/ha	92.19	91.19	23.51	23.08	3.946	3.942	7.111	8.133	107.7	108.7	7.33	8.33	81.15	80.98
15 kg P_2O_5/ha	94.65	93.15	24.09	24.57	4.201	4.161	7.501	8.411	122.4	123.4	7.96	8.95	78.72	79.73
20 kg P_2O_5/ha	97.06	104.25	24.36	24.84	4.250	4.546	7.771	8.780	141.5	142.5	8.62	9.62	73.90	78.55
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	11.21	12.91	2.05	2.23	0.461	0.589	0.545	0.592	1.4	1.3	0.04	0.05	0.49	0.47
D- Interaction (F. test):														
A × B	*	*	*	*	*	*	*	*	*	*	*	*	NS	NS

Fertilizing rice plants with 36 kg P_2O_5/ha came in the second rank after fertilizing with 48 kg P_2O_5/ha with respect to these characters with lowest difference between them, followed by fertilizing with 24 then 12 kg P_2O_5/ha and lastly rice plants growing without phosphorus fertilization (control treatment) in both seasons.

These results can be easily ascribed to the low soil content of available nitrogen, phosphorus and potassium (Table 2), whereas the phosphorus is considered as one of the major elements for plant nutrition. Where, plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Phosphorus is particularly important to the rice seedling during the time it is recovering from transplanting shock. Phosphorus greatly stimulates root development in the young plant, thus increasing its ability to absorb other nutrients from the soil. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds such as ATP and ADP for later use in growth and reproduction, consequently, enhancement most growth measurements and yield components that mentioned and demonstrated formerly.

These results are agree with those reported by many workers including Das *et al.* (2003), Alam *et al.* (2009), Slaton *et al.* (2009b), Bünemann *et al.* (2011), Sharma *et al.* (2012), Yoseftabar (2013b), Dakshina-Murthy *et al.* (2015) and Ochwoh *et al.* (2015).

C- Effect of interaction:

There are many significant interaction effects between rice cultivars and phosphorus fertilizer levels on most reported characters in both seasons as shown in Tables 3-4. We enough reported the significant interaction between rice cultivars and phosphorus fertilizer levels on grain and straw yields/ha only.

From data graphically illustrated in Figs. 1-2 which indicate that, the highest values of grain and straw yields/ha of rice were obtained when fertilizing Giza 179 cultivar with kg 48 P_2O_5/ha in the first and second seasons. Followed by fertilizing Giza 179 cultivar too with 36, then 24, 12 and 0 kg P_2O_5/ha in both seasons. On the other hand, the lowest values of grain and straw yields/ha of rice were resulted from planting Giza 182 cultivar without phosphorus fertilization in both seasons. Alam *et al.* (2009) and Sharma *et al.* (2012) confirmed these results.

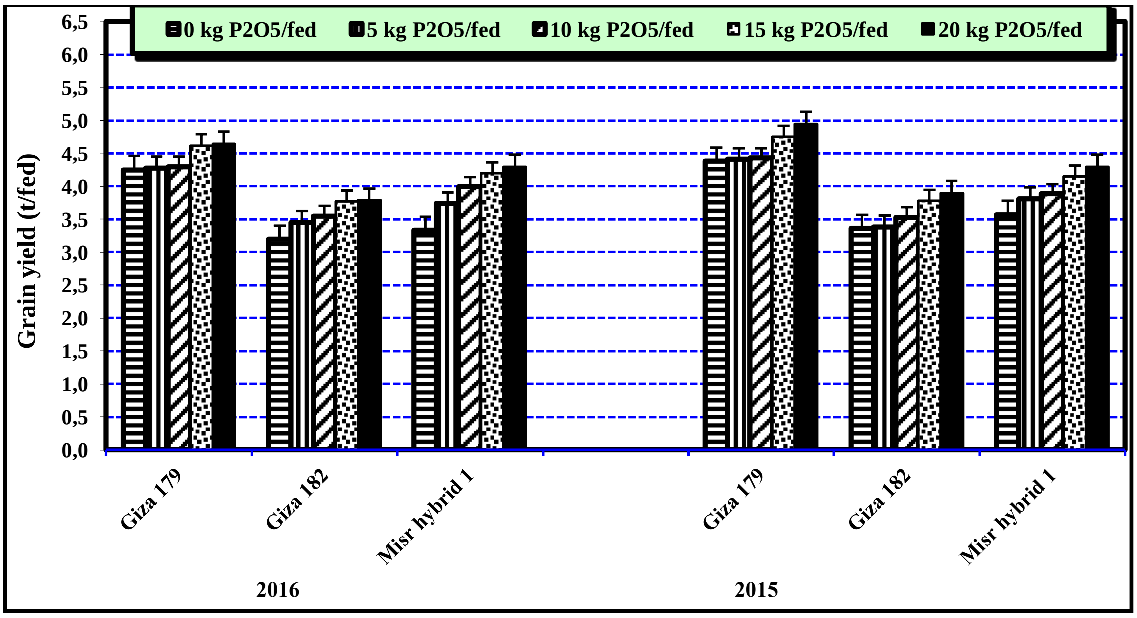

Fig. 1: Grain yield (t/ha) as affected by the interaction between rice cultivars and phosphorus fertilizer levels during 2015 and 2016.

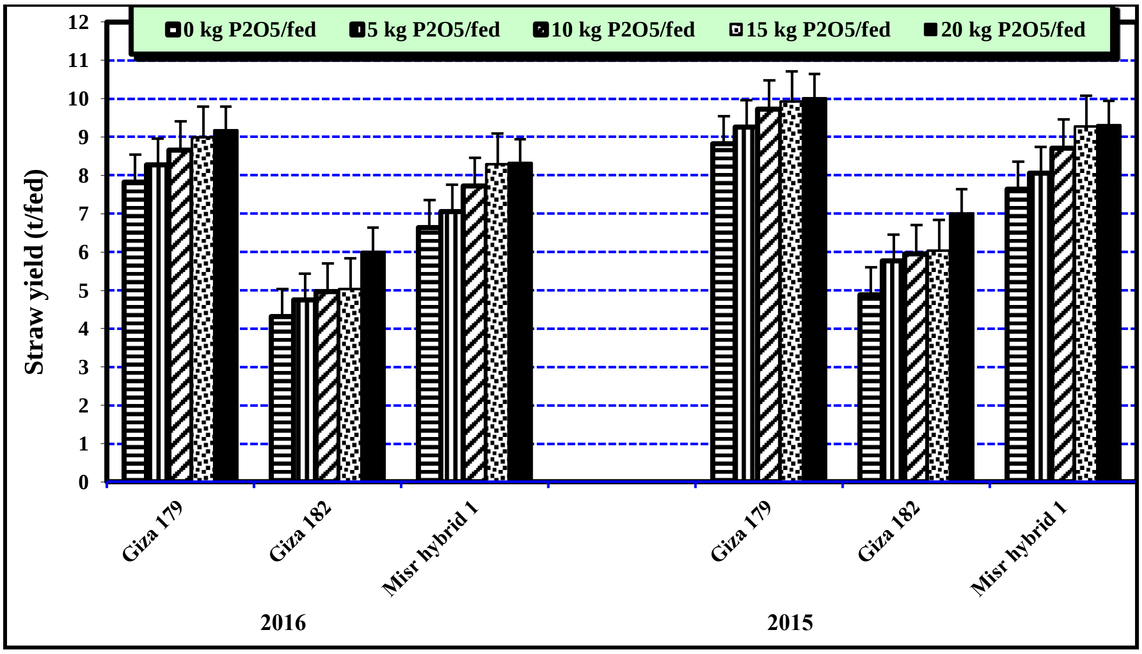

Fig. 2: Straw yield (t/ha) as affected by the interaction between rice cultivars and phosphorus fertilizer levels during 2015 and 2016.

CONCLUSIONS

According to the obtained results from this study, it can be concluded that fertilizing rice Giza 179 cultivar with kg 48 P_2O_5/ha could be recommend to achieve maximum grain and straw yields per unit area and fertilizing Misr hybrid 1 cultivar with kg 48 P_2O_5/ha to obtained growth and individual yield of plant under the environmental conditions of Kafr El-Sheikh Center, Kafr El-Sheikh Governorate, Egypt.

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