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Effect of Phosphorus Fertilizer Levels on Productivity and Grains Quality of Some Rice Cultivars

Badawi, M. A.[1] ; S. E. Seadh[1] ; E. S. B. Naeem[2] and A. S. E. I. El-Iraqi[1]
[1] Agrono. Dept. Fac. of Agric., Mansoura Univ., Egypt.
[2] Rice Res. Dept. ent in Sakha, Field Crops Res. Inst., ARC, Giza, Egypt.

ABSTRACT

In order to determine the effect of phosphorus fertilizer levels (0, 5, 10, 15 and kg P2O5/fed) on growth, grain yield and its attributes and grains quality characters of some rice cultivars (Giza 179, Giza 182 and Misr hybrid 1), two field experiment were conducted at Kafr El-Tayfa Village, Kafr El-Sheikh Center, Governorate of Kafr El-Sheikh in 2015 and 2016 years. The experiments were done in design of strip-plot with 4 replicates. The obtained results showed that Misr hybrid 1 cultivar significantly superior over Giza 179 and Giza 182 cultivars in all studied characters, except total carbohydrates percentages in rice grains in both seasons. Whereas, Giza 179 cultivar ranked secondly after Misr hybrid 1 and Giza 182 cultivar recorded the highest values of total carbohydrates percentages in rice grains in the two years. Applying of 20 kg P2O5/fed recorded the highest growth characters, productivity and grains quality, excluding total carbohydrates percentages in rice grains in both seasons. It can be concluded that, fertilizing rice Misr hybrid 1 with kg 20 P2O5/fed could be recommend for achieving maximum productivity and quality characters under conditions of Center of Kafr El-Sheikh, Governorate of Kafr El-Sheikh, Egypt.

Keywords: Rice, cultivars, varieties, genotypes, phosphorus fertilizer levels, growth, yield, grains 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 affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions and play a dominant role in crop production systems. Significant varietals differences in grain yield and its attributes and grains quality were 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) growth, yield and its attributes characters. Badawi *et al.* (2013) showed that IET 1444 cultivar significantly superior the two local cultivars Giza 177 and Giza 178 and resulted in the highest values of growth, yield and its attributes characters in both seasons. Tripathi *et al.* (2013) showed that studied varieties were differed in growth 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. 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 major functions are in energy storage and transfer within the plant (Dick, 2011). It is also a component of genetic material DNA and RNA (Zhang and Raun, 2006). So, the requirement of plants for phosphorus is only next to nitrogen. 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 of 72 kg P/ha produced the highest 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) showed that application 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 impact of phosphorus fertilizer levels on growth, grain yield and its attributes and grains quality characters of some rice cultivars under Kafr El-Sheikh Center, Kafr El-Sheikh Governorate conditions.

MATERIALS AND METHODS

Two field experiment were conducted in 2015 and 2016 seasons at Village of Kafr El-Tayfa, Center of Kafr El-Sheikh, Governorate of Kafr El-Sheikh, to determine

the effect of phosphorus fertilizer rates on growth, grain yield, yield attributes and quality of grains characters of several rice cultivars.

Strip-plot design with four replications was used 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.

The horizontal plots were occupied with the phosphorus fertilizer levels *i.e.* 0, 5, 10, 15 and kg P_2O_5/fed. Ca-super-phosphate (15.5 % P_2O_5) was additional at the aforementioned rates on the dry soil after ploughing and division to experimental plots and before leveling. The experimental plot area was 6.0 m^2 (2.0 m width and 3.0 m length) *i.e.* 1/700 fed. The mechanical and chemical soil properties and the corresponding data are presented in Table 2.

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

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
Available (ppm)	N	55.20	53.80
	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/kirat (1 kirat = 175 m^2) on the dry soil before ploughing. Nitrogen fertilizer (urea, 46.0 % N) was added (3 kg/kirat) after last ploughing before leveling and zinc sulphate (24 % Zn SO_4) at the rate of one kg/kirat was also incorporated with soil after leveling and before sowing. Rice seeds of Giza 179 and Giza 182 cultivars at 60 kg/fed and Misr hybrid 1 at 10 kg/fed soaked in the running water for 48 hours in addition to incubated for 24 hours. Afterward, they were broadcasted in the nursery on the first week of May in the first and second seasons.

The permanent land was prepared as recommended. Seedlings age 25 days transplanted (4-5 seedlings/hill for Giza 179 and Giza 182 cultivars and 1-2 seedlings/hill for Misr hybrid 1) adopting a spacing of 20 x 20 cm. Nitrogen fertilizer at 69 kg N/fed (urea, 46 % N) was added in two equal portions. The first part was added after 15 days from transplanting and the second part was added after 150 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/fed) with the first dose of nitrogen fertilizer. The weeds were chemically controlled with Saturn 50 % as mentioned after transplanting with four days.

Data Recorded:

A. Growth characters: Number of days from transplanting to 50 % heading, total chlorophyll content (SPAD) and flag leaf area (cm^2), which estimated at maximum tillering stage after 90 days from sowing following the formula reported by Yoshida *et al.* (1976) as follows: Flag leaf area (cm^2) = K x leaf length (cm) × maximum width (cm).

B. Yield and its attributes: Height of plant (cm), panicles number per m^2, length of panicle (cm), branches number per panicle, grains number per panicle, weight of thousand grains (g) and grain yield (t/fed) as well as straw yield (t/fed).

C- Grains quality: Phosphorus content (mg/100 g): It was determined in rice grains colorimetric at spectrophotometer at wave length 640 nm (Jackson, 1967). Crude protein (%) calculated by multiply total nitrogen values which estimated in rice grains by the improved Kjeldahl – method according to A.O.A.C. method (1990) by 5.57. Total carbohydrates (%) was determined in rice grains as described by Sadasivam and Manickam (1996).

All data were statistically analyzed according to design of strip-plot as mentioned by Gomez and Gomez (1984). In order to test the differences between treatment means, LSD method at 5 % level of probability was used (Snedecor and Cochran, 1980).

RESULTS

A- Performance of cultivars:

The obtained results showed that the three studied cultivars i.e. Giza 179, Giza 182 and Misr hybrid 1 cultivars were significantly differed in growth characters, yield and its attributes and grains quality in both seasons, as shown in Tables 3 and 4.

It could be observed that Misr hybrid 1 significantly superior Giza 179 and Giza 182 cultivars and resulted in the highest values of number of days from transplanting to 50 % heading, total chlorophyll content, area of flag leaf, height of plant, panicles number per m2, length of panicle, branches number /panicle, grains number/panicle, 1000-grain weight, grain and straw yields/fed, phosphorus, total

nitrogen and crude protein percentages in rice grains in both seasons. This means that Misr hybrid 1 cultivar had greater growth and productivity than Giza 179 and Giza 182 cultivars in the first and second seasons of this study. On the other side, Misr hybrid 1 resulted in the lowest values of total carbohydrates percentages in grains, as presented in Tables 3 and 4.

Table 3. Number of days to 50 % heading, total chlorophyll, area of fag leaf, height of plant, number of panicles/m^2, panicle length and number of branches/panicle as inflected 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)		Area of flag leaf (cm^2)		Height of plant (cm)		Panicles number/ m^2		Length of panicle (cm)		Branches number/ panicle	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
A- Cultivars:														
Giza 179	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
Giza 182	49.10	50.05	11.14	11.14	34.46	34.71	73.75	74.73	445.0	451.2	19.23	20.19	6.79	7.79
Misr hybrid 1	66.85	67.85	17.09	16.78	43.67	44.63	95.79	95.64	720.6	706.8	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
B- Phosphorus fertilizer levels:														
0 kg P_2O_5/fed	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/fed	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/fed	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/fed	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/fed	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 (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
C- Interaction (F. test):														
A × B	NS	NS	*	*	*	*	*	*	*	*	*	*	*	*

Table 4. Number of grains/panicle, weight of thousand grains, yields of grain and straw per fed, phosphorus content, protein and total carbohydrates percentages in grains as inflected 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/fed)		Straw yield (t/fed)		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	81.63	82.46	23.70	23.58	3.919	3.943	6.083	6.880	111.0	112.0	7.34	8.34	80.02	80.99
Giza 182	78.35	79.15	21.97	22.31	3.556	3.591	4.010	4.743	107.2	108.2	7.12	8.12	80.38	81.21
Misr hybrid 1	109.65	109.21	24.04	24.28	4.434	4.708	6.864	7.640	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	0.411	0.491	0.9	0.8	0.06	0.07	0.42	0.39
B- Phosphorus fertilizer levels:														
0 kg P_2O_5/fed	79.75	78.65	21.39	21.47	3.618	3.60	5.005	5.689	88.3	89.2	6.13	7.12	82.40	83.13
5 kg P_2O_5/fed	85.71	84.11	22.82	22.99	3.833	3.894	5.352	6.156	96.7	97.6	6.66	7.66	81.24	82.24
10 kg P_2O_5/fed	92.19	91.19	23.51	23.08	3.946	3.942	5.688	6.506	107.7	108.7	7.33	8.33	81.15	80.98
15 kg P_2O_5/fed	94.65	93.15	24.09	24.57	4.201	4.161	6.000	6.728	122.4	123.4	7.96	8.95	78.72	79.73
20 kg P_2O_5/fed	97.06	104.25	24.36	24.84	4.250	4.546	6.216	7.024	141.5	142.5	8.62	9.62	73.90	78.55
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD (5 %)	11.21	12.91	2.05	2.23	0.461	0.589	0.436	0.473	1.4	1.3	0.04	0.05	0.49	0.47
C- Interaction (F. test):														
A × B	*	*	*	*	*	*	*	*	*	*	*	*	NS	NS

Whereas, Giza 179 cultivar ranked secondly after Misr hybrid 1 concerning the all studied characters in the two seasons. While, Giza 182 cultivar recorded the highest values of total carbohydrates percentages in rice grains and the lowest values of all studied characters in the two growing seasons.

These results might be related to genetic factors which resulted from genetic makeup relations for the varieties. These results are partially agreement with those found 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 levels:

The obtained data in Tables 3 and 4 revealed that phosphorus fertilizer levels significantly impacted growth characters, yield and its attributes and grains quality in the two seasons.

All studied characters were significantly increment by increasing phosphorus levels from 0 to, 5, 10, 15 and 20 kg P_2O_5/fed and the differences among them were clear, with exception carbohydrates percentages in rice grains which was decreased by increasing phosphorus fertilizer levels in both seasons. Application of 20 kg P_2O_5/fed gave highest growth characters, yield and its components 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 20 kg P_2O_5/fed. Fertilizing rice plants with 15 kg P_2O_5/fed came in the second rank after fertilizing with 20 kg P_2O_5/fed with respect to these characters with lowest difference between them, followed by fertilizing with 10 then 5 kg P_2O_5/fed and lastly rice plants growing without phosphorus fertilization (control treatment) in both seasons as shown in Tables 3 and 4.

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 and, 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.* (2009), Bünemann *et al.* (2011), Sharma *et al.* (2012), Yoseftabar (2013), 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 and 4. We enough reported the significant interaction between rice cultivars and phosphorus fertilizer levels on grain and straw yields/fed only.

From data graphically illustrated in Figs. 1 and 2, which indicate that, the highest values of grain and straw yields/fed of rice were obtained when fertilizing Misr hybrid 1 with kg 20 P_2O_5/fed in the two seasons. Followed by fertilizing Misr hybrid 1 too with 15, then 10, 5 and 0 kg P_2O_5/fed in both seasons. On the other hand, the lowest values of grain and straw yields/fed 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.

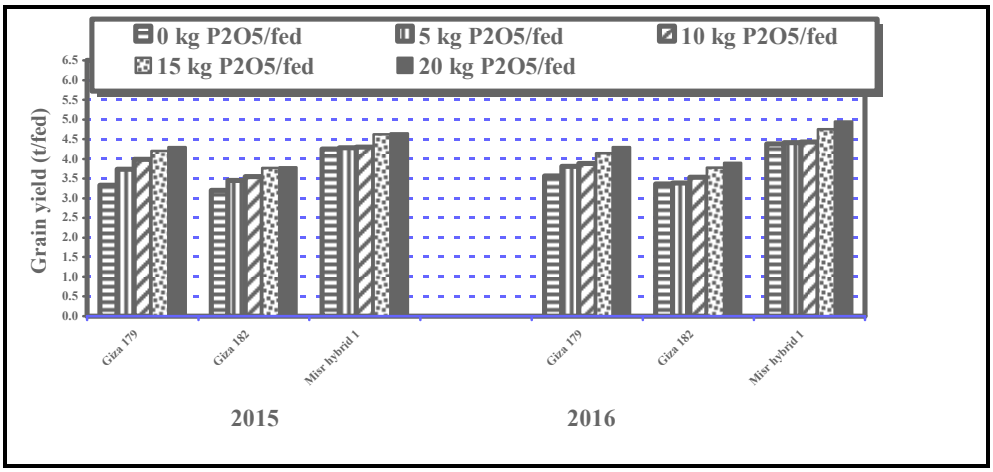

Fig. 1. Grain yield (t/fed) as inflected by the interaction between rice cultivars and phosphorus fertilizer levels during 2015 and 2016 seasons.

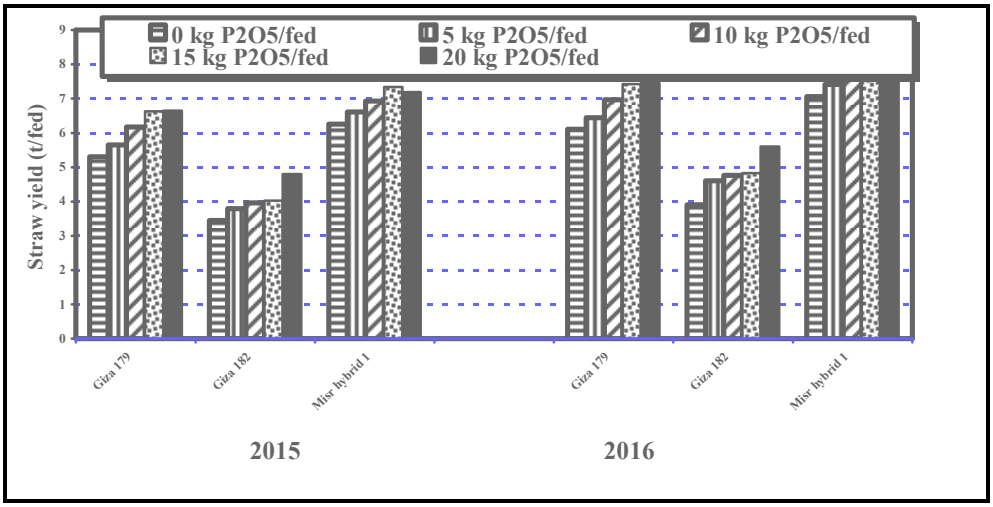

Fig. 2. Straw yield (t/fed) as inflected by the interaction between rice cultivars and phosphorus fertilizer levels during 2015 and 2016 seasons.

CONCLUSION

The obtained results from this study revealed that, fertilizing rice Misr hybrid 1 with 20 kg P2O5/fed to achieving maximum productivity and quality characters under Kafr El-Sheikh Center, Kafr El-Sheikh Governorate, Egypt.

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تأثير مستويات السماد الفوسفاتى على إنتاجية وجودة حبوب بعض أصناف الأرز

محسن عبد العزيز بدوى[1] ، صالح السيد سعده[1] ، السيد سعد بسطويسى نعيم[2] وأحمد صقر العراقى إبراهيم العراقى[1]

[1] قسم المحاصيل ، كلية الزراعة ، جامعة المنصورة ، مصر.

[2] قسم بحوث الأرز بسخا ، معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية ، الجيزة ، مصر.

أجريت تجربتان حقليتان بقرية كفر الطايفة – مركز كفر الشيخ - محافظة كفر الشيخ، خلال الموسمين الصيفيين 2015 و 2016 بهدف دراسة سلوك بعض أصناف الأرز وهى؛ جيزة 179 ، جيزة 182 وهجين مصر 1 وتأثير مستويات السماد الفوسفاتى (صفر ، 5 ، 10، 15 و20 كجم P_2O_5 / فدان) على النمو والمحصول ومكوناته وصفات جودة الحبوب. وقد أجريت التجارب في تصميم الشرائح المتعامدة في أربع مكررات. حيث تضمنت الشرائح الرأسية أصناف الأرز. بينما احتوت الشرائح الأفقية على مستويات السماد الفوسفاتى ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:1- تشير النتائج أن الصنف هجين مصر 1 قد تفوق بشكل ملحوظ على الصنفين جيزة 179والجيزة 182 وأنتج أعلى القيم من جميع الصفات المدروسة، ما عدا النسبة المئوية للكربوهيدرات الكلية بالحبوب في كلا الموسمين. في حين جاء الصنف جيزة 179 في المرتبة الثانية بعد هجين مصر 1 في كلا الموسمين. أما الصنف جيزة 182 فقد سجل أعلى القيم لصفة النسبة المئوية للكربوهيدرات الكلية بالحبوب في كلا الموسمين.2- أظهرت النتائج المتحصل عليها من هذه الدراسة أن جميع الصفات تحت الدراسة قد زادت بشكل ملحوظ نتيجة لزيادة مستويات التسميد الفوسفاتى من 0 إلى 5، 10، 15 و 20 كجم P_2O_5 / فدان ، باستثناء صفة النسبة المئوية للكربوهيدرات الكلية بالحبوب في كلا الموسمين. عموماً أدى استخدام المستوى الأعلى من السماد الفوسفاتى (20 كجم P_2O_5 / فدان) للحصول على أعلى القيم من صفات النمو والمحصول ومكوناته وأيضاً صفات جودة الحبوب، باستثناء نسب النسبة المئوية للكربوهيدرات الكلية بالحبوب في كلا الموسمين. من النتائج المتحصل عليها فى هذه الدراسة فإنه يمكن التوصية بتسميد الأرز هجين مصر 1 بـ 20 كجم P_2O_5 / فدان للحصول على أعلى نمو وإنتاجية وصفات جودة للحبوب تحت ظروف بمركز كفر الشيخ – محافظة كفر الشيخ - مصر.