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PERFORMANCE OF DIFFERENT RICE GENOTYPES UNDER APPLICATION OF PHOSPHORUS FERTILIZER LEVELS

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ABSTRACT

Phosphorus is one of the essential macronutrient element not only for rice but also for other plants, it is important for plant metabolism and enzymatic activity during the periods of growth and grain filling. Rice growth, yield and its attributes strongly influenced by phosphorus nutrition. This investigation was conducted to study the performance of different rice genotypes i.e. Sakha105 and Sakha106 (japonica), Giza178 (indica/japonica) and Giza182 (indica) under four phosphorus levels namely 0, 18, 36 and 54 P_2O_5 ha^{-1}. This study was carried out at Experimental Farm of Rice Research and Training Center during both 2010 and 2011 growing seasons. At harvest, plant height, number of panicles m^{-2}, panicle weight, panicle length, number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$, 1000 grain weight, grain and straw yield were determined. After harvest, N and P content of rice grain and straw were measured as well as hulling, milling, head rice and amylose percentages were assessed. The obtained results revealed that the rice genotypes were significantly differed in their response to phosphorus application according to genetic background. indica or indica/japonica genotypes responded up to 54 kg P_2O_5 ha^{-1} without significant differences with 36 kg P_2O_5 ha^{-1} more than japonica type which responded up to 18 kg P_2O_5 ha^{-1}. Application of phosphorus fertilizer up to 36 kg P_2O_5 ha^{-1} improved rice growth traits i.e. plant height and panicle length as well as grain yield and its attributes. Combination of Giza178 with 36 kg P_2O_5 ha^{-1} produced the highest grain yield followed by Giza182 with the same levels of phosphorus. Application of phosphorus fertilizer up to 18 kg P_2O_5 ha^{-1} gave the maximum grain yield of Sakh105 and Sakha106. Concerning grain quality traits had positive significant effect with increasing phosphorus levels.

Keywords: Rice, phosphorus, genotypic differences, grain yield, grain quality.

INTRODUCTION

Rice is a major food cereal crop in Asia, Africa, and South America. These countries are having higher population growth so yields of food cereal crops including rice have to be increased to keep pace with increasing population. Yield can be increased by adopting appropriate technology, which may reflect plant growth or dry matter production. Use of adequate quantity of nutrients is one of the important strategies for increasing lowland rice yield (Fageria *et al.* 1997, Fageria and Baligar 1996). Nutrient uptake in rice varied with the growth and development stages. Changes in the nutritional status of plants bring variation in their growth reactions and metabolism (Fageria *et al.* 1997).

In many regions of the world, phosphorus is one of the main essential macronutrient factor controlling crop growth and yield, and it is mainly found in the forms not readily available (Xu *et al.* 2007). Phosphorus is one of the most important energetic elements involved in plant growth and metabolism.

Cellular inorganic orthophosphate regulates enzyme activity and metabolic pathways as well as the transport processes. Phosphorus also affects various aspects of photosynthesis (Terry and Rao 1991).

Inhibition of photosynthesis by P limitation has often been explained by depressing the Calvin cycle activity, in particular, by depressing the amount and activity of Rubisco (Brooks 1986) and the regeneration of ribulose-1,5-bisphosphate (RuBP) (Brooks 1986 and Pieters *et al.* 2001). Photosynthesis is the most important photochemical sink for energy absorbed by leaves, and therefore the photosynthetic apparatus is liable to be exposed to harmful excess light energy due to the strong CO_2 assimilation inhibition in plants evoked by P deficiency.

Tang and Yu (2002) studied the effects and mechanisms of P nutrient on protein content of rice through pot experiment and biochemical analysis. The results showed that the increase of phosphorus nutrient enhanced the activities of PEP carboxylase (PEPC), glutamine synthase (GS) and sucrose phosphate synthase (SPS) in leaves, sucrose synthase (SS), ADP glucose pyrophosphorylase (ADPGP) and GS in grains, and the chlorophyll content in leaves, soluble sugar and starch content in grains, protein nitrogen and total nitrogen content in leaves and grains. Excessive phosphorus nutrients slightly reduced SPS and ADPG activity in leaves and grains respectively. Tripathi *et al.* (2001) found that increasing levels of phosphorus significantly enhanced the yield. Also, increasing levels of phosphorus significantly enhanced the uptake of P.

Wilson *et al.* (1999) reported that phosphorus application significantly increased rice grain yield and P tissue content. Panda *et al.* (1995) and Heluf and Seyoum (2006) indicated that increased dry matter production including grain yield and yield attributing characters of rice (number of panicles m^{-2}, number of spikelets panicle^{-1}, panicle length, dry matter accumulation, plant height and straw yield) due to P uptake in response to external supply P fertilizers. Ali and Ansari (2006) indicated that increasing phosphorus levels significantly increased dry matter, leaf area index, chlorophyll content, panicles number, filled grains, panicle weight, grain and straw yields. Shah (2002) and Ehsan *et al.* (2009) reported that grain yield and its attributing characters were significantly increased by phosphorus application and rice varieties significantly varied in their response to phosphorus fertilizer.

This study aims to investigate the response of some Egyptian rice genotypes to phosphorus fertilizer levels application.

MATERIALS AND METHODS

The present investigation was carried out at Experimental Farm of the Rice Research and Training Center experimental farm, Sakha , Kafr EL-Sheik, Egypt, during both 2010 and 2011 growing seasons to study the performance of some rice genotypes under application of phosphorus fertilizer levels under broadcast seeded rice.

Representative soil samples were taken from the experimental site at the depth of 0-30 cm from the soil surface before sowing. Samples were air-dried, then ground to pass through a two mm sieve and well mixed. The procedure of soil analysis was conducted according to the methods described by Black *et al.* (1965). Soil chemical analysis in both seasons are shown in Table 1.

Table (1): Soil prosperities and chemical analysis of the soil at the experimental sites in 2010 and 2011 seasons.

Soil prosperities and chemical content	2010	2011
Texture	Clay	Clay
pH	7.8	8.0
EC (ds/m)	1.73	2.37
OM(%)	1.7	1.6
Ca^{++} (meq. L^{-1})	4.00	4.63
Mg $^{++}$ (meq. L^{-1})	5.71	5.62
K^{+} (meq. L^{-1})	469	467
Na^{+}(mg/L)	11	12
P mg kg^{-1}	14	15
Total nitrogen , mg kg^{-1}	445	563

The experiments were laidout in a split plot design with four replications. Main plots were adopted to four Egyptian rice varieties namely Sakha105, Sakha106, Giza178 and Giza182 while subplots were developed to phosphorus fertilizer levels i.e. 0, 18, 36 and 54 P_2O_5 kg ha^{-1}. The size of each subplot was 12 m^2 (3m X 4m). Phosphorus in the form of calcium mono phosphate (15.5% P_2O_5) was added and incorporated into dry soil during land preparation according to the previously mentioned four rates of phosphorus fertilizer in each subplot.

Table (2): Origin and pedigree of the rice varieties utilized in the current study.

Variety	Parentage	Group	Origin	Grain type
Sakha105	Z5581-46-3/Gz4316-7-1-1	Japonica	Egypt	Short
Sakha106	iza177/Hexi	Japonica	Egypt	Short
Giza178	iza175/Milyang49	Indica/Japonica	Egypt	Medium
Giza182	iza181/IR39422-161-1-3/Giza181	Indica	Egypt	Long

Seeds at the rate of 90 kg ha^{-1} were soaked in fresh water for 24 hr then incubated for 48 hr to hasten early germination. Pre-germinated seeds were uniformly broadcasted in the field on 17th and 15th of May in 2010 and 2011, respectively. The field was well prepared, i.e. plowed twice and then well dry leveld. Nitrogen in the form of urea (46.5%N) was added according to the recommendation (165 kg N ha^{-1}) and immediately flooded. Weeds were chemically controlled. All recommended agricultural practices were applied.

At harvest, Plant height (cm), number of panicles m^{-2}, panicle weight, panicle length, number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$ and 1000 grain weight were determined.

Harvesting was done when rice plants reached to full maturity. A guarded area of ten square meters was harvested, air-dried, weighted for estimate biomass production, then threshed. The grain yield was measured in kg $plot^{-1}$ (10 m^2) and adjusted to 14% moisture basis, then converted to tons ha^{-1}. Straw yield t ha^{-1} and harvest index were calculated.

After harvest, samples of grain and straw were collected, oven dried at 70C^o for 48 hours, ground to powder and digested by the wet oxidation procedures according to Johnson and Ulirch (1959) method. Nitrogen content in rice grain and straw was determined by the Microkjeldahl method (Jackson 1967). Total phosphorus content in grains and straw was determined using the procedures of Watanabe and Olsen (1962).

Hulling, milling, head rice and amylose content percentages, were determined. For each plot, 250 g of rough rice was de-hulled with Sataka laboratory huller. Brown rice was weighed and hulling percentage was determined. The brown rice samples consequently milled by MC Gill miller No.2. The samples of milled rice were weighed and milling percentage was determined. Whole grains were separated from the total milled rice using a rice sizing device. The amount of head rice was weighted and head rice percentage was calculated. Amylose content was determined by the procedure of Juliano (1971).

All collected data were subjected to an ordinary analysis of variance according to the proceeding described by Gomez and Gomez (1984). Significant different means were compared at $P < 0.05$ by the revised least significant difference (LSD) test, which adopted by Waller and Duncan (1969). Statistical analyses were made with commercial computer software.

RESULTS AND DISCUSSION

1- Plant height (cm):

Data in Table 3 indicated that plant height of different rice varieties at maturity was significantly affected by phosphorus levels and their interaction in 2010 and 2011 seasons. Sakha106 markedly recorded the tallest plants, while Giza178 significantly recorded the shortest plants. This mainly is due to the genetic background among varieties under study.

Table (3): Plant height (cm), number of panicles m^{-2}, panicle weight (g) and panicle length (cm) of some rice varieties as affected by the application of phosphorus fertilizer levels in 2010 and 2011.

Treatments	Plant height (cm)		No. of panicles (m^{-2})		Panicle weight (g)		Panicle length (cm)	
	2010	2011	2010	2011	2010	2011	2010	2011
Varieties:								
Sakha105	100.77	101.90	353.02	357.26	2.475	2.461	21.909	22.082
Sakha106	107.41	107.86	330.02	333.97	2.628	2.645	22.802	23.304
Giza178	97.83	100.75	432.74	437.92	1.960	1.977	23.909	23.887
Giza182	101.13	101.32	401.36	406.18	1.936	1.953	27.725	27.777
L.S.D 0.05	1.47	1.113	10.07	11.14	0.024	0.023	0.150	0.297
P_2O_5 kg ha^{-1}								
0	96.69	99.49	362.61	366.96	2.088	2.102	22.521	22.651
18	102.16	103.41	377.22	381.74	2.286	2.302	24.361	24.541
36	103.90	104.63	389.15	393.82	2.304	2.321	24.738	24.795
54	104.40	104.80	388.14	392.80	2.294	2.311	24.726	25.064
L.S.D 0.05	0.725	0.476	9.78	10.85	0.023	0.022	0.141	0.157
Interaction	**	**	NS	NS	*	**	**	**

Plants received phosphorus exhibited significant increase compared with those received no phosphorus. Data indicated also that there was no significant differences between the plants received 36 or 54 kg P_2O_5 ha^{-1} over the control. This has been substantiated by other workers, Nagappa and Biradar (2002). The effect of phosphorus application on plant height might be due to that phosphorus is an important essential macronutrient required for the biosynthesis of energetic compound (ATP, NADP) which supplies the plant by energy required for cell division and elongation of rice organ. Blevins (1999) reported similar conclusions.

Effect of interaction between varieties and phosphorus levels on plant height presented in Table 4. Plant height of Sakha105, Sakha106 and Giza182 responded to phosphorus fertilizer levels up to 18 kg P_2O_5 ha^{-1}. While, plant height of Giza178 responded to 36 kg P_2O_5 ha^{-1}.

Table 4. Plant height (cm), panicle weight (g) and panicle length (cm) as affected by the interaction between rice varieties and phosphorus fertilizer levels in 2010 and 2011.

Variety/ P_2O_5 kg ha^{-1}	2010				2011			
	Sakha 105	Sakha 106	Giza 178	Giza 182	Sakha 105	Sakha 106	Giza 178	Giza 182
Plant height (cm)								
0	93.33	103.11	93.33	97.00	97.88	105.11	96.33	98.65
18	101.87	108.44	96.67	101.67	103.11	108.67	98.33	101.55
36	103.55	108.74	100.33	102.99	103.53	108.88	104.00	102.11
54	104.34	109.37	101.00	102.88	103.11	108.79	104.33	102.99
L.S.D0.05	1.78				1.28			
Panicle weight (g)								
0	2.3517	2.5250	1.7067	1.7667	2.3578	2.5415	1.7239	1.7839
18	2.4827	2.6483	2.0483	1.9633	2.4992	2.6647	2.0653	1.9804
36	2.4789	2.6613	2.0737	2.0033	2.4954	2.6777	2.0906	2.0203
54	2.4767	2.6780	2.0117	2.0100	2.4932	2.6943	2.0286	2.0270
L.S.D0.05	0.0446				0.0431			
Panicle length (cm)								
0	21.110	22.003	22.003	24.967	21.313	22.103	22.087	25.100
18	22.207	23.037	24.033	28.167	22.327	23.627	24.097	28.113
36	22.217	23.103	24.767	28.867	22.343	23.793	24.263	28.780
54	22.103	23.067	24.833	28.900	22.347	23.693	25.100	29.117
L.S.D0.05	0.274				0.374			

2- Number of panicles per m^2:

Data in Table 3 showed that number of panicles per m^{-2} was significantly varied among varieties and phosphorus levels in 2010 and 2011. Giza178 produced the maximum values of number of panicles per m^2 followed by Giza182. While, Sakha 106 gave the minimum values of number of panicles per m^2. This mainly due to high heterosis in number of panicles for Giza178 (indica/japonica type) and Giza182 (indica type) than Sakha105 and Skha106 (japonica type). Similar trend was found by Sedeek *et al.* (2009).

Increasing phosphorus levels from 0 up to 36 kg P_2O_5 ha^{-1} significantly increased number of panicles per m^2. There was no significant effect between 36 or 54 kg P_2O_5 ha^{-1} in both season. The effect of phosphorus application on number of panicles per m^2 could be attributed mainly to that phosphorus application before planting encourages the up ground nodes to emerge early and effective tillers as well as the role of phosphorus for increase the flowering hormones (phytocrom) which increase number of panicles during panicle initiation beside improve panicle growth rate include number of branches and spikelets. Increasing phosphorus levels from 36 to 54 kg P_2O_5 ha^{-1} gave insignificant differences between the two levels. Similar trend was found by Ali and Ansari (2006) and Metwally (2007). The interaction between phosphorus and rice varieties had no significant effect on the number of panicles per m^2 in the both seasons.

3- Panicle weight (g):

Panicle weight was significantly differed among verities, phosphorus levels and their interaction in 2010 and 2011 (Table 3). The heaviest panicles were obtained by Sakha106, while the lightest panicles were produced by Giza182 and Giza178. This might be due to the differences among the genotypes in their filling percentages and weight of 1000 grain weight beside grain type and genetic make-up. These results are in agreement with those reported by Sedeek (2001).

Plots which were fertilized with any of the level of phosphorus fertilizer significantly gave heavier panicle weight more than the unfertilized plots. Plants which fertilized by 36 kg P_2O_5/ha produced the maximum values of panicle weight. The minimum values of panicle weight were obtained when phosphorus was not applied. These findings are supported by the work done by Shah (2002), Ali and Ansari (2006) and Ehsan *et al.* (2009). Concerning the interaction effect between varieties and phosphorus levels, data in Table 4 indicated that panicle weight of Sakha 105, Sakha 106 and Giza 178 significantly increased by application of phosphorus at the rate of 18 kg P_2O_5 ha^{-1}, while panicle weight of Giza 182 increased by increasing phosphorus level up to 36 kg P_2O_5 ha^{-1}. It means that Giza182 responded more to phosphorus and gave the heaviest panicle.

4- Panicle length (cm):

Data in Table 3 indicated that panicle length of the tested varieties was significantly affected by varieties, phosphorus levels and their interaction in 2010 and 2011. Giza 182 markedly had the longest panicle followed by Giza 178 but the shortest one was produced by Sakha 105. The variations among rice varieties in panicle length are mainly due to the differences in their genetic background. Increasing phosphorus fertilizer application from 0 up to 36 kg P_2O_5 ha^{-1} significantly increased panicle length. There was no significant difference between the application of 36 and 54 kg P_2O_5 ha^{-1}. As for interaction between rice varieties and phosphorus levels, data in Table 4 revealed that Giza 178 as indica gave the tallest panicle followed by Giza 182 as indica/japonica when fertilized with 36 kg P_2O_5 ha^{-1}. On contrast the lowest values of panicle length was obtained from Sakha 105 under control treatment.

5- Number of filled grains panicle^{-1}:

Number of filled grains per panicle of some Egyptian rice varieties as affected by phosphorus application levels are presented in Table 5. Data indicated that the highest number of filled grains panicle^{-1} were markedly produced by Giza178 followed by Giza182, while the lowest values were produced by Sakha105. The varietal differences in number of filled grains panicle^{-1} could be attributed to genetic background. Similar trend was found by Ebaid and El-Rewainy (2005).

Increasing phosphorus levels from 0 up to 36 kg P_2O_5 ha^{-1} significantly increase the number of filled grains panicle^{-1}. This mainly due to the role of phosphorus for increase the photosynthesis resulted in increase the metabolite stream translocated from source to sink resulted in increase the filling of high number of spikelets which produce more number of filled grains panicle^{-1}. These findings are consistent with those reported by Ibrahim (2001), Kumar and Singh (2001), Ali and Ansari (2006) and Metwally (2007).

Table (5): Number of filled and unfilled grains panicle^{-1} and 1000 grain weight (g) of some rice varieties as affected by the application of phosphorus fertilizer levels in 2010 and 2011.

Treatments	No filled grains panicle^{-1}		No unfilled grains panicle^{-1}		1000 grain weight (g)	
	2010	2011	2010	2011	2010	2011
Varieties:						
Sakha105	124.14	128.03	8.667	7.508	29.210	29.0613
Sakha106	147.58	148.19	6.567	5.963	28.061	28.9193
Giza178	174.92	178.44	11.813	10.880	19.748	19.1958
Giza182	154.99	159.06	10.150	9.808	26.704	26.5198
L.S.D 0.05	1.61	0.89	0.546	0.482	0.294	0.1063
P_2O_5 kg ha^{-1}						
0	142.44	146.10	11.188	10.336	25.114	25.3004
18	149.13	151.86	8.979	8.466	25.970	25.8437
36	155.08	157.55	8.500	7.696	26.451	26.2756
54	154.97	158.21	8.529	7.662	26.188	26.2766
L.S.D 0.05	1.02	1.31	0.296	0.276	0.204	0.0489
Interaction	**	**	**	**	*	**

Interaction of varieties and phosphorus levels significantly affected number of filled grains panicle^{-1} (Table 6). Giza178 and Giza182 produced the highest number of filled grains panicle^{-1} when fertilized with 36 kg P_2O_5 ha^{-1}. The lowest values of number of filled grains panicle-1 were obtained when unfertilized plots (control) planted by Sakha105 variety followed by Sakha106. It can be noticed that japonica varieties (Sakha105 and Sakha106) responded only to 18 kg P_2O_5 ha^{-1} in number of filled grains panicle^{-1}, while Giza 178 and Giza182 as indica/japonica and indica respectively responded to 36 kg P_2O_5 ha^{-1}.

6- Number of unfilled grains panicle^{-1}:

Rice varieties and phosphorus levels had a significant effect on number of unfilled grains panicle^{-1} in 2010 and 2011 (Table 5). Giza178 significantly gave the highest number of unfilled grains panicle^{-1} followed by Giza182, Sakha105 and Sakha106 respectively. This might be due to the difference in nature of rice variety, whereas some of the grains on the same panicle of Giza178 (indica/japonica type) didn't mature in the same time especially in the lower part of panicle. While in japonica type Sakha105 and Sakha106, the panicles are completely excreted thus, most of grains are mature in the same time. In addition, the number of spikelets of japonica type under study less than both indica and indica/japonica, so the photosynthetic products are sufficient for filling most of spikelets of japonica resulted in less number of unfilled grains panicle^{-1}. Similar findings were reported by Sedeek *et al.* (2009).

Table (6): Number of filled and unfilled grains panicle^{-1} and 1000 grain weight (g) affected by the interaction between rice varieties and phosphorus fertilizer levels in 2010 and 2011.

Variety/ P_2O_5 kg ha^{-1}	2010				2011			
	Sakha 105	Sakha 106	Giza 178	Giza 182	Sakha 105	Sakha 106	Giza 178	Giza 182
Number of filled grains panicle^{-1}								
0	119.00	138.33	165.33	147.10	121.57	140.67	170.33	151.83
18	125.57	149.77	170.77	150.43	129.77	150.33	172.67	154.67
36	126.67	151.10	181.57	161.00	130.00	150.67	185.43	164.10
54	125.33	151.10	182.00	161.43	130.77	151.10	185.33	165.67
L.S.D0.05	2.22				2.37			
Number of unfilled grains panicle^{-1}								
0	9.333	7.833	15.583	12.000	8.773	7.120	13.333	12.117
18	8.333	6.083	11.250	10.250	7.230	5.633	11.667	9.333
36	8.417	6.250	10.167	9.167	7.100	5.433	9.333	8.917
54	8.583	6.100	10.250	9.183	6.927	5.667	9.187	8.867
L.S.D0.05	0.692				0.629			
1000 grain weight (g)								
0	28.765	27.073	18.870	25.747	28.882	28.407	18.140	25.773
18	29.204	28.353	19.622	26.701	29.145	29.073	18.573	26.583
36	29.646	28.443	20.262	27.454	29.149	29.072	20.000	26.882
54	29.225	28.374	20.238	26.914	29.070	29.125	20.070	26.841
L.S.D0.05	0.430				0.126			

Number of unfilled grains panicle^{-1} was significantly affected by application of phosphorus levels (Table 5). The plants that fertilized with 36 or 54 kg P_2O_5 ha^{-1} produced the lowest number of unfilled grain. While the plants that didn't receive phosphorus fertilizer gave the highest values of number of unfilled grains. These results were true in both seasons. Tanaka *et al.* (1995) reported that the effect of phosphorus application on unfilled grain mainly attributed to that phosphorus 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 functions to adjust the concentration of phosphoric acid utilized for the starch synthesis. These findings are in consistent with those reported by Metwally (2007).

Interaction effect of varieties and phosphorus levels had a significant effect on number of unfilled grains panicle^{-1} (Table 6). The lowest number of unfilled grains panicle^{-1}was found when Sakha 106 fertilized with any of the tested rate of phosphorus under study. The highest number of unfilled grains panicle^{-1}was observed in Giza178 when phosphorus fertilizer didn't apply (unfertilized treatment).

7- 1000 grain weight (g):

Data in Table 5 Showed that 1000 grain weight of rice varieties was significantly influenced by phosphorus application in 2010 and 2011. The heaviest 1000 grain weight was markedly produced by Sakha105 followed by

Sakha106 compared with other varieties, while Giza178 gave the lightest 1000 grain weight. These varietal differences might be due to the differences in their genetic structures. These results are in agreement with those reported by Hammoud *et al.* (2006). Data showed also that application of phosphorus significantly increased 1000-grain weight. Thus, the highest values of 1000-grain weight significantly appear when phosphorus was applied at the rate of 36 and 54 kg P_2O_5 ha^{-1} in the first and second season respectively. No marked differences were detected between 36 and 54 kg P_2O_5 ha^{-1}. While the lowest values were obtained with control. These results are in agreement with those reported by Metwally (2007).

The interaction effect between varieties and phosphorus levels showed significant influence in 1000 grain weight (Table 6). Sakha105 and Sakh106 produced the heaviest 1000 grain weight when fertilized with phosphorus without any significant differences among different rates. While the lowest values were obtained when Giza178 did not receive any phosphorus fertilizer. It can be easily noticed that Giza178 and Giza182 responded to 36 kg P_2O_5 ha^{-1} and gave its maximum values in this aspect. This might be due to the translocation of phosphorus from shoot to grains increased in Giza178 and Giza182 at higher dose of phosphorus. Islam *et al*. (2008) reported similar conclusion.

8- Grain yield (t ha^{-1}):

Data in Table 7 indicated that rice varieties, phosphorus application and their interaction significantly affected grain yield in 2010 and 2011. Giza178 rice variety significantly surpassed grain yield followed by Giza182 which was statistically similar to Sakha105 and Saka106. The superiority of Giza178 (indica/japonica type) in grain yield might be due to its higher numbers of panicles m^{-2} and number of filled grains $panicle^{-1}$. These results are in agreement with those obtained by Abd El-Wahab (1998). Data showed also that significant increase in grain yield as phosphorus level increased from 0 up to 36 kg P_2O_5 ha^{-1} in the first and second seasons. No marked differences in grain yield was happened when phosphorus levels increased from 36 to 54 kg P_2O_5 ha^{-1}.

Table (7): Grain yield t ha^{-1}, straw yield t ha^{-1} and harvest index of some rice varieties as affected by the application of phosphorus fertilizer levels in 2010 and 2011.

Treatments	Grain yield t ha^{-1}		Straw yield t ha^{-1}		HI	
	2010	2011	2010	2011	2010	2011
Varieties:						
Sakha105	10.396	10.740	13.586	14.005	0.43333	0.43367
Sakha106	10.497	10.851	14.306	14.725	0.42317	0.42400
Giza178	11.057	11.473	14.083	13.184	0.43975	0.46529
Giza182	10.525	10.883	13.511	13.930	0.43783	0.43842
L.S.D 0.05	0.237	0.252	0.106	0.106	0.00264	0.00276
P_2O_5 kg ha^{-1}						
0	9.759	10.033	13.051	13.099	0.42800	0.43375
18	10.761	11.145	14.024	14.033	0.43425	0.44283
36	10.989	11.397	14.229	14.381	0.43583	0.44233
54	10.966	11.372	14.181	14.331	0.43600	0.44246
L.S.D 0.05	0.220	0.233	0.137	0.147	0.00244	0.00251
Interaction	**	**	**	**	*	**

The increase in grain yield by increasing phosphorus level up to 36 kg P_2O_5 ha^{-1} was due to the increase in most of yield components, i.e. the number of panicles m^{-2}, panicle weight and the number of filled grain per panicle. Similar trend was found by Wilson (1999), Hood (2002), Tripathi *et al.* (2001) and Metwally (2007).

Data in Table 8 present grain yield as affected by the interaction between rice varieties and phosphorus fertilizer. Combination of Giza178 with 36 or 54 kg P_2O_5 ha^{-1} produced the highest grain yield followed by Giza182 with the same levels of phosphorus. Application of any phosphorus level over the control increase the grain yield of Sakh105 and Sakha106 without any significant differences among the phosphorus levels under study. The previously mentioned results were hold true in the two studied seasons.

Table (8): Grain yield t ha^{-1}, straw yield t ha^{-1} and harvest index as affected by the interaction between rice varieties and phosphorus fertilizer levels in 2010 and 2011.

Variety/ P_2O_5 kg ha^{-1}	2010				2011			
	Sakha 105	Sakha 106	Giza 178	Giza 182	Sakha 105	Sakha 106	Giza 178	Giza 182
				Grain yield t ha^{-1}				
0	9.298	9.677	10.558	9.503	9.521	9.941	10.920	9.749
18	10.770	10.830	10.996	10.448	11.155	11.221	11.406	10.798
36	10.737	10.833	11.307	11.078	11.118	11.225	11.750	11.496
54	10.780	10.647	11.367	11.070	11.166	11.018	11.817	11.488
L.S.D0.05	0.235				0.261			
				Straw yield t ha^{-1}				
0	12.400	13.753	13.573	12.477	12.819	14.172	12.510	12.896
18	13.900	14.500	14.173	13.523	14.319	14.919	12.951	13.942
36	14.013	14.587	14.283	14.033	14.432	15.005	13.633	14.452
54	14.030	14.383	14.300	14.010	14.449	14.802	13.643	14.429
L.S.D0.05	0.251				0.267			
				Harvest index				
0	0.4287	0.4133	0.4373	0.4326	0.4260	0.4123	0.4660	0.4307
18	0.4363	0.4277	0.4370	0.4360	0.4377	0.4293	0.4680	0.4363
36	0.4340	0.4263	0.4417	0.4413	0.4350	0.4280	0.4630	0.4423
54	0.4343	0.4253	0.4430	0.4423	0.4360	0.4263	0.4642	0.4433
L.S.D0.05	0.0047				0.0049			

9- Straw yield (t ha^{-1}):

Straw yield of different varieties as affected by phosphorus levels is presented in Table 7. Data indicated that there were significant differences among the varieties in straw yield. Skha106 significantly recorded the highest values of straw yield, followed by Sakha105, while Giza178 gave the lowest straw yield. This mainly due to genetic structure among the different tested genotypes. Increasing phosphorus level up to 36 kg P_2O_5 ha^{-1} significantly increased straw yield. While there was a slight reduction in straw yield due to increasing phosphorus level from 36 to 54 kg P_2O_5 ha^{-1}. The effect of phosphorus application on straw yield might be attributed to the increase in vegetative growth due to enhancement of cell division and elongation in stem internodes. These findings are in close agreement with those reported by Tang and Yu (2002), Ali and Ansari (2006) and Metwally (2007).

As for interaction (Table 8), the highest straw yield was recorded with Sakha106 when fertilized with 36 kg P_2O_5 ha^{-1} and it was statistically at par with 18 or 54 kg P_2O_5 ha^{-1} while, the lowest values were obtained from Sakha105 under unfertilized treatment. It can be easily noticed that application of any of phosphorus rate to all tested varieties cause an increase in straw yield.

10- Harvest index:

Data in Table 7 showed that harvest index significantly affected by rice varieties, phosphorus levels and their interaction in the both seasons. The highest values of harvest index was markedly found with Giza178 followed by Giza182 while, Sakha106 gave the lowest value. Harvest index was significantly increased by the application of phosphorus fertilizer. There was no significant differences among plants received 18 and those received 36 or 54 kg P_2O_5 ha^{-1}.

Concerning the interaction effect, the highest values of harvest index was found by Giza178 when fertilized with 54 kg P_2O_5 ha^{-1} in the first season and with 18 kg P_2O_5 ha^{-1} in the second season. Adding phosphorus at the rate of 18, 36 and 54 kg P_2O_5 ha^{-1} showed similar response towards harvest index of Sakha105 and Sakha106 rice varieties.

11- Hulling (%):

Data in Table 9 indicated that hulling percentage of the different genotypes was significantly affected by application of phosphorus levels in 2010 and 2011. The highest hulling percentage was significantly observed in variety Giza182 followed by Sakha106, while the lowest value was obtained by Giza178 followed by Sakha 105. These differences between varieties might due to genetic make up.

Phosphorus application had a significant effect on hulling percentage in the both seasons. Increasing phosphorus level up to 54 kg P_2O_5 ha^{-1} significantly increased hulling percentage although it was statistically insignificant with 36 kg P_2O_5 ha^{-1}. Matsuzaki (1995) found that the effect of phosphorus on hulling percentage mainly due to that the storing of starch in the endosperm cells occurs through phosphorilation processes by phosphorylase enzyme. Carbohydrates translocated from stems and leaves in the form of sucrose, glucose or other reduced sugars, are synthesized into starch granules in endosperm cells and aided by phosphorylase. In this case the spikelets were completely filled and that produce a thin hull with lighter weight corresponding to the grain weight. These findings are consistent with those reported by Metwally (2007).

Concerning the interaction between rice varieties and phosphorus levels, phosphorus fertilizer levels caused different responses in hulling percentage in different varieties (Table 10). Sakha106 and Giza182 produced the highest values of hulling percentage when fertilized with any of the phosphorus levels, while Giza178 recorded the lowest values of hulling percentage under unfertilized plots.

12- Milling (%):

Data in Table 9 showed that milling percentage of different rice genotypes were significantly affected by application of phosphorus levels in 2010 and 2011. The highest value of milling percentage was found in

Skha106 while the lowest value was obtained by Giza182 variety. These differences between varieties might due to genetic make up.

Table (9): Hulling, milling, head rice and amylose percentage of some rice varieties as affected by the application of phosphorus fertilizer levels in 2010 and 2011.

Treatments	Hulling (%)		Milling (%)		Head rice (%)		Amylose (%)	
	2010	2011	2010	2011	2010	2011	2010	2011
Varieties:								
Sakha105	80.894	80.837	71.579	71.607	63.506	63.542	18.742	18.830
Sakha106	83.815	83.750	74.063	74.089	64.077	64.113	18.163	18.248
Giza178	80.483	80.422	69.710	69.740	62.277	62.315	18.791	18.878
Giza182	84.101	84.036	66.291	66.325	67.572	67.604	20.779	20.888
L.S.D 0.05	0.191	0.188	0.849	0.848	1.081	1.080	0.308	0.309
P_2O_5 kg ha^{-1}								
0	81.375	81.318	68.804	68.836	61.602	61.640	18.040	18.121
18	82.265	82.202	70.327	70.356	64.455	64.490	19.402	19.498
36	82.785	82.721	71.231	71.260	65.670	65.704	19.564	19.661
54	82.868	82.804	71.281	71.309	65.705	65.740	19.469	19.565
L.S.D 0.05	0.173	0.173	0.317	0.317	0.427	0.427	0.150	0.153
Interaction	**	**	**	**	*	*	**	*

Milling percentage was significantly affected by the application of phosphorus levels. Increasing phosphorus levels up to 36 or 54 kg P_2O_5 ha^{-1} significantly increased significantly milling percentage. The milling percentage obtained with 54 kg P_2O_5 ha^{-1} was statistically identical with 36 kg P_2O_5 ha^{-1}. The increase in milling percentage due to increasing phosphorus level might be due to that phosphorus is involved as an energy carrier in carbohydrate metabolism which increase starch endosperm inside the grain resulted in minimization of hull thickness consequently increase milling output. The Similar trend was found in the both seasons. These findings are consistent with those reported by Matsuzaki (1995) and Metwally (2007).

The interaction effect of variety and phosphorus had significant effect on the milling percentage in 2010 and 2011. Application of phosphorus fertilizer generally increased milling percentage across varieties. The increase in milling percentage was observed with combination of Sakha106 with 18 kg P_2O_5 ha^{-1}, while the lowest value was found by Giza182 under control treatment. It can be observed that japonica varieties responded to 18 kg P_2O_5 ha^{-1}, while indica and indica/japonica varieties responded to 54 kg P_2O_5 ha^{-1} with insignificant differences with 36 kg P_2O_5 ha^{-1} but the values of milling in the japonica type were dramatically higher.

13- Head rice (%):

Head rice percentage of the tested genotypes was significantly affected by phosphorus levels and the interaction in 2010 and 2011 (Table 9). The rice variety Giza182 significantly produced the highest head rice recovery followed by Sakha106, while the lowest value was found in Giza178. Head rice percentage increased progressively with an increase in phosphorus rate up to 54 kg P_2O_5 ha^{-1}, although there was no any significant difference between 36 and 54 kg P_2O_5 ha^{-1}.

Concerning the interaction effect (Table10), Giza182 combined with 36 kg P_2O_5 ha^{-1} produced the highest head rice percentage, while Giza178 under control gave the lowest value and the two japonica varieties came in between.

14- Amylose (%):

Data in Table 9 indicated that amylose percentage in the tested rice varieties was significantly affected by the application of phosphorus levels in 2010 and 2011. Sakha106 variety showed lowest amylose content, while highest amylose content was recorded in Giza182 variety followed by Giza178. Amylose content in rice grain increased with increasing phosphorus fertilizer levels up to 36 kg P_2O_5 ha^{-1}. Increasing phosphorus levels from 36 to 54 kg P_2O_5 ha^{-1} caused a slight reduction in amylose content.

Significant variation in amylose content was observed due to the interaction between varieties and phosphorus levels in 2010 and 2011 (Table10). Combination of Giza182 with 36 or 54 kg P_2O_5 ha^{-1} produced the highest percentage of amylose. Sakha106 variety produced significantly the lowest percentage of amylose when grown under control (without phosphorus fertilizer).

Table (10): Hulling, milling, head rice and amylose percentage as affected by the interaction between rice varieties and phosphorus fertilizer levels in 2010 and 2011.

Variety/ P_2O_5 kg ha^{-1}	2010				2011			
	Sakha 105	Sakha 106	Giza 178	Giza 182	Sakha 105	Sakha 106	Giza 178	Giza 182
				Hulling percentage (%)				
0	80.169	83.050	78.849	83.433	80.128	82.986	78.789	83.369
18	81.077	84.091	80.060	83.833	81.015	84.026	79.999	83.768
36	81.076	84.069	81.507	84.490	81.014	84.004	81.444	84.424
54	81.256	84.051	81.518	84.647	81.193	83.986	81.455	84.581
L.S.D0.05	0.247				0.245			
				Milling percentage (%)				
0	70.051	72.247	68.109	64.811	70.081	72.275	68.141	64.846
18	71.944	75.027	68.469	65.867	71.973	75.052	68.500	65.901
36	72.204	74.551	71.009	67.160	72.232	74.577	71.038	67.193
54	72.116	74.429	71.251	67.327	72.143	74.454	71.280	67.359
L.S.D0.05	0.938				0.937			
				Head rice percentage (%)				
0	60.072	61.833	58.783	65.718	60.112	61.871	58.824	65.753
18	64.661	64.804	61.587	66.769	64.696	64.839	61.625	66.801
36	64.656	64.817	64.380	68.826	64.69264	64.852	64.416	68.857
54	64.633	64.853	64.360	68.975	.668	64.888	64.395	69.006
L.S.D0.05	1.213				1.212			
				Amylose percentage (%)				
0	17.987	17.030	17.970	19.173	18.067	17.100	18.050	19.267
18	18.990	18.543	19.067	21.010	19.080	18.633	19.157	21.120
36	18.990	18.633	19.167	21.467	19.080	18.723	19.257	21.583
54	19.003	18.447	18.960	21.467	19.093	18.533	19.049	21.583
L.S.D0.05	0.372				0.376			

15- Nitrogen % in rice grain and straw:

Data in Table 11 showed that nitrogen % in rice straw and grain of the tested varieties significantly affected by phosphorus levels and their interaction in the both seasons. Sakha106 gave the highest values of nitrogen % in rice grain and straw followed by Sakha105. The lowest values of nitrogen % in rice grain of Giza178 and in straw of Giza182 varieties.

Table (11): Nitrogen and Phosphorus percentage of rice straw and grain of some rice varieties as affected by the application of phosphorus fertilizer levels in 2010 and 2011.

Treatments	N % in straw		N % in grain		P % in Straw		P % in grain	
	2010	2011	2010	2011	2010	2011	2010	2011
Varieties:								
Sakha105	1.2800	1.2900	0.6742	0.6842	0.0713	0.0663	0.1663	0.1647
Sakha106	1.3383	1.3483	0.7800	0.7900	0.0857	0.0831	0.1473	0.1585
Giza178	0.9700	0.9801	0.5992	0.6086	0.1405	0.1358	0.1743	0.1572
Giza182	0.8792	0.8892	0.7258	0.7358	0.1063	0.0905	0.1553	0.1661
L.S.D 0.05	0.0266	0.0239	0.0127	0.0124	0.0020	0.0022	0.0045	0.0018
P_2O_5 kg ha^{-1}								
0	0.9242	0.9350	0.6042	0.6142	0.0706	0.0644	0.1322	0.1287
18	1.1467	1.1575	0.7117	0.7217	0.1058	0.0834	0.1507	0.1592
36	1.1850	1.1958	0.7333	0.7433	0.1099	0.1080	0.1692	0.1818
54	1.2117	1.2193	0.7300	0.7394	0.1174	0.1198	0.1911	0.1768
L.S.D 0.05	0.0166	0.0161	0.0266	0.0176	0.0014	0.0014	0.0023	0.0010
Interaction	**	**	*	**	**	**	**	**

Data showed that nitrogen % in rice straw and grain significantly increased with phosphorus application. Increasing phosphorus levels up to the highest level (54 kg P_2O_5 ha^{-1}) significantly increased the nitrogen % in rice straw and grain. This trend was found in the both seasons. The nitrogen translocation to rice straw and grain could be dependent upon availability of the high-energy required for absorption of nitrogen and its metabolism and contribution in both grain and straw. These findings are in close agreement with those reported by Rajkhowa *et al.* (1997), Ranjha *et al.* (2001) and Tang and Yu (2002).

The interaction between the studied factors had significant effect on nitrogen % in rice grain and straw in both seasons (Table 12). Nitrogen % in rice grain and straw of all tested varieties were significantly responded to phosphorus application. Sakha105 and Sakha106 significantly responded to phosphorus application up to 18 kg P_2O_5 ha^{-1} while Giza178 and Giza182 were significantly responded to 36 kg P_2O_5 ha^{-1}. The highest values were obtained when Sakha106 fertilized with 54 kg P_2O_5 ha^{-1} while, the lowest values of N% in straw of Giza182 was recorded when grown under control treatment.

16- Phosphorus % in rice grain and straw:

Phosphorus % in rice grain and straw was significantly differed among verities, phosphorus levels and their interaction in 2010 and 2011 (Table 3). Giza178 markedly other tested varieties regarding phosphorus % in rice straw in both seasons while, Giza 178 and Sakha105 recorded the highest percentage of phosphorus content % in rice grain in 2010 and 2011 respectively.

Grain and straw phosphorus concentration tended to increase as phosphorus fertilizer level increased. Increasing phosphorus level from 0 up to 54 kg P_2O_5 ha^{-1} significantly increased phosphorus % in rice grain and straw. This could be attributed to that most of phosphorus applied to rice plants was accumulated in seeds. Tanaka *et al.* (1995) and Sasaki and Hirata (1995) reported that more than 70% of absorbed phosphorus by rice plants translocated to and accumulated in seeds is stored in the form of phytin.

The interaction between rice varieties and phosphorus levels had significant effect on phosphorus % in rice grain and straw (Table 12). The highest percentages of phosphorus in rice grain and straw were recorded when 54 kg P_2O_5 ha^{-1} applied to Giza178 and Giza182 in 2010 and 2011 respectively. While the lowest values were observed when Sakha105 cultivated under unfertilized plots.

Table (12): Nitrogen and phosphorus content percentage of rice straw and grain as affected by the interaction between rice varieties and phosphorus fertilizer levels in 2010 and 2011.

Variety/ P_2O_5 kg ha^{-1}	2010				2011			
	Sakha 105	Sakha 106	Giza 178	Giza 182	Sakha 105	Sakha 106	Giza 178	Giza 182
				N % in straw				
0	1.1100	1.0500	0.8267	0.7100	1.1233	1.0600	0.8367	0.7200
18	1.3267	1.4267	0.9467	0.8867	1.3400	1.4367	0.9567	0.8967
36	1.3367	1.4333	1.0533	0.9167	1.3500	1.4433	1.0633	0.9267
54	1.3467	1.4433	1.0533	1.0033	1.3467	1.4533	1.0637	1.0133
L.S.D0.05	0.0364				0.0342			
				N %in grain				
0	0.5933	0.6967	0.5133	0.6133	0.6033	0.7067	0.5233	0.6233
18	0.7000	0.8067	0.5933	0.7467	0.7100	0.8167	0.6033	0.7567
36	0.7067	0.8100	0.6467	0.7700	0.7167	0.8200	0.6567	0.7800
54	0.6967	0.8067	0.6433	0.7733	0.7067	0.8167	0.6510	0.7833
L.S.D0.05	0.0156				0.0158			
				P % in Straw				
0	0.1433	0.1010	0.1515	0.1330	0.1210	0.1110	0.1517	0.1310
18	0.1533	0.1527	0.1527	0.1440	0.1627	0.1610	0.1617	0.1513
36	0.1767	0.1543	0.1913	0.1543	0.1833	0.1710	0.1920	0.1810
54	0.1916	0.1810	0.2017	0.1901	0.1917	0.1910	0.1233	0.2010
L.S.D0.05	0.0055				0.0023			
				P % in grain				
0	0.0410	0.0801	0.0701	0.0913	0.0430	0.0650	0.0657	0.0840
18	0.0710	0.0804	0.1613	0.1107	0.0510	0.0757	0.1210	0.0860
36	0.0723	0.0907	0.1650	0.1117	0.0750	0.0957	0.1753	0.0860
54	0.1010	0.0917	0.1657	0.1113	0.0959	0.0960	0.1813	0.1060
L.S.D0.05	0.0029				0.0030			

CONCLUSION

Combination of Giza178 variety (indica/japonica type) with 36 kg P_2O_5 ha^{-1} produced the highest grain yield followed by Giza182 (indica type) with the same level of phosphorus. Sakha105 and Sakha106 varieties (japonica type) responded to only 18 kg P_2O_5 ha^{-1} and came in the second rank. hulling, milling and head rice of japonica varieties were the highest under 18 kg P_2O_5 ha^{-1}, while indica or indica/japonica responded up to 36 kg P_2O_5 ha^{-1}. Amylose content reached to the maximum value under 18 kg P_2O_5 ha^{-1} for all the tested varieties. Although japonica type contain the lowest values than the other varieties under study.

REFERENCES

Abd El-Wahab, A.E. (1998). Physiological behavior of Egyptian rice cultivars under different nitrogen levels. Egypt. J. Appl. Sci. 13 (4): 15-25.

Ali, Q. and Z.A Ansari. (2006). Phosphorus requirements of rice grown in Soils with different sodicity. J. Plant Nutr. 29(12):2105-2117.

Black, C.A., D.D. Evans, L.E. Ensminger, and F.E. Clark. (1965). Methods of Soil Analysis. Part 2- Chemical and microbiological properties. J. Am. Soc. Agro. Inc. Publisher Madison Wisconsin, USA.

Blevins, D.G. (1999). Why plants need phosphorus. Better Crops with Plant Food., 83(4):29-30.

Brooks, A. (1986). Effects of Phosphorus Nutrition on Ribulose-1,5-Bisphosphate Carboxylase Activation, Photosynthetic Quantum Yield and Amounts of Some Calvin Cycle Metabolites in Spinach Leaves, Aust. J. Plant Physiol., 13:221–237.

Ebaid, R.A. and I.M. El-Rewainy. (2005). Response of some rice cultivars to different levels of nitrogen fertilizer. Egypt. J. Agric. Res., 83(5B):359-367.

Ehsan U., A. Rehman, Q. Arshad and S. S. Shah. (2009). Yield response of fine rice to NP fertilizer and weed management practices. Pak. J. Bot., 41(3): 1351-1357,

Fageria, N.K., V. C. Baligar. (1996_. Response of lowland rice and common bean grown in rotation to soil fertility levels on a Varzea soil. Fert. Res., 45:13–20.

Fageria, N.K.; Baligar, V.C.; Jones, C.A. (1997). Growth and Mineral Nutrition of Field Crops, 2nd Ed., Marcel Dekker Inc., New York, USA.

Gomez, K.A. and A.A. Gomez. (1984). Statistical Procedures for Agricultural Research. 2nd ed. Jahn Wiley Sons, New York, USA.

Hammoud, S.A.; A.B. Khattab; S.E.M. Sedeek and A.B. EL-Abd (2006). Genetic analysis of grain yield, panicle traits and some grain quality in Rice (Oryza Sativa L.). The first field Crops Conference, Field Crops Res. Inst., ARC, Egypt. 157-170.

Heluf, G. and M. Seyoum. (2006). Effects of mineral N and P fertilizer on yield and yield components of flooded lowland rice on vertisols of fogera plain. Ethiopia J. Agric. and Rural Develop. in the Tropics and Subtropics. 107(2):161-167

Hood, M. (2002). Rice responds to phosphorus and zinc. Farmers' Newsletter, 160: 34-35

Ibrahim, R. (2001). Effects of nitrogen and phosphorus levels on yield and yield components of three upland rice (Oryza sativa L.) varieties at Samaru, Nigeria. ASSET Series A: Agric. and Env., 1(2): 115-119

Islam, M. A. ; M. R. Islam and A. B. S. Sarker. (2008). Effect of phosphorus on nutrient uptake of japonica and indica rice. J. Agric. Rural Dev. 6(1&2):7-12.

Jackson, M.L. (1967). Soil Chemical Analysis. Printic Hall of India, New Delhi. 144-197.

Johonson, C.W. and A. Ulrich. (1959). Analytical Methods For Use in Plant Analysis. Calif. Agric. Expt. Station. Bull. 716:32-33.

Juliano, B.O. (1972). Physicochemical properties of starch and protein in relation to grain quality and nutritional value of rice. In IRRI Rice Breeding. IRRI, Los Baños, Philippines, pp: 389-405.

Kumar, S. and R.S. Singh. (2001). Phosphorus management in rice-wheat cropping system. J. Res. Birsa. Agric. Univ., 13(1):51-56.

Matsuzaki, A. (1995). Development And Aging of Panicles. Science of the Rice Plant. Volume two, physiology. Food and Agricultural Police Research Center, Tokyo. 156-164.

Metwally, T.F. (2007). Performance of Sakha104 rice cultivar as affected by the interaction between Zn and N, P and K fertilizer. Ph.D. Thesis, Agron. Dep., Fac. Agric., Kafr El-Sheikh Univ., Egypt.

Nagappa M. A. and, D. P. Biradar, (2002). Response of hybrid rice to different levels of nutrient application in TBP area. Karnataka Journal of Agricultural Sciences,15(2): 356-358.

Panda, S.C.; P.C. Panda and S.S. Nada. (1995). Effect of levels of N and P on yield and nutrient uptake of rice. Oryza, 32:18-20.

Pieters, A.J., M.J. Paul, and D.W. Lawlor. (2001). Low Sink Demand Limits Photosynthesis under Pi De ficiency, J. Exp. Bot., vol. 52, pp. 1083–1091.

Rajkhowa, D. J.; S.R. Baroova, and N.N. Sharma. (1997). Phosphorus utilisation and nutrient concentrations in rice as influenced by source and level of phosphorus. J. Agric. Sci. Soc. of North East India.10(2):182-185.

Ranjha, A. M.; A.Iftikhar,; M. Iqbal, and M.J. Ahmed, (2001). Rice response to applied phosphorus, zinc and farmyard manure. Int. J. Agric. and Biol. 3(2):197-198.

Sasaki, Y. and H. Hirata. (1995). Absorption and Metabolism of Phosphate. Science of the Rice Plant. Volume two, physiology. Food and Agric. Police Res. Center, Tokyo. 368-383.

Sedeek, S.E.M. (2001). Studies of morphological and agronomical characteristics of some early varieties and lines of rice. M.Sc. Thesis Agron. Dep., Fac. of Agric., Tanta Univ., Egypt.

Sedeek, S.E.M.; S.A.A. Hammoud; M.H. Ammar and T.F. Metwally. (2009). Genetic variability, heritability, genetic advance and cluster analysis for some physiological traits and grain yield and its components in rice (*Oryza sativa* L.). J. Agric. Res. Kaferelsheikh Univ., 35 (3):858-878.

Shah, M.A.L. (2002). Phosphorus nutrition of rice varieties in relation to phosphorus sources and rates on a phosphorus deficit soil. Ph.D. Thesis Dept. Soil Sci., Banghabandhu Seikh Mujibur Rahman Agric. Univ., Gazipur.

Tanaka, K., Z. Kasai and M. Ogawa. (1995). Physiology of Ripening. Science of the Rice Plant. Volume two, physiology. Food and Agricultural Police Research Center, Tokyo. 97-118.

Tanaka, K.; Z. Kasai and M. Ogawa. (1995). Physiology of Ripening. Science of the Rice Plant. Volume two, physiology. Food and Agric. Police Res. Center, Tokyo. 97-118.

Tang, X.R. and T.Q. Yu. (2002). Effects and mechanisms of P and K nutrients on yield and protein content of fodder rice. Agric. Sci. in China, 1(4): 432-437.

Terry, N. and I.M. Rao. (1991). Nutrient and Photosynthesis: Iron and Phosphorus as Case Studies, Plant Growth: Interaction with Nutrition and Environment, Porter, J.R. and Lawlor, D.W., Eds., Cambridge: Cambridge Univ. Press, pp. 54–59.

Tripathi, B. N., V. K. Dixit and C. N. Chaubey. (2001). Influence of various levels of moisture regimes, puddling and phosphorus application on the yield and nutrients uptake by rice. Bhartiya Krishi Anusandhan Patrika.16 (1/2): 45-50.

Waller, R.A. and D.B. Duncan. (1969). Bayes rule for the Symmetric Multiple Comparison Problem. J. Am. Stat. Assoc.64:1484 -1499.

Watanabe, F.S. and S.A. Olsen (1962). Calorimetric determination of phosphorus in water extract. Soil Sci. 93:183-188.

Wilson, C.E.; N.A. Slaton, S. Ntamatungiro, D.L. Frizzell, W.B. Koen and R.J. Normas. (1999). Phosphorus fertilizer recommendations for rice. Better crops, 83(4):9-11.

Xu, H.X., X.Y. Weng and Y. Yang. (2007). Effect of Phosphorus Deficiency on the Photosynthetic Characteristics of Rice Plants. Russ. J. Plant Phys,. 54-6:741-748.

سلوك بعض أصناف الأرز تحت إضافة مستويات مختلفة من الفوسفور

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مركز البحوث والتدريب في الأرز- معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية - مصر

يعتبر الفوسفور احد العناصر الضرورية الكبرى التي تؤثر على محصول ونمو نبات الأرز لدوره في عملية التمثيل الغذائي والنشاط الأنزيمي خلال فترتي النمو الخضري وامتلاء الحبوب. أجريت دراسة حقلية لدراسة سلوك بعض أصناف الأرز المصرية وهي سخا 105 و سخا106 (يابانية)، وجيزة178 (هندية / يابانية)، جيزة182 (هندية) تحت أربع مستويات من السماد الفوسفوري وهي 0، 18، 36، 54 كجم فو2أ5 للهكتار. أجريت هذه الدراسة في المزرعة البحثية لمركز البحوث والتدريب في الأرز بسخا – كفرالشيخ – جمهورية مصر العربية خلال عامي 2010 و 2011. وقد أوضحت النتائج أن أصناف الأرز اختلفت استجابتها للسماد الفوسفوري. استجابة الأصناف ذات الخلفية الوراثة الهندية إلى 54 كجم فو2أ5 للهكتار دون فروق معنوية مع 36 كجم فو2أ5 للهكتار.إضافة السماد الفوسفوري أدي إلى تحسين صفات النمو (ارتفاع النبات وطول الدالية) فضلا عن زيادة في محصول الحبوب ومكوناته . إضافة 36 أو 54 كجم فو2أ5 للهكتار لصنف الأرز جيزة178 أعطى أعلى إنتاج من محصول الحبوب تلاه صنف الأرز جيزة182 مع نفس مستويات الفوسفور.إضافة 18 كجم فو2أ5 لصنفي الأرز سخا105 وسخا106 أعطى أعلى محصول لهما. إضافة السماد الفوسفوري بمعدل 36 كجم فو2أ5 للصنف الهندي او الهندي/الياباني أعطي أعلى القيم لصفات جودة الحبوب بينما 18 فو2أ5 كانت كافيه لهذه الصفات مع الأصناف اليابانية وكذلك محتوى الاميلوز الذي لم يتأثر إلا بمعدل18 فو2أ5 فقط.

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