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DIFFERENCES IN PHOSPHORUS-USE EFFICIENCY OF SOME LOWLAND RICE (*Oryza sativa L.*) VARIETIES.

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ABSTRACT

Many soils are deficient in phosphorus, but this is not the only reason for continued use of P fertilizers. Genotypic differences in absorption or utilization of P might be exploited to improve efficiency of fertilizer use or to obtain higher productivity on P-deficient soils. The objective of this study was to evaluate 11 rice cultivars for P-use efficiency. To achieve this goal, the rice cultivars were grown in culture solution at three levels of P (0, 5 and 10 ppm P) for 35 days after transplanting in the greenhouse. Plant height, number of tillers, root length, as well as dry matter production, P uptake in partitioned plant parts and P-use efficiency parameters were estimated after harvesting. The results revealed that plant height, tillers number, root length, shoot and root dry weight, shoot/root ratio, P content in root and shoot were significantly affected by P treatments as well as rice cultivars. Shoot dry weight, tillers number as well as shoot and root P uptake were found to be the plant parameters most sensitive to P deficiency suggesting that there were four parameters may be the most suitable for screening rice cultivars for P-use efficiency under culture solution conditions. Based on dry matter production and P-use efficiency. Rice cultivars were classified as efficient and responsive (ER) represented by (Giza 181 and Giza 182), efficient and non-responsive (ENR) (Giza 171), non-efficient and responsive (NER) (Giza 176, Giza 178 and Sakha 104) and non-efficient and non-responsive (NENR) represented by (Giza 172, Giza 177, Sakha 101, Sakha 102 and Sakha 103).
Keywords: P-use efficiency, rice varieties, plant growth, P-uptake.

INTRODUCTION

Rice is a vital to more than half the world's populations. It is the most important food grain in the diets of hundreds of millions of Asians, Africans, and Latin Americans living in the tropics and subtropics. Rice production decline may continue despite increased consumption in the last years. Rice is grown on approximately more than 1.5 million feddans in Egypt (MALR, 2006), where phosphorus deficiency is important limitation to its production. Availability of P to plant roots is limited in alkaline soils, mainly, due to formation of sparingly soluble phosphate compounds with calcium. (Marschner,1997). Among the factors of rice production, fertilizers play an important role. Application of phosphoric fertilizer has great impact on rice yield (Alaam et al., 2003). Every year large amounts of P fertilizers, up to 35 million tons of P_2O_5 (Isherwood, 2000) are applied to soils for crop production globally, and only 10-20 % of the applied P fertilizers can be absorbed by plants (Holford,1997). The remaining is rapidly transformed into unavailable P forms, which are not readily absorbed by plant roots. However, many resource-poor farmers can not afford to apply the full dose of P fertilizers needed for high yields. They need rice varieties which are efficient users of soil and fertilizers phosphorus. Genotypical differences in nutrient efficiency occur of reasons, these being related to uptake, transport, and utilization within plants (Marschner, 1997). For phosphorus higher use efficiency in certain genotypes may be related to better use of stored Pi (Hart and Colville, 1988) either within a given tissue or by better retranslocation between shoot organs (Youngdahl, 1990).

Several studies (Fageria and Baligar, 1997a; Oikeh et al., 2003; Hogh-Jensen and Pedersen, 2003 and Kadiata and Lumpungu, 2003) have highlighted the fact that plant species and even varieties withen species vary in their behavior to acquire and utilize nutrients for forage dry metter and/ or grain production. This property is yet to be fully explored, especially for rice. Identification of rice varieties that can efficiency utilize soil P would assist in improving the yield of the crop on alkali, P-defficient soils. Thus, as first step in breeding P-efficient cultivars, it is important to identify P-efficient rice genotypes. Many scientists have tried to select different rice genotypes with a greater ability to absorb P under P-deficient soils. The objective of this study was to evaluate some rice genotypes for P-use efficiency.

MATERIALS AND METHODS

In the present investigation, P-use efficiency was used as the main criterion with the objective to identify any differences among rice cultivars in response to increasing P levels on solution culture.

Growth conditions:

Plants were grown in a big net house without any environmental control, having glass covered roof, sides open, having only wire gauze and no any problem of sunlight. During the time of the experiment and inside the net house, average of maximum daily temperature 35-40 ºC, minimum temperature 26-28 ºC, relative air humidity 70-80 % and bright sunlight, with active photoperiod of 13-14 hours.

Experimental procedure:

The experiment was carried out using 11 different rice varieties grown on culture solution with different levels of phosphorus to evaluate the growth and P-use efficiency of these varieties.

Seeds of eleven rice varieties (Giza 171,172,176,177,178,181,182 and Sakha 101,102,103 and 104) were surface-sterilized with 0.1 % HgCl for 5 minutes and washed twice with distilled water and then soaked for 24 h in distilled water at 20 -25 °C. The seeds were germinated in Petri dishes over three layers of cotton saturated with distilled water. The dishes were then covered and left in the incubator for 48 h at 28-30 °C. The germinated rice seeds were raised on nylon seedbed floating in seven liters plastic tray containing a phosphorus- free culture solution (from Yoshida et al.,1976) (ppm): 40 N, 40 K, 40 Ca, 40 Mg, 0.5 Mn, 0.05 Mo,0.2 B, 0.01 Zn, 0.01 Cu and 2 ppm Fe. Nutrient solution was changed every 5 day and the pH adjusted daily for pH (5.5-6). Fifteen-days-old seedlings of similar size from all the cultivars were selected and transplanted to 3-L plastic containers containing 2.5 liter from nutrient solution as described by Yoshida, et al. (1976) with different levels of phosphorus added as KH_2PO_4 with phosphorus concentration as: (Zero, 5 and 10 ppm P). Each container was used for a single variety having sixteen seedlings held with cotton plugs through plastic lids with equidistant holes. The pH of the nutrient solution was adjusted daily by NaOH or H_2SO_4 to pH (5.5-6). The nutrient solution was changed every three days. Plants were allowed to grow 35 days after the addition of phosphorus. At the end of the experiment, plant height, root length measurements and tiller counts were recorded according to Fageria and Baligar (1997a). After harvest, plant were first washed with tap water several times then rinsed with distilled water, separated to shoot and root and blotted between filter papers. Dry weight of shoot and root were recorded after drying at 70 ºC in a forced-air oven. Oven dried plant material was ground in a rotary grinder. Samples of finely ground of shoot and root were digested with concentrated sulphoric and perchloric acids until the mixture becomes colorless (Jakson, 1973). Phosphorus was determined by using molybdenum blue method as described by El-Hineidy and Agiza (1959).

RESULTS AND DISCUSSION

Nutrient-efficient crops have an important role in modern agriculture. In the low-input systems that characterize most of world agriculture, nutrient-efficient crops improve crop productivity. In high-input systems of the developed world, nutrient-efficient crops are valuable in reducing pollution of surface and ground water resources from intenseive fertilization.

1- plant growth:-

Growth parameters, P concentration and P uptake responses to increase P levels in the culture solution are presented in Table (1).

Table 1: Influence of P levels on growth parameters, plant tissue P concentration and P-uptake of 11 rice cultivars.

Plant parameter [1]	P levels		
	Low	Medium	high
	0 ppm	5 ppm	10 ppm
Plant height (cm)	25.8 b	59.2 a	58.4 a
Root length (cm)	44.0 a	17.4 b	14.5 c
Tillers per pot	7.0 b	24.4 a	24.8 a
Dry shoot weight (g / pot)	1.24 c	7.87 b	8.64 a
Dry root weight (g / pot)	0.84 b	2.27 a	2.34 a
Shoot / Root ratio	1.49 c	3.38 b	3.88 a
P conc. In shoot %	0.07 c	0.22 b	0.32 a
P conc. In Root %	0.05 c	0.13 b	0.22 a
P uptake in shoot (mg/pot)	0.88 c	16.98 b	27.54 a
P uptake in Root (mg/pot)	0.43 c	2.92 b	5.0 a

[1] Data are averaged over genotypes.
Values for each plant parameter under different P levels followed by same letter are not significantly different at the 1 % probability level.

All growth and P uptake parameters increased significantly with increasing levels of P in external media except the plant height, tillers number and dry root weight, which increased up to the "medium" P level. Root length was significantly reduced at medium and high P levels as compared to low P level. At the media (5 ppm) P level, plant height increase was 129 %, root length decrease was 60 %, tillers number increase was 248 %, shoot dry weight increase was 535 %, root dry weight increase was 170 %, and shoot / root ratio increase was 127 % as compared to the low (zero ppm) P level.

Similarly, the increase in P uptake parameters at the "medium" P level was 214 % for P concentration in the shoot, 160 % for P concentration in the root,1830 % for P uptake in shoot, and 579 % for P uptake in root as compared to low P level. All growth and uptake parameters increased significantly with increasing levels of P in the culture solution. This mean that the culture solution used in the experiment was appropriate for screening purposes. In this respect, Fageria, (1989); Fageria and Baligar, (1997b), and Akinrinde and Gaizer (2006) documented that one of the prerequisites of varietal screening for mineral stress is that the growth media should be deficient in the nutrient under investigation.

To identify which of the growth parameters is most sensitive to P deficiency increases in plant height, tillers number, shoot dry weight, root dry weight, shoot / root ratio, P concentration in shoot, P concentration in root, P uptake in shoot, and p uptake in root at medium and high P levels as compared to a low P level were calculated and illustrated in (Fig. 1). Among the growth parameters, shoot dry weight (followed by tillers number) exhibited maximum growth increase with P addition. Among P-uptake parameters, shoot P uptake (followed by root P uptake) increased maximally. Thus shoot dry weight, tillers number as well as shoot and root P uptake were the most sensitive parameters to p deficiency. Since shoot weight and tillers number are the most easily determined among the parameters, it can be used for screening rice genotypic responses to P under culture solution conditions.

1-1- plant height and tillers number:

In general plant height and tillers number were markedly affected by phosphorus application but the magnitude of response varied within rice varieties (Table 2). Tillers at the medium and high P levels were about three-folds higher than the low P level. Plant height varied from 19.7 to 29.7 cm at the low P level, 50.3 to 70.7 cm at the medium P level and 48.3 to 66.3 cm at the high P level. These results indicate that tillers did not change between medium and high P levels. The number of tillers is an important yield contributing component because the number of panicles is closely associated with the number of tillers in rice crop, and in general, increased panicles per unit area are the single most important component of yield associated with rice yield (Gravois and McNew, 1993).

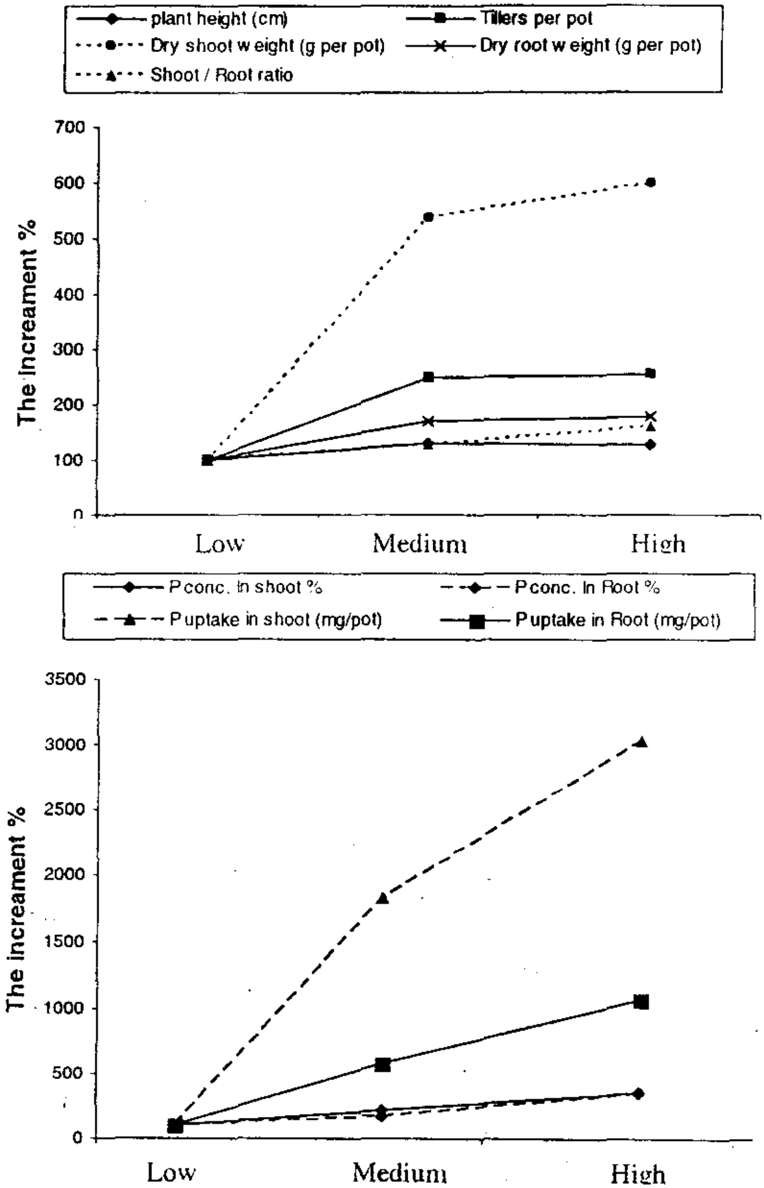

Fig.1 Increase (%) in rice growth and uptake parameters at medium and high P levels as compared to low P level.

1-2- shoot and root dry weight:-

There were significant differences among varieties for each P level for root and shoot dry weight. The data presented in Table 3 reveal that, irrespective of rice varieties, increasing P levels up to 5 ppm, significantly increase in dry matter accumulation in root, while up to 10 ppm in shoot. Dry weight was nearly about three folds for root and about six folds for shoot as the P application increased from 0 to 5 ppm P. Moreover, further increase in P level up to 10 ppm P induced a significant increase in shoot dry weight to reach about seven folds over that of zero P level, while root dry weight was not affected. In this respect, Fageria et al. (1988) and Hedley et al. (1994) documented that growth and yield of different rice genotype responded positively to p fertilizer.

Significant differences could be observed in dry matter accumulation among rice varieties, regardless of P levels. The highest root and shoot dry weight was recorded for Giza 171 and Giza 181, respectively, while the lowest one for Sakha 101 in both root and shoot. Concerning the interaction effect of P-levels and varieties, data presented in Table 3 reveal significant differences in root and shoot dry weight between different varieties at each P-level. This was in accordance with the findings of Abou-Zeid et al. (2005), who found that the magnitude of response to P fertilization varied markedly among varieties.

1-3- Root length and shoot / root ratio:-

Root length and shoot / root ratio were different among rice varieties (Table 4). Root length across P levels of the eleven genotypes ranged from 19.11 to 32.11 cm. Based on root length, the rice varieties can be grouped in descending order as: Sakha 101 > Sakha 104 > Giza 172 > Giza 176 > Giza 181 > Giza 177 and Giza 171 > Sakha 103 > Sakha 102 > Giza 182 > Giza 178. The results indicated that Sakha 101 recorded the highest root length (32.11 cm), while Giza 178 recorded the lowest (19.11 cm). The differences of root length between varieties agree with the finding of Fageria and Baligar (1997b) who also observed that rice genotypes had significant differences in relation to root length.

Shoot / root ratio was affected by phosphorus levels in all varieties as it could be noticed from Table 4. The highest shoot / root ratio was obtained at the highest P level and decreased by decreasing P application shoot / root ratios varied from 1.21 to 1.79 at the low p level, 3.04 to 4.11 at the medium P level, and 3.14 to 4.58 at the high P level. This mean that the shoot / root ratio varied more at the high P level as compared to the low and medium P levels. This may be associated with a significant increase in dry weight of shoot with an increasing of the P level up to the medium P level. Similarly Bahadoria et al. (2002) reported that shoot-root ratio of several species increased with higher P level as the internal P concentration exceeded that giving maximum root development.

Table 2: Number of tillers and plant height of 11 rice cultivars under three P levels.

Genotype	Tillers/pot			Average	Plant height (cm)			Average
	Low P 0 ppm	Medium P 5 ppm	high P 10 ppm		Low P 0 ppm	Medium P 5 ppm	high P 10 ppm	
Giza 181	10.3	36.7	38.3	28.4 a	26.7	54.0	51.0	43.9 c
Giza 176	11.0	36.7	33.3	27.0 a	21.3	50.3	48.3	40.0 c
Giza 178	6.0	22.7	26.7	18.4 bc	19.7	53.0	59.7	44.1 c
Giza 182	6.7	23.0	30.7	20.1 b	21.7	52.0	58.0	43.9 c
Giza 171	7.3	28.3	27.0	20.9 b	32.7	63.0	61.3	52.3 ab
Giza 172	6.7	25.0	21.0	17.6 bc	25.3	62.7	62.0	50.0 b
Giza 177	5.3	17.0	19.7	14.0 d	29.7	70.7	65.0	55.1 a
sakha 101	5.3	17.7	18.3	13.8 d	20.3	50.7	51.3	40.8 c
sakha 102	6.7	21.7	21.3	16.6 cd	29.0	62.7	58.7	50.1 b
sakha 103	6.3	22.3	20.0	16.2 cd	27.0	62.0	61.0	50.0 b
sakha 104	5.3	17.0	16.7	13.0 d	29.7	67.3	66.3	54.4 ab
Average	7.0 b	24.4 a	24.8 a		25.7 b	58.9 a	58.4 a	
L.S.D 0.01 for Genotype * P	6.11				4.88			

Values for each plant parameter under different P levels followed by same letters are not significantly
different at the 1 % probability level

Table 3: Root and shoot dry weight of 11 rice cultivars under three P levels.

Genotype	Root dry weight (g/pot)			Average	Shoot dry weight (g/pot)			Average
	Low P 0 ppm	Medium P 5 ppm	high P 10 ppm		Low P 0 ppm	Medium P 5 ppm	high P 10 ppm	
Giza 181	0.93	2.32	2.44	1.90	1.67	9.25	9.41	6.78
Giza 176	0.80	2.13	2.02	1.65	0.97	8.95	8.12	6.01
Giza 178	0.65	2.96	2.84	2.15	1.01	6.85	8.93	5.60
Giza 182	0.93	2.38	2.57	1.96	1.49	7.85	8.75	6.03
Giza 171	1.21	2.91	2.74	2.29	1.65	8.65	9.49	6.60
Giza 172	0.84	2.82	2.58	2.08	1.09	8.43	8.76	6.09
Giza 177	0.74	1.90	1.96	1.53	1.33	7.53	8.99	5.95
sakha 101	0.80	1.70	1.81	1.44	0.95	6.57	7.37	4.96
sakha 102	0.68	1.77	1.89	1.45	1.10	7.22	8.42	5.58
sakha 103	0.78	1.95	2.14	1.62	1.29	6.98	8.95	5.74
sakha 104	0.81	1.90	1.97	1.56	1.07	8.32	7.84	5.74
Average	0.83	2.25	2.27		1.24	7.87	8.64	
L.S.D. 0.01 for Genotype	0.27				0.84			
P levels	0.14				0.44			
Genotype * P levels	0.46				1.45			

Table 4: Root length and shoot/root ratio of different rice cultivars under different P levels.

Genotype	Root length (cm)			Average	Shoot/ root ratio			Average
	Low P	Medium P	high P		Low P	Medium P	high P	
	0 ppm	5 ppm	10 ppm		0 ppm	5 ppm	10 ppm	
Giza 181	49.69	16.67	15.00	27.12	1.79	3.53	3.86	3.06
Giza 176	46.67	20.00	16.33	27.67	1.22	4.11	4.02	3.12
Giza 178	34.00	11.33	12.00	19.11	1.55	3.04	3.14	2.58
Giza 182	32.00	14.33	12.00	19.44	1.61	3.51	3.41	2.84
Giza 171	49.00	17.33	12.33	26.22	1.38	3.37	3.48	2.74
Giza 172	48.00	19.33	16.67	28.00	1.31	3.30	3.44	2.68
Giza 177	47.00	19.33	12.33	26.22	1.80	3.05	4.58	3.14
sakha 101	44.33	32.00	20.00	32.11	1.21	3.28	4.07	2.85
sakha 102	38.33	13.00	12.00	21.11	1.61	3.21	4.45	3.09
sakha 103	43.67	11.33	12.00	22.33	1.65	3.59	4.19	3.14
sakha 104	51.33	17.00	18.33	28.89	1.35	3.21	3.99	2.85
Average	44.00	17.42	14.45		1.50	3.38	3.88	
L.S.D. 0.01 for								
Genotype	4.15				0.40			
P levels	2.17				0.21			
Genotype * P	7.20				0.70			

2- phosphorus uptake:-

Phosphorus uptake in root and shoot under the three P levels differed significantly among varieties (Table 5). At low P level, P uptake in root ranged from 0.31 to 0.72 mg pot^{-1} , at the medium P level, from 2.39 to 3.76 mg pot^{-1}, and at high P level, from 4.08 to 7.74 mg pot^{-1}.

Table 5: Phosphorus uptake in root and shoot of different cultivars of rice under different P levels.

Genotype	P uptake in root (mg/pot)			Average	P uptake in shoot (mg/pot)			Average
	Low P	Medium P	high P		Low P	Medium P	high P	
	0 ppm	5 ppm	10 ppm		0 ppm	5 ppm	10 ppm	
Giza 181	0.56	2.72	5.03	2.77	1.11	17.69	28.28	15.69
Giza 176	0.42	2.76	4.85	2.68	0.64	19.68	25.38	15.23
Giza 178	0.33	2.47	5.70	2.83	0.57	14.41	26.80	13.93
Giza 182	0.37	2.53	4.89	2.60	0.90	13.88	25.07	13.28
Giza 171	0.72	3.16	6.02	3.30	1.20	17.91	29.43	16.18
Giza 172	0.42	3.31	5.91	3.21	0.81	19.37	28.94	16.37
Giza 177	0.45	3.76	4.90	3.04	1.08	17.99	30.85	16.64
sakha 101	0.48	2.39	7.74	3.54	0.76	14.46	23.54	12.92
sakha 102	0.35	3.08	4.55	2.66	0.89	16.32	28.91	15.37
sakha 103	0.31	2.85	5.38	2.85	1.03	16.80	30.69	16.17
sakha 104	0.37	3.11	4.08	2.52	0.72	18.26	25.06	14.68
Average	0.43	2.92	5.37		0.88	16.98	27.54	
L.S.D. 0.01 for								
Genotype	0.53				2.36			
P levels	0.27				1.23			
Genotype * P	0.54				4.09			

Regarding the of P uptake in shoot, the variation was 0.57 to 1.20 mg pot^{-1} at the low P level, 13.38 to 19.68 mg pot^{-1} at the medium P level and 23.54 to 30.85 mg pot^{-1} at the high P level. P uptake in shoot is related to dry matter production. Sakha 101 variety had the highest P uptake in root, while Giza 177 had the lowest one. This was in harmony with the results obtained by Fageria and baligar (1999) who demonstrated that p uptake in shoot was significantly varied among different wheat genotypes.

3- Phosphorus use efficiency:-

Data presented in Table 6 show that P-use efficiency differed among rice varieties across P levels. Dry matter of root and shoot, P-accumulation in root and shoot under the P application levels differed among varieties. Giza 182 and Giza 178 had the highest P-use efficiency, while Sakha 103 and Giza 177 had the lowest one.

Using total biomass production (root plus shoot) with low P level and genotype P-use efficiency (Table 6), the tested rice varieties classified into four categories (Fig. 2) according the methodology of Fageria and Baligar (1993). These categories were as follows:-

1) Efficient and responsive : Genotypes which produced dry matter yield higher than the average of eleven genotypes at the low P level and responded well with the addition of P (average P-use efficiency, higher than the average of eleven genotypes), were classified as efficient and responsive. Genotypes Giza 181 and Giza 182 fall into this category.
2) Efficient and non responsive: In this group are the genotypes which produced higher than average dry matter yield, but P-use efficiency was lower than the average of eleven genotypes. Genotyes Giza 171 fall into this category.

Table 6: Dry matter yield of roots and shoots, P accumulation and P-use efficiency of different rice cultivars.

Genotype	Dry matter yield of roots and shoots (mg/pot)		P-accumulation in roots and shoots (mg/pot)		P- use efficiency (mgdry matter/ mg P-absorbed
	At low P level	Across medium and highP levels	At low P level	Across medium and high P levels	
1-Giza 181	2600	11.83	1.67	26.86	366.20
2-Giza 176	1770	10.64	1.06	26.28	350.90
3-Giza 178	1660	10.44	0.90	24.69	368.90
4-Giza 182	2420	10.73	1.27	23.19	379.00
5-Giza 171	2860	11.73	1.92	28.26	336.60
6-Giza 172	1930	11.00	1.23	28.77	329.40
7-Giza 177	2070	10.50	1.53	28.75	309.70
8-Sakha 101	1750	8.88	1.24	24.07	312.20
9-Sakha 102	1780	9.89	1.24	26.43	322.00
10-Sakha 103	2070	10.02	1.34	27.86	299.80
11-Sakha 104	1880	10.37	1.09	25.26	351.10
Mean	2072				338.71

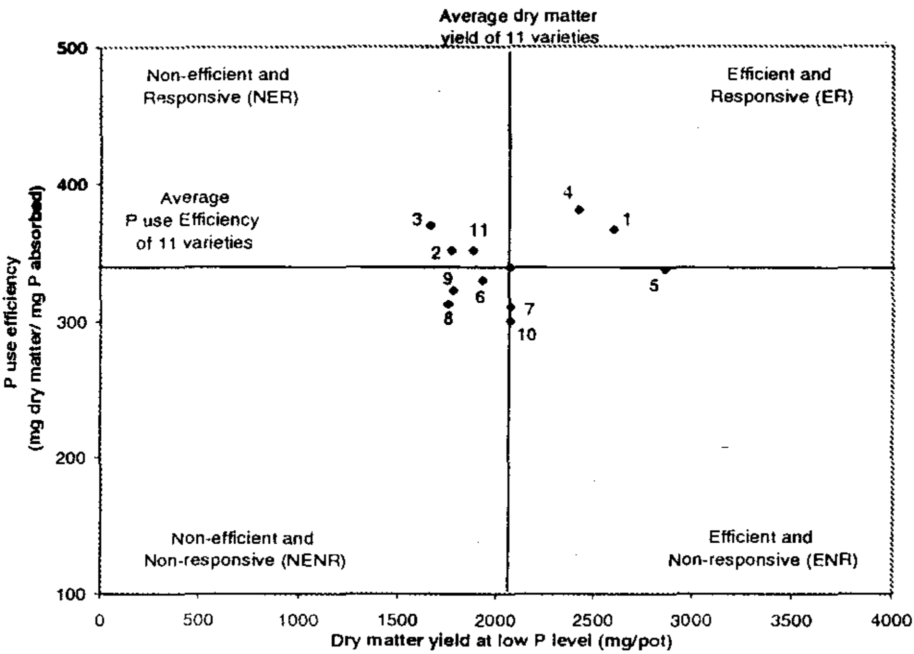

Fig.(2) Classification of several rice varieties for P- use efficiency

3) Non efficient and responsive: In this group are the genotypes which produced less than average dry matter yield, but P-use efficiency was higher than average. In this group fall genotypes Giza176, Giza 178 and Sakha 104.
4) Non efficient and non responsive : In this group are the genotypes which produced lower than average dry matter yield as well as lower than average P-use efficiency. In this group fall genotypes Giza 172, Giza 177, Sakha 101, Sakha 102 and Sakha 1C3.

From a practical point of view, genotypes which fall under the group efficient and responsive are the best ones. These genotypes can produce well under a low P level and respond well with P application. The second group, which can be used under low technology or under a low P level and can produce well are the efficient and nonresponsive.

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اختلاف كفاءة استخدام الفوسفور فى بعض أصناف الأرز.

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كثير من الاراضى بها نقص فى عنصر الفوسفور، ولكن ليس هذا هو السبب الذى يـؤدى إلـى الاستمرار في استخدام الأسمدة الفوسفاتية. أن اختلاف الأصناف في امتصاصها والاستفادة من الفوسفور أدى إلي تحسين الاستفادة من الأسمدة وكذلك الحصول على أعلى إنتاجية وذلك فى الاراضى التى تعـانى مـن نقص الفوسفور. وتهدف هذه الدراسة إلى تقييم ١١ صنف من أصناف الأرز من حيث كفاءتها فى استخدام الفوسفرر. ولتحقيق هذا الهدف، أقيمت تجربة مزارع غذائية فى الصوبة، حيث تم إنماء أصناف الأرز فـى محلول غذائى تحت ثلاث مستويات من الفوسفور وهى (صفر، ٥، ١٠ جزء فى المليون فوسفور) وذلـك لمدة ٣٥ يوم بعد الشتل وتم فى هذه التجربة قياس طول النباتات وطول الجذر وعدد الأفرع وكذلك تقـدير المادة الجافة للجذور والمجموع الخضرى ومحتواها من الفوسفور وحساب كفاءة الاستفادة من الفوسفور بعد عملية الحصاد.

أوضحت النتائج أن كل من طول النباتات وعدد الأفرع وطول الجذر وكذلك إنتاج المادة الجافـة لكل من المجموع الخضرى والجذور ونسبة المجموع الخضرى الى الجذور ومحتـوى كـل منهمـا عـن الفوسفور قد تأثر٩ن معنويا بكل من معاملات الفوسفور وكذلك أصناف الأرز.

وجد أن الرزن الجاف للمجموع الخضرى وعدد الأفرع وكذلك محتوى كل من الجذور والمجموع الخضرى كانت أفضل مقياس وذلك لدرجة حساسيتها لنقص الفوسفور، ولهذا يقترح أن هذه الأربعة مقـاييس تعتبـر أفضل شئ لعمل تقسيم لأصناف الأرز تحت ظروف النمو فى مزارع غذائية.

وبناء على إنتاج المادة الجافة وكذلك كفاءة استخدام الفوسفور، تم تقسيم أصناف الأرز تحـت الدراسة إلى :

أصناف كفؤ وذات استجابة وهى (جيزة ١٨١ ، جيزة ١٨٢)، أصناف كفؤ وعديمـة الاسـتجابة وهى (جيزة١٧١) ، وأصناف غير كفؤ وذات استجابة للفوسفور وهى (جيزة ١٧٦، جيـزة ١٧٨، وسـخا ١٠٤)، واصناف غير كفؤ وعديمة الاستجابة للفوسفور وهى (جيزة ١٧٢، جيزة ١٧٧، سخا ١٠١، سـخا ١٠٢ و سخا ١٠٣).