INFLUNENCE OF SEASONAL FLOODING PERIOD AND THE APPLICATION OF ZINC, IRON, AND MANGANESE ON THE AVAILABILITY OF APPLIED PHOSPHOROUS, GROWTH AND YIELD OF RICE.

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Abstract

Two field experiments were conducted at the Rice Research and Training Center, at Sakha, Kafr El-Sheikh, Egypt in 1993 and 1994 rice seasons to study the effect of seasonal Flooding period, zinc, iron and manganese application on the utiliation of applied phosphorous, content and uptake as well as the productivity of Giza 181 rice variety. Three phosphorous levels and the recommended dose of Zn, Fe and Mn were applied. Soil samples were collected every week after flooding up to 12 weeks and chemically analyzed for available phosphorous in the soil. Plant samples were collected at tillering, panicle initiation, booting and flowering stages, moreover, phosphorous content and uptake were estimated. Yield and yield components were evaluated at harvest.

The main results showed that the utilization of applied phosphorous increased with period of flooding up to the 12 weeks. The application of Zn, Fe, and Mn significantly with plant age up to booting stage and decreased at flowering stage. Results showed also that plant phosphorous content and uptake decreased significantly with the application of Zn, Fe and Mn to the rice soil. The reduction in phosphorous content and uptake was less pronounced with zinc application than with iron or manganese application. Yield and yield components were increased significantly with increasing phosphorous level up to 72 kg P2O5/ha with or without the application of micronutrients. While, the application of Fe and Mn caused a significant reduction in yield and yield components compared with control.

INTRODUCTION

Understanding the chemical changes that accompany flooding or submergence of the soil are important for determining the suitability of nutrients for rice production. Flooding the soil sets in motion a series of chemical and biochemical changes profoundly affect the availability and losses of nutrients and the generation of substances that can interfere with nutrient uptake. DeDatta (1981 and 1983) reported that available phosphorous in the soil increased significantly after flooding.

Flooding the soil has been found to increase the concentration of phosphorous in the soil solution from less than 0.05 ppm to about 0.60 ppm (Yoshida, 1981). Halder and Mandal (1981); Kuo and Mikkelsen (1981) and Biswapati and Mandal (1990) attributed the appearance of zinc deficiency symptoms on rice plants to the increase in phosphorous availability in the soil after flooding. Iron and mangamese they also tended to increase ofter flooding due to the reduction conditions followed the soil flooding.

In recent years, fertilizers containing micronutrients became widespread in the Egyptian market. Under these conditions questions could be raised, 1-Is there any need to any of these micronutrients? and 2- Is there any relation between these micronutrients and both soil and applied phosphorous?. The present study is a try to answer these two questions under the flooded rice conditions.

MATERIALS AND METHODS

Two field experiments were conducted at the Rice Research and Training Center (RRTC), at Sakha, Kafr El-Skcikh Egypt during 1993 and 1994 rice seasons to study the effect of flooding time, Zinc, iron and manganese application on the availability of applied phosphorous and their affects on the productivity of Giza 181 rice variety. Three phosphorus levels namely 0.36 and 72 kg P2O5/ha in the single super phosphate form were incorporated into the dry soil before flooding an d24 kg ZnSO4m 12 Kg FeSO4 and 12 kg MnSO4/ha were applied to the soil after wet land leveling and before transplanting. Three to four, 30 days old seedings of Giza 181 rice variety were transplanted into 15 m2 plots in 20 x 20 cm apart between rows and hills on the 25th of May in both seasons. Nitrogen fertilizer was applied in two splits at the rate of 144 kg N/ha and potassium fertilizer was applied to the dry soil before flooding at the rate of 48 kg K2O/ha. All other cultural practices were appled as recommended for this variety.

Representative soil samples were collected from the experimental sites in both seasons and chemically analyzed according to the standard methods for soil analysis (Black. 1982) and the results are presented in Table (1).

Split plot design with four replications was used. Phosphorous levels were allocated in the main plots, while the micronutrients Zn, Fe, and Mn were allocated in the sub plots.

Table 1. Some chemical properties of the soil at the experimental sites in both season.

Characters	1993	1994
EC ds/m	2.0	2.0
pH 1:2.5	8.2	8.0
O.M %	1.3	1.2
CaCO3 %	3.7	3.8
Available P (ppm)	12.6	14.2
Available Zn (ppm)	0.7	0.8
Available Fe (ppm)	5.2	6.1
Available Mn (ppm)	2.1	2.5

During the two growing seasons, soil samples were collected at 0, 4, 8 and 12 weeks from flooding and chemically analyzed for phosphorous availability following the method outlined by Watanabe and Olsen (1965). Plant samples (Five hills each) from each plot were collected at tillering, panicle initiation, booting and flowering stages then placed in paper bags and oven dried at 70°C for 48 hours. Samples were ground and analyzed for their P. Ten panicles were collected randomly from each plot at harvest and panical weight, percentage of filled grains, and 1000-grain weight were estimated. Number of panicles per square meter was also estimated from each plot. Ten guarded square meters were harvested from each plot and left for air drying three days then threshed and grain moisture content was adjusted to 14%. All the collected data were subjected to the statistical analysis following the methods which described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Phosphorous availability in the rice soil:

Availability of applied phosphorous in rice soil as affected by flooding time, Zn, Fe, and Mn application is presented in Figs. 1, 2, 3 and 4. Data indicated that, phosphorous availability strongly increased as the time of flooding increased up to the 12th week. Native soil phosphorous (no phosphorous was applied) increased from about 13 ppm before flooding to about 55 ppm after 12 weeks of flooding. The appli-

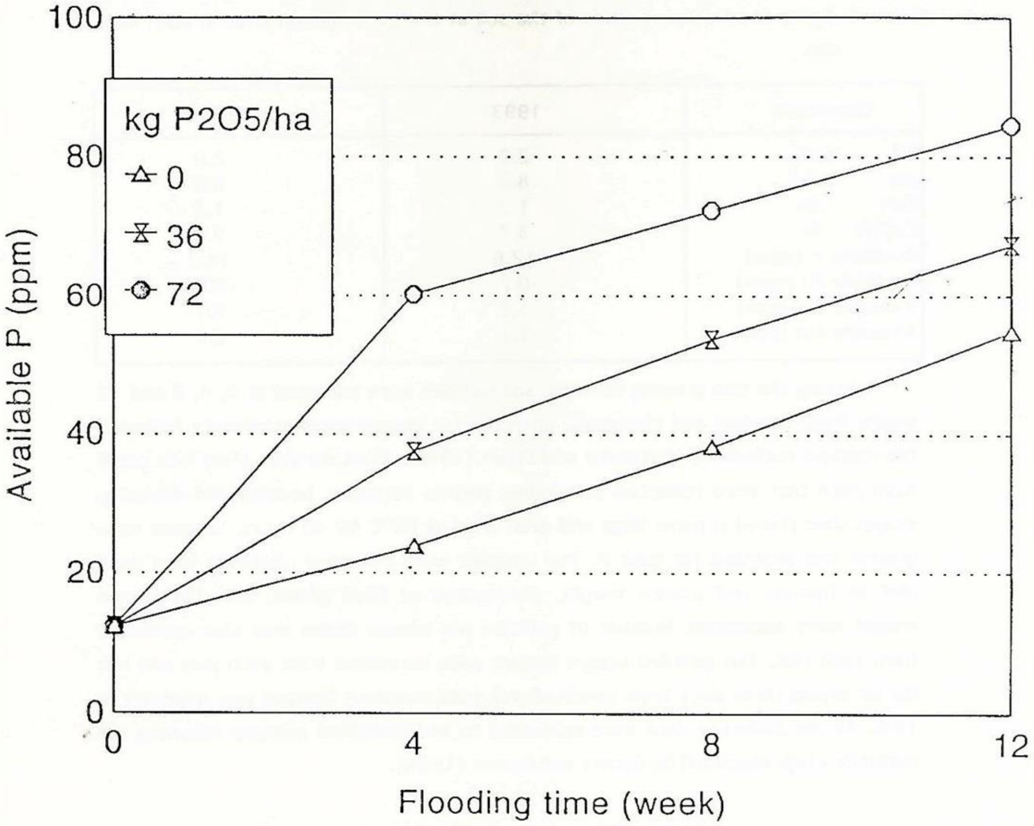

Fig. 1. Effect of flooding on the availability of soil and applied phosphorous.

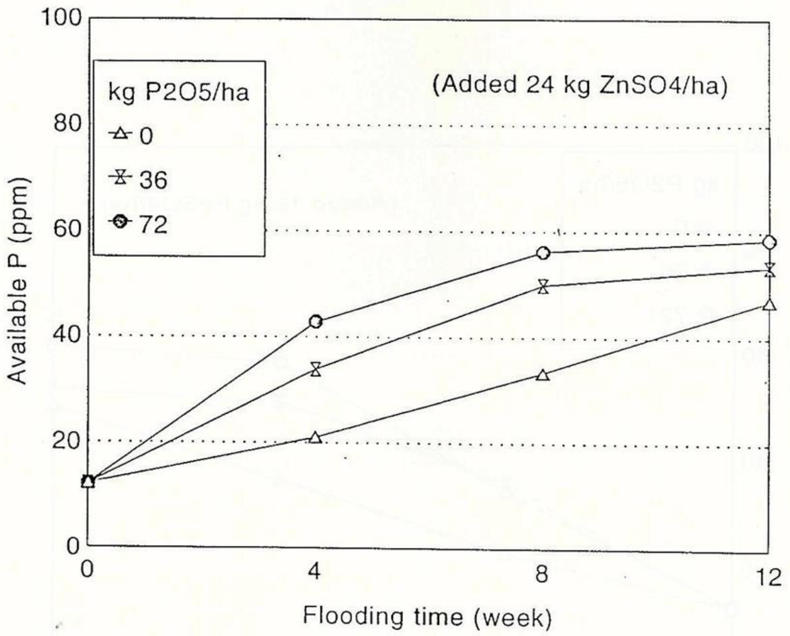

Fig. 2. Effect of flooding and Zn application on the availability of soil and applied phosphorous.

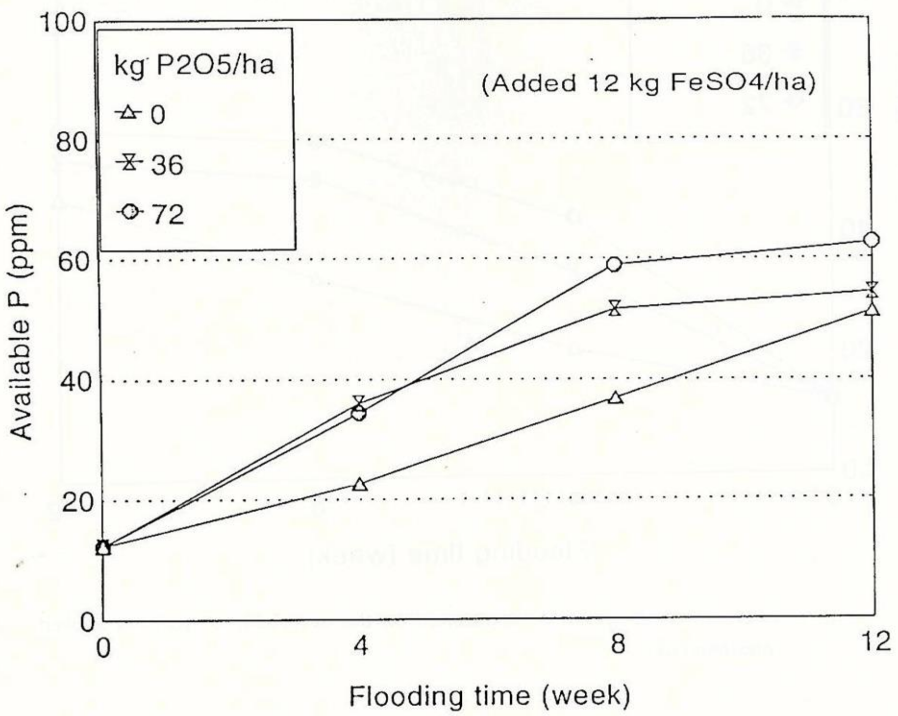

Fig. 3. Effect of flooding and Fe application on the availability of soil and applied phosphorous.

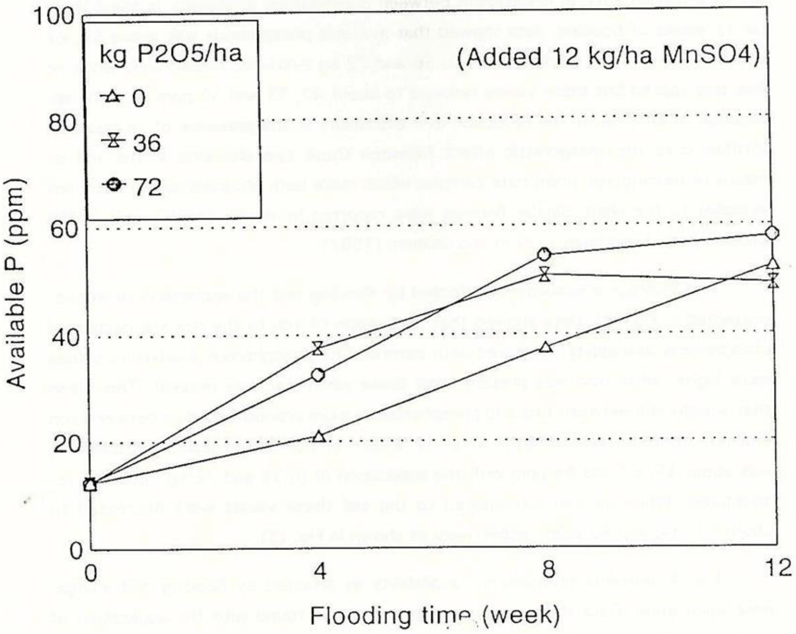

Fig. 4. Effect of flooding and Mn application on the availability of phosphorous.

cation of phosphorous to the rice soil at the rate of 36 and 72 kg P_2O_5/ha increased its availability to about 76 and 84 ppm, respectively at the 12th week after flooding. Increasing in native phosphorous due to flooding could be attributed to the reduction of iron, manganese and aluminum and increasing their solubility, consequently will release the phosphate ions which were associated with them. (Lindsay, 1979 and De Datta, 1981 and 1983).

When zinc was applied to the soil at the rate of 24 kg ZnSO4. 7H2O,/ha, availability of phosphorous decreased compared with control treatment (no zinc added Fig. 2). Accordingly, zinc application decreased the availability of phosphorous in the soil to a certain limit. In comparison between phosphorous availability in the soil after 12 weeks of flooding, data showed that available phosphorous was about 54, 67 and 84 ppm with the application of 0, 36 and 72 kg P2O5/ha, respectively when no zinc was applied but these values reduced to about 47, 53 and 59 ppm with the application of Zn (Fig.2). The reduction in P availability in the presence of Zn could be attributed to the antagonistic effect between these two elements in the soil by means of forming zinc phosphate complex which make both phosphorous and zinc not available to the plant. Similar findings were reported by Halder and Mandal (1979) Choudhry and Longragan, (1972) and Ghanem (1987).

Phosphorous availability as affected by flooding and the application of iron is presented in Fig. (3). Data showed that application of iron to the rice soil decreased phosphorous availability compared with control. The phosphorous availability values were higher when iron was present than those when zinc was present. This mean that antagonism between zinc and phosphorous is more pronounced than between iron and phosphorous (Wild, 1988). After 12 weeks of flooding available phosphorous was about 55, 67 and 84 ppm with the application of 0, 36 and 72 kg P2O5/ha, respectively. When no iron was applied to the soil these values were decreased to about 51, 54, and 63 ppm, respectively as shown in Fig. (3).

Fig. 4. presents phosphorous availability as affected by flooding and manganese application. Data showed that similar trend was found with the application of manganese to the soil and caused significant reduction in phosphorous availability.

Generally, these results indicated that phosphorous availability in the soil increased significantly with time of flooding. While, it decreased by the application of any of the micronutrients zinc, iron or manganese under the condition of the present study. These findings were in agreement in agreement with those reported by Nagrale et al. (1991).

Phosphorous content of rice plant:

Table (2) presents the effect of applied phosphorous, zinc, iron and manganese on phosphorus content in the rice plant at different growth stages in 1993 and 1994 seasons. Data indicated that phosphorus content increased as plant age increased up to booting in 1993 and up to panicle initiation stage in 1994, then decreased afterwards. This could be attributed to the reduction of FePO4. 2H2o, desorption following reduction of Fe (III) hydrous oxides to Fe (II), release of occulted phosphorus and anion exchange. The subsequent decrease could be due to sorption on clays and Al hydroxides and microbial utilization which in turn affect the amount taken up by the plant (Sanchez, 1976; and Lindsay, 1979). Data also indicated that increasing phosphorus levels up to 72 kg P2O5/ha increased P content in the rice plant significantly in both seasons. On the other hand, application of micronutrients Zn, Fe and Mn decreaed phosphorus content in rice plants compared with untreated plants. The application of these nutrients may be reduced the availability of phosphorous in the soil as explained earlier.

Regarding the interaction between P and micronutrients, Zn, Mn and Fe, data revealed that at any of the phosphorus levels, there was an antagonistic effect in both seasons, since application of Zn, Fe and Mn reduced phosphorus availability in the soil. These findings are in agreement with those reported by Halder and Mandal, (1981), who found that application of phosphorus caused reduction in the concentration of Zn, Mn and Fe in rice plant and vice versa.

Yield Components:

Number of panicles per hill, panicle weight, percentage of filled grains and 1000-grain weight as affected by phosphorous, zinc, iron and manganese application are presented in Table (3). Data showed that most of the components increased significantly as phosphorous level increased up to 72 kg P2O5/ha. Number of panicles per hill and panicle weight showed no significant difference in their values when phosphorous was applied at either rates 36 or 72 kg P2O5/ha in both seasons. When Zn, Fe and Mn were applied a significant increase in number of panicles per hill in both seasons was recorded. Panicle weight increased only when zinc was applied and reduced when either iron or manganese was applied (Table 4). Percentage of filled grains and 100-grain weight showed also significant increase with increasing phosphorous level up to 72 P2O5 kg/ha. Significant reduction was recorded in the per-

Table 2. Effect of P levels, Zn, Fe, and Mn application on total phosphorus content (mg/g) of rice plant at different growth periods in 1993 and 1994 season.

Growth stages	T*	1993 P2O5 kg/ha			T. mean	1994 P2O5 kg/ha			T. mean
		0	36	72		0	36	72	
Tillering	Cont.	2.76f	3.25 b	3.65 a	3.22 a	2.75 d	3.21 bc	3.64 a	3.20 a
	Zn	2.21 h	2.85 a	3.14 c	2.73 c	2.29 e	2.89 cd	3.15 bc	2.77 b
	Fe	2.14 i	2.78 f	2.69 g	2.54 d	2.39 e	2.73 d	3.27 b	2.80
	Mn	2.16 i	3.09 d	3.16 c	2.80 b	2.55 de	2.87 cd	3.11 bc	2.84 b
M. mean		2.32 c	2.99b	3.16 a	2.82	2.49 c	2.92 b	3.29 a	2.90
Panicle initiation	Cont.	2.96 e	3.34 b	4.04 a	3.44 a	3.76 e	4.46 b	4.65 a	4.29 a
	Zn	2.81 fg	2.85 f	3.16 c	2.94 b	3.32 f	3.40 f	3.16 g	3.29 d
	Fe	2.86 f	3.07 d	2.72 h	2.88 c	3.41 f	4.57 ab	4.19 c	4.06 b
	Mn	2.67 i	2.79 g	3.17 c	2.87 c	2.97 h	3.90 d	4.06 c	3.65 c
M. mean		2.82 c	3.01 b	3.27 a	3.03	3.37 b	4.08 a	4.02 a	3.82
Booting	Cont.	3.50 f	4.13 c	4.30 a	3.98 a	2.72 d	2.91 c	3.72 a	3.12 a
	Zn	2.81 i	3.55 e	2.20 b	3.52 c	2.39 h	2.65 e	2.50 g	2.51 c
	Fe	3.35 g	3.47 f	4.03 d	3.62 b	2.48 g	2.64 c	2.90 c	2.67 b
	Mn	2.86 h	2.85 h	4.04 d	3.25 d	2.53 f	2.49 g	2.97 b	2.66 b
M. mean		3.13 c	3.50 b	4.14 a	3.59	2.53 c	2.67 b	3.02 a	2.74
Flowering	Cont.	1.88 f	2.36 b	2.57 a	2.27 a	0.97 g	1.60 b	1.68 a	1.42 a
	Zn	1.74 g	1.95 e	2.10 d	1.93 c	0.91 h	1.24 c	1.42 c	1.19 b
	Fe	1.73 g	2.22 c	2.12 d	2.02 b	0.82 j	1.33 d	1.23 e	1.13 c
	Mn	1.54 h	1.89 1	2.35 b	1.93 c	0.87 i	1.32 d	1.09 f	1.09 d
M. mean		1.72 c	2.10 b	2.29	2.04	0.89 c	1.37 a	1.36 b	1.21

Means followed by a common letter are not significantly different at the 5% level by DMRT.

* T = Treatments

centage of filled grains values when manganese was applied, while, the application of zinc or iron did not show any significant effect on these components relative to control treatment. On the other hand, 1000-grain weight values showed significant reduction when either zinc, iron ormanganese was applied individually.

These data concluded that there was an antagonistic effect between P and Zn, Fe and Mn and this antagonism has a reverse effect on rice production. These findings were in agreement with those reported by Megler and Ligier (1986), Dang et al (1989) and Basak and Dravid (1992).

Grain Yield :

Grain yield of rice Giza 181 as affected by phosphorous levels and application of zinc. iron and manganese is presented in Table (3). Data showed that, grain yield increased significantly as phosphorous level increased up to 72 kg P2O5/ha in both seasons. The application of 36 kg P2O5 increased grain yield from 8.42 to 9.13 ton/ha in 1993 and from 9.28 to 9.49 ton/ha in 1994 season, while when phosphorous fertilizer was applied at the rate of 72 kg P2O5/ha, grain yield increased to 9.40 and 9.82 ton/ha in 1993 and 1994 seasons, respectively. It can be concluded that the difference in grain yield between phosphorous levels should be studied economically based on the net return. These data are in agreement with those reported by Mclgar and Ligier (1986); Roy and Jha (1987) Dang et al., (1989) and Basak and Dravid (1992).

Regarding zinc application, grain yield increased significantly when zinc was applied at the rate of 24 kg ZnSO4/ha and no phosphorous was applied. while, it decreased when phosphorous was applied at cither rate (36 or 72 kg P2O5/ha). The reduction in grain yield which occurs when phosphorous and zinc were applied together is attributed to the antagonistic effect between both elements, so, may be Zn as a foliar application can solve the Zn problem. Similar findings were reported by Halder and Mandal (1981); Kuo and Mikkelsen (1981) and Verma and Tripathi (1981).

When iron and manganese were applied, grain yield decreased significantly whether or not phosphorous was applied. These results indicated that, under the experimental sites conditions no need for application either one iron or manganese.

Finally, this study concluded that, under these experimental soil conditions, zinc is the only micronutrient needed to be applied particularly with the application

Table 3. Effect of P levels, Zn, Fe, and Mn application on total phosphorus content (mg/hill) by rice plant at different growth stages in 1993 and 1994 season.

Growth stages	T*	1993 P2O5 kg/ha			T. mean	1994 P2O5 kg/ha			T. mean
		0	36	72		0	36	72	
Tillering	Cont.	43.65 e	48.82 b	63.34 a	51.94 a	34.10 de	44.97 ab	48.96 a	42.64 a
	Zn	36.81 h	48.32 bc	49.57 bc	44.90 b	29.65 e	40.72 bcd	42.77 abc	37.71 b
	Fe	34.79 i	38.90 d	45.36 g	39.69 d	30.50 e	36.01 cde	40.14 bcd	35.55 b
	Mn	34.29 i	41.14 c	46.97 f	40.80 c	30.10 e	36.23 cde	41.98 cde	36.10 b
M. mean		37.38 c	44.30 b	51.31 a	44.33	31.06 c	39.48 b	43.45 a	38.00
Panicle initiation	Cont.	51.60 cd	68.92 a	70.25 a	63.92 a	66.79 e	93.87 a	94.94 a	85.20 a
	Zn	53.93 c	52.58 cd	51.43 de	52.65 b	63.59 f	57.64 g	68.43 d	63.21 d
	Fe	50.20 e	60.09 b	43.85 h	51.40 c	63.14 f	80.30 b	94.12 a	79.18 b
	Mn	48.57 f	46.30 g	46.37 g	47.11 d	54.77 h	65.71 e	78.74 e	66.40 c
M. mean		51.34 c	56.65 a	52.97 b	53.77	62.06 c	74.38 b	84.06 a	73.50
Booting	Cont.	74.64 j	118.33 a	110.60 a	110.60 a	62.77 d	77.19 b	89.99 a	76.65 a
	Zn	93.99 h	110.16 b	110.12 ab	110.12ab	60.05 e	55.38 f	64.28 c	59.90 c
	Fe	114.13 d	101.72 d	109.48 b	109.48 b	60.14 e	60.82 e	62.18 d	61.05 b
	Mn	86.94 i	85.69 i	93.08 c	93.08 c	60.97 e	55.78 f	60.86 e	59.20 d
M. mean		92.43 c	103.96 b	121.07 a	105.82	60.98 e	62.29 b	69.32 a	64.20
Flowering	Cont.	73.85 d	85.46 b	101.73 a	87.01 a	32.09 a	56.38 a	57.55 ab	48.67 b
	Zn	72.62 d	68.39 f	71.14 e	70.71 c	31.10 a	40.39 a	45.56 b	39.02 e
	Fe	70.12 c	65.48 g	80.24 c	71.95 b	26.07 a	39.46 a	66.34 a	43.75 a
	Mn	61.73 h	62.88 h	74.11 d	66.24 d	29.35 a	35.47 a	41.65 b	35.49 d
M. mean		69.58 c	70.55 b	81.81 a	73.98	29.65 c	42.93 b	67.62 a	46.73

Means followed by a common letter are not significantly different at the 5% level by DMRT.

* T = Treatments

Table 3. Effect of phosphorus, zinc, iron and manganese application on yield and some yield components of Giza 181 rice variety.

Variables	T*	1993 P2O5 kg/ha 0	1993 P2O5 kg/ha 36	1993 P2O5 kg/ha 72	T. mean	1994 P2O5 kg/ha 0	1994 P2O5 kg/ha 36	1994 P2O5 kg/ha 72	T. mean
No. of panicle /hill	Cont.	12.70e	15.25 abc	16.65 a	14.87 b	13.60 f	15.50 e	16.55 bc	15.22 c
	Zn	15.20 abc	15.95 abc	16.33 ab	15.83 a	16.20 cd	17.33 a	16.78 ab	16.77 a
	Fe	13.68 de	14.88 bed	14.53 cd	14.36 b	15.35 e	17.10 a	17.23 a	16.56 a
	Mn	13.08 e	15.50 abc	15.90 abc	14.83 b	15.78 de	16.38 bc	16.53 bc	16.23 b
Mean		13.66 b	15.40 a	15.85 a	14.97	15.23 b	16.58 a	16.77 a	16.19
Panicle weight (g)	Cont.	3.02 d	3.14 ab	3.17 a	3.11 b	3.02 g	3.15 b	3.12 c	3.09 b
	Zn	3.16 a	3.15 a	3.11 b	3.13 a	3.15 b	3.15 b	3.18 a	3.16 a
	Fe	3.05 cd	3.04 cd	3.03 cd	3.04 c	3.05 f	3.04 f	3.07 de	3.05 c
	Mn	3.06 c	3.01 d	3.03 cd	3.03 c	3.06 ef	3.05 f	3.07 de	3.06 c
Mean		3.07 b	3.09 a	3.09	3.08	3.07 b	3.10 a	3.11 a	3.09
Filled grains %	Cont.	86.70 de	86.08 e	93.25 a	88.68 a	82.80 e	89.02 c	89.95 bc	87.26 c
	Zn	87.45 de	90.10 bc	88.48 cd	88.68 a	86.32 d	90.95 b	94.75 a	90.60 a
	Fe	83.75 f	91.08 b	94.20 a	89.68 a	81.13 f	90.60 b	83.95 e	85.22 d
	Mn	77.10 g	83.45 f	88.28 cd	82.94 b	84.30 e	83.38 c	89.65 bc	88.78 b
Mean		83.75 e	87.68 b	91.05 a	87.50	83.64 c	88.49 b	89.58 a	87.23
1000-grain weight (g)	Cont.	17.78 c	19.15 a	18.78 ab	18.57 a	19.64 c	19.70 a	18.25 d	19.10 a
	Zn	17.33 c	16.45 de	19.53 a	17.77 b	19.53 b	18.55 c	19.65 a	18.94 b
	Fe	15.68 e	17.78 c	18.00 bc	17.15 c	18.63 c	17.45 ef	19.20 b	18.08 c
	Mn	17.15 cd	14.85 f	17.78 c	16.59 d	17.58 e	17.20 f	18.73 c	17.71 d
Mean		16.99 b	17.06 b	18.52 a	17.52	17.20 f	18. 23 b	18.96 a	18.46
Grain yield T/ha	Cont.	8.17 h	10.19 bc	10.23 b	9.53 b	18.19 b	10.07 b	10.11 b	9.33 c
	Zn	10.07 c	9.11 d	10.38 a	9.85 a	7.82 i	9.32 e	10.15 b	10.08 a
	Fe	7.84 i	8.88 e	8.37 g	8.36 c	10.76 a	8.61 h	9.47 d	9.25 d
	Mn	7.62 j	8.33 g	8.63 f	8.20 d	9.67 f	9.95 c	9.53 d	9.48 b
Mean		8.42 c	9.13 b	9.40 a	9.98	8.95 g	9.49 b	9.82 a	9.53

Means followed by a common letter are not significantly different at the 5% level by DMRT.

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تأثير مده الغمر وإضافه الزنك والحديد والمنجنيز على تيسر الفوسفور المضاف ومحصول الارز ومكوناته

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أقيمت تجربتان حقليتان بمزرعة مركز البحوث والتدريب فى الأرز - سخا - كفر الشيخ خلال موسمى ١٩٩٣ و ١٩٩٤ لدراسة تأثير الغمر بالمياه وإضافة الزنك والحديد والمنجنيز على صلاحية الفوسفور الأرضى وكذلك على نمو ومحصول الصنف جيزة ١٨١ . تمت إضافة ثلاث مستويات من الفوسفور وهى بدون إضافة، ٣٦ وحدة من فو٢أ٥ ، ٧٢ وحدة فو ٢ أ٥ / هكتار فى صورة الفوسفات الأحادى وتمت إضافتها الى التربة الجافة قبل الغمربالمياه . أما الزنك والحديد والمنجنيز فتم إضافتها بالمعدل الموصى به لهذا الصنف بعد إجراء عملية التلويط مباشرة. تم أخذ عينات من التربة قبل التجهيز للزراعة وكذلك اسبوعيا من بداية الغمر وحتى الاسبوع الثانى عشر وقد تم تقدير الفوسفور الميسر فى هذه العينات. كما تم أخذ عينات نباتية عند التفريع، بداية تكوين السنبلة، عند الإزهار وتم تقدير الوزن الجاف وكذلك تم تقدير محتوى النبات من الفوسفور. وعند تمام النضج تم الحصاد وقدر محصول الحبوب ومكوناته.

وقد أوضحت النتائج أن الفوسفور الميسر فى التربه زاد زيادة معنوية مع اسابيع الغمر حتى الأسبوع الثانى عشر وان إضافة كل من الزنك والحديد والمنجنيز عمل على تقليلها. كما وجد أن محتوى النبات من الفوسفور زاد بتقدم عمر النبات حتى مرحلة ماقبل التزهير ثم تناقصت عند التزهير. وجد كذلك ان محتوى النباتات من الفوسفور نقصت معنويا باضافة الزنك والحديد والمنجنيز الى التربة لكن هذا النقص كان أقل ما يمكن مع الزنك اذاما قورن بالحديد والمنجنيز. زاد المحصول ومكوناته زيادة معنوية باضافة الفوسفور حتى ٧٢ كجم فو ٢ أ ٥ / هكتار سواء مع اضافة العناصر الصغرى او بدونها. أوضحت الدراسة أن الزنك يجب إضافته بغرض الحصول على محصول عال خاصة عندما يضاف السماد الفوسفاتى.