EFFECT OF NITROGEN, POTASH LEVELS AND TRANSPLANTING REGULARITY ON RICE CROP PRODUCTIVITY

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Abstract

Two field experiments were conducted at the farm of Faculty of Agriculture, Kafr El-Sheikh, Egypt, during two successive seasons, 2003 and 2004. The present study aimed to study the impact of three nitrogen levels; 0, 40, & 60 kg /fed, three potassium levels; 0, 30 & 60 kg k_2o/fed under regular and irregular transplanting on growth, yield, yield components and some chemical contents of Giza 178 rice cultivar. The experiments were laid out in strip split plot design with four replications. The nitrogen and potassium levels were distributed in the first and second main plots, respectively, while transplanting regularity occupied the sub plots. The main results could be summarized as follows :

The nitrogen levels had positive and significant effects on flag leaf area, plant height, tiller number, panicle length, panicle number, filled grains/panicle, panicle weight, 1000-grain weight, grain yield, straw yield, harvest index, potassium content and nitrogen content. Increasing nitrogen levels up to 60 kg N/fed significantly increased the abovementioned traits.

The economic level of potassium fertilizer (30 kgk_2o/fed) had favorable effect on growth yield attributing characters, yield and nitrogen content. Potassium level of 60 kg k2o/fed gave the highest value of potassium content in grain. The regularity of transplanting had a pronounced effect on the majority of the studied characters involving grain yield. The regular transplanting exceeded the irregular transplanting in all studied traits. Some interactions had significant effects on some traits, and it would be discussed in the text of the paper.

INTRODUCTION

Rice (*Oryza sativa*, L.) is considered as one of the most important food and cereal grain crops after wheat. It is a staple food for nearly one half of the world population, most of them live in developing countries.

In the 2000 year, the annual area cultivated to rice in Egypt is about 1.57 million feddans (o.66 million hectare) and the total rice production reached about 6 million tons with a national average of 9.10 tons/ha. This average ranked first among all rice cultivating countries in the world (Badawi 2000).

Nitrogen fertilization is applied to meet the needs of the crop during the early growth stages and accumulated in the vegetative parts to be utilized for grain formation. A large portion of the nitrogen is absorbed during differentiation. The leaves and stems contain a large portion of the nitrogen taken up by the plant (Milkkelson 1982).

Also nitrogen fertilization has a vital role in nitrogen% in rice grains and nitrogen uptake by rice plants (Ebaid and Ghanem 2000).

Kumar *et al.* (1995) and Maske *et al.* (1997) reported that increasing nitrogen levels up to 120 Kg N/ha significantly increased plant height, leaf area, yield component and grain yield.

El-Shayeib (2003) found that increasing nitrogen up to 80 kg N/fed significantly increased plant height, panicle length, panicle number, filled grains/ panicle, panicle weight and straw and grain yield.

Potassium is recommended to be applied during final land preparation because of its relative immobility in clay soils. Potash fertilization had a marked influence on the overall nutrient levels in grain (Grist 1965). Sonbol *et al.* (1981) reported that potash fertilizer increased 1000-grain weight. El-Kassaby and Kandil (1985) observed that potash fertilization increased grain yield of rice, but comparatively lesser than nitrogen effect. Nour *et al.* (1997) and Ebaid and Ghanem (2001) found that potash fertilization increased rice yield and its components.

Zayed (2002) studied the effect of three potassium levels(0, 20 and 40 kg K_2O/fed) on growth yield, yield component and chemical contents of rice. He found that potassium application had positive effect on growth, yield component, grain yield and nitrogen and potassium contents.

Concerning transplanting regularity, El-Keredy (1992) investigated broadcasting, drilling, hand transplanting (local irregular and recommended regular at 20 x 20 cm) and mechanical transplanting. He found that plant height, number of panicles/m^2, panicle length and grain yield were increased with mechanical transplanting. El-Weheashy (1983) planted rice using broadcasting, as well as, machinery transplanting, farmer transplanting and recommended transplanting. He reported that panicle length, number of grains/panicle, panicle weight and grain yield increased with regular transplanting. Attia *et al.* (1994) found that regular transplanting method surpassed the irregular one in plant height, number of panicles/m^2 , panicle length, number of grains/panicle, 1000-grain weight, panicle weight, grain yield and grain protein content. Bassal *et al.* (1998) indicated that regular transplanting method surpassed the irregular one in plant height, number of panicles/m^2, panicle length, number of filled grains/panicle, 1000-grain weight, panicle weight and grain and straw yields.

Accordingly, this investigation was carried out to study the effect of nitrogen, potash and transplanting regularity on growth, yield and yield components of rice cv. Giza 178.

MATERIALS AND METHODS

To study the effect of nitrogen , potassium and transplanting regularity on rice productivity, two field experiments were carried out at the farm of the Faculty of Agriculture, Kafr El-Sheikh, Tanta University, during 2003 and 2004 seasons. Three nitrogen levels, i.e. 0, 40 and 60 kg N/fed were applied as urea form (46.5% N) in two splits (2/3 basal in the dry soil before flooding and 1/3 at panicle initiation).Three potassium levels i.e. 0, 30 and 60 kg K_2O/fed.were applied in the dry soil before flooding as potassium sulphate (48% K_2O).Two transplanting methods were adopted, i.e. regular transplanting and irregular transplanting with 20 x 20 cm (25 hills/m^2) on the productivity of Giza 178 rice cultivar. The previous crop was wheat in the two seasons of experiments. The nursery was sown on May 15^{th} in the two seasons.

Three seedlings/hill of 30 days old seedling were transplanted in the plots (10.5m^2) according to the treatment. The other agricultural practices of transplanted rice were conducted as the package of recommendations of Ministry of Agriculture and Land Reclamation.

The experiments were laid out in a strip split plot design with four replications, the first main plots were designated for nitrogen levels, the second main plots were designated for potassium levels, while the sub-plots were designated for transplanting methods. The area of each sub-plot measured 10.5 m^2 (1/400 fed.).

Soil samples were collected from the experimental site 0-30 cm depth and analyzed in the National Research Center Lab. Mechanical analysis was carried out according to the procedures of Piper (1950), while chemical analysis was carried out according to Black *et al.* (1965). Results of mechanical and chemical analysis of the experimental field site in the two seasons are presented in Table 1.

Table 1. Mechanical and chemical analysis of the experimental soil (0-30 cm).

Determination	2003	2004
Mechanical analysis :		
Sand %	16.49	15.86
Clay %	52.96	53.98
Silt %	30.55	30.16
Chemical analysis :		
pH	8.03	7.94
Organic matter %	1.48	1.53
Calcium carbonate	2.97	3.01
E.C. (m mhose)	1.85	1.92
Available N ppm	19.11	18.46
P mg/100 g	2.03	1.95
K mg/100 g	42.11	40.98
Mg mg/100g	90.31	88.62
Na mg/100g	99.14	97.64
Fe ppm	9.09	6.18
Mn ppm	3.79	4.14
Zn ppm	0.93	0.89
Cu ppm	1.09	1.79

At complete panicle initiation, flag leaf area was measured from 10 random flag leaves by multiplying the maximum length and width of the flag blade by a constant factor (0.75) according to Palamiswany and Gomez (1974). At harvest time, 10 hills were randomly selected from each sup plot to estimate the plant height, number of panicles/m^2, panicle length, panicle weight, number of filled grains/panicle and 1000-grain weight. The total area of each sub plot was manually harvested and mechanically threshed. The grain and straw weight were recorded for each sub-plot and then converted to tons per feddan. Harvest index was calculated using the following equation :-

Harvest index = Economic yield / Biological yield x 100

About 250 g paddy rice samples from each sub plots were collected to determine nitrogen and potassium content in rice grain. Nitrogen content in rice grain was determined according to the standard Keldahl method (A.O.A.C 1985), while potassium content in rice grain was determined using the atomic absorption spectrophotometer and crude protein content in grains was calculated by multiplying nitrogen percent by a factor of 5.95.

All the collected data were subjected to the standard statistical analysis and the difference among treatment means were compared by Duncan Multiple Range Test at Least Significant Difference (LSD).

RESULTS AND DISCUSSION

1. Nitrogen level:

Data arranged in Tables 2, 6 and 10 show that nitrogen levels had marked positive and significant effects on all the studied traits regarding the current study. It was obviously that increasing nitrogen level up to 60 kg N/fed significantly magnified the growth yield and yield components of rice . In addition increasing nitrogen levels up to 60 kg N/fed significantly increased nitrogen and potassium contents. By the way, the potassium content did not exceed high nitrogen level that might be due to the antagonist effect between $NH4^+$ and K^+ cations. Increasing nitrogen level failed to exert any improvement in the harvest index of Giza 178 in the second season. Generally, the lowest values of flag leaf area, plant height, panicle length, panicle number/m^2 , number of filled grains/panicle, panicle weight, 1000- grain weight, grain yield, straw yield, harvest index, nitrogen and potassium content in grains in the first and the second seasons were obtained when nitrogen fertilizer was not applied. On contrary, the highest values of there traits were produced when the high nitrogen level of 60 kg was added for the rice crop in both seasons. The enhancing grain yield of rice resulting from increasing nitrogen level might be due to increasing growth, photosynthetic rate, net assimilation rate, yield components such as panicle number and number of filled grains/panicle. Another achievement was detected in this study, Giza 178 rice cultivar as a short stature variety significantly responded to nitrogen. application beyond 60 kg N/fed. These data are in a complete conformity with those obtained by Kumar *et al.* (1995), Maske *et al.* (1997), Ebaid and Ghanem (2000) and El-Shayieb (2003).

2. Potassium level:

General speaking, the potassium fertilizer had a fruitful effect on the rice crop involving growth, yield, yield components and chemical content in grains. As presented in Tables 2, 6 and 10, increasing potassium fertilizer up to 60 kg K_2O /fed significantly increased the majority of the studied traits. In one season with some traits, it was found that increasing potassium level was only effective up to 30 kg K_2O/fed . The grain yield responded to potassium application up to 60 kg K_2O/fed (Table 6) . The increment percents over control were 2.7 & 4.2 for 30 and 60 kg K_2O/fed.,respectively in the first season, and 2.9 & 4.8 for 30 & 60 kg K_2O /fed. in the second season ,respectively. Also, from the point view of economic application, 30 K_2O/fed could be recommended under saline soil. The lowest flag leaf area, plant height, panicle length, panicle number/m^2, number of filled grains/ panicle, panicle weight, 1000-grain weight, grain yield, straw yield, harvest index, nitrogen content and potassium content were observed when no potassium was applied while the highest values were found when the high potassium level of 60 kg K_2O/fed was applied. It is mentioning here, that potassium fertilizer improved both source and sink of rice leading to high grain yield. Potassium fertilizer encouraged the photosynthesis process and produced large leaf area involving flag leaf area which contributes to a great part in the grain filing. In addition, potassium fertilizer enhanced the reserve of assimilates to sink resulting in more filled grains/panicle, heaviest panicle and more panicle number/m^2. All abovementioned effects enable potassium to produce a considerable grain yield. The obtained data are in a good harmony with those reported by Sonbol *et al.* (1981), El-Kassaby and Kandil (1985), Nour *et al.* (1997). Ebaid and Ghanem (2001) and Zayed (2002).

3. Transplanting regularity :

Data listed in Tables 2, 6 and 10 revealed that regular transplanting is more needed for better growth, optimum yield component and high grain yield .The transplanting regularity had a positive effect on grain yield under regular transplanting and a bad effect under irregular transplanting. The highest values of flag leaf area, plant height, panicle length, panicle number/m^2, number of filled grains/panicle, panicle weight(g), 1000-grain weight(g), grain yield(t/fed), straw yield(t/fed), nitrogen content and potassium content were produced by regular transplanting .The lower values were recorded when the irregular transplanting was followed. It was also observed that transplanting regularity did not have any significant effect on harvest index in both seasons and straw yield in 2004 season. The irregular transplanting restricted the growth and the major yield components, such as panicle number/m^2, filled grains/panicle and panicle weight. The constraints resulting from irregularity of transplanting might be mainly due to the high competition within rice hills, or / and betweenrice plants and weeds. In addition, this competition reduced light pentration through rice canopy. The variation regarding effect of transplanting regularity has been reported by El-Keredy (1982), El-Weheshy (1983), Attia *et al.* (1994) and Bassal *et al.* (1998).

4. Interaction effect :

From data documented in Tables 2, 6 and 10, the interaction between potassium and nitrogen levels had significant effects on panicle number/m^2 and 1000-grain weight in both seasons, and on flag leaf area, plant height, number of filled grains/panicle and grain yield in only one season. From data in Tables 3, 4, 5, 7, 8 and 9, the best combination was potassium level of 30 kg K_2O/fed. and 0 kg N/fed. while the worst combination was 0 kg K_2O/fed and 60 kg N/fed. The highest values of the previous mentioned traits were produced by the combination of 30 kg K_2O /fed. and 60 kg N/fed. The lowest values were recorded by the combination of 0 kg K_2O and 0 kg N/fed. in both seasons. Similar data were recorded by Ebiad and Ghanem (2001). Thus, potassium has a lower effect on grain yield than nitrogen has particularly under normal soils. The potassium level of 30 kg K_2O /fed could be recommended under similar condition.

Table 2. Flag leaf area, plant height, panicle length and panicle number/m^2 as affected by nitrogen level, potassium levels and transplanting regularity as well as their interaction.

Traits / Main Effect	Flag leaf area(cm^2)		Plant height(cm)		Panicle length(cm)		Panicle number/m^2	
	2003	2004	2003	2004	2003	2004	2003	2004
Nitrogen levels Kg/fed. (N)								
0	15.52 c	15.83 c	71.35	71.32	20.08	19.85	279.58	275.64
40	17.71 b	17.76 b	82.02	82.91	23.13	22.93	333.90	333.98
60	20.11 a	20.14 a	89.89	92.18	24.37	24.35	359.58	360.81
L.S.D. 5%	0.40	0.24	3.34	1.00	0.20	0.19	4.9	3.6
Potassium levels Kg/fed.: (K)								
0	17.30	17.34	79.40	74.84	22.15	21.96	311.81	309.51
30	17.74	18.03	79.61	81.88	22.61	22.41	327.54	326.53
60	18.31	18.37	84.25	84.67	22.82	22.76	333.71	334.40
L.S.D. 5%	0.30	0.23	4.07	0.8	0.22	0.13	4.7	5.75
Transplanting regularity:(T)								
Irregular (T1)	17.5	17.58	79.38	81.09	22.42	22.28	321.00	318.05
Regular (T2)	18.06	18.24	82.80	83.19	22.63	22.47	327.70	328.91
F. test	**	**	**	**	**	**	**	**
Interaction effect:								
N X K	NS	**	NS	**	NS	NS	**	**
N X T	NS	NS	NS	NS	NS	NS	NS	NS
K X T	NS	NS	NS	NS	NS	NS	NS	NS
N X K X T	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Flag leaf area as affected by the interaction between nitrogen levels and potassium levels at 2004 season.

Potassium levels kg K_2O/fed.	Nitrogen levels kg N/fed.		
	0	40	60
0	15.21	17.22	19.58
30	16.14	17.57	20.38
60	16.13	18.50	20.46
L.S.D. 5%	0.43		

Table 4. Plant height(cm) as influenced by the interaction between N and K levels during 2004 season

Potassium levels kg K_2O/fed.	Nitrogen levels kg N/fed.		
	0	40	60
0	68.30 c	80.61 b	90.61 b
30	71.54 b	81.80 b	92.31 a
60	74.13 a	86.33 a	93.62 a
L.S.D. 5%	1.36		

Table 5. Panicle number/m^2 as affected by the interaction between nitrogen and potassium levels.

Seasons	Potassium levels kg K_2O/fed.	Nitrogen levels kg N/fed.		
		0	40	60
2003	0	262.32 b	320.19 c	352.90 b
	30	285.42 a	334.99 b	362.20 a
	60	291.00 a	346.53 a	363.62 a
	L.S.D. 5%	8.10		
2004	0	251.46 b	324.63 b	352.43 b
	30	286.99 a	331.47 b	361.11ab
	60	288.49 a	345.84 a	368.89 a
	L.S.D. 5%	9.50		

Table 6. Number of filled grains/ panicle, panicle weight (g), 1000-grain weight (g) and grain yield (t/fed.) as influenced by nitrogen, potassium levels and transplanting regularity as well as their interaction.

Traits / Main Effect	Number of filled grains/panicle		Panicle weight (g)		1000- grain weight (g)		Grain yield (t/fed.)	
	2003	2004	2003	2004	2003	2004	2003	2004
Nitrogen levels								
Kg/fed. (N)	104.22	101.93	2.51	2.48	19.01	18.97	2.698	2.675
0	138.79	130.93	3.21	3.25	22.16	22.18	4.024	4.020
40	146.79	142.44	3.39	3.37	22.33	22.34	4.221	4.249
60	2.11	3.34	0.03	0.04	0.08	0.08	0.05	0.02
L.S.D. 5%								
Potassium levels								
Kg/fed.: (K)	124.99	119.37	21.03	2.95	21.03	21.01	3.566	3.557
0	130.55	125.91	21.16	3.05	21.16	21.16	3.662	3.660
30	134.26	129.91	21.31	3.10	21.31	21.31	3.716	3.727
60	2.20	2.7	0.05	0.05	0.08	0.05	0.04	0.05
L.S.D. 5%								
Transplanting								
regularity:(T)	128.77	123.30	3.00	3.00	21.13	21.10	3.613	3.611
Irregular (T1)	131.10	126.83	3.21	3.06	21.20	21.23	3.683	3.685
Regular (T2)	NS	**	**	**	**	**	**	**
F. test								
Interaction effect :								
N X K	NS	**	NS	NS	**	**	NS	**
N X T	NS	NS	NS	NS	NS	NS	NS	NS
K X T	NS	NS	NS	NS	NS	NS	NS	NS
N X K X T	NS	NS	NS	NS	NS	NS	NS	NS

Table 7. Average of number of filled grains/panicle as affected by the interaction between nitrogen and potassium levels during 2004 season.

Potassium levels kg K_2O/fed.	Nitrogen levels kg N/fed.		
	0	40	60
0	93.51 c	124.31 b	140.29 a
30	103.4 ab	132.54 a	141.69 a
60	108.80 a	135.61 a	145.33 a
L.S.DL.S.D at 5%	4.82		

Table 8. Average of 1000-grain weight (g) as affected by the interaction between nitrogen and potassium levels.

Seasons	Potassium levels kg K_2O/fed	Nitrogen levels kg N/fed.		
		0	40	60
2003	0	18.82 b	21.96 b	22.32 a
	30	18.91 b	22.22 a	22.33 a
	60	19.30 a	22.30 a	22.34 a
	L.S.D. 5%	0.13		
2004	0	18.70 c	22.00 c	22.33 a
	30	18.95 b	22.21 b	22.33 a
	60	19.26 a	22.34 a	22.35 a
	L.S.D at 5%	0.10		

Table 9. Average of grain yield(t/fed) of rice as affected by the interaction between nitrogen and potassium levels during 2004 season.

Potassium levels kg K_2O/fed.	Nitrogen levels kg N/fed.		
	0	40	60
0	2.571 c	3.891 c	4.207 b
30	2.673 b	4.033 b	4.272 a
60	2.780 a	4.135 a	4.266 a
L.S.DL.S.D at 5%	0.05		

Table 10. Average of straw yield (t/fed.), harvest index, N% and K% of rice as affected by nitrogen levels, potassium levels and transplanting regularity as well as the interaction effects.

Traits / Main Effect	Straw yield		Harvest index		N %		K %	
	2003	2004	2003	2004	2003	2004	2003	2004
Nitrogen levels Kg/fed. (N)								
0	2.793	2.829	48.61	49.13	0.92	0.92	1.89	1.90
40	4.158	4.121	48.88	49.18	1.15	1.15	1.99	2.00
60	4.368	4.420	49.01	49.18	1.27	1.28	1.99	1.99
L.S.D. 5%	0.19	0.162	0.20	NS	0.02	0.01	0.03	0.08
Potassium levels Kg/fed.: (K)								
0	3.710	3.755	48.66	49.01	1.08	1.09	1.34	1.34
30	3.774	3.820	48.88	49.25	1.12	1.12	2.18	2.19
60	3.830	3.794	48.98	49.24	1.14	1.14	2.36	2.36
L.S.D. 5%	0.03	NS	0.23	NS	0.02	0.01	0.05	0.07
Transplanting regularity: (T)								
Irregular (T1)	3.750	3.799	40.72	49.07	1.10	1.10	1.94	1.93
Regular (T2)	3.792	3.781	48.96	49.26	1.12	1.12	1.98	1.99
F. test	**	NS	NS	NS	**	**	**	**
Interaction effect :								
N X K	NS	NS	NS	NS	NS	NS	NS	NS
N X T	NS	NS	NS	NS	NS	NS	NS	NS
K X T	NS	NS	NS	NS	NS	NS	NS	NS
N X K X T	NS	NS	NS	NS	NS	NS	NS	NS

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تأثير النيتروجين والبوتاسيوم وانتظام الشتل على إنتاجية محصول الأرز

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أقيمت تجربتان حقليتان بمزرعة كلية الزراعة بكفر الشيخ في موسمي ٢٠٠٣ ، ٢٠٠٤ لدراسة تأثير ثلاثة مستويات نيتروجين هي صفر، ٠ ، ٤٠ ، ٦٠ كجم / ف وثلاثة مستويات بوتاسيوم هي صفر ، ٣٠ ، ٦٠ كجم / ف، وكذلك تأثير انتظام الشتل من عدمه على النمو والمحصول ومكونات المحصول وبعض المحتويات الكيماوية لصنف الأرز جيزة ١٧٨. كانت أرض التجربة طينية، واستخدم تصميم الشرائح المتعامدة في أربع مكررات حيث وزعت مستويات النيتروجين في القطع الرئيسية الأولى و مستويات البوتاسيوم في القطع الرئيسية الثانية ووزعت طريقتا الشتل المنتظم والغير منتظم في القطع تحت الشقية. يمكن ايجاز النتائج فيما يلى : التسميد النيتروجيني تأثيره إيجابي على مساحة ورقة العلم وطول النبات وعدد الفروع وطول السنابل وعدد السنابل وعدد الحبوب الممتلئة / سنبلة ووزن السنبلة ووزن ١٠٠٠ حبة ومحصول الحبوب ومحصول القش ودليل الحصاد ومحتوى البوتاسيوم ومحتوى النيتروجين .

كما أوضحت النتائج أن زيادة مستويات النيتروجين إلى ٦٠ كجم / ف تسببت في زيادة معنويه في كل الصفات،كما أدى التسميد البوتاسى إلى تحسن ملحوظ في جميع الصفات المدروسة وكان المستوى الاقتصادي لاستخدام البوتاسيوم هو ٣٠ كجم / ف(ك ٢أ) فيما يتعلق بالنمو ومكونات المحصول والمحصول ومحتوى النيتروجين ومحتوى البوتاسيوم في الحبوب كان عاليا بدرجة معنوية تحت نظام الشتل المنتظم عما كان عليه تحت نظام الشتل الغير المنتظم . أثر بعض التفاعل معنويا فى جميع الصفات في الشتل المنتظم عن الشتل الغير منتظم.