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Effects of Soil Fertilization on Sakha 105 Rice Cultivar Productivity, NPK Uptake and Soil Nutrient

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ABSTRACT

Balanced supply of essential nutrient is one of the most important factor for increasing rice yield. Hence, knowledge of interaction of N with other nutrients are very important for improving fertilizer use efficiency and consequently increasing rice yield. A Field experiment was carried out at Rice Research and Training Center experimental farm during 2016 and 2017 seasons to assess the influence of different combinations of N, P, K and Zn fertilizer on yield of Sakha105 rice variety, its attributes, NPK uptake, N-recovery efficiency and agronomic nitrogen use efficiency. The fertilizer combinations were: (1) control, (2) N, (3) N + P, (4) N + K, (5) N + Zn, (6) N + P + Zn, (7) N +K + Zn, (8) N + P + K, and (9) N + P + K + Zn. Yield and yield attributes of Sakha 105 rice cultivar were significantly affected by different combinations of N, P, K and Zn fertilizer. The NPKZn treatment resulted in the highest grain yield, number of panicles hill^{-1}, number of filled grain panicle^{-1} and lowest sterility percentage compared with the control. In addition, the uptake of N, P and K varied significantly by the application of different combinations of N, P, K and Zn fertilizer in both growing seasons. Nitrogen recovery efficiency % varied significantly with different fertilizers and ranged from 24.01 to 41.39% and from 26.08 to 43.99% in 2016 and 2017, respectively. The application of different chemical fertilizers significantly increased the available soil NH_4^+ content and available soil P concentration at different days after transplanting compared with the control. The study suggests that balance nutrient application using N, P, K and Zn fertilizers is a key management strategy for sustaining soil fertility and therefore increasing rice yield.
Keywords: chemical fertilizer, rice growth, yield, nutrient uptake, soil.

INTRODUCTION

Fertilizers play an important role in improving rice crop productivity through the provision of essential nutrients required by rice plants at both vegetative growth and reproductive growth stages. Furthermore, it has been proven that better rice crop productivity can be achieved only when the nutrients are applied at balanced rate (Zaman *et al*. 2007). Excess of N in rice may result in lodging, greater weed competition and pest attacks, with substantial losses of yield. On the other hand, if the N fertilizer is not taken up by the crop, is it likely to be lost to the environment (Fageria *et al*. 2008).

Especial attention is required to enhance higher rice yield and quality through improved production technology. Among various factors that are responsible for better rice yield and quality, the proper use of fertilizers is of prime importance (Sankaran *et al*. 2005). Determination of optimum levels of NPK fertilizers is essential for obtaining maximum economic returns. According to Ananthi *et al*. (2010), the best rate of fertilizer application is that which gives maximum economic returns at least cost. Among various essential plant nutrient, the macronutrient such as N, P and K are crucial for determining the rice yield and its quality. It has been noticed that farmers, utilize imbalanced doses of N fertilizer, which lead to higher insect/disease attack and ultimately produce lower yield (Mannan *et al*. 2009; Alam *et al*. 2011). Therefore, there is a need to determine the best level of NPK fertilizer, in addition to Zn fertilizers that may give maximum rice crop productivity with minimum nutrient losses (Zafar *et al*. 2018; Wattoo *et al*. 2018).

Research contact at IRRI (2002) suggests that under intensive rice cropping systems, the demand for P and K fertilizer increases over time. Results showed that, without P and K application, N efficiency declines, whereas when all nutrient are applied together, P and K efficiency increases steadily, and thereby indicates interactions among these nutrient (Manjappa and Shailaja, 2014). Thus, on all depleted soils, which have been cultivated for a long time, in addition to unavoidable losses of nutrients, unbalanced fertilization in favors of N is not only contrary to good agricultural practices, it is also a waste of labor and capital, environmentally detrimental and not sustainable (Sachiko *et al*. 2009).

Primary and secondary nutrients, which are the most deficient in the soil, limit the rice yield and affect the quality (Ghoneim and Ebid 2015). Therefore, for good agricultural practices, balanced fertilization is primarily important. Nutrient losses caused by denitrification, volatilization and naturally occurring leaching are unavoidable, even under the best agricultural practices (Noor, 2017). The farmers should be aware of these consequences, because the most persuasive argument for farmers in developing and developed countries is still the return the farmers will receive through the application of fertilizer to his crop during the season of application (Salem, 2006).

Therefore, the present study was conducted to study the effects of different combinations of N, P, K and Zn fertilizers on yield of Sakha 105 rice cultivar and its attributes, N, P, K uptake, N-recovery efficiency and agronomic nitrogen use efficiency.

MATERIALS AND METHODS

Soil samples were collected before tillage from Rice Research and Training Center experimental farm, Sakha, Kafr El-Sheikh, Egypt. Soil samples were air-dried at room temperature, then cursed and sieved by 2-mm stainless steel sieve. The pH of the soil was measured using (1: 2.5) soil suspension, and EC in soil paste extract. Soil texture was determined according to (Gee and Bauder, 1996). Organic matter was determined according to Allison (1965), while available nutrients were assessed using the method of (Jackson, 1967). Soil was silt clay loam in texture and the main soil properties is presented in Table 1.

Table 1. Soil properties of rice research and training center experimental farm

Soil property	2016	2017
Clay (%)	55.7	55.3
Silt (%)	31.7	32.3
Sand (%)	12.6	12.4
pH (1:2.5 soil suspension)	8.25	8.15
EC dS m^{-1} (soil paste extract)	2.30	2.55
OM %	1.60	1.51
Total N (%)	0.0065	0.0052
P (available) ppm	12.8	11.2
K (available) ppm	340	360
Zn (available) ppm	0.40	0.58

Field experiment design and agronomic practices

The field experiment was conducted in a Randomized Complete Block Design (RCBD) with four replicates with a plot size of 3x5 m. The fertilizer combination treatment included: (1) control, (2) N, (3) N + P, (4) N + K, (5) N + Zn, (6) N + P + Zn, (7) N +K + Zn, (8) N + P + K, and (9) N + P + K + Zn. Nitrogen fertilizer was applied at a rate of 165 kg ha^{-1} as urea form (46.5% N). Two thirds of N fertilizer was applied as soil basal application, and the other one third was top dressed 35 days after transplanting (DAT). P fertilizer was applied at 36 kg P_2O_5 ha^{-1} as superphosphate (15.5% P_2O_5), K fertilizer at a rate of 60 kg K_2O ha^{-1} as potassium sulfate (50% K_2O). Both P and K fertilizer were applied as soil basal application in one dose during soil preparation. Zinc sulphate was applied at the rate of 24 kg $ZnSO_4.7H_20$ ha^{-1} as basal dose just before transplanting. Seeds of Sakha 105 rice cultivar, at the level of 96 kg ha^{-1}, were soaked in water for 24 hour, and then incubated for 48 hour to hasten early germination. Pre-germinated seeds were sown in May 5th in both growing seasons. Seedlings of Sakha 105 rice variety (4 weeks old) were transplanted at spaces of 0.20 m×0.20 m with three seedlings per hill. All plots received identical cultural treatments in terms of ploughing, cultivation, seed rate, sowing method and disease control.

At maturity, five representative hills of the plants were separately sampled from each plot to determine number of panicles $hill^{-1}$, panicle length, number of filled grain $panicle^{-1}$, sterility % and 1000-grain weight. At harvest, grain and straw yields were estimated from 10 m^2, and grain yield was adjusted to t ha^{-1} at 14% moisture content.

Plant analyses

Grain and straw samples were oven dried at 70 °C till constant weight. Samples (0.10 g) from each treatment were digested with H_2SO_4-H_2O_2 (5:1, v/v) using a hot block heater. After cooling, the digest was transferred to a 20-ml volumetric flask. Concentration of total-N, total-P and total-K in grain and straw were determined according to method of Yoshida *et al.* (1976).

N-recovery efficiency percentage and Agronomic Nitrogen Use Efficiency (ANUE) were calculated according to Fageria *et al.* (2007) equations as following:

$$\text{N-recovery efficiency (\%)} = \frac{\text{N uptake(treatment)} - \text{N uptake (control)}}{\text{N applied rate}} \times 100$$

$$\text{ANUE} = \frac{\text{Grain yield (treatment)} - \text{Grain yield (control)}}{\text{N applied rate}}$$

Soil samples and chemical analyses

At 30, 60 and 90 days after transplanting, represented soil samples were collected, air-dried, crushed, sieved (2-mm) and analyzed for available soil NH_4^+, available soil-P, available soil-K and available soil-Zn using the methods described by Sparks (1996).

Statistical analysis

The collected data were analyzed statistically with Fisher's analysis of variance at 5% probability level. The treatments were compared using a protected LSD test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth parameters

Table 2 show the effect of different fertilization treatments on number of panicles $hill^{-1}$, panicle weight and panicle length in 2016 and 2017 seasons. Number of panicles $hill^{-1}$, panicle weight and panicle length were greatly influenced by fertilizer applications, and the differences among the treatments were statistically significant. In both seasons, the highest number of panicles $hill^{-1}$ and panicle length were obtained with N, P, K, Zn combinations, while application of NP only gave the heaviest panicles. The lowest number of panicles $hill^{-1}$, panicle weight and panicle length were recorded with the control. This could be attributed due to the favorable effect of fertilizers balance on rice plants that causes an increase in all biological and physiological processes, which encouraged the growth of rice plant, subsequently increase number of panicles and other yield components. These data are in agreement with those obtained by (Sangeetha *et al.* 2010).

Table 2. Number of panicles, panicle weight, and panicle length of Sakha 105 rice cultivar as affected by fertilization treatments

Treatment	No. Panicles $hill^{-1}$		Panicle weight (g)		Panicle length (cm)	
	2016	2017	2016	2017	2016	2017
Control	17.01	16.83	2.74	2.36	19.20	18.40
N	22.25	21.67	3.28	3.17	21.35	21.50
N P	23.75	22.91	3.30	3.25	21.25	21.45
N K	22.50	21.75	2.89	2.88	20.90	20.55
N Zn	23.15	22.33	3.04	3.12	20.95	21.05
N P K	25.10	24.00	2.90	2.84	21.00	20.95
N P Zn	26.00	25.25	2.99	3.04	20.40	21.25
N K Zn	24.67	23.25	3.07	3.13	21.00	20.85
N P K Zn	27.20	26.42	2.91	2.98	21.95	21.85
LSD %	2.05	1.94	0.55	0.37	1.20	1.30

Number of filled grain $panicle^{-1}$ was significantly affected by fertilization (Table 3). Maximum number of filled grain $panicle^{-1}$ (106.30 and 102.10) were obtained with N, P, K, and Zn application, while the control gave the minimum numbers of filled grain $panicle^{-1}$. These increases are mainly attributed to favorable effect of fertilizers on panicle length of panicle branches or/and increase in grain filling rate and hence, causing an increase in number of filled grains panicle^{-1}. Data also showed that the sterility % was significantly influenced by fertilizers application. In both seasons, the highest sterility percentage was obtained with the control treatment, while NPKZn treatment induced the lowest sterility percentage. Weight of 1000-grain was significantly affected by different fertilization treatments (Table 3). Data indicate that application of different fertilizer combinations caused a significant increase in 1000-grain weight as compared with the control especially the treatments contain P, this may be due to P gave the energy for carbohydrate assimilation in the rice grain. The highest values of 1000-grain weight was recorded with NP treatment followed by NPKZn treatment without any significant difference between them, while control treatment produced the lowest values of 1000-grain weight in both seasons.

Grain and straw yield

Regarding the influence of fertilization application on grain yield, data in (Table 4) indicate that all fertilization treatments led to an increase in the grain yield considerably over control. Appling the treatment NPKZn fertilizers produced the maximum grain yield (10.55 and 10.48 t ha^{-1} with increase of 58.89 and 63.49 % over control), closely followed by NPZn treatment, which produced 10.31 and 10.21 t ha^{-1} (with increases of 55.27 and 59.28 % over control) in the first and second seasons, respectively. These results may be due to the treatment NPKZn had the highest panicles hill^{-1}, number of filled grain panicle^{-1} and lowest sterility percentage. Ghanbari-Malidareh (2011) recorded a positive correlation between yield and number of panicle per square meter and number of grain panicle^{-1}. The increases in yield could be attributed due to greater number of productive tillers, spikelets per panicle and 1000-grain weight of rice by the application of balanced NPKZn fertilizer. However, NK treatment gave no significant yield increase compared to no applied N. this is emphasizes that inbred rice does not respond to K fertilizer because the amount of available-K is sufficient. Similarly, straw yields of 11.85 and 11.32 t ha^{-1} were recorded when NPKZn treatment was applied with an increase of 49.81 and 48.17% over control which recorded only 7.91 and 7.64 t ha^{-1} of straw yield in the first and second seasons, respectively.

Table 3. Number of filled grain panicle^{-1}, sterility percentage and 1000-grain weight of Sakha 105 rice cultivar as affected by fertilization treatments

Treatment	No. filled grain panicle^{-1}		Sterility (%)		1000-grain weight (g)	
	2016	2017	2016	2017	2016	2017
Control	87.40	84.20	8.71	9.37	24.55	24.84
N	95.60	92.20	5.81	6.86	26.95	25.47
N P	100.50	99.30	5.19	4.72	27.99	27.85
N K	96.10	93.90	7.77	8.52	25.87	25.95
N Zn	97.00	95.10	5.18	6.24	27.74	27.65
N P K	99.40	99.00	5.78	6.22	27.17	26.78
N P Zn	103.80	100.50	4.48	3.98	26.62	26.45
N K Zn	98.60	98.40	6.01	6.32	26.37	26.08
N P K Zn	106.30	102.10	3.54	3.02	27.82	27.01
LSD %	4.92	4.36	0.96	0.65	1.70	1.78

Table 4. Grain and straw yields of Sakha 105 rice cultivar as affected by different fertilization treatments

Treatment	Grain yield (t ha^{-1})				Straw yield (t ha^{-1})			
	2016	Increase %	2017	Increase %	2016	Increase %	2017	Increase %
Control	6.64	-	6.41	-	7.91	-	7.64	-
N	9.17	38.10	9.05	41.19	10.94	38.31	10.73	40.45
N P	9.81	47.74	9.56	49.14	10.98	38.81	10.69	39.92
N K	9.46	42.47	9.33	45.55	10.75	35.90	10.59	38.61
N Zn	9.51	43.22	9.47	47.74	10.85	37.17	10.79	41.23
N P K	10.09	51.96	10.11	57.72	11.24	42.10	11.28	47.64
N P Zn	10.31	55.27	10.21	59.28	11.42	44.37	11.44	49.74
N K Zn	9.90	49.10	9.63	50.23	11.10	40.33	10.48	37.17
N P K Zn	10.55	58.89	10.48	63.49	11.85	49.81	11.32	48.17
LSD %	0.63		0.55		0.90		0.76	

Grain and straw nutrients uptake

The results reveal that uptake of N, P and K were significantly affected by the various combinations of N, P, K, Zn fertilizer in both growing seasons (Tables 5, 6 and 7). All fertilization treatments led to increase in the nutrient uptake compared with the control. The results could be attributed to more nutrient translocation to sink inducing balanced plant growth and development, which leads to higher nutrient uptake (Rasool *et al*. 2007; Ghoneim *et al*. 2012). Salahuddin *et al*. (2009) also reported that the application of NPK fertilizer increased rice uptake. Excessive fertilizers application resulted in some nutrient losses and damage to the rice plants through toxicity, while application of nutrient in lesser amounts is not satisfactorily to optimum rice yield (Paramasivam *et al*. 2005). In addition, different rice cultivars may vary in their response to N, P, K uptake and translocation, which leads to variable responses of various genotypes to the applied NPKZn fertilizers (Jiang *et al*. 2005; Melero *et al*. 2007). The current results revealed a positive correlation between produced rice grain and uptake of N (R^2=0.907), K uptake (R^2=0.808) and medium correlation with P uptake (R^2=0.514) as shown in Figure (1).

Table 5. Nitrogen uptake (kg ha^{-1}) of Sakha 105 rice cultivar as affected by fertilization treatments

Treatment	Grain uptake		Straw uptake		Total uptake	
	2016	2017	2016	2017	2016	2017
Control	79.90	76.07	36.28	34.84	116.18	110.90
N	99.64	99.55	56.16	55.36	155.81	154.92
N P	106.60	103.25	57.10	57.48	163.70	160.73
N K	103.83	101.97	55.18	54.40	159.02	156.36
N Zn	103.26	105.75	56.24	55.78	159.50	161.53
N P K	109.31	108.18	58.11	58.54	167.42	166.72
N P Zn	117.88	110.27	59.46	59.14	177.34	169.41
N K Zn	106.95	104.33	57.54	53.97	164.49	158.30
N P K Zn	123.44	124.36	61.03	58.48	184.46	182.85
LSD 5 %	2.67	2.32	1.47	1.29	3.10	2.52

Table 6. Phosphorus uptake (kg ha^{-1}) of Sakha 105 rice cultivar as affected by fertilization treatments

Treatment	Grain uptake		Straw uptake		Total uptake	
	2016	2017	2016	2017	2016	2017
Control	13.94	12.82	5.93	6.03	19.88	18.85
N	19.25	19.31	8.75	8.80	28.01	28.10
N P	25.90	25.78	8.97	8.23	34.87	34.01
N K	22.55	22.21	8.38	8.26	30.93	30.47
N Zn	15.69	16.29	7.05	7.66	22.74	23.95
N P K	26.23	25.68	9.18	9.59	35.41	35.27
N P Zn	18.11	18.96	8.38	8.20	26.49	27.16
N K Zn	17.82	17.49	7.77	7.37	25.74	24.86
N P K Zn	24.09	24.11	9.48	9.28	33.57	33.38
LSD 5 %	1.22	0.88	0.67	0.68	1.61	1.21

Table 7. Potassium uptake (kg ha^{-1}) of Sakha 105 rice cultivar as affected by fertilization treatments

Treatment	Grain uptake		Straw uptake		Total uptake	
	2016	2017	2016	2017	2016	2017
Control	15.74	14.76	99.08	98.05	114.82	112.81
N	24.12	24.22	165.19	162.63	189.31	186.86
N P	22.92	22.24	148.23	146.81	171.15	169.05
N K	23.46	22.80	173.61	171.49	197.07	194.28
N Zn	23.33	22.85	158.16	156.60	181.49	179.45
N P K	23.95	24.77	184.63	183.11	208.58	207.88
N P Zn	24.92	25.25	165.59	172.36	190.51	197.62
N K Zn	26.04	25.94	175.47	162.44	201.46	188.38
N P K Zn	27.71	26.65	194.93	187.54	222.65	214.19
LSD 5 %	0.96	1.25	1.27	2.52	1.19	3.15

Agronomic nitrogen use efficiency

Results in Table 8 show that, fertilizers combination improved ANUE value compared with N treatment alone in both rice-growing seasons. The highest values of ANUE (the economic production obtained per unit of N applied) were achieved when the combinations of NPKZn fertilizer were applied, while N treatment alone recorded the lowest ANUE value. It was noticed that the higher ANUE value was associated with higher grain yield. Huber *et al*. (2012) reported that without P and K application, ANUE value declined, whereas when all nutrients were applied together, P and K efficiency increased steadily, thereby due to interactions among these nutrients (EL-Refaee *et al*. 2014).

N-recovery efficiency percentage

N-recovery efficiency percentage (quantity of nutrient uptake per unit of nutrient applied) ranged from 24.01 to 41.39% and from 26.08 to 43.99% in 2016 and 2017, respectively. Data revealed that, fertilizers combinations increase N-recovery efficiency percentage compared with N fertilizer only. The maximum N-recovery efficiency percentage was recorded in NPKZn treatment followed by NPZn and NPK treatments. The minimum N-recovery efficiency percentage was recorded in N treatment alone and with K fertilizer due to effects of K^+ in leaching of NH_4^+ ion from clay surface. Jongkaewwattana and Geng (2001) found that N-recovery percentage varied greatly among rice cultivars and rate of applied fertilizer. Under the current study, the recovery efficiency percentage of applied N fertilizer by Sakha 105 rice cultivar is medium. This may be due to de-nitrification, volatilization of NH_3 gas, and leaching process (Nishida *et al*. 2004). In addition, continuous addition of chemical fertilizers may accelerate the depletion of soil organic matter and soil fertility (Mubarak *et al*. 2003).

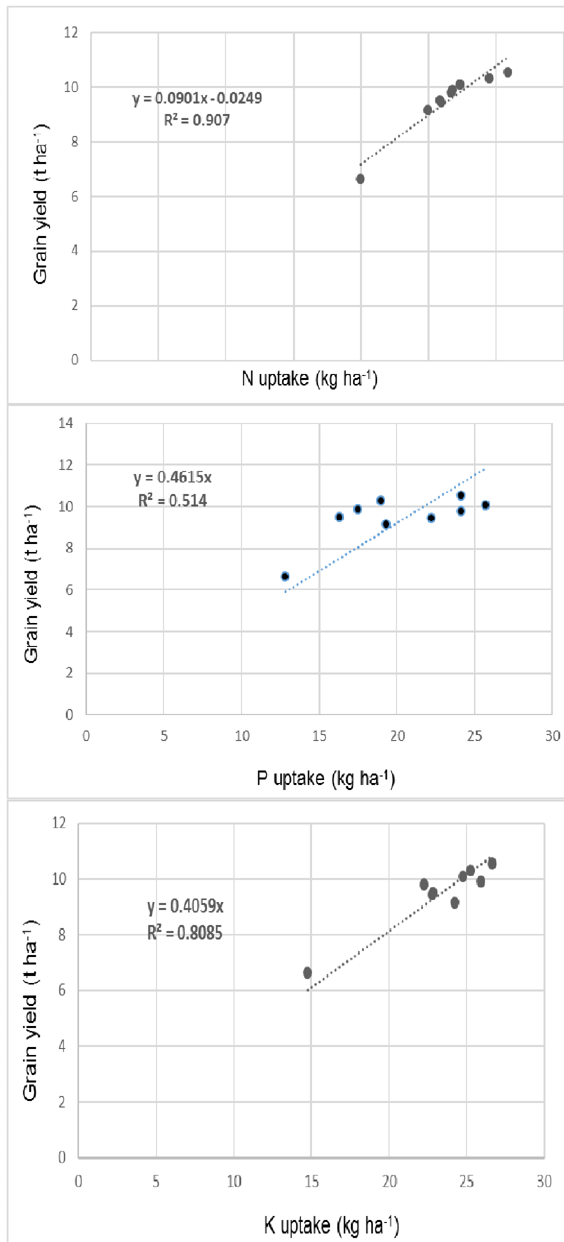

Figure 1. Correlation relationship between rice grain and uptake of N, P and K.

Table 8. Estimated N-recovery percentage and agronomic nitrogen use efficiency (ANUE) of Sakha105 rice cultivar as affected by fertilization treatments

Treatment	N-recovery efficiency (%)		ANUE (kg rice produced per kg of N applied)	
	2016	2017	2016	2017
Control	-	-	-	-
N	24.01	26.08	15.33	16.00
N P	28.80	30.19	19.21	19.09
N K	25.96	27.55	17.09	17.70
N Zn	26.25	30.68	17.39	18.55
N P K	31.05	33.82	20.91	22.42
N P Zn	37.07	35.05	22.24	23.03
N K Zn	29.28	28.72	19.76	19.52
N P K Zn	41.39	43.99	23.70	24.67

Available soil nutrients

Available soil-NH_4^+ (ppm), as affected by fertilizer applications is shown in (Table 9). The soil-NH_4^+ availability under all fertilization treatments was higher compared to control. The highest content of available NH_4^+ in soil was found at 30 DAT, and then declined to the minimum at 90 DAT. This decrease may be due to the absorption by rice plants and the losses by different ways.

Table 9. Concentration of available soil NH_4^+ (ppm) 30, 60 and 90 days after transplanting as affected by fertilizer treatments

Treatment	30 DAT		60 DAT		90 DAT	
	2016	2017	2016	2017	2016	2017
Control	40.17	35.20	27.00	29.00	18.60	19.22
N	52.00	50.09	45.12	40.17	23.10	20.15
N P	51.03	49.00	40.35	41.20	20.07	19.65
N K	54.00	51.14	47.16	40.90	21.80	21.09
N Zn	49.00	50.34	43.12	42.00	21.95	20.35
N P K	48.00	48.59	40.50	39.55	20.15	18.95
N P Zn	45.00	49.58	39.00	42.35	22.05	19.23
N K Zn	55.00	51.65	44.05	41.06	24.18	20.16
N P K Zn	47.00	48.05	35.26	39.18	20.51	21.23

Available soil-P content at different days from transplanting as affected by applying fertilizers is presented in Table (10). Data indicated that the fertilizers treatment which contains P fertilizer, led to an increase in available soil-P compared with other fertilizer treatments. The highest amounts of available soil-P were recorded at 30 DAT, then decreased afterwards due to the absorption of plant and adsorption-precipitation reaction by soil minerals, which caused a decline in available soil-P. The results are in line with those reported by (Gewaily *et al*. 2011). Hartinee *et al*. (2011) found that anion nutrients like H_2PO_4 are co-transported with NH_4^+ ions nutrients during nutrient absorption process. When NH_4^+ ion is absorbed by rice roots, counter release of protons (H+) takes place to balance the charge. These decreases in soil pH intern releases the dissolution of insoluble P compounds in oxidised rhizosphere, which helps absorb more P by rice. In addition, P with iron when iron changed to ferrous under submerged condition led to increases more P for plant. When more water soluble-P was applied as P fertilizer, the available soil-P content increased significantly. The increases in available soil-P concentration could be attributed to high microbial activity induced by the addition of mineral-P soluble forms (Bhattacharyya *et al*. 2008).

Table 10. Available soil P concentration (ppm) 30, 60 and 90 days after transplanting as affected by fertilizer treatments

Treatment	2016			2017		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Control	45.23	28.00	15.47	44.00	30.01	14.05
N	45.08	26.52	15.85	42.75	25.52	15.97
N P	49.67	29.85	16.05	48.75	28.17	17.02
N K	44.18	27.02	15.72	47.75	27.00	15.45
N Zn	42.21	28.10	15.87	43.00	29.17	16.65
N P K	50.22	26.30	16.34	52.10	28.92	17.35
N P Zn	50.67	27.07	16.20	52.00	29.65	17.92
N K Zn	43.08	25.02	14.95	45.23	28.15	17.21
N P K Zn	48.17	26.45	15.22	47.85	29.35	16.45

The application of different chemical fertilizers into soil slightly enhances contents of available soil-K up to 30 DAT then, decrease to the minimum at 90 DAT (Table 11). These results could be confirmed those obtained by Hammad (1995) who reported that the availability of K decreases with continuous flooding and development of plant growth.

Zinc availability, as affected by different soil fertilization treatments is presented in Table (12). Data indicate that the fertilizers treatment having Zn, recorded higher available soil- Zn compared with other fertilizer treatments. Data also showed that soil-Zn availability decreases to minimum at 60 DAT, followed by a slight increase up to 90 DAT. This is mainly due to the improving the soil aeration (Ghoneim, 2016).

Table 11. Available soil K concentration (ppm) 30, 60 and 90 days after transplanting as affected by fertilizer treatments

Treatment	2016			2017		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Control	361.20	355.86	348.10	345.17	334.10	325.00
N	352.04	347.25	344.12	337.39	332.21	322.55
N P	358.87	339.14	333.42	335.54	329.24	321.01
N K	386.42	352.85	351.32	361.35	348.50	336.21
N Zn	348.20	332.00	339.85	330.45	329.01	320.25
N P K	377.25	337.65	334.05	355.96	350.00	339.45
N P Zn	345.27	339.78	338.92	334.65	327.56	321.03
N K Zn	362.00	349.47	341.15	350.55	349.00	328.75
N P K Zn	361.54	357.22	352.11	352.22	335.14	322.00

In soil, nutrient concentration is present in a different number of chemical forms with different in solubility and these forms includes soluble present in soil solution and associated with organic matter (Arnold *et al*. 2010). These different forms of nutrient mainly control solubility and availability of nutrients of rice plant. In addition, soil chemical properties such as pH and soil organic matter, have a critical role in regulating nutrients solubility and availability (Depar *et al*. 2011).

Table 12. Available Zn concentration (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by fertilizer treatments

Treatment	2016			2017		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Control	0.775	0.549	0.850	0.765	0.532	0.870
N	0.737	0.585	0.870	0.725	0.607	0.900
N P	0.763	0.608	0.844	0.753	0.615	0.850
N K	0.655	0.540	0.792	0.685	0.593	0.811
N Zn	0.827	0.613	0.845	0.801	0.672	0.894
N P K	0.755	0.621	0.818	0.763	0.602	0.835
N P Zn	0.804	0.694	0.894	0.799	0.683	0.907
N K Zn	0.775	0.660	0.915	0.787	0.654	0.898
N P K Zn	0.682	0.508	0.890	0.692	0.578	0.879

CONCLUSION

Rice crop productivity and nutrient uptake depend on availability of essential nutrients. However, application of nutrients at optimum application rates essentially depends on soil fertility and cultivated rice cultivar. Application of appropriate levels of fertilizers is a major concern to increase nutrients use efficiency by rice cultivars. Improved nutrient use efficiency can be achieved through optimum soil fertilizer application. Therefore, to increase fertilizer use efficiency, balanced fertilization is necessary. The balanced fertilizer application is not only essential for producing higher rice yield, but also for improving soil fertility and environmental sustainability.

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تاثير التسميد الأرضي علي إنتاجية الصنف سخا 105 , إمتصاص NPK ومحتوي العناصر بلارض

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مركز البحوث والتدريب في الارز- معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر

يعتبر توزان العناصر الغذائية الضرورية من أهم العوامل المؤثرة لزيادة محصول الأرز. وعليه فإن معرفة التداخل بين عنصر N و العناصر الغذائية الأخري هام جدا لزيادة كفاءة استخدام الاسمدة وزيادة المحصول. اجريت تجربة حقلية بمركز البحوث و التدريب في الارز خلال موسمي 2016 و 2017 لمعرفة تاثير الإضافات المختلفة من NPKZn علي إنتاجية الصنف سخا 105 وإمتصاص NPK وكفاءة إستخدام الأسمدة. شملت المعاملات: (1) Control, (2) N, (3) N + P, (4) N + K, (5) N + Zn, (6) N + P + Zn, (7) N +K + Zn, (8) N + P + K, and (9) N + P + K + Zn. اوضحت النتائج تاثر المحصول ومكوناته بإضافة الأسمدة المختلفة و خاصة معاملة NPKZn حيث أعطت أعلي محصول حبوب, أعلي عدد سنابل للجورة وعدد الحبوب الممتلة لكل سنبلة وأقل نسبة عقم بالمقارنة بمعاملة الكنترول. كما تاثر إمتصاص هذه العناصربالمعاملات المختلفة وخاصة معاملة NPKZn . تروحت قيم كفاءة إستخدام السماد النيتروجيني من 24.01% to 41.39% و 26.08% to 43.99% في موسم 2016 و 2017 علي التوالي. أدت إضافة الأسمدة المختلفة إلي زيادة في محتوي الأرض من الأمونيوم والفوسفورالمتاح بعد أزمنة مختلفة من الشتل. تقترح الدراسة أن التوزان في إضافة الأسمدة هام جدا في المحافظة علي خصوبة الأرض وبالتالي زيادة محصول الأرز.