Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 07 | Issue : 04 | Oct.-Dec. | 2018
Pages:1352-1358

Growth, productivity of some rice cultivars in relation to nano-zinc and iron fertilizer

[1]Gomaa, M. A., E. E. Kandil[1], Nader R. Abdelsalam[2] and Malik A.M. Al-Jaddadi[3]

[1]Plant production Department, Faculty of Agriculture (Saba Basha), Alexandria University, Egypt
[2]Agricultural Botany Department, Faculty of Agriculture (Saba Basha), Alexandria University, Egypt
[3]Ministry of Commerce, Trade and Financial Control Department, Trade Control Department, Division Quality Control, Baghdad, Iraq

Received: 25 Sept. 2018 / Accepted 30 Oct. 2018 / Publication date: 15 Nov. 2018

ABSTRACT

Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture (Saba Basha), Abess Region, Alexandria University, Egypt, during two seasons of 2017 and 2018 to study the response of some rice cultivars to nano- Zn and iron fertilizer (ZN, Fe NPs) form. The experimental design was split- plot system with three replicates. The main plots were occupied by the four rice cultivars "Sakha 101, Giza178, Yasmeen and Amber", while, the sub-plots contain four foliar applications of nano- fertilizer "Water, Zn, Fe, Fe & Zn". Plant height, panicle length (cm), number of panicles/m^2, number of filled grains/panicle, 1000- grains weight (g), biological, grain, and straw yields (t/ha.) were determined in both seasons. The obtained results revealed that the rice cultivar Sakha 101 recorded the highest values of most of the pervious characters and surpassed all other varieties. Foliar application of Zn, Zn & Fe showed increased yield and its components of rice crop. The interaction between nano- Zn and Fe increased significantly yield and its components in both seasons under the environmental conditions of Alexandria Governorate this study.

***Keywords*:** Egyptian, Iraqi, wheat, cultivars, yield, Nano, fertilization

Introduction

Rice (*Oryza sativa* L.) is considered one of the most important summer crops worldwide, grown in wide range of climatic zones (Osman *et al*., 2013). In Egypt, the area devoted to rice cultivation is about 673000 ha. and the average yield of rice reached about 9.3 t/ha, while, in Iraq reached to 377000 ha with an average about 4.8 t/ha. On the other hand, the cultivated area in the World reached about 160 million ha with an average 4.6 t/ha (FAO, 2016). Today, nano- fertilizers are the most technically advanced way of supplying mineral nutrients to crops, compared to chemical fertilizers, their supply nutrient for plant needs, minimizes leaching, and therefore improves fertilizer use efficiency (Subbarao *et al.,* 2013). Nano-fertilizer technology is designed to deliver nutrients in a regulated pattern in correspondence with the crop demand thereby nutrient use efficiency can be improved. The growth, yield, quality and nutrient uptake were consistently higher for nano- zeourea treatment than conventional urea (Manikandan and Subramanian 2016). Nanoparticles applications as foliar can be increased 25-45% in the number of tomato fruit and flowers (Ferbanat 2013). Nanotechnology liquid fertilizer (Zinc and Iron) treatment increased the parameters of plant yield and growth compared to the control in carrot. The interaction effect of nano Zn and nano Fe on plant height of carrot was also found significant. It is generally beneficial for root and shoots growth of plants, increasing cell permeability and supply plant nutrients (Elizabath *et al.,* 2017). Also, in cereals crops such as wheat, application of nano-iron fertilizer increased protein and Fe concentration in grains and straw and increased grain yield by 20 % (Balali and Malakouti 2002). In addition to, other research for Delgado and Sanchez-Raya (2007) revealed that application of Fe fertilizer in sunflower resulted in the reduction of adverse effects of stress and enhancement of NPK absorption and consequently plant growth and yield. Fe NPs increased root length, stem length, chlorophyll content and shoot dry weight compared with the common iron fertilizers (Peyvandi *et al*., 2011). Also,

Corresponding Author: E. E. Kandil, Plant production Department, Faculty of Agriculture (Saba Basha), Alexandria University, Egypt. E-mail: essam.kandil@alexu.edu.eg

Moghadam *et al*. (2012) studied the effect of iron nanofertilizer on spinach and reported that application of 4 kg/ha iron nanofertilizer increased leaf weight by 58% and leaf area index by 47% compared with the control. An increase in yield due to foliar application of nano particles 640 mg/ha application of foliar application (40 ppm concentration) of Nano phosphorus gave 80 kg/ha P equivalent yield of bean and pearl millet under arid environment (Tarafdar *et al*., 2014). Effect Nano-fertilizers on the growth and yield of selected cereals showed that the full recommended rate of conventional dose nano fertilizers (FRR-CF+FRR-NF) enhanced the plant height, chlorophyll content, number of reproductive tillers, panicles and spikelet's in rice (Jyothi *et al.,* 2017). Significant increases in plant height, spikes number/m^2, spikelets number/spike, grains number/spike, 1000-kernel weight, grain, straw, and biological yields/fed., as well as harvest index (%) using nano-fertilizer + amino acids during both growing seasons. Meanwhile, the applied mineral fertilizer, alone; gave the lowest mean values of the studied traits. Spray "Sids 12" cultivar by nano- fertilizer and amino acids; recorded the highest mean values of yield and its components. On the other hand, "Giza 168" cultivar, possessed the lowest ones (Kandil and Marie 2017). The objective of current investigation is to estimate some rice cultivars productivity under Zn and Fe nano- fertilizer.

Materials and Methods

Two experiments were carried out at the Experimental Farm, Faculty of Agriculture (Saba Basha), Abess Region, Alexandria University, Egypt, during 2017 and 2018 seasons, to investigate the response of four rice cultivar to nano Zn and Fe fertilizer. The preceding crop was clover in the two growing seasons. Soil samples of the experimental sites were taken at the depth of (0-30 cm). Physical and chemical analysis are presented in Table (1) and were determined according to the method described by Chapman and Pratt (1978).

Table 1: Some physical and chemical properties of the experimental soil in 2017 and 2018 seasons.

Soil properties	Seasons	
	2017	2018
A- Mechanical analysis		
Sand	14.50	14.70
Silt	42.10	42.10
Clay	43.40	43.20
Soil texture	Clay loam	Clay loam
B- Chemical properties		
pH (1:1)	7.70	7.60
EC (1:1) dS/m	3.40	3.50
1- Soluble cations (1:2)		
K^+	1.40	1.45
Ca^{++}	14.20	15.40
Mg^{++}	11.30	11.50
Na^+	13.60	13.80
2- Soluble anions (1:2)		
CO^-_3+ HCO^-_3	2.80	2.90
CL^-	19.70	19.80
SO^-_4	12.40	12.50
Calcium carbonate (%)	6.70	6.90
Total nitrogen (%)	1.10	1.20
Available P (mg/kg)	3.70	3.60
Organic matter (%)	1.50	1.60

Each experimental design was a split- plot design with three replicates, the main plots were occupied by the four rice cultivars "Sakha 101, Skha178, Yasmeen and Amber", while, the four foliar applications of nanofertilizer "Water, Zn, Fe, Fe + Zn" were distributed at random in sub plots. The structure of nano- Zn and nano- Fe fertilizer is shown in Table (2). Mineral Nitrogen fertilizer at rate of 168 kg N/ha., was added at two equal doses. The first dose was added 15 days after transplanting, the second one was added 25 days after the first dose. In the two experiments N- fertilizer was added

on the form of urea (46.5 % N). Super phosphate fertilizer at the rate of 60 kg P_2O_5/ha and Potassium sulphate fertilizer at rate of 100 kg K_2O/ha treatments were applied during soil preparation.

Foliar application of Nano- Zn at the rate of 2.5 kg/ha and nano- Fe fertilizer at the rate of 3 L/fed were sprayed at three equal doses after transplanting by 15, 30 and 45 days. Each sub plot size was 10.50 m^2 (3 m in length and 3.5 m in width). The grains of the tested two Egyptian and two Iraqi rice cultivars were obtained from rice Research Section of Agriculture Research Center, Ministry of Agriculture in Egypt and Iraq, respectively. Sowing dates of the rice nurse were at 10th and 5th April in both seasons, respectively, while, transplanting was at 10th and 5th May in both seasons, respectively.

Table 2: Structure of nano- Zn and nano- Fe fertilizer.

Element	Super nano- Zn (%)	Active nano- Iron (%)
Iron (nano form)	-	6
Zinc (nano form)	10	-
Vitamins	1	1
Sea weed extracts	2	2
Amino acids	0	10
Organic acids	25	-

Plant height, panicle length (cm), number of panicles/m^2, number of grains/panicle, 1000- grain weight (g), biological, grain, and straw yields (t/ha.) were recorded at harvest time in both seasons. All collected data were subjected to analysis of variance according to Gomez and Gomez (1984). All statistical analysis was performed using analysis of variance technique by means of CoStat computer software package (CoStat, Ver. 6.311., 2005). The least significant differences (LSD at 0.05) were used to compare the treatment means.

Results and Discussion

Results in Table (3) reveals the effect of foliar application of Nano- fertilizer (Zn and Fe NPs) and their interactions during 2017 and 2018 seasons on plant height, panicle length (cm), number of panicles/m^2 and number of filled grains/panicles of four rice cultivars. The results shown in Table (3) indicated that there was significant difference between the four rice cultivars to morphological characters, where the rice cultivar Amber recorded the longest plants height and panicles were (106.3 and 107.7 cm) and (12.3 and 13.3 cm), in respect on the other side, the rice cultivar Sakha 101 detected the shortest plants height and panicles were (92.5 and 100.0 cm) and (12.0 and 12.1 cm), respectively during 2017 and 2018 seasons. Meanwhile, Sakha 101 produced significantly the highest values of number of panicles/m^2 (348.1 and 350.6), number of filled grains/panicle (128.9 and 134.9). While, Amber cultivar recorded the lowest ones for number of panicles/m^2 (393.4 and 383.4), number of filled grains/panicle (116.9 and 121.9) in the first and second seasons, respectively. These results may be due to the genetic makeup of different varieties. In addition, these results agreed with those obtained by Kanegana and Kargbo (2011) and Sadimantra *et al*. (2014) who reported that the different among varieties due to genetically difference. Genotypes relationship is mainly based on information about plant characteristic.

Data in Table (3) showed the significant effect of nano-Zn and nano-Fe, where nano- Zn gave the highest mean values of plant height (106.4 and 112.6 cm), panicle length (13.0 and 13.7 cm), number of panicles/m^2 (330.5 and 339.4), and number of filled grains/panicle (131.0 and 137), respectively in 2017 and 2018 seasons. While, the lowest values of plant height (90.4 and 97.5 cm), panicle length (11.0 and 11.8 cm), number of panicles/m^2 (275.2 and 267.9) and number of filled grains/panicle (109.9 and 114.8) were recorded under the control treatment (water) during both seasons, respectively. These results are in harmony with those obtained by Balali and Malakouti (2002); Delgado and Sanchez-Raya (2007); Peyvandi *et al*., (2011); Moghadam *et al*., (2012) and Elizabath *et al.,* (2017).

The interaction between rice cultivars and nano-fertilizer (Zn, Fe NPs) had significant effect on all characters, where nano-Zn and nano-Fe with the rice cultivar Amber with nano-Zn and Fe gave the longest plants height (115.7 and 112.7 cm) and the longest panicles (13.3 and 14.3), on the other hand Sakha 101 with spraying with water (control) recorded the shortest plant (85.1 cm) in the first season and Giza 178 with water gave the shortest plant (91.6 cm) in the second season. In addition, foliar

Table 3: The effect of foliar nano- Zn and Fe fertilizers and their interactions on some attributes of four rice cultivars in both seasons.

Attributes	Treatments	Seasons														
		2017								2018						
	Cultivars (A)	Nano- Zn and Fe fertilizer (B)				Means	LSD at 0.05 (A)	LSD at 0.05 (B)	LSD at 0.05 (Ax B)	Nano- Zn and Fe fertilizer (B)				Means	LSD at 0.05 (A)	LSD at 0.05 (B)	LSD at 0.05 (Ax B)
		Water	Fe	Zn	Zn + Fe					Water	Fe	Zn	Zn + Fe				
Plant height	Sakha 101	85.1	92.9	99.2	92.7	92.5c	4.9	4.0	8.0	94.1	94.9	106.8	104.1	100.0b	5.1	4.7	9.3
	Giza 178	86.6	97.9	106.9	104.0	98.9b				91.6	97.1	107.8	105.1	100.4b			
	Yasmeen	92.7	91.3	106.0	113.3	100.8b				103.4	106.6	116.6	128.6	113.8a			
	Amber	97.2	106.7	105.7	115.7	106.3a				100.7	111.0	106.3	112.7	107.7a			
Means		90.4c	97.2	104.5a	106.4a					97.5c	102.4c	109.4b	112.6a				
Panicle length	Sakha 101	11.0	13.0	11.0	13.0	12.0 ab	0.35	0.74	1.47	11.0	12.0	12.0	13.3	12.1b	0.81	0.78	1.56
	Giza 178	11.0	13.0	11.3	13.0	12.1ab				12.0	13.0	12.3	13.3	12.7ab			
	Yasmeen	11.0	13.0	11.0	12.8	11.9 b				12.0	14.0	12.0	13.8	13.0 a			
	Amber	11.0	13.0	12.0	13.3	12.3 a				12.0	14.0	13.0	14.3	13.3 a			
Means		11.0b	13.0a	11.3b	13.0a					11.8b	13.3a	12.3b	13.7b				
Number of panicles/m^2	Sakha 101	367.3	354.7	340.3	330.0	348.1a	27.3	32.4	64.8	343.7	352.0	338.3	368.3	350.6a	22.6	14.7	61.4
	Giza 178	245.7	252.0	297.7	351.3	286.7ab				247.7	254.0	299.0	353.3	288.5b			
	Yasmeen	255.0	315.3	306.0	321.0	299.3a				252.3	324.0	308.7	318.0	300.8b			
	Amber	232.7	275.3	345.7	319.7	293.4b				227.7	272.3	315.7	318.0	283.4b			
	Means	275.2b	299.3b	322.4b	330.5a					267.9c	300.6b	315.4a	339.4a				
Number of filled grains/panicle:	Sakha 101	110.0	130.7	136.7	138.3	128.9a	4.8	2.4	4.7	115.0	135.7	141.0	148.0	134.9a	45	2.7	5.3
	Giza 178	118.7	129.7	126.3	136.0	127.7a				123.7	134.7	131.3	141.0	132.7a			
	Yasmeen	107.0	122.3	120.0	125.7	118.8b				111.7	128.0	124.0	130.7	123.6b			
	Amber	103.7	116.3	123.7	124.0	116.9b				108.7	121.3	128.7	129.0	121.9b			
Means		109.9c	124.8b	126.7b	131.0a					114.8c	129.9b	131.3b	137.2a				

Table 4: The effect of foliar nano- Zn and Fe fertilizers and their interactions on yield attributes of four rice cultivars in both seasons.

Yield attributes	Treatments	2017								2018							
	Cultivars (A)	Nano- Zn and Fe fertilizer (B)				Means	LSD at 0.05 (A)	LSD at 0.05 (B)	LSD at 0.05 (A x B)	Nano- Zn and Fe fertilizer (N)				Means	LSD at 0.05 (A)	LSD at 0.05 (B)	LSD at 0.05 (A x B)
		Water	Fe	Zn	Zn + Fe					Water	Fe	Zn	Zn + Fe				
1000-grain weight	Sakha 101	20.2	21.1	23.3	22.8	21.9a	0.95	0.96	1.9	19.6	20.7	22.9	22.3	21.4a	0.58	0.90	1.8
	Giza 178	19.7	20.7	22.7	23.0	21.5a				19.3	20.4	22.0	23.1	21.2a			
	Yasmeen	19.4	19.9	20.3	21.2	20.2b				18.8	18.5	19.8	19.8	19.2c			
	Amber	18.3	19.8	20.2	20.7	19.8b				19.5	19.9	18.8	21.2	19.9b			
Means		19.4c	20.4b	21.6a	21.9a					19.3b	19.9b	20.9a	21.6a				
Biological yield	Sakha 101	17.2	17.1	19.0	19.3	18.2c	0.56	0.69	1.4	15.3	15.4	18.3	17.6	16.7b	1.0	0.81	1.6
	Giza 178	17.1	18.8	18.9	20.3	18.8b				14.6	17.9	16.6	18.3	16.9b			
	Yasmeen	19.1	20.4	20.4	21.5	20.4a				16.4	17.6	18.1	19.0	17.8b			
	Amber	19.7	20.8	21.7	21.4	20.9a				17.5	18.1	19.8	20.6	19.0a			
Means		18.3c	19.3b	20.0a	20.6a					16.0c	17.3b	18.2a	18.9a				
Straw yield (t/ha)	Sakha 101	9.9	8.5	10.0	10.7	9.8d	0.78	1.03	2.5	7.8	6.7	9.2	8.9	8.2d	1.0	0.55	1.6
	Giza 178	11.4	12.1	11.2	13.2	12.0c				8.6	11.0	8.5	10.7	9.7c			
	Yasmeen	13.6	13.8	13.3	14.5	13.8b				11.1	11.8	12.0	12.9	12.0b			
	Amber	14.8	15.3	16.2	15.6	15.5a				12.2	12.7	14.4	14.9	13.6a			
Means		12.4b	12.4b	12.7a	13.5a					9.9	10.6a	11.0a	11.9a				
Grain yield (t/ha)	Sakha 101	7.3	8.6	9.0	8.6	8.4a	0.60	0.48	0.96	7.5	8.7	9.1	8.7	8.5a	0.32	0.28	0.77
	Giza 178	5.7	6.7	7.7	7.1	6.8b				6.0	6.9	8.1	7.6	7.2bb			
	Yasmeen	5.5	6.6	7.1	7.0	6.6b				5.3	5.8	6.1	6.1	5.8c			
	Amber	4.9	5.5	5.5	5.8	5.4c				5.3	5.4	5.4	5.7	5.5d			
Means		5.9b	6.9a	7.3a	7.1a					6.0	6.7b	7.2a	7.0a				

application of nano- Zn and Fe with Giza 178 recorded the highest number of panicles/m^2 (351.3) in the first season but foliar application of nano- Zn + nano- Fe with Sakha 101 gave the highest number of panicles/m^2 in the second season, while the lowest ones recorded by spraying Amber by water (control) in both seasons. Also, foliar application of nano- Zn + nano- Fe with Sakha 101 gave the highest number of filled grains/panicle (138.3 and 148.0), meanwhile the lowest ones were recorded with spraying Amber by water (control) in both seasons, respectively

The results in Table (4) showed the effect of foliar application of nano- Zn and nano- Fe fertilizers and their interactions during 2017 and 2018 seasons on 1000-grain weight, biological yield, grain yield and straw yield of four rice cultivars. In respect to effect of rice cultivars, Table (4) showed the significant variations between the four rice cultivars, where the rice cultivar Skha101 gave the heaviest 1000- grain weight (21.9 and 21.4 g), grain yield (8.4 and 8.5 t/ha) while Amber cultivar recorded the heaviest biological yield (20.9 and 19.0 t/ha) and straw yield (15.5 and 13.6 t/ha). On the other side the rice cultivar Amber and Yasmin gave the lowest 1000- grain weight in 2017 and 2018 seasons. Meanwhile, Sakha 101 produced the lightest biological yield (18.2 and 16.7 t/ha) and straw yield (9.8 and 8.2 t/ha) in both seasons, respectively. Genetic differences between different varieties also caused variation in plant lengths. Plant attributes depends on genetic character of a plant and environmental conditions. These results are in harmony with that obtained by Kanegana and Kargbo (2011) who reported that the difference among rice cultivars due to genetically difference. Genotype relationship is mainly based on information about plant characteristic.

In regards to effect of nano-fertilizer, Table (4) revealed the significant effect of Zn NPs and Fe NPs, where Zn NPs and Fe NPs gave the heaviest 1000- grain weight (21.9 and 21.6 g), biological yield (20.6 and 18.9 t/ha), grain yield (7.1 and 7.0 t/ha), and straw yield (13.5 and 11.9) with no significant difference between foliar application of Zn NPs, respectively in 2017 and 2018 seasons. Meanwhile, control (water) treatment gave the lightest 1000- grain weight (19.4 and 19.3 g), biological yield (18.3 and 16.0 t/ha) and straw yield (12.4 and 9.9 t/ha) in both seasons, respectively. These results are confirmed with those reported by Raliya and Tarafdar (2013); Ramesh *et al*. (2014); Yuvaraj and Subramanian (2014); Bakhtiari *et al.* (2015); Upadhyaya *et al.* (2017) and Sheykhbaglou *et al.* (2018) which indicated that ZnO NPs and FeO NPs increased yield and its components.

Concerning the interaction between rice cultivars and nano- fertilizer, Table (4) reported that Zn and Fe NPs had significant effect on all characters under this study, where (Zn NPs) + Sakha 101 and (Zn NPs and Fe NPs) + Giza 178 gave the heaviest 1000- grain weight (23.3 and 23.1) while the lowest ones recorded with Amber + water and Yasmeen + Fe NPs in both seasons, respectively. on the other hand, Amber cultivar + Zn NPs recorded the heaviest biological yield (21.7 t/ha) and straw yield (16.2 t/ha) during 2017 season. On the other hand, foliar application of nano- Zn with Sakha 101 recorded the heaviest grain yield (9.0 and 9.1 /ha) in the two seasons, respectively. Meanwhile, Amber + water treatment and Yasmeen + Fe gave the lightest 1000- grain weight, but Giza 178 + water treatment recorded the lightest biological yield and Sakha1010 + Fe NPs gave the lightest straw yield in both seasons, respectively. The lightest grain yield recorded with Amber + water treatment in both seasons. These showed that rice cultivars under this study act dependently on nano- Zinc and nano- Fe fertilizers on the previous studied characters as shown in Table (4).

Conclusion

Sparying rice plant with the combination of nano-Fe at the rate of 3 L/ha and nano-Zn at the rate of 2.5 kg/ha increased significantly yield and yield components of Egyptian and Iraqi cultivars.

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