Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 04 | Issue : 04 | Oct.-Dec. | 2015
Pages: 919-924

Impact of Micronutrients and Bio- Fertilization on Yield and Quality of Rice (*Oryza sativa,* L.)

Gomaa, M. A., F.I. Radwan, E. E. Kandil and M. A. M. Shawer

Plant production Department, The Faculty of Agriculture (Saba Basha), Alexandria University

ABSTRACT

In order to examined the impact of micronutrient and biofertilizers on the yield, its components and quality characters in rice plant, two field experiments were conducted at the Rosseta region, El_Behira Governorate, Egypt, during 2013 and 2014 summer growing seasons, in split plot design based on three replication. The main plots included the micronutrients fertilizer (untreated, Zn, Fe and mixed (Zn + Fe), while the bio-fertilizers (uninoculation, Blue green algae, Mycorrhizal and mixed (Blue green algae + Mycorrhizal) was arranged in the sub plot. The results could be summarized as follows; significant increase was recorded on panicle weight (g), number of filled grains/panicle, number of panicle/m^2, 1000- grain weight, grain, straw, and biological yield (tons/fed.) as well as harvest index with mixture application (Zn +Fe) in both growing seasons. Inoculation at Blue green + Mycorrhizal gave the highest most of characters under study. Applying with mixture (Zn + Fe) with Blue green +Mycorrhizal inoculation was the best combination to obtain the highest most of yield and its components, Zn , Fe concentration as well as hulling and milling percentages under El-Behira conditions.

Key words: Zn, Fe, fertilization, Blue green, Mycorrhizal, inoculation, yield, grain quality

Introduction

Rice (*Oryza sativa* L.) is the most important food crop and a major food grain for more than a third of the world's population (Zhao *et al.*, 2011). It is now the major stable food of over half of the world's population. Rice occupies a conspicuous position in the predominately agricultural economy of Egypt thus attention is quality of elements nutrition (Badr, 2014). Rice however, is a poor source of many essential micronutrients. Increasing amount of bio -available micronutrients is rice food for human consumption is a challenge which is particularly important for developing countries. Theoretically; this could be achieved by increasing the total level of micronutrients in the edible part of staple crops, such as rice grains (Michael and Richard, 2007).

Zinc (Zn) application, significantly increased tillers m^{-2}, total biomass and paddy yield, as well as the Zn concentration in the grain and the straw, except phosphorus (P) content in the paddy and straw. Incorporeity Zn-EDTA in soil (10.0 kg ha^{-1}), resulted in greater values for grain, its components and grain chemical composition parameters of rice as compared to other sources of Zn application. Among the method of Zn application, soil application resulted in higher yield, biomass, N and K contents in the grain and straw. Foliar application caused greater P concentration in both grain and straw, however, chlorophyll, K contents in paddy remained unaffected by method of Zn application. However, Zn-EDTA proved to be the most efficient source of Zn for rice production. Noticeably, Zn-EDTA applied to in the soil 14 days after transplantation, along with recommended N: P: K proved to be appropriate to ameliorate zinc deficiency. Soil application of Zn-EDTA significantly increased yield components, as well as nutrient contents in paddy grains and straw. Application of Zn-EDTA will be helpful to reduce zinc deficiency in rice (Rana and Kashif, 2014).

Balancing the micronutrients for rice cultivation enhanced both the quality and yield of rice (Ma, 2007). Nevertheless, the availability of micronutrients such as Fe and Zn was much affected by pH, $CaCO_3$ content and soil texture. Each element of these micronutrients has its own function in plant growth (Fouly, 1983). Foliar application of micronutrients particularly Zn and Fe in small amounts had significant positive effect on 1000 grain weight, plant height, biological yield, grain yield, harvest index and oil content of sunflower (Babaeian, 2011), and growth of rice (Wissuma, 2008). The highest grain number per panicle was recorded when Fe+Si and mixture of the three elements were applied. Meanwhile, maximum 1000 grain weight was obtained in Zn+ Si foliar application treatment. The simultaneously application of these elements had the highest biomass weight and grain yield. Also, grain yield in Zn + Fe foliar application treatment was 9 and 13 percent greater than those in Fe and Zn treatments, respectively (Esfahani *et al*., 2014).

Bio- fertilizers, as alternate low cost resource have gained prime importance in recent decades and play a vital role in maintaining long term soil fertility and sustainability. They are cost effective, eco-friendly and

Corresponding Author: Mohamed Abd Alla Mohamed Shawer, Plant Production Department, The Faculty of Agriculture (Saba Basha), Alexandria University.
E-mail: mohamedabdalla361@yahoo.com

renewable sources of plant nutrients to supplement chemical fertilizers. Nitrogen fixing and P- solubilizing inoculants are important bio-fertilizers used in rice (Wijebandara *et al*., 2009). Utilization of biological N_2-fixation (BNF) can decrease the application of mineral N- fertilizer and reducing environmental pollution for the crops (Choudhury and Kennedy, 2004). Also, Mycorrhizal fungi play an important role in whole plant nutrient balance by adding in the uptake of limiting nutrient and maintaining the nutrient balance (Ning and Gumming, 2001; Tabl, 2014). Using biofertilization or microbial inoculates to replace of increase the efficiency of chemical fertilizer partially or totally as effective in reducing the cost of crop production and maintaining the natural fertility of soil (Mohamed, 2001 ; Radwan *et al*., 2008).

Usage of different organic amendments *viz.* Blue Green Algae, Azolla, Vermicompost and Farm Yard Manure in a cumulative manner can meet the nutrient requirement of organic scented rice in rice- wheat-green gram cropping system. Organic farming enhanced soil organic carbon, available phosphorus content and microbial population/ enzymatic activity of soil thus making it sustainable for organic crop production. Increase in Fe and Mn content in rice grain further indicated that their use not only maintain the soil productivity, but also improve the grain quality (Singh *et al.,* 2007).

Therefore, the present investigation was conducted to study the effect of micronutrient and bio-fertilizers on the productivity and quality characters of rice plants.

Materials and Methods

Two filed experiments were effectuated for two consecutive seasons, 2013 and 2014 on rice crop (*Oryza sativa*, L.) at a private farm of Rosseta region, El_Behira Governorate, Egypt. The experiments were conducted to investigate the effect of micronutrients and bio- fertilizers on productivity and quality characters of rice plants (*Oryza sativa* L. cv. Giza 177).

Soil samples of the experimental sites were taken at the depth of (0 and 30 cm) and its physical and chemical analysis were analyzed and presented in Table (1) were done according to Chapman and Pratt (1978).

Table 1: Physical and chemical properties of the experimental soil sites during both cropping seasons (2012/2013 and 2013/2014).

Soil characteristics		
Physical and chemical properties	Seasons	
	2013	2014
Soil texture (%)	Sandy clay loam	
Sand %	56.99	58.22
Silt %	9.63	8.92
Clay %	33.38	32.86
pH (1: 2.5 water suspension)	8.30	8.00
EC (dSm^{-1})	0.958	0.988
Cations (meq/L.)		
Ca^{++}	1.87	1.77
Mg^{++}	3.27	2.98
Na^{+}	55.00	53.10
K^{+}	5.10	4.98
Anions (meq/L.)		
HCO_3^{-}	2.00	1.95
Cl^{-}	3.85	3.77
SO_4^{--}	10.50	12.20
O.M. (%)	1.85	1.90
$CaCO_3$ (%)	0.198	0.192
Available Mineral N(mg/kg)	89.40	90.60
Available P (mg/kg)	20.12	28.50

Nursery seed bed was well ploughed and dry leveled- phosphorus fertilizer in the form of single calcium superphosphate (15.5 % P_2O_5) was added at the rate of 100 kg/fed before tillage. Nitrogen in the farm of urea (46%N) was added at the rate of 70 kg/fed., in two split doses, and first dose (2/3) was add to the dry soil as basal application before flooding, and the second dose (1/3) was applied at 30 days after transplanting crop was:

A. Biofertilization treatment:

-Inoculation of blue green algae at the rate of 200g inoculation/fed.. The blue green algae (Biofertilizer) were obtained from Botany Department, Faculty of Agriculture, Al-Azhar University, Egypt.

-Mycorrhizal fungi with fungi (*Glomus macropium*) strain as an inoculation for rice which it obtained from plant production Department (Saba Basha), Alexandria University at a rate 250 ml of infected roots and was mixed with seeds.

The preceding crop was barseem (*Trifolium alexandrinum* L.) for both growing season. The experimental design was split plot with three replications. The main plots included the micronutrients fertilizer (untreated, Zn,

Fe and mixed (Zn + Fe), while the bio-fertilizers (uninoculation, Blue green, Mycorrhizal and mixed (Blue green algae + Mycorrhizal) was arranged in the sub plot. The plot area was 10.5 m^2 (3.5 m length x 3 m width). Rice seeds at the rate of 42 kg/fed., were soaked in fresh water for 24 hours then drained and inoculated. For 48 hours to hasten early germination, the pre –germination seeds were, uniformly, broadcasted in the nursery in 8th May in 2013 and 2014 seasons.

B. Data recorded

Yield and its components (panicle length (cm), number of filled grains/panicle, number of panicle/m^2, 1000- grain weight (g), grain yield (tons/fed.), straw yield (tons/fed.), biological yield (tons/fed.) and harvest index (%) were estimate at the every both experiments during both seasons.

Chemical analysis of grains (Zn and Fe content), after harvest sub plots from grains was taken and then placed in paper bags and oven dried in 70°C for 48 hours. Dried samples were ground to powder and digested by the wet oxidation procedures of Johanson and Ulrich (1959). A Perkin-Elemer plasma 400 spectrophotometer was used for analysis of Zn and Fe.

Grain quality characters as milling characters i.e. hulling percentage, milling percentage and broken rice percentage were estimated according to the methods reported by Adain (1952).

Hulling percentage (about 150 g cleaned rough rice samples at moisture content 12-14 %) was estimated using experimental huller machine (Satake) at rice technology and training center, Alexandria.

Hulling %= brown rice weight/rough rice weight *100.

Milling percentage brown rice was consequently milled using milling machine model. TMOS at rice Technology and training center, Alexandria. The milled rice sample was than collected and weighted taken and percentage of total milled rice calculated by the following equation.

Milling %= Milled rice weight/rough rice weight*100

Broken rice percentage (%): broken rice milled rice grains were separated from the total milled rice by using sieving device. Then, the percentage of broken rice was obtained and calculated as follows:
Broke (%) = Broken grain milled weight/Total milled sample weight*100

Statistical analysis

All data collected were subjected to analysis of variance analysis according to Gomez and Gomez (1984). Treatment means were compared by LSD test. All statistical analysis was performed using analysis of variance technique by means of CoStat computer soft ware package.

Results and Discussion

Statistical analysis of the data revealed that micronutrients fertilizer led to a significant increase in yield and its components during both seasons (Tables 2 and 3). The highest mean values of all yield and its components as panicle length (cm), number of filled grains/panicle, number of panicle/m^2, 1000- grain weight (g), grain yield (tons/fed.), straw yield (tons/fed.), biological yield (tons/fed.) and harvest index (%), were produced by mixture application (Zn + Fe) than untreated plots. It is clear from (Tables 2 and 3) that the highest all yield and its components were recorded under the treatment including the combination of application mixture (Blue green + A. Mycorrhizal) in 2013 and 2014 seasons. These results might be take place due to the grain yield, in fact are the out product of its main components. Therefore, the increase in grain yield owing to applied mixture (Zn + Fe) was the logical resultant of the achieved increase in components. Similar results were reported by Ghonem (1992; 1996); Ali (2002).

With regard to the effect of biofertilization on rice yield and its components, the obtained results are shown in Tables (2 and 3). It could be concluded that inoculation of rice with mixed Blue green + A-Mycorrhizal inoculation; encourage the increase of panicle length, number of filled grains/panicle, number of panicle/m^2, 1000- grain weight (g), grain yield (tons/fed.), straw yield (tons/fed.), biological yield (tons/fed.) and harvest index (%) when compared with the uninoculation (control) in both seasons. This finding may be taken place due to the effect of mixed blue green + A- Mycorrhizal inoculation which plays an important role in the assimilation of rice plants that, reflected on enhancing these characteristics. Also, they could be attributed to the role of plants phytohormones like IAA, GAs and CKs which promote plant growth cell division, breaking the a apical dominances; hence encouraging the photosynthesis and assimilation accumulation (El-Khawas, 1990).Similar results, more or less, were obtained by Mohamed (2001); Radwan *et al.* (2008); Wijebandara *et al.* (2009); Table (2014).

Application of micronutrients fertilization led to a significant increase in Zn and Fe concentrations in rice grains (Table, 3). The highest mean values of Zn and Fe concentrations were produced by application of mixture (Zn + Fe) when compared with the untreated in both seasons, respectively. Similar results were reported by Ghonem (1992); Ali (2002).

Also, the data in Table (3) indicated that the inoculation with biofertilization produced a highly significant increase in the concentration of micronutrient (Zn and Fe). The inoculation mixed (Blue green algae + A Mycorrhizal) gave the highest mean value of Zn and Fe concentration in grain than the uninoculation treatments in both seasons. This finding may be existed due to the stimulating effect of A- Mycorrhizal and Blue green on plant growth often related in the increase nutrients uptake. The various mechanisms have been suggested to include the increase of surface area by growth of Mycorrhizal hyphae associated with roots into soil, the absorption of nutrient by hyphae and their translocation to plant, mobilizing sparingly available nutrients (Bolen, 1991). This result was in harmony with others obtained by Radwan *et al.* (2008).

Table 2: Panicle length, Number of filled grains/panicle, number of panicles /m^2 , and 1000- kernel weight (g) of rice as affected by mineral, organic and bio- N- fertilization, application method of zinc and their interaction during 2013 and 2014 seasons.

Treatments	Panicle length (cm)		Number of filled grains/panicle		Number of panicles /m^2		1000- kernel weight (g)	
	Seasons							
	2013	2014	2013	2014	2013	2014	2013	2014
Micronutrients								
Untreated	19.88c	19.95c	104.63c	109.10d	397.52d	419.07d	18.80c	18.32c
Zn	22.78a	21.08b	108.43b	112.12c	457.13b	463.97b	20.12b	20.32b
Fe	20.72b	20.13c	110.08b	113.45b	424.30c	451.90c	21.88a	19.81b
Zn + Fe	23.25a	21.48a	115.33a	117.11a	506.25a	502.83a	22.53a	22.18a
Biofertilization								
Uninoculation	20.21d	19.51d	100.02d	104.82d	411.98c	425.08d	19.10c	18.61c
Mycorrhizal	20.98c	20.15c	108.52c	112.48c	438.86b	459.19c	20.47b	19.38b
Blue green algae	21.85b	20.93b	110.78b	115.28b	467.67a	472.00b	21.15b	19.98b
Mixed	23.60a	22.03a	119.17a	119.21a	466.69a	481.49a	22.60a	22.66a
Interaction								
Micronutrients x Biofertilization	*	**	**	**	**	**	*	*

- *Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.*
- **, **: significant at 0.05 level of probability.*

Table 3: Straw yield tons/fed., Grain yield tons/fed., Biological yield tons/fed., and harvest index % of rice as affected by mineral, organic and bio- N- fertilization, application method of Zinc and their interaction during 2013 and 2014 seasons.

Treatments	Straw yield tons/fed.		Grain yield tons/fed.		Biological yield tons/fed.		Harvest index %	
	Seasons							
	2013	2014	2013	2014	2013	2014	2013	2014
Micronutrients								
Untreated	4.61d	4.44c	3.20c	2.98c	7.81c	7.42c	40.75b	40.02b
Zn	4.81c	4.94b	3.33c	3.28b	8.14c	8.22b	40.77b	39.78b
Fe	4.99b	4.93b	3.50b	3.39b	8.50b	8.32b	41.04ab	40.53ab
Zn + Fe	5.23a	5.36a	3.73a	3.80a	8.96a	9.16a	41.55a	41.44a
Biofertilization								
Uninoculation	4.19d	4.36d	2.71d	2.81d	6.90d	7.17d	39.22c	39.14c
Mycorrhizal	4.79c	4.70c	3.35c	3.15c	8.14c	7.85c	41.12b	40.09b
Blue green algae	5.11b	5.06b	3.63b	3.46	8.73b	8.52b	41.51b	40.61b
Mixed	5.56a	5.56a	4.07a	4.02a	9.64a	9.58a	42.26a	41.93a
Interaction								
Micronutrients x Biofertilization	*	*	*	*	*	*	*	*

- *Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.*
- ** : significant at 0.05 level of probability.*

Data in Table (4) showed that hulling, milling and broken rice percentages were affected by Zn and Fe application. The highest values of hulling and milling percentages were obtained by the application mixture of (Zn + Fe) in both seasons, except broken percentage significantly increased by untreated treatment in the two seasons, respectively.

Data presented in Table (4) indicated that of hulling and milling significantly increased by inoculation of rice grain with Blue green algae + A-mycorrhizal inoculation except the broken percentage significantly increased by blue green and uninoculation in both seasons. This may be due to blue green algae and A-Mycorrhizal inoculation had favorable effect on grain quality characters via improved growth escalating photosynthetic rate consequently improving both grain yield and grain quality as shown in Table (4). These results were agreement with those recorded by Radwan *et al*. (2008) and Table (2014).

As for the interaction between micronutrients fertilization and biofertilization was significant for all yield, its components, Zn, Fe concentrations and grain quality in both seasons (Tables, 2, 3 and 4). The highest all yield and its components were recorded under the treatment including the combination of application mixture (Zn + Fe) with inoculation mixed (Blue greenalgae + A. Mycorrhizal) in 2013 and 2014 seasons.

Table 4: Hulling %, milling %, and broken rice % of rice as affected by mineral, organic and bio- N- fertilization, application method of Zinc and their interaction during 2013 and 2014 seasons.

Treatments	Hulling %		Milling %		Broken rice %	
	Seasons					
	2013	2014	2013	2014	2013	2014
Micronutrients						
Untreated	75.06d	76.48c	68.54d	66.03d	2.55a	2.40a
Zn	77.48b	78.38b	70.68c	67.66c	2.16b	1.90b
Fe	76.73c	78.27b	72.04b	69.00b	1.92c	1.88b
Zn + Fe	78.47a	80.03a	74.09a	70.38a	1.08d	1.15c
Biofertilization						
Uninoculation	75.25d	76.78c	69.91c	66.21c	1.96a	1.94a
Mycorrhizal	76.46c	78.06b	70.96b	67.26bc	2.06a	2.00a
Blue green algae	77.48b	79.12a	71.41b	67.94b	1.94a	1.71b
Mixed	78.53a	79.21a	73.08a	71.65a	1.75b	1.67b
Interaction						
Micronutrients x Biofertilization	*	**	**	*	**	**

- *Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.*
- **, **: significant at 0.05 level of probability.*

Conclusion:

As a result of this two growing seasons field's study, it was concluded that yield, its components, microelements concentration and quality of rice crop increased with application mixture (Zn + Fe) with inoculation mixed (Blue green algae + *A. Mycorrhizal*) under study conditions at Rasheed, El-Behira governorate, Egypt.

References

Adain, C. R., 1952.The Mc. Gill miller method 20 for determining the milled quality of small samples of rice. J. of Appl., Sci., Res. SS., (2):20-21.

Ali, T.F., 2002. Methods of zinc, iron and manganese application to rice grown under submerged conditions. M.Sc. Thesis, Fac., of Agric., Kafr El-Sheikh-Tanta Univ., Egypt.

Babaeian, M, I. Piri, A. Tavassoli, Y. Esmaeilian and H. Gholami, 2011. Effect of water stress and micronutrients (Fe, Zn and Mn) on chlorophyll fluorescence, leaf chlorophyll content and sunflower nutrient uptake in Sistan region. Afri. J. of Agric. Res., 6:3526-3531.

Badr, M. M. Amany, 2014. Impact of organic and inorganic fertilization, quality of rice and soil fertility. Ph.D.Thesis, Fac. Agric. Kafr El-Sheikh Univ. Egypt.

Chapman, H.D. and P.F. Partt, 1978. Methods of analysis for soils and plant and water. Division Agric. Sci. Univ. Calif. pp.162-172.

Choudhury, A.T.M. and I.R. Kennady, 2004. Prospects and Potential for systems of biological nitrogen fixation in sustamable rice production. Bioferti. Soils.39:217-227.

CoStat Ver. 6.311, 2005. Cohort software798 light house Ave. PMB320, Monterey, CA93940, and USA. email: info@cohort.com and Website: http://www.cohort.com/DownloadCoStatPart2.html.

El-Khawas, M. A., 1990. Effect of *Azotobacter chrooccocum* and *Azosprillum brasilience* inoculation under graded levels of nitrogen growth and yield of wheat. Plant and Soil.69:61-67.

Esfahani, A. A., H. Pirdashti and Y. Niknejhad, 2014. Effect of iron, zinc and silicon application on quantitative parameters of rice (*Oryza sativa* L. CV. *Tarom Mahalli*). Intl. J. Farm & Alli. Sci., 3 (5): 529-533

Fouly, M. M., 1983. Micronutrients in arid and semi arid areas: Level in soils and plants and the need for fertilizers with reference to Egypt. In: Proceedings of the 17th Colloquium of the International Potash Institute (IPI), Bern, Switzerland, p. 163-173.

Ghanem, S.A., M.S. Abo-Soliman, A. M. El-Serafy and M.Abo El-Soaud, 1992.Productivity of Broadcasting seeds rice as affected by different application methods of some micronutrients. Proc. 5th Conf. Agron. Zagazig, (1):71-79.

Ghoneim, A.M., 1996. Effect of submergence on some physical chemical and biological changes of some North Delta as well as yield and yield components of rice plants. M.Sc. Thesis, The Fac. Agric. Tanta Univ.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Produces for Agriculture Research. 2nd Ed. John Wiley and Sons Inc. New York.

Johanson, C.W. and A. Ulrich, 1959. Analytical Methods for use in plant analysis.Calif. Agric.Exp. Station Bull.766:32-33.

Ma, J.F., K. Tamai, N. Yamaji, N. Mitani, S. Konishi, M. Katsuhara, T. Fujiwara and M. Yano, 2007. An efflux transporter of silicon in rice. Nature 448, 209-212.

Michael, B. Z. and H.F. Richard, 2007. Nutritional iron deficiency, 370(5):11-20.

Mohamed, A.A.A., 2001. Response of rice to bio, organic and mineral fertilizers and its combinations under two irrigation intervals. M.Sc. Thesis, the Fac. Agric. Kafr El-Sheikh. Tanta Univ., Egypt. 54 (388):1447-1459.

Ning, N. and J.R. Cumming, 2001.Arbuscular mycorrhizal fungi enhance aluminum resistance of brooms edge (*Andropogon vinginieus* L.). J. Exp., Bio., 54(388) 1447-1459.

Radwan, F.I., I. Abou El-Seoud and El-Ham A. Badr, 2008. Response of two rice cultivars to blue green algae. A Mycrrhizal inoculation and mineral nitrogen fertilizer. J. Plant Sci., and Biotechnology.17 March.

Rana, K. Waleed and S. R. Kashif, 2014. Effect of different Zinc sources and methods of application on rice yield and nutrients concentration in rice grain and straw. J. of Environ. and Agric. Sci., 1:9.

Singh, Y. V., B. V. Singh, S. Pabbi and P. K. Singh, 2007. Impact of organic farming on yield and quality of basmati rice and soil properties. Wissenschaftstagung Ökologischer Landbau.Beitrag archiviert unter ,9:1-4. http://orgprints.org/view/projects/wissenschaftstagung-2007.html

Tabl, D. M.M., 2014. Response of some rice cultivars to plant spacing and nitrogenous bio-fertilization. PhD. Thesis, Fac., of Agric. (Saba Basha), Alex., Univ., Egypt.

Wijebandara, D.M.,D.I. Raine, G.S. Dasog, P.L. Patil and M.Hebban, 2009. Response of rice to nutrients and bio-fertilizer under conventional and system on rice intensification methods of cultivation in Tungabhadra Command of Kamataka Dept. of soil Sci. and Agric., Chem., Univ., India J. Agric., Soil,22(4):741-753.

Wissuma, M., A.M. Ismail and R.D. Graham, 2008. Rice grain zinc concentrations as affected by genotype native soil –zinc availability, and zinc fertilization. Plant Soil, 306: 37-48.

Zhao, L., L.Wu, M. Wu and Y. Li, 2011.Nutrient uptake and water use efficiency as affected by modified rice cultivation methods with irrigation. Paddy Water Environment 9, 25-32.