Journal of Agri-Food and Applied Sciences

Journal of Agri-Food and Applied Sciences

Available online at jaas.blue-ap.org

©2016 JAAS Journal. Vol. 4 (3), pp. 60-72, 31 October, 2016

E-ISSN: 2311-6730

Yellow corn Productivity and quality Under Using Different minerals and Bio-fertilizer rates

Hoda Kh.A.El-Mekser[1], Zahrat El-Ola M. Mohamed[2*] and W.M.Elsayed[1]

1- Maize Research Program, Agricultural Research Center, Giza, Egypt
2- Department of Crops Technology Research, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

Corresponding Author: Zahrat El-Ola M. Mohamed

Received: 4 October, 2016 *Accepted: 15 October, 2016* *Published: 31 October, 2016*

A B S T R A C T

The present investigation was conducted on sandy soil at Is mailia Agricultural Research Station during the two successive summer seasons 2014 and 2015 to study the effect of biofertilizers with nitrogen (N) and potassium (K) mineral fertilizers at different rates on yellow corn single cross 173(SC 173) yield and some crop physicochemical as well as technological parameters. Three treatments of biofertilizer: 1) rhizobacterin, 2) potassiomage, 3) microbin and control (untreated) with two N rates: 60 and 120 kg fed-1 and two K rates: 12 and 24 kg K2 O fed-1 were used. Results showed significant differences among biofertizers for all traits. Corn plants were earlier in days to 50% tasseling (DTT) and days to 50% silking (DTS) when rhizobacterin or potassiomage was applied at 120:12 N:K kg fed-1 in the two seasons. The highest grain yield was obtained when potassiomage was applied at 120:12 N:K (kg fed-1) in both seasons. Analysis of grains showed that protein content significantly increased by biofertilizer application and the highest value of protein content was recorded by potassiomage treatment at 120:12 N:K (kg fed-1). Fat content increased significantly in potassiomage and microbin treatments relative to control at different N:K rates . Germ percentage increased significantly in all biofertilzer treatments. Applying of biofertilizers increased 100 grain weight, potassiomage treatment at 120:12, N:K (kg fed -1) s howed the highest value being 29.05g. NPK levels increased by biofertilizer application. Moreover, there was a significant increase of total carotenoid in bioferilized treatments relative to control. Regarding to corn protein fractions, results indicated that albumins and globulins fractions percentage increased significantly by biofertilizer application. The highest values of albumins and globulins were observed in potassiomage treatments at all N:K (kg fed-1) rates. Results of sensory evaluation revealed that tortilla with high quality produced by biofertilizer application.

Keywords: *Fertilizers, Grain yield, N:K fertilizers rates, Physiochemical properties, Yellow Corn.*

INTRODUCTION

Corn (*Zea mays* L.) is the most important cereal crop. It is one of the three most important cereal crops in the world. Corn is high yielding, easy to process, readily digested and cheaper than other crops. Every part of the maize plant has economic value which the grain, leaves, stalk, tassel and cob can all be used to produce a large variety of food and non food production (IITA, 2006).

Corn crop is considered among the most important cereal crops either in Egypt or all over the world .It is one of the food crops that have several uses, whether as a food for human or as animal feed, due to its high nutrition value. Also, corn enters in the process of manufacturing some important products such as corn oil, fructose and starch. To obtain high yields in most crops, as is particularly true in corn, it is necessary to apply mineral fertilizers to the soil. However, the application of agricultural inputs, especially in non-leguminous crops, causes imbalance in natural ecosystems in addition to being one of the most expensive practices in agriculture. On global scale, more than 175.6 million tonnes of chemical fertilizers are applied to soils to improve crop yields annually (El-Kholy et al., 2005; Kennedy et al., 2004, Mesbah et al., 2012 and Abd el Fatah et al., 2015). Hence, in order to increase crop yield per unit area, largely chemical fertilizers are used. The result of these activities in recent years has been the crisis of environmental pollution, especially water and soil pollution that threatens human society. Sustainable agriculture based on using biological fertilizers is an effective solution for overcoming these problems (Darzi et al., 2006 and Ekin et al., 2009).

Bio-fertilizers are used in live formulation of beneficial microorganism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost microflora and in turn improve the soil health in general (Ismail et al., 2014). Bio fertilizer is holistic production which promotes and enhances agro ecosystem, health, including biodiversity, biological cycles, and soil biological activity (Shaban et al., 2013). It is one of the management goal to increase and maintain soil quality with a high biological activity. Today application of bio fertilizer is considered to limit the use of mineral fertilizers and supports an effective tool for new lands development under less polluted environments, decreasing agricultural costs, maximizing crop yield due to providing them with an available nutritive elements and growth promoting substances (Metin et al., 2010). Bio fertilizer is very safe for human, animal and environment to get lower pollution and saving fertilization cost. In addition, their application in soil improves soil structure and minimizes the sole use of chemical Fertilizers (Sabashini et al., 2007). Biofertilizers, an alternate low cost resource have gained prime important in recent decades and play a vital role in maintaining long term soil fertility and sustainability. The bio-fertilizers provide nutrients to the plants, maintain soil structure, and gain importance in sustainable cropping systems. The application of cyanobacteria as a biofertilizer can reduce the need for chemical fertilizers and subsequently reduce environmental pollution compared with other mineral chemical fertilizers and it can positively affect the maize yield and its attributes. (Ghazal et al. 2013).

Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution (Das et al., 2008).

Bio-fertilizers were successfully used to minimize the dependence on chemical fertilizers. Biofertilizers are environment friendly, less costly, and therefore lead to sustainable crop production(Kassem and Hassouna, 2004; Choudhury et al., 2014 and Naher et al., 2016)

Biofertilizer gave the highest values of biological yield, 1000 grain weight as well as grain and straw yield. The yield and protein content of grains had a strong association with nitrogen fertilization and biofertilizer (Ali &Teymur, 2013 and Azimi et al., 2014).

The aim of the present work was to study the effect of some commercial bio-fertilizers (rhizobacterin, potassiomage and microbin) under different rates of N and K on productivity and grain quality of yellow maize grains.

MATERIALS AND METHODS

A two-year experiment was conducted on sandy soil under sprinkler irrigation system at Ismailia Agric. Res. Stn., Egypt in 2014 and 2015 seasons to study the effect of bio-fertilizer inoculation treatments (rhizobacterin, potassiomage, microbin, and non- inoculation (control) with two N rates (60 and 120 kg fed^{-1}), and two K rates (12 and 24 kg K_2O fed^{-1}) on growth, grain yield, and its components of yellow corn single cross173 (SC 173). Soil samples were taken before planting and chemical as well as physical analysis were done as shown in Table (1).The bio-fertilizers used were obtained from the Soil and Water Research Institute, ARC, Giza, Egypt and used as powder. The biofertilizer was mixed with the seeds (seed coating method) before planting. The N rates were used in the form of ammonium nitrate (33.5% N) and splited into 8 doses. The first was added after a week from planting and the rest were added weekly. A side dress application of 12-24 kg K_2O fed^{-1} was applied for all plots before planting. The yellow single cross 173(SC 173) was grown in both seasons. The experimental design was randomized complete blocks with four replications. Experimental plot consisted of four rows 6m in length, 80 cm in width and hills were spaced 20 cm within the row. One blank row was left between plots. All plants in the two inner rows of each plot were harvested and grain yield was adjusted to 15.5% moisture. All cultural practices for maize production were applied as recommended. No. of days from planting to 50% tasseling (DTT) and silking (DTS) were recorded, plant and ear heights (cm) were estimated. Plant height (PHT) and ear height (EHT) were measured from the ground surface to the top of the tassel and the highest ear-bearing node, respectively, ear length (cm), rows ear^{-1}(RPE), 100 kernel weight(100-KWT.),number of ears/plot (EAR), and grain yield in arddab fed^{-1} (ard fed^{-1}) were estimated.

Chemical composition was determined according to the method of AOAC, 2007. Amylose content was determined using the method outlined by Juliano 1971.The weight of 100 kernels, pericarp, endosperm and germ percentage was determined according to Hussein (1981). Nitrogen, P and K content was determined according to the method outlined in AOAC, 2007.Estimation of starch was carried out by the method of Jarvis and Walker (1993). Carotenoids content was determined using the method described in AOAC, 2007.

Color determination

Color of corn grain was determined by Minolta Chroma-meter (CR-410, Konica Minolta, Osaka, Japan) in the CIE L a b space (McGurie, 1992). The L value indicates the lightness, representing dark to light (0– 100). The a (redness) value gives the degree of the red–green color, with a higher positive a value indicating more red color. The b (yellowness) value indicates the degree of the yellow–blue color, with a higher positive b value indicating more yellow color. Corn samples replicates were recorded in triplicate and average value was taken.

Protein fraction: The nitrogen content was determined in six fractions obtained after dissolve of defatted corn sample in a series of solvents according to Landry and Moureaux (1970).

Tortilla preparation: Yellow corn grains were milled to give180 micron by using an attenzione Mill, type Hz 50, 220 volts Italy. Corn tortillas were produced using the method described by Rendon-Villalobos *et al.* (2009).Corn flour was treated hydrothermally to reach the optimum ratio of added water (70, 80 and 90%). For preparation tortilla dough, the optimum condition was found to be 85% adding water and 10 min heating time. The dough of each treatment divided into 50 g pieces. Then every pieces of dough shaped, into roller shape (2 mm thick and 15 diameter) and baked in electric oven at 250°C for 5 min. Then air cooled, packed in polyethylene bags.

Organoleptic evaluation: Tortilla was evaluated according to Salem *et al* (1999) for general appearance, roundness, separation of layer, color, taste and odor by 20,10,10,20,20 and 20, degree, respectively with total score (100) by a trained taste panel (n/10) of Food Technology Research Institute, Agricultural Research Centre, Giza Egypt.

Statistical Analysis: The obtained data were statistically analyzed according to Steel and Torrie (1997)..

Table 1. Chemical and Physical analysis of the sandy soil at the experimental site in 2014 and 2015 seasons.

Chemical analysis	Season 2014	Season 2015
pH	8.00	7.80
Total soluble salt %	0.25	.21
Total N %	.07	.09
Available N (ppm)	28.00	27.30
Available K(ppm)	155.00	175.95
Available P(ppm)	10.00	9.50
Partial size distribution		
Clay %	14.00	13.70
Silt %	20.00	20.22
Fine sand %	52.82	53.78
Coarse sand %	13.02	12.30
Texture	Sandy loam	Sandy loam

RESULTS AND DISCUSSION

Effect of biofertilizer

Data in Tables (2 and 3) revealed that all studied traits were significantly affected by applying biofertilizer in both seasons, except for 100-kernel weight in the first season, ear height in the second season and No. of ears in both seasons. Maize plants were earlier in 50% tasseling and silking when rhizobacterin and potassiomage were applied compared to microbin and control (untreated) in both seasons. It could be noticed that there were no significant differences between microbin and control for DTT and DTS in the first season. The shortest plants were associated with applying rhizobacterin or the control in the first season, and microbin in the seconed one, while the tallest plants were linked to applying potassiomage and microbin in the first season, and rhizobacterin in the second one. There were no significant differences among rhizobacterin, potassiomage, and control in the second season. The lowest ear height was associated with applying rhizobacterin in both seasons, while the highest ear height was linked to microbin application in both seasons. There were no significant differences among biofertilizer treatments for (EHT) in the second season. The tallest ears were obtained when potassiomage was applied followed by microbin in both seasons, but there was no significant difference between potassiomage and microbin in the first season. The shortest ears resulted from rhizobacterin and control treatment in the first and second season, respectively. The highest values for rows ear^{-1} were obtained when microbin was applied in both seasons, but without significant difference with rhizobacterin in the first season. Effect of biofertilizer on (100 KWT) was not significant in the first year, while this effect was significant in the second one. Applying of potassiomage was associated with the highest value for (100 KWT.) followed by control, whereas the lowest value was linked to applying rhizobacterin in the second year. Results cleared that the highest grain yield was obtained when potassiomage was applied in both seasons followed by microbin in the first season and rhizobacterin in the second one. The lowest grain yield resulted from control in both seasons.

Table 2. Effect of biofertilizer, nitrogen (N), and potassium (K) on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT), ear height (EHT), and No. of ears/plot (EAR), in 2014 / 2015 seasons.

Treatments	Days to 50% tasseling		Days to 50% silking		PHT (cm)		EHT (cm)		EAR	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Bio										
Rhizobacterin	52.3	53.1	54.0	54.8	245	252	121	136	50.0	49.0
Potassiomage	52.3	52.6	54.6	54.3	252	249	128	138	49.0	49.0
Microbin	53.3	53.7	55.5	55.4	252	240	131	140	49.0	49.0
Control	53.3	54.4	55.5	56.5	244	254	124	137	49.0	49.0
LSD $_{0.05}$	0.4	0.6	0.6	0.6	5	10	3	NS	NS	NS
N(kg fed^{-1})	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
60	53.0	53.8	55.2	56.1	231	232	118	124	49.0	49.0
120	52.6	53.1	54.6	54.4	266	265	134	152	49.0	49.0
LSD $_{0.05}$	0.3	0.4	0.4	0.4	4	7	2	3	NS	NS
K(kg fed^{-1})	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
12	52.9	53.7	55.2	55.7	244	250	124	135	49.0	49.0
24	52.7	53.2	54.7	54.8	253	247	128	140	49.0	49.0
LSD $_{0.05}$	NS	0.4	0.4	0.4	4	NS	2	3	NS	NS
CV	1.o	1.5	1.3	1.5	2.7	5.7	2.4	4.0	1.89	3.12

Effect of Nitrogen

Results in Tables (2 and 3) showed that all studied traits were significantly affected by applying nitrogen rates in both seasons, except for (rows ear^{-1}, and 100-KWT) in the first season, and No. of ears in both seasons. Maize plants were earlier in DTT and DTS when 120kg N fed^{-1} was applied in the two seasons. The reduction in DTT and DTS could be attributed to the effect of nitrogen fertilization on accelerating vegetative growth, which led to reduction in DTT and DTS. These results are in agreement with those obtained by Faisal et al(2012) and Ghazal et al (2013) . The tallest plants and the highest ear placement resulted from applying 120 kg N fed^{-1} compared to 60 kg N fed^{-1} in both seasons. These results are in agreement with those reported by Hassan (2004) and Hassan et al. (2009). Concerning ear length, data showed that the tallest ears were associated with applying 120 kg N fed^{-1} in both seasons. The highest values for rows ear^{-1} resulted from applying 120 kg N fed^{-1} in the second year. Effect of N on 100- KWT was not significant in the first year, while it showed significant differences in the second one. Applying 120 kg N fed^{-1} gave higher value for (100- KWT) compared to 60 kg N fed^{-1} in 2015 season. Results revealed that the highest grain yield was obtained when 120 kg N fed^{-1} was applied compared to 60 kg N fed^{-1} in both seasons. Effect of nitrogen fertilization on maize grain yield was mainly attributed to its effect on vegetative growth of maize plants, ear characters, and yield components. These results are in harmony with those obtained by Gouda et al. (2009), Faisal et al (2012) and Ghazal et al (2013). Generally, Applying 120 kg N fed^{-1} was the best for all these traits.

Table 3. Effect of biofertilizer (Bio), nitrogen (N), and potassium (K) on ear length (EL), Rows ear^{-1}(RPE), 100 KWT and grain yield (GY) in 2014 / 2015 seasons.

Treatments	EL (cm)		RPE		100 KWT.		GY (ard fed^{-1})	
	2014	2015	2014	2015	2014	2015	2014	2015
Bio								
Rhizobacterin	15.2	17.8	13.0	13.0	25. 5	22.3	20.32	27.88
Potassiomage	18.5	19.2	12.8	13.1	25.8	24.7	23.60	29.81
Microbin	18.2	18.1	13.2	13.4	25.6	23.8	22.19	26.56
Control	15.8	17.5	12.9	13.1	24.1	24.2	19.56	23.55
LSD $_{0.05}$	0.5	0.5	0.2	0.3	NS	0.3	1.25	1.84
N(kg fed^{-1})	2014	2015	2014	2015	2014	2015	2014	2015
60	16.0	17.0	13.0	12.8	24.5	23.4	18.60	22.46
120	17.8	19.4	12.9	13.5	26.0	24.1	24.24	31.44
LSD $_{0.05}$	0.3	0.3	NS	0.2	NS	0.2	0.89	1.30
K(kg fed^{-1})	2014	2015	2014	2015	2014	2015	2014	2015
12	16.6	18.1	12.7	13.0	25.1	23.2	19.83	27.40
24	17.2	18.2	13.2	13.3	25.3	24.2	23.00	26.51
LSD $_{0.05}$	0.3	NS	0.2	0.2	NS	0.2	0.89	NS
CV	3.4	3.5	2.13	3.04	10.7	1.46	7.01	9.58

Effect of Potassium

Results in Tables (2 and 3) indicated that all studied traits were significantly affected by potassium application in both seasons, except for DTT and 100-KWT in the first season, PHT, EL, and GY in the second season, and No. of ears in both seasons. Increasing K rates from 12 to 24 kg K_2O fed^{-1} significantly decreased DTT in 2015 season and decreased DTS in both seasons. Effect of K on DTT was not significant in the first season. Plant and ear heights were significantly increased by increasin potassium rate from 12 to 24 kg K_2O fed^{-1} in the two years, except for plant height in the second year. Ear length was significantly affected by K rates in the first season. Application of 24kg K_2O fed^{-1} was linked to the highest value for ear length. The highest values for rows ear^{-1} resulted from applying 24 kg K_2O fed^{-1} in both seasons. Effect of K on 100- KWT was not significant in the first year, while it was significant in the second one. The highest value for 100- KWT was associated with applying 24 kg K_2O fed^{-1} compared to 12kg K_2O fed^{-1} in the second year. Increasing K fertilizer rate up to 24 kg K_2O fed^{-1} was associated with a significant increase in grain yield in the first season. There was no significant difference between the two K rates for grain yield in the second season.The general trend cleared that applying 24 kg K_2O fed^{-1} was associated with the best results for almost all triats compared to 12 kg K_2O fed^{-1}. Similar results were obtained by Yibirin et al.(1993) and Mallarino et al.(1999). However, other researchers found no effect of K application on yield and other traits (Khalil, 1994 and Amer et al., 1995).

Biofertilizer x Nitrogen interaction effect

Effect of Bio x N interaction on DTT and DTS was significant in 2014 and 2015 seasons (Table 4). Application of 120 kg N fed^{-1} with rhizobacterin was associated with the earliest plants in DTT and DTS in the two seasons. Effect of N x bio interaction on PHT was not significant in 2014 season, but it was positively significant in 2015 season (Table 4). Application of 120 kg N fed^{-1} with rhizobacterin was associated with the tallest plants (277cm), but non significant difference with potassiomage (272 cm). In contrast, the shortest plants (226 or 227 cm) were obtained by application of 60 kg N fed^{-1} with each of rhizobacterin, potassiomage, and microbin. Concerning ear length, the effect of Bio x N interaction on ear length was significant in the two years. Application of 120 kg N fed^{-1} with potassiomage was linked to the tallest ears in both seasons, but without significant difference between potassiomage and microbin in the first season. Effect of Bio x N interaction on GY was not significant in the first season, but it showed significant in the second season. The highest grain yield (35.93 ard fed^{-1}) was associated with application of 120 kg N fed^{-1} with potassiomage in the second season. While the lowest grain yield (20.41 ard fed^{-1}) was linked to applying 60 kg N fed^{-1} with control. It could be noticed that there were no significant differences among rhizobacterin, potassiomage, and microbin at 60 kg N fed^{-1} for grain yield. However, rhizobacterin and potassiomage had significant effect on high grain yield compared to the control at 60 kg N fed^{-1}. On the other hand, there were no significant differences between rhizobacterin and microbin at 120kg N fed^{-1} for grain yield, but the three biofertilizers had significant effect on high grain yield compared to the control at the same level of nitrogen.

Table 4. Effect of interaction between biofertilizer (Bio) and nitrogen (N) rates on days to 50% tasseling(DTT) , days to 50% silking(DTS), plant height (PHT), ear Length (EL) and grain yield (ard fed^{-1}) in 2014 /2015 seasons.

N(kg fed^{-1})	Bio	DTT		DTS		PHT (cm)		EL (cm)		GY(ard fed^{-1})	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
60	Rhizobacterin	52.3	54.0	54.3	56.1	209	227	14.9	17.0	18.84	23.26
	Potassiomage	52.3	52.5	54.4	54.9	209	226	17.3	17.7	21.96	23.69
	Microbin	51.1	54.3	53.1	56.4	208	227	17.1	16.6	20.50	22.50
	Control	52.1	54.4	54.1	57.0	208	250	14.6	16.6	22.33	20.41
120	Rhizobacterin	48.9	52.1	50.9	53.5	214	277	15.4	18.6	34.33	32.51
	Potassiomage	51.1	52.6	53.1	53.6	208	272	19.6	20.8	32.42	35.93
	Microbin	52.1	53.1	54.1	54.4	197	252	19.3	19.7	31.40	30.63
	Control	51.3	54.4	53.3	56.0	203	258	17.1	18.4	33.22	26.70
$LSD_{0.05}$		0.6	0.8	0.8	0.8	NS	14	0.7	0.6	NS	2.59

Biofetilizer x potassium interaction effect:

Effect of Bio x K interaction on DTT was significant in both years, but it was non significant for DTS, EHT, and grain yield in the first year (Table 5). Application of 12 kg K_2O fed^{-1} with potassiomage was associated with the earliest plants in DTT in the two years. While, control with 12 kg K_2O fed^{-1} was linked to the latest plants in DTT in both years. Applying potassiomage with 24 kg K_2O fed^{-1} was accompanied with the earliest plants in terms of DTS, however there was no significant difference between applying 12 and 24 kg K_2O fed $^{-1}$ with potassiomage for DTS in the second year. On the other hand, the latest plants for DTS were detected when 12 kg K_2O fed $^{-1}$ was applied with control (untreated). Ear height, was significantly affected by the tested treatments in the second season. Applying microbin with 24 kg K_2O fed^{-1} was associated with the highest value for ear height, while the lowest values for ear height were linked to application of rhizobacterin and control treatment with 12 kg K_2O fed $^{-1}$ in 2015 season. There were no significant differences among the four treatments of biofertilizers with 12 kg K_2O fed $^{-1}$ and no significant differences among rhizobacterin , potassiomage, and control with 24 kg K_2O fed^{-1} for ear height. The effect of Bio x K interaction on grain yield was significant only in the second season. Grain yield is the main target of crop production. The highest grain yield (32.02 ard fed^{-1}) was obtained when potassiomage was applied with 12 kg K_2O fed^{-1}, whereas untreated control gave the lowest grain yield (23.28 ard fed^{-1}) in 2015 season. It could be noticed that there were no significant differences between rhizobacterin and microbin with 12 K_2O fed^{-1}, and no significant differences among the three biofertilizers with 24 K_2O fed^{-1} for grain yield in the second season.

Nitrogen x potassium interaction effect:

Effect of N x K interaction on DTT, DTS, PHT, and GY was significant in both years, except for GY in 2014 season (Table 6). Results indicated that applying 24 kg K_2O with 60 kg N fed^{-1}, or 12 or 24 kg K_2O with 120 kg N fed^{-1} were associated with the earliest plants in DTT and DTS in both seasons. Whereas, the latest plants in DTT and DTS were linked to the application of 60 kg N with12 kg K_2O fed^{-1} in both seasons. Concerning PHT, the effect of N x K interaction on PHT was significant in 2014 and 2015 seasons. Applying of 60 kg N with12 kg K_2O fed^{-1}was accompanied with the shortest plants in both seasons, while increasing N level up to 120 kg with 24 kg K_2O fed^{-1} in the first season, and with 12kg K_2O fed^{-1} in the second season gave the tallest plants.

Table 5. Effect of interaction between biofertilizer (Bio) and potassium (K) rates on days to 50% tasseling and silking, ear height (EHT), and grain yield (ard fed^{-1}) in 2014 / 2015 seasons.

K	Bio	DTT		DTS		EHT (cm)		GY (ard fed^{-1})	
		2014	2015	2014	2015	2014	2015	2014	2015
12	Rhizobacterin	52.7	53.3	54.2	54.9	118	134	18.96	28.24
	Potassiomage	51.7	52.5	55.0	54.5	128	136	21.19	32.02
	Microbin	53.3	53.8	55.7	55.9	129	136	20.56	26.06
	Control	54.0	55.1	55.8	57.4	120	134	18.61	23.28
24	Rhizobacterin	51.8	52.9	53.8	54.8	124	138	21.68	27.53
	Potassiomage	53.0	52.6	54.2	54.0	127	139	26.01	27.60
	Microbin	53.3	53.6	55.3	54.9	134	144	23.83	27.07
	Control	52.7	53.6	55.3	55.6	127	140	20.50	23.83
$LSD_{0.05}$		0.6	0.8	NS	0.8	NS	5.5	NS	2.59

Regarding grain yield, the effect of N x K interaction on GY showed no significant effect in 2014 season, but this effect was significant in 2015 season. Applying of 120 kg N with12 kg K_2O fed^{-1} was associated with the highest GY (32.78 ard fed^{-1}) followed by applying of 120 kg N with 24 kg K_2O fed^{-1} (30.10 ard fed^{-1}) in the second season, whereas applying of 60 kg N with 12 or 24 kg K_2O fed^{-1} was linked to the lowest GY.

Table 6. Effect of interaction between nitrogen (N) and potassium (K) rates on days to 50% tasseling and silking, plant height (PHT), and grain yield (ard fed^{-1}) in 2014 and 2015 seasons.

N	K	DTT		DTS		PHT (cm)		GY (ard fed^{-1})	
		2014	2015	2014	2015	2014	2015	2014	2015
60	12	53.3	54.3	55.9	56.8	224	225	16.60	22.02
	24	52.7	53.3	54.5	55.4	238	240	20.59	22.91
120	12	52.5	53.1	54.4	54.5	264	275	23.06	32.78
	24	52.8	53.1	54.8	54.3	268	255	25.41	30.10
$LSD_{0.05}$		0.4	0.6	0.6	0.6	5.5	10	NS	1.83

Physical properties:

The effect of bio-fertilizer under different N: K ratio on physical properties of corn grains is shown in Table 7. Results indicated that there were significant differences between bio-fertilizer and control (untreated) in 100-grain weight . Applying of bio-fertilizer increased 100 grain weight and potassiomage treatment at 120:12, N:K (kg fed^{-1}) showed the highest value of 100 grain weight (29.05 g) relative to other treatments.

Naseri et al. (2013) reported that the increasing 1000 grain weight under bio-fertilizer inoculation treatment is due to improving attributes such as leave number, ear length and height that finally caused to increasing assimilates production. Also, due attention to longer period of ripening maize due to inoculation of biofertilizer it is possible to transform more photosynthetic matter from source to grains and as a result increasing 1000 grain weight.

At the same Table, it could be noticed that endosperm and germ percentage increased as a result of using biofertilizer at different ratios of N:K (kg fed^{-1}) The highest endosperm percentage was observed in potasiomage at 120:12, N:K (kg fed^{-1}) 82.89%. Applying of microbin showed the highest germ percentage at 120:12 N:K (kg fed^{-1}) 10.86%. Moreover, there was a significant decrease in pericarp percentage due to biofertilizer application. Control had higher pericarp percentage than biofertilized treatments. Potassiomage and microbin at 120:12, N:K (kg fed^{-1}) had the lowest pericarp percentage 6.52 and 6.57%, respectively. Similar results obtained by El-Amry et al.(2006).

Berger and Singh (2010) stated that maize kernel is constituted by three principal parts, where the endosperm represents 80–85%, the germ 10–12% and pericarp 5–6%.

Chemical Composition

Data in Table (8) showed that the effect of three biofertilizer with different ratios of N and K on corn grains composition .

The results indicated that there was a significant increase in protein content in all samples treated with commercial biofertilizers compared with control (untreated) . The highest value of protein content was significantly recorded by potassiomage biofertilzer treatment at 120:12,N:K (kg fed^{-1}) . The protein increment may be due to its promotion of free living nitrogen fixing bacteria and enhancing nitrogen fixation, and then supplying of different nutrients like nitrogen. (McMillan. 2007 and Cakmakci et al., 2006).

Similar results obtained by Saber and Sharaf (2013) who reported that protein was increased due to the biofertilizer treatments in all wheat cultivar.

Also, Helmy (2014) found that using the bio-fertilizer (Microbon) increased protein content in barley especially with increasing N rate.

The statistical analysis indicated that there are significant differences between bio-fertilizer treatments and control on fat content of grain (Table 8). Data indicate that fat content increased significantly in potassiomage and microbin treatments relative to control at different N:K ratios .

Shehata and El-Khawas (2003) reported that there was a significant increase in oil content of sunflower with applying bio-fertilizer. Biofertilizers increased protein and fat content of grain.

At the same Table, results showed that fiber content was decreased by applying biofertilizer . The lowest fiber content was observed in Potassiomage at 120:12 N:K (kg fed-1). However, applying biofertilizer had no significant effect on ash content of treated samples relative to control.

Concerning to starch content , the results indicated that , there were significant decrease of starch content in biofertoilizer treated samples relative to control.

Amylose content was increased with biofertilizer application and the highest value was recorded in rhizobacterin followed by potassiomage at 60:12,N:K (kg fed^{-1}).

McNeill et al. (2005) reported that the concentration of starch was generally inversely proportional to the sum of protein and oil content. Meanwhile, Ram et al. (2011) stated that amylose content of rice grain was increased by biofertilizer.

Table 7. Effect of the interaction between bio-fertilizers and N:K rates on physical properties of corn grains

Treatments N:K (kg fed^{-1})	Biofertilizers	Endosperm%	Germ%	Pericarp%	100-grain weight (g)
60:12	Control (Untreated)	82.10 ± 0.170^{b}	10.30 ± 0.21^{b}	7.60 ± 0.42^{a}	27.85 ± 0.45^{b}
	Rhizobacterin	82.79 ± 0.16^{a}	10.54 ± 0.16^{ab}	6.67 ± 0.15^{b}	28.30 ± 0.42^{b}
	Potassiomage	82.75 ± 0.35^{a}	10.60 ± 0.14^{ab}	6.65 ± 0.28^{b}	28.75 ± 0.49^{a}
	Microbin	82.60 ± 0.14^{ab}	10.79 ± 0.10^{a}	6.61 ± 0.12^{b}	28.55 ± 0.21^{ab}
60:24	Control	82.01 ± 0.16^{a}	10.28 ± 0.02^{a}	7.31 ± 0.28^{a}	27.55 ± 0.21^{b}
	Rhizobacterin	82.3 ± 0.45^{a}	10.50 ± 0.28^{a}	7.20± 0.31a	28.00 ± 0.28^{ab}
	Potassiomage	82.24 ± 0.17^{a}	10.52 ± 0.14^{a}	7.24± 0.14a	28.27 ± 0.18^{a}
	Microbin	82.37 ± 0.47^{a}	10.63 ± 0.18^{a}	7.00 ± 0.28^{a}	28.45 ± 0.21^{a}
120:12	Control	82.40 ± 0.19^{a}	10.40 ± 0.14^{b}	7.20 ± 0.14^{a}	28.06 ± 0.28^{c}
	Rhizobacterin	82.55 ± 0.16^{a}	10.56 ± 0.04^{ab}	6.89 ± 0.09^{b}	28.30 ± 0.28^{bc}
	Potassiomage	82.89 ± 0.14^{a}	10.59 ± 0.12^{ab}	6.52 ± 0.11^{b}	29.05 ± 0.21^{a}
	Microbin	82.62 ± 0.10^{ab}	10.86 ± 0.27^{a}	6.57 ± 0.14^{b}	28.78 ± 0.11^{ab}
120:24	Control	82.12 ± 0.18^{a}	10.37 ± 0.14^{a}	7.51 ± 0.10^{a}	27.8 ± 0.14^{c}
	Rhizobacterin	82.36 ± 0.11^{a}	10.44 ± 0.04^{a}	7.20 ± 0.03^{ab}	28.05 ± 0.21^{bc}
	Potassiomage	82.54 ± 0.14^{a}	10.51 ± 0.12^{a}	6.95 ± 0.21^{b}	28.50 ± 0.03^{a}
	Microbin	82.47 ± 0.52^{a}	10.61 ± 0.21^{a}	6.89 ± 0.07^{b}	28.34 ± 0.08^{ab}

Values are means ± SD of three measurements. Means in the same column with different letters are significantly different ($p < 0.05$).

Table 8. Effect of the interaction between bio-fertilizers and N:K rates on corn grains composition (% dry basis).

Treatments N:K (kg fed^{-1})	Biofertilizers	Protein	Oil	Fiber	Ash	Starch	Amylose
60:12	Control	9.01± 0.06^{c}	3.50 ± 0.1^{c}	2.17±0.02a	1.42± 0.04^{a}	71.89 ±0.35^{a}	22.15 ±0.03^{d}
	Rhizobacterin	9.41 ± 0.08^{b}	3.80± 0.02^{b}	2.16±0.04a	1.37± 0.07^{a}	71.19± 0.10^{b}	23.49± 0.05^{a}
	Potassiomage	10.23 ±0.18^{a}	4.04± 0.07^{a}	2.13±0.01a	1.42± 0.04^{a}	70.76± 0.08^{b}	23.18± 0.014^{b}
	Microbin	9.63 ±0.08^{b}	3.94 ± 0.02^{a}	2.11±0.02a	1.35 ± 0.07^{a}	0.07± 0.10^{c}	22.67 ±0.03^{c}
60:24	Control	9.10 ±0.14^{c}	3.47± 0.03^{b}	2.26± 0.03^{a}	1.45± 0.07^{a}	71.40± 0.28^{a}	22.30 ± 0.15^{b}
	Rhizobacterin	9.51± 0.13^{bc}	3.59± 0.05^{b}	2.24± 0.04^{a}	1.38± 0.03^{a}	71.32± 0.13^{a}	22.33± 0.12^{b}
	Potassiomage	10.29± 0.03^{a}	3.94± 0.03^{a}	2.20± 0.03^{a}	1.41± 0.07^{a}	69.49± 0.86^{b}	23.15± 0.03^{a}
	Microbin	9.69 ±0.04^{b}	3.86± 0.06^{a}	2.15± 0.02^{a}	1.32 ± 0.04^{a}	70.46± 0.09^{ab}	22.31± 0.15^{b}
120:12	Control	10.20± 0.20^{b}	3.55± 0.07^{c}	2.18± 0.04^{a}	1.46 ± 0.03	70.09± 0.34^{a}	22.35± 0.27^{a}
	Rhizobacterin	10.47 ± 0.10^{b}	3.66± 0.08^{c}	2.03± 0.02^{b}	1.37± 0.07	0.05± 0.08^{a}	22.36 ±0.14a
	Potassiomage	11.07 ± 0.18^{a}	3.85± 0.07b	2.00± 0.07^{b}	1.44± 0.06	69.20 ± 0.59^{a}	22.91± 0.05^{a}
	Microbin	10.59± 0.14^{b}	4.09± 0.03^{a}	2.06 ± 0.02^{ab}	1.41± 0.12	0.07± 0.09^{a}	22.54± 0.44^{a}
120:24	Control	9.68 ± 0.04^{b}	3.39± 0.08^{c}	2.44± 0.05^{a}	1.50± 0.04^{a}	1.90± 0.28^{a}	22.22± 0.08^{a}
	Rhizobacterin	9.75± 0.18^{b}	3.58± 0.12^{bc}	2.19± 0.04^{b}	1.48± 0.14^{a}	71.61± 0.35^{ab}	22.63 ± 0.26^{a}
	Potassiomage	10.71± 0.24^{a}	3.73± 0.13^{ab}	2.17± 0.09^{b}	1.42± 0.01^{a}	0.78± 0.31^{c}	22.34± 0.02^{a}
	Microbin	10.66± 0.09^{a}	3.88± 0.03^{a}	2.14 ± 0.04^{b}	1.46 0.05^{a}	71.03± 0.18^{bc}	22.70± 0.22^{a}

Values are means ± SD of three measurements. Means in the same column with different letters are significantly different ($p < 0.05$).

Nitrogen, P and K content of yellow corn grain

Minerals are inorganic nutrients, usually required in small amounts from less than 1 to 2500 mg per day, depending on the mineral. As with vitamins and other essential food nutrients, mineral requirements vary with animal species. For example, Phosphorus is an important constituent of adenosine triphosphate (ATP) and nucleic acid and is also essential for acid-base balance, bone and tooth formation. Potassium is important in the maintenance of osmotic balance between cells and the interstitial fluid. (Soetan et al., 2010).

Data in Table (9) indicated that there were significant differences between the effect of biofertilizer treated corn and control on the nitrogen, potassium and phosphorus content. Results showed that there was a significant increase in nitrogen level in biofertilized treatments relative to control. Potassiomage treatments had the highest nitrogen values in all N:K ((kg fed^{-1}) ratios. Potassium levels of corn grin due to biofertilizer application were higher than control . The highest level of potassium was recorded in Rhizobacterin treatment at 60:24 N:K (kg fed^{-1}) .

At the same Table, results showed that increasing in phosphorus content via biofertilizer application and the maximum level was observed in potassiomage treatment at 60:12, N:K ((kg fed^{-1}).

Meshram and Shende (1993) suggested that *Azospirillum* increases root surface area and thus promotes intake of N, P, K, other nutrients, water and consequently above ground weight of plants.

Sofy and Rashid (2014) reported that biofertilized treatments in corn gave phosphorus values higher than control. Also, Singh et al. (2012) stated that the highest N and P content was observed in corn treated with *Azotobacter*.

Color and carotenoids

Total carotenoid content (mg kg^{-1}) and colour parameters in CIE Lab space were determined for unbiofertilizer and biofertilizer treatments (Table 10).

Results indicated that there was a significant increase of total carotenoid due to bioferilized treatments relative to control. The highest value of total carotenoid content was 14.45 mg kg^{-1} in microbin at 120:12 N:K (kg fed^{-1}) .

These results in agreement with Hulshof et al.(2007) who found that similar values of carotenoids ranged from 9.90 to 39.96 mg kg^{-1} .While, Kurilich and Juvik (1999) noticed that carotenoids ranged from 0.15 to 33.11 mg kg^{-1} in 44 corn lines.

Color analysis showed that the L (lightness) values of biofertilized treatments decreased significantly compared to control and microbin at 120:12 N:K (kg fed^{-1}) had the lowest L value 60.05 .

The a (redness) values ranged from 2.44to 6.03 for microbein and rhizobacterin at 120:24 and 120:12 N:K (kg fed^{-1}),respectively. The b (yellowness) increased significantly with biofertilizer application, the highest value of b was 55.87 for microbin at 120:12 N:K (kg fed^{-1}) relative to control and other samples.

Sandhu et al. (*2007*) reported L values ranged from 81.94 to 86.96 for nine corn hybrids, and b ranged from 7.83 to 24.12 . Kljak et al. (2012) stated that there was a high positive correlation between b value and total carotenoid content . Also, Chandler et al. (2013) reported that existing relationship between the yellow or orange color of the endosperm and the presence of carotenoids.

Table 9. Effect of the interaction between bio-fertilizers and N:K rates on N (%) ,P and K $mg100g^{-1}$ content of yellow corn grains.

Treatment N:K ($kg fed^{-1}$)	Biofertilizers	N (%)	K ($mg100g^{-1}$)	P ($mg100g^{-1}$)
60:12	Control	1.44±0.02[c]	347.60±0.56[c]	239.18±5.26[c]
	Rhizobacterin	1.50±0.01[b]	381.46± 1.32[a]	256.25± 6.98[b]
	Potassiomage	1.61±0.03[a]	379.46 ±0.19[a]	288.83±.19a
	Microbin	1.54 ±0.01[b]	359.25± 1.3[b]	265.45±2.05b
60:24	Control	1.45± 0.02[c]	361.89±0.15[d]	251.42±4.01[ab]
	Rhizobacterin	1.53±0.01[b]	384.62±1.24[a]	261.49±2.20[a]
	Potassiomage	1.69±0.04[a]	374.56±1.32[b]	255.82 ±0.96[ab]
	Microbin	1.68±0.01[a]	369.62±1.85[c]	245.65±6.15[b]
120:12	Control	1.65±0.035[b]	301.19 ±1.45[c]	249.57±1.40[b]
	Rhizobacterin	1.67±0.01[b]	310.65± 1.62[b]	254.94 ±5.26[b]
	Potassiomage	1.77±0.03[a]	324.79± 0.36[a]	277.02±1.44[a]
	Microbin	1.69±0.02[b]	307.6 ±0.87[b]	252.48±0.73[b]
120:24	Control	1.54±0.01[b]	313.15±1.25[d]	254.39±3.46[b]
	Rhizobacterin	1.56±0.02[b]	339.13±1.23[b]	256.50±4.53[b]
	Potassiomage	1.71±0.04[a]	360.34±0.48[a]	275.19±3.69[a]
	Microbin	1.70±0.02[a]	332.29±1.56[c]	255.00±4.24[b]

Values are means ± SD of three measurements. Means in the same column with different letters are significantly different ($p < 0.05$).

Table 10. Effect of the interaction between bio-fertilizers and N:K rates on total carotenoid content ($mgkg^{-1}$) and colour parameters in CIE Lab space of yellow corn grains

Treatments N:K ($kg fed^{-1}$)	Biofertilizers	L	a	b	Total carotenoid ($mgkg^{-1}$)
60:12	Control	73.10 ± 0.14[a]	3.64 ± 0.28[c]	27.89± 0.08[d]	9.03±0.24[c]
	Rhizobacterin	67.88± 1.25[b]	4.60± 0.01[b]	32.68± 0.11[c]	9.94±0.17[b]
	Potassiomage	65.86± 0.04[c]	3.83± 0.07[c]	35.59± 0.01[b]	10.32±0.17[b]
	microbin	68.00± 0.28[b]	5.56± 0.07[a]	38.40± 0.014[a]	11.08±0.11[a]
60:24	Control	71.05± 0.21[a]	3.22± 0.01[b]	37.17± 0.09[c]	10.60±0.21[c]
	Rhizobacterin	68.28± 0.02[b]	4.81± 0.25[a]	49.30± 0.14[a]	13.44±0.35[a]
	Potassiomage	70.88± 0.15[a]	3.55± 0.01[b]	38.38± 1.99[c]	10.85±0.21[c]
	microbin	70.80± 0.02[a]	3.50± 0.02[b]	42.99± 0.01[b]	12.53±0.24[b]
120:12	Control	70.00± 0.28[a]	3.86± 0.02[c]	32.42 ± 0.06[d]	9.41±0.27[d]
	Rhizobacterin	64.83± 0.14[c]	6.03± 0.00[a]	35.29 ± 0.03[c]	10.24±0.16[c]
	Potassiomage	67.10± 0.56[b]	4.45 ± 0.04[b]	41.71± 0.03[b]	12.16±0.21[b]
	microbin	60.05 ± 0.12[d]	2.78± 0.16[d]	55.87± 0.10[a]	14.45±0.21[a]
120:24	Control	70.95± 0.07[a]	3.55 ± 0.04[b]	33.81± 0.042[d]	9.78±0.23[c]
	Rhizobacterin	70.27 ± 0.09[a]	3.87± 0.11[a]	38.72± 0.11[b]	11.29±0.21[b]
	Potassiomage	70.87± 0.09[a]	3.64± 0.03[b]	34.78± 0.06[c]	10.14±0.20[c]
	microbin	65.10± 0.42[b]	2.44± 0.03[c]	46.15± 0.04[a]	13.18±0.25[a]

Values are means ± SD of three measurements. Means in the same column with different letters are significantly different ($p < 0.05$).

Protein fractions

Data in Table (11) showed the effect of biofertilizer on corn protein fractions; albumins globulins, zein , G1-glutelins,G2-glutelins and G3-glutelins. The results indicated that the water- and salt-soluble proteins (albumins and globulins) fractions percentage increased significantly by biofertilization application. The highest values of albumins and globulins were observed in potassiomage treatments at all N:K ($kg fed^{-1}$) ratios. Saber and Sharaf (2013) reported that albumins globulins fractions has shown pronounced increases caused by biofertilizer treatments regardless of the cultivar.

Data in the same Table revealed that zein fraction was the predominant fraction for all corn samples. No significant differences were observed in zein percentage between treated samples and control . All biofertilizers had caused considerable reductions in the glutelins (G1,G2 and G3) level.

Biofertizer application had no significant effect on residual protein percentage at all N:K ($kg fed^{-1}$) ratios except for 120:12, N:K ($kg fed^{-1}$) ratios . The lowest residual protein percentages were 1.93 and 1.98 for Rhizobacterin and potassiomage at 120:12, N:K ($kg fed^{-1}$) ratios, respectively.

The value of corn protein is expected to be improved, as a result of increasing the levels of albumin+globulin fractions. (Fageer and Tinay,2004).

Table 11. Effect of the interaction between bio-fertilizers and N:K rates on corn protein fractions; globulin albumin, zein, G1-glutelin,G2-glutelin and G3-glutelin.

Treatments N:K (kg fed^{-1})	biofertilizers	Globulin + albumin (%)	Zein (%)	G1glutelin (%)	G2-glutelin (%)	G3-glutelin (%)	Insoluble protein(%)
60:12	Control	23.00±0.10^{c}	34.63± 0.92^{a}	14.05± 0.70a	5.90± 0.14^{a}	19.60± 0.01^{a}	2.82 ± 0.03^{a}
	Rhizobacterin	23.54 ± 0.19^{b}	35.10± 0.14^{a}	12.40± 0.28b	5.65± 0.07^{b}	19.54± 0.09^{a}	2.78± 0.05^{a}
	Potassiomage	24.34± 0.13^{a}	34.74 ± 0.08^{a}	12.50± 0.14^{b}	5.63± 0.04^{b}	19.25± 0.35^{a}	2.75± 0.18^{a}
	microbin	23.23± 0.25^{bc}	34.8±0.06^{a}	13.73± 0.18^{a}	5.49± 0.04^{b}	19.42± 0.31^{a}	2.53± 0.15^{a}
60:24	Control	23.01 ± 0.26^{c}	34.94 ± 0.19^{a}	13.12± 0.46^{a}	5.96± 0.19^{a}	20.10± 0.14^{a}	2.89± 0.09^{a}
	Rhizobacterin	23.9 0± 0.14^{b}	35.14± 0.36^{a}	12.10± 0.14^{bc}	5.81± 0.04^{ab}	19.90± 0.14^{a}	2.53± 0.176^{a}
	Potassiomage	24.31± 0.04^{ab}	35.38± 0.33^{a}	11.65 ± 0.21^{c}	4.97± 0.07^{c}	20.02± 0.31^{a}	2.81± 0.07^{a}
	microbin	23.61± 0.29^{b}	35.11± 0.15^{a}	12.79± 0.22^{ab}	5.54± 0.01^{b}	9.59± 0.13^{a}	2.55 ± 0.18^{a}
120:12	control	23.29± 0.07^{c}	35.75± 0.35^{a}	12.41 ±0.13^{a}	5.22± 0.03^{a}	21.87± 0.19^{a}	2.13± 0.04^{a}
	Rhizobacterin	23.97± 0.04^{ab}	35.91±0.30^{a}	10.80± 0.16^{a}	5.16± 0.09^{a}	21.70± 0.14^{a}	1.93± 0.04^{c}
	Potassiomage	24.41± 0.43^{a}	36.11 ± 0.35^{a}	10.54± 0.45^{b}	4.95± 0.07^{a}	21.52± 0.11^{a}	1.98± 0.03^{bc}
	microbin	23.68± 0.20^{ab}	35.92± 0.20^{a}	11.0± 0.04b	4.81 ± 0.43^{a}	21.80± 0.14^{a}	2.07± 0.01^{ab}
120:24	control	23.25± 0.14^{b}	35.99± 0.14^{a}	12.10± 0.02^{a}	5.83± 0.03^{a}	20.08± 0.11^{a}	2.56± 0.02^{a}
	Rhizobacterin	23.80± 0.14^{ab}	36.15± 0.42^{a}	11.37± 0.14^{c}	5.76± 0.02^{a}	20.00± 0.14^{a}	2.25 ± 0.21^{a}
	Potassiomage	24.25 ± 0.35^{a}	36.30± 0.07^{a}	11.30± 0.04^{b}	5.35± 0.04^{b}	20.03± 0.17^{a}	2.32± 0.25^{a}
	microbin	23.67± 0.30^{ab}	36.01± 0.28^{a}	11.70± 0.14^{b}	5.42± 0.05^{b}	20.05± 0.07^{a}	2.46± 0.19^{a}

Values are means ± SD of three measurements. Means in the same column with different letters are significantly different ($p < 0.05$).

Organoleptic Evaluation

Maize tortillas and derived products such as tortilla chips, corn chips, taco shells, among others, have increased their commercial importance. (Mora-Rochin et al., 2010).

Organoleptic evaluation of different tortillas made from yellow corn is shown in Table (12).

Data indicates that there were no significant differences between treated tortilla samples and control on sensory attributes (general appearance, separation of layer, roundness, odor and taste). Color of the tortilla is one of the properties that determine the purchasing decision and acceptance for the consumer (Claudia et al., 2012) . Results showed that color scores increased with biofertilizer application and the highest color score was recorded in microbin tortilla at 120:12 N:K (kg fed^{-1}). Tortilla's color could be related to its quality, health condition and nutrient content, indicating the presence of carotenoids, and other pigments (Irani et al., 2003) .

At the same Table , results indicated that all biofertilized corn tortillas had high total scores. Generally, tortilla with high total score produced by biofertilizer application.

CONCLUSION

It could be concluded from the obtained data that application of biofertilizers in the presence of mineral fertilizers improved grain yield and quality of yellow corn, particularly in potassiomage at 120 :12 N:K kgfed^{-1}. Biofertilzers increased the nutritional value of corn grain especially protein, fat and caroteinoids content . Also, the hundred grain weight and germ percentage were increased. Furthermore, high acceptability tortilla was produced. So, Biofertilzer application effort to provide food and health security as well as decrease use of chemical inputs with adverse effects on environmental health .

Table 12. Organoleptic evaluation of tortilla prepared from corn grains treated with biofertilizers.

Treatments N:K (kg fed^{-1})	Biofertilizers	General appearance (20)	Separation layer (10)	Roundness (10)	Odor (20)	Taste (20)	Color (20)	Total score (100)
60:12	Control	18.43±1.51^{a}	7.50±1.38^{a}	9.14±0.74^{a}	19.14±1.21^{a}	18.00±1.73^{a}	18.50±1.19^{a}	90.71± 6.66^{a}
	Rhizobacterin	18.47±1.22^{a}	7.57±0.73^{a}	9.03±0.76^{a}	19.07±0.73^{a}	18.14±0.99^{a}	18.64±0.55^{a}	90.93± 2.47^{a}
	Potassiomage	18.57±0.45^{a}	7.86±.89^{a}	9.14±0.69^{a}	19.12±0.66^{a}	18.36±0.67^{a}	18.79±0.48^{a}	91.84± 3.46^{a}
	microbin	18.79±0.64^{a}	7.71±0.48^{a}	9.00±0.5^{a}	18.93±1.09^{a}	18.21±0.69a	18.86±0.47a	91.50± 1.47^{a}
60:24	Control	18.07±0.44^{a}	7.71±0.48^{a}	9.07±0.84^{a}	18.64±1.18^{a}	17.79±0.56^{a}	18.79±0.56^{b}	90.07± 2.30^{a}
	Rhizobacterin	18.21±0.26^{a}	7.79±1.14^{a}	9.01±1.08^{a}	18.36±0.74^{a}	17.86±0.69^{a}	19.50±0.57a	90.73± 3.08^{a}
	Potassiomage	18.17±0.23^{a}	8.07±0.44^{a}	9.00±1.154^{a}	18.41±0.56^{a}	18.10±0.85^{a}	18.90±0.67^{ab}	90.66± 2.51^{a}
	microbin	18.29±0.39^{a}	7.97±0.41^{a}	9.00±0.63^{a}	18.29±0.26^{a}	17.93±0.67^{a}	19.14±0.47^{ab}	90.61± 2.13^{a}
120:12	Control	18.71±1.38^{a}	8.29±0.79^{a}	9.43±0.78^{a}	19.30±0.70^{a}	18.22±1.52^{a}	18.64±0.47^{b}	92.59 ± 5.63^{a}
	Rhizobacterin	18.79±0.85^{a}	8.29±0.48^{a}	9.50±0.76^{a}	19.29±0.75^{a}	18.28±1.22a	18.64±0.55^{b}	92.79± 2.65^{a}
	Potassiomage	18.8±0.65^{a}	8.7±0.93^{a}	9.14±0.89^{a}	18.90±1.07^{a}	18.29±0.69^{a}	18.90±0.44^{b}	92.97± 2.77^{a}
	microbin	18.93±0.73^{a}	8.43±0.53^{a}	9.00±0.89^{a}	8.70±0.899^{a}	18.20±0.39a	19.61±0.45^{a}	92.87± 2.53^{a}
120:24	Control	18.57±0.60^{a}	8.23±0.644^{a}	9.16±0.454^{a}	19.00±1.15^{a}	18.21±0.81a	18.79±0.57^{b}	91.96±2.41^{a}
	Rhizobacterin	18.57±0.53^{a}	8.29±0.75^{a}	9.14±0.69^{a}	8.79±1.286^{a}	18.21±0.99a	18.89±0.66^{ab}	91.89±2.18^{a}
	Potassiomage	18.66±1.10^{a}	8.64±0.48^{a}	9.10±0.46^{a}	18.71±0.75^{a}	18.36±1.31a	18.86±0.37^{ab}	92.33±2.87a
	microbin	18.73±1.07^{a}	8.28±0.951^{a}	9.00±0.5^{a}	18.64±0.37^{a}	18.13±1.19a	19.43±0.53^{a}	92.21± 2.27^{a}

Means in the same column with different letters are significantly different ($p < 0.05$).

REFERENCES

Abd el Fatah, H. Y., Mohamed, E. A., Hassan, M.B. and Mohamed, K. A. 2015. An Economic Analysis for Maize Market in Egypt. Mi ddle East J. Agric. Res., 04 : 873-878.

Ali,N. and Teymur k.. 2013. Response of wheat to mineral nitrogen fertilizer and biofertilizer inoculation under different levels of weed interference,"Ekologija, ,59.(2), 85-94.

Amer, S. M., Mahgoub, G.M.A. Khedr, S.A.K. 1995. Response of maize to nitrogen, phosphorus, and potassium. Zagazig J. Agric.Res., 22(2): 387-398.

AOAC, 2007. Official Methods of Analysis of AOAC International. 18th Edition, AOAC, Washington D. C.

Azimi, S. M. , Nabati E., Lak M. and Shaban M.. 2014. Effect of N and P bio fertilizers on yield components of barley. Int. J. Adv. Biolog. Biomed. Res., 2: 365-370.

Berger, L., and Singh V.. 2010. Changes and evolution of corn co-products for beef cattle. J. Anim. Sci. 88:143–150.

Cakmakci R, Donmez F, Aydın A and Sahin A. 2006. Growth promotion of plants by plant growthpromoting rhizobacteria under greenho use and two different field soil conditions, Soil Biol. Biochem. 38, 1482–1487.

Chandler, K., Lipka, A.E., Owens, B.F., Li, H., Buckler, E.S., Rocheford, T. and Gore, M.A. (2013) Genetic Analysis of Visually Scored Orange Kernel Color in Maize. *Crop Science*, 53, 189-200.

Choudhury, A. T. M. A., Kecsk M. L. and Kennedy I. R.. 2014. Utilization of BNF technology supplementing urea N for sustainable rice production. J. Plant Nutr., 37:1627–1647.

Claudia, H. A. , Domínguez-Pacheco F. A., Cruz-Orea A., Herrera C. A. , Gutierrez C. D. , Zepeda B.R. and Ramírez M. E. 2012. Optical absorption coefficient of different tortillas by photoacoustic spectroscopy. African Journal of Biotechnology ,11(92):15916-15922.

Darzi, M.T., Ghalavand A, Rejali F. and Sefydkan F. 2006. Study of application of biological fertilizers on the yield and yield components of fennel herbs. J. Med. Arom. Plants Res. 22(4): 276-292.

Das K, Dang A and Shivananda TN. (2008). Influence of bio-fertilizers on the availability of nutrients (N, P and K) in soil in re lation to growth and yield of *Stevia rebaudiana* grown in South India. International Journal of Applied Research in Natural Products, Vol. 1(1): 20-24.

Ekin, Z, Oguz F, Erman M and Ogun E .2009. The effect of Bacillus sp. OSU-142 inoculation at various levels of nitrogen fertilization on growth,tuber distribution and yield of potato (*Solanum tuberosum* L.). Afr. J. Biotechnol. 8(18): 4418-4424.

El-Amry, H.G., Al-Kassas, A.R. and Saleem, H.S.2006. The effect of biofertilizers use on maize grain quality and quant ity, as well as , bread quality when mixed with wheat flour. Egypt. J. of Appl. Sci, 21(2):222-233.

El-Kholy, M.A.. S. El-Ashry, and A.M. Gomaa.2005. Biofertilization of maize crop and its impact on yield and grains nutrient content under low rats of mineral fertilizers. J. Appl. Sci. Res., 1(2): 117-121.

Fageer, A. S.M. and Tinay A.H. El . 2004. Effect of genotype, malt pretreatment and cooking on in vitro protein digestibility and protein fractions of corn. Food Chem., 84: 613–619.

Faisal, R.I.I., Balbaa M.G. and El-Koomy M.B.A. El-Gazzar I.A.I..2012. Effect of nitrogen fertilization on growth, grain yield, and nitrogen use efficiency of some newly released maize single crosses.Egypt. J. of Appl. Sci., 27(12): 508-519.

Ghazal, F.M., Hassan M.M.M., El-Sayed G.A.M. and Desoky A.H.. 2013. Response of Maize crop to Cyanobacteria Applied Under Different Nitrogen Rates. . Nat. Sci. J.,11 (12): 172-181.

Gouda, A.Sh.A., A.M.K. El-Galfy and M.M.M. Hassan .2009. Response of some white maize single crosses to nitrogen fertilization. Egypt. J. of Appl.Sci., 24(11): 148- 163.

Hassan, M.M.M. (2004): Response of yellow maize to nitrogen, potassium fertilization and plant density. Ph. D. Thesis, Fac. Agric., Al-Azhar Univ., Egypt.

Hassan, M.M.M., Hoda Kh.A.. El-Mekser and El-Galfy A.M.K. 2009. Response of some maize inbred lines to nitrogen fertilizer rates and plant population densities. Annals of Agric. Sci., Moshtohor, 47(3): Ag. 175 -184.

Helmy, A.M., 2014. Response of seed irradiation with gamma ray, N-fertilization and bio-fertilization of barley (Hordeum vulgare L.) grown on a sand soil. J. Soil Sci. and Agric. Eng., Mansoura Univ., 5(1): 1-18.

Hulshof, P.J.M., Kosmeijer-Schuila T., West C.E. and Hollman P.C.H. 2007. Quick screening of maize kernels for provitamin A content. Journal of Food Composition and Analysis, 20: 655-661.

Hussein S.M. 1981. Some biochemical studies on opaque-2 maize. M.Sc. Thesis, Fac. Agric. Cairo Univ., Egypt.

IITA (International Institute of Tropical Agriculture). 2006. Maize overview. In:Research to Nourish Africa. www. iitaresearc h.org. on 7/10/2006.

Irani N, Hernandez M and Grotewolda E 2003. Regulation of anthocyanin pigmentation: integrative phytochemistry. Ethnobotany Mol. Ecol.37:59-78.

Ismail, E. G. , Walid.W.M. , Khattab S. and El Sherif F.2014. Effect of Manure and Bio -fertilizers on Growth, Yield, Silymarin content, and protein expression profile of Silybummarianum. Adv. Agric. Biol. 2 (1): 36-44

Jarvis, C. E. and Walker, J. R. L. 1993. "Simultaneous, rapid; spectrophotometric determination of total starch, amylose and amylopectine," Journal of the Science of Food and Agriculture,63: 53–57,

Juliano, B. O. ,1971. A simplified assay milled rice amylose. Cereal Sci. Today, 16(10): 334-339.

Kassem, M.M. and Hassouna, B.A. 2004. Efficiency of seed inoculation with N-fixing bacteria in decreasing the mineral requirements for early and late sown cotton planting. J. Agric. Sci. Mansoura Univ., 29(2): 517 - 526**.**

Kennedy, I.R., Choudhury, A.T.M.A. and Kecskés, M.L., 2004. Non-symbiotic bacterial diazotrophs in crop-farming systems: can their potentialfor plant growth promotion be better exploited? Soil Biol. Biochem. 36, 1229–1244.

Khalil, F.A.S. 1994. Studies on some macro and micronutrients fertilization on corn (*Zea mays* L.) in upper Egypt. Ph.D Thesis, Fac. Agric, El-Minia Univ., Egypt.

Kljak, K., Drdić M., Karolyi D. and Darko G. 2012..Pigmntation Effi ciency of Croatian Corn Hybrids in Egg Production. Croatian J. Food Technol. Biotechnol. Nutr., 7:23-27

Kurilich, A.C. and Juvik J.A. 1999. Quantifi cation of carotenoid and tocopherols antioxidants in Zea mays. J. Agric.Food Chem 47: 1948-1955.

Landry, J. and Moureaux, T. 1970. Heterogeneity of the glutelins of the grain corn. Selective extraction and composition in amino acids of the three isolated fractions. Bull. Soc. Chem. Bio., 52, 1021–1037.

Mallarino, A.P.; J.M. Bordoli and R. Borges 1999. Phosphorus and potassium placement effects on early growth and nutrient uptake of No-Till corn and relationships with grain yield. Agron. J. 91(1): 37-45.

McMillan M. 2007. Promoting growth with PGPR, Soil Food web Canada Ltd. Soil Bio. Laboratory and Learning Centre, 32-34

McNeill, S.G., M.D. Montross and S.A. Shearer. 2005. Spatial variation of protein, oil and starch in yellow corn. Applied Engineering for Agriculture. 21(4):619-625.

Mesbah, H.A., Aboul-Nasr, Amal, EL-Sayed, Nagda Ahmed and Mohamed, Rokaia.2012. Efficiency of Certain Arbuscular Mycorrhizal Fungi and Rhizosphere Bacterium Treatments on the Incidence of Corn Stem Borers Infestation. Alexandria Science Exchange Journal, 33 (4) : 230-240.

Meshram, SU. andShende, S.T. 1993. Total nitrogen uptake by maize with Azotobacter inoculation. *Plant and Soil*. 69: 275-280.

Metin, T.A. ; G.B. Medine ; C.C. Ramazan; O.F. Taskin and D.Sahin 2010. The effect of PGPR strain on wheat yield and quality parameters. Proceeding of Worled CLongress of Soil Science, Soil Solutions for a Changing World., Brisbane, Australia.

Mora-Rochin, S., Gutiérrez-Uribe, J. A., Serna-Saldivar, S. O., Sánchez-Peña, P., Reyes-Moreno, C., and Milán-Carrillo, J. 2010. Phenolic content and antioxidant activity of tortillas produced from pigmented maize processed by conventional nixtamalization or extrusion cooking. Journal of Cereal Science, 52(3), 502–508.

Naher, UA, Panhwar QA, Othman R, Ismail MR and Berahim Z. 2016.Fertilizer as a supplement of chemical fertilizer for yield maximization of rice. . J. Agric. Food Dev., 2:16-22.

Naseri, R., Moghadam,A., Darabi, F., Hatami, A., and Tahmasebei, G. R. 2013.The Effect of deficit irrigation and *Azotobacter Chroococcum* and *Azospirillum brasilense* on grain yield, yield components of maize (S.C. 704) as a second cropping in western Iran Bulletin of Environment, Pharmacology and Life Sciences, 2 (10): 104-112.

Ram.M ,Dawari. R and Sharma.N 2011. Effect of organic manures on basmati rice (Oryza sativa L)under organic forming of rice – wheat cropping system. Int.,Journal of Agricultural and crop sciences. 3(3): 76-84.

Rendon-Villalobos R., Agama-Acevedo E., Osorio-Diaz P., Tovar J., Bello-Perez L.A. (2009): Proximal composition and in vitro starch digestibility in flaxseed added corn tortilla. Journal of the Science of Food and Agriculture, 89: 537–541.

Sabashini, H.D. , S. Malarvannan and P. Kumar 2007. Effect of biofertilizers on yield of rice cultivars in Pondicherry, India. Asian Journal of Agriculture Research, 1(3): 146- 150.

Saber, R. A. and Sharaf A. 2013. Biochemical studies on the effect of some biofertilizers on the chemical constituents in wheat grains. Int. J. Sci.Res.,4 : 2319-7064.

Salem, F.A., Hegazy N. A., Abd El-Moneim, S. M., Shalaby, A.R. and Hussein, A.M., 1999. Evaluation of Egyptian corn varieties for tortilla bread production. Proc. 6th Arabic Conference on Food Science and Technology, Cairo, Egypt, 334-352.

Sandhu K.S., Singh N. and Malhi N.S. 2007. Some properties of corn grains and their fl ours I: Physicochemical, functional and chapati-making properties of fl ours. Food Chemistry 101: 938–946.

Shaban, Kh.A., Ahmed H.M.R.M. and El-Maaz E.I.M.. 2013. Effect of mineral, organic and biofertilization and cultural practices on some soil physical properties and wheat productivity in saline soil. Egypt. J. of Appl. Sci., 28(11): 612-623.

Shehata, M.M. and EL-Khawas S.A.2003.Effect of two bio-fertilizers on growth parameters, yield characters, nitrogenous components, nucleic acids content, minerals, oil content, protein profiles and DNA banding pattern of sunflower yield. Pakistan Journal o f Biological Sciences, 6(14): 1257-1268.

Singh, G., Sharma G. L., Golada, S. L and Choudhary, R. .2012. Effect of integrated nutrient management on quality protein maize (Zea maysL.). Crop Res. 44 (1 & 2) : 26-29.

Soetan K. O. , Olaiya C. O. and Oyewol O. E. 2010. The importance of mineral elements for humans, domestic animals and plan ts: A review. Afr. J.Food Sci., 4(5) : 200-222.

Sofy, S. O. and Rashid, A. H. A. H.2014. Effect of phosphate biofertilize and different levels of chemical phosphorus fertilizer applicat ion on growth and yield of maize (zea mays l.). international journal of plant, animal and environmental sciences, 4: 2231-4490.

Steel R.G.D. and Torrie J.H. 1997. Principles and Procedures of Statistics. A Biometrical approach. McGraw Hill Book Co., New York, USA.

Yibirin, H., Johnson J.W. and Eckert D, J. 1993. No- Till corn production as affected by mulch, potassium placement, and soil exchangeable potassium. Agron. J. 85(3): 639-644.