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Growth, yield, bulb quality and storability of some onion cultivars response to compost, vermicompost and plant growth promoting rhizobacteria

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ABSTRACT

Field experiment was conducted at Giza Agriculture Research Station, Giza Governorate, Egypt, during the winter seasons of 2015/2016 and 2016/2017. This study aims to evaluate the effect of compost, vermicompost and plant growth promoting rhizobacteria (PGPR) on growth, yield, quality and storage of some onion cultivars. Compost, vermicompost and PGPR as individual or combined treatments and recommended mineral fertilizers (RMF) were applied on three onion cultivars (Giza 20, Giza Red and Giza 6 Mohassan). The results showed that "Giza 20" cultivar was superior in most vegetative growth and total yield than the other two cultivars. "Giza 20" and "Giza red" recorded the highest values of bulb quality (TSS, dry matter and firmness) compared to "Giza 6 mohassan" at harvesting and during storage periods. "Giza 6 mohassan" gave the highest weight loss of bulbs at the end of storage period. Vermicompost + PGPR treatment gave the highest values of all growth properties and yield of bulbs without significant differences with RMF. Using RMF decreased bulb quality at harvesting and at the end of storage period, as well as increased total weight loss of bulbs at the end of the storage period. Application of RMF or 100% V+PGPR with "Giza 20" achieved the highest total gross return, total net return and benefit cost ratio. This study suggested possibility for using vermicompost + PGPR with "Giza 20" to produce good yield of onion similar to use RMF and higher bulb quality at harvesting and during storage, as well as to obtain the highest total net return and benefit cost ratio.

Key words: Onion, compost, vermicompost, plant growth promoting rhizobacteria, economic analysis.

Introduction

Onion (*Allium cepa* L.) is one of the most important vegetable crops grown in Egypt, not only for local consumption but also for exportation, it's total cultivated area is about 203 thousand feddans (feddan = 0.42 hectare), produced about 2.947 million tons (Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, 2015). It is considered a high cash crop for Egyptian farmers because Egyptian onion is demanded for international markets. The exported onion was amounted by 492 thousand tons at a value of 203 million US$ (General Authority for the Control of Exports and Imports, 2015). The main determinant of Egyptian fresh or dry onion exports, is the residues of pesticides and mineral fertilizers (Magdi and Mohamed, 2009)

Overall, excessive amounts of inorganic fertilizers are applied to onion in order to achieve a higher bulb yield (Shedeed, *et al.,* 2014). However, chemical fertilizers generate several deleterious effects on the environment and human health. The synthetic fertilizers are rapidly lost by leaching in drainage water; this causes dangerous environmental pollution (Aisha *et al.,* 2007; Hernandez *et al.,* 2010). As well as, soil fertility is associated with nutrient mineralization in organic matter and release to soil solution in available form for plant absorption. Mineralization is the result of normal biological cycles within the soil, it can be stimulated by adding appropriate amount of quality compost and biofertilizers (Paulin and Peter, 2008; Guimaraes *et al.,* 2013). Application of organic fertilizers and/or biofertilizers to the soils promoted nutrients availability, plant uptake, increased crop yield and quality (Shaheen *et al.,* 2007; Shedeed *et al.,* 2014).

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Compost is an aerobically decomposed organic material derived from plants and animal residues by mesophilic and thermophilic microorganisms (Martens, 2000). Vermicompost is a product of organic matter degradation through interactions between earthworms and microorganisms (Arancon *et al.,* 2008). In this process earthworms fragment the waste, enhance microbial activity and accelerate rates of decomposition, as in composting, but by non thermophilic process (Abduli *et al.,* 2013).

Compost and vermicompost are not only the sources of organic matter and nutrient, but also improve microbial population, physical, biological and chemical properties of the soil, as well as produce vigorous plants (Manivannan *et al.,* 2009; Mavaddati *et al.,* 2010; Shehata and El-Helaly, 2010). Many researchers studied the role of organic fertilizers as a stimulant of plant growth and yield of onion (Rizk *et al.,* 2002; Ahmed, 2004; Shaheen *et al.,* 2007), improving bulb quality and its storability (Geries *et al.,* 2012; Kandil, *et al.,* 2013; Al-Fraihat, 2016).

Biofertilizers have many benefits such as nitrogen fixation, solubilizing of phosphate, potassium and micronutrients through the production of organic acids and lowering soil pH (Saber, 1993). Biofertilizers could be produced growth promoting factors, e.g., gibberellins, cytokinins and auxins (Vessey, 2003; Saharan and Nehra, 2011). Biofertilizers combined with organic manure influences the plant growth by enhancing root biomass, total root surface, facilitate higher absorption of nutrients which led to increase yield of a wide range of crops (Yadav and Yadav, 2011). Many studies mentioned positive effects of organic fertilizer with biofertilizer on vegetative growth, yield and quality of onion (Shedeed *et al.,* 2014; Indira and Singh, 2014; Singh and Ram, 2014; Singh *et al.,* 2015).

This study aims to evaluate the effect of compost, vermicompost and plant growth promoting rhizobacteria in relative to RMF on growth, yield and storability of some onion cultivars.

Material and Methods

Field experiment was carried out at Giza Agriculture Research Station, Giza Governorate, Egypt, during the two successive winter seasons of 2015/2016 and 2016/2017. The experimental soil was analyzed according to FAO (2008) and presented in Table 1. The experimental soil was ploughed and constructed the ridges (60 cm width). The plot area was 9 m^2 (3 m length and 3 m width). Each plot included 5 ridges. Seedlings of three onion cultivars (Giza 20, Giza Red and Giza 6 Mohassan) were planted at a distance of 10 cm on both sides of ridge on on 26th and 23rd of December in the first and second seasons, respectively. Onion seedlings were obtained from Onion Research Dept., Field Crops Research Institute, Agricultural Research Center.

Table 1: Analyses of the experimental soil.

Clay %	Silt %	Sand %	Texture	pH	EC dS/m	Cations meq/l				Anions meq/l			
						Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$Co_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
39.8	37.5	22.7	Clay loam	7.59	1.58	3.30	1.85	0.80	7.85	-	0.75	11.65	1.40

The Experimental Treatments

The treatments included three onion cultivars (Giza 20, Giza Red and Giza 6 Mohassan) and eight combinations of fertilizer treatments 100% compost (100% C) as recommended N,100% vermicompost (100% V) as recommended N, Plant Growth Promoting Rhizobacteria (PGPR), 50% C + 50% V, 100% C + PGPR, 100% V + PGPR, 50% C + 50% V + PGPR, and recommended N, P and K of mineral fertilizers (RMF) as a control treatment.

The treatments were arranged in a split plot design with three replicates, where the three cultivars of onion were randomly distributed in the main plots and the eight fertilizer treatments were randomly arranged in the sub plots.

The mineral fertilizers of N, P and K were applied according to Ministry of Agriculture and Land Reclamation (2013) as follow 90 kg N/fed. as 439 kg ammonium sulphate (20.5% N), 30 kg P_2O_5/fed. as 194 kg calcium super phosphate (15.5%P_2O_5) and 24 kg K_2O/fed. as 50 kg potassium sulphate (48% K_2O). The quantities of compost and vermicompost were calculated based on nitrogen

recommended dose in clay soil (90 kg/fed.), that were about 9.5 and 6.8 tons/fed. on respectively. Analyses of the used compost and vermicompost are showed in Table 2. Plant growth promoting rhizobacteria (PGPR) were used as mixture of *Azotobacter chroococcum, Azospirillium brasilense* (nitrogen fixing bacteria), *Bacillus megaterium* (phosphate dissolving bacteria) and *Bacillus circulans* (potassium releasing bacteria). Each kind was added at a rate of 5 L/fed (1ml contains10^6-10^8cell) according to Mashhoor *et al.* (2002).

Table 2: Analyses of the compost and vermicompost fertilizers

Type	pH 1:5	EC 1:10 dS/m	O.M (%)	Macro elements (%)					Micro elements (ppm)			
				N	P	K	Ca	Mg	Fe	Zn	Mn	Cu
Compost	7.53	2.67	27.13	0.95	0.37	0.74	0.36	0.67	644	98	203	11
Vermicompost	8.13	4.29	20.60	1.33	0.67	0.94	0.47	0.64	567	88	205	13

Time and Method of Application

Calcium super phosphate was added as one dose during soil preparation, whereas ammonium sulphate and potassium sulphate were added at two equal portions, after 30 and 60 days from transplanting. Two-thirds of both compost and vermicompost were added in solid form during soil preparation, while the other third was added as water extract (1:20 v:v) to the soil beside plants every two weeks at rate of 1 l/m^2 (Abou-El-Hassan *et al.,* 2014). PGPR were supplemented with the surface irrigation after 2 and 4 weeks from transplanting date.

Data Recorded

Vegetative growth and nutritional status

After 75 days from transplanting, five plants were randomly chosen from each sub plot to determine characteristics of vegetative growth and nutritional status onion plants. Plant length, leaf number/plant and plant fresh weight, were measured. Chlorophyll reading was measured in dried leaves samples of the inner mature leaf by using Minolta Chlorophyll Meter SPAD 501. Nutrient contents (N, P and K) in onion plants were determined in the inner mature leaf according to Cottenie *et al.* (1982). Total nitrogen was determined by Kjeldahl method, phosphorus was determined using spectrophotometer and potassium was determined photometrically using flame photometer according to the procedure described by FAO (2008).

Yield and bulb quality characters

At harvesting stage (120 days from transplanting date) total yield/feddan was calculated from sub plot yield. Five bulbs from each replicate were randomly chosen to measure diameter, average bulb weight. As well as, firmness and dry matter percent of bulb were determined. Bulb firmness was measured by Pressure Tester (1.5 mm diameter). Total soluble solids (TSS) were measured by using Digital Refractometer.

Storability characters

A representative sample of 50 healthy onion bulbs from each sub plot was selected to store at natural atmosphere for 4 months from mid-May to mid-September. Data of bulb firmness, percentage of dry matter and total soluble solids were estimated monthly during storage period. During the storage period, no appeared any decayed bulbs in all treatments. The percentage of weight loss was calculated at the end storage period according to equation of wills *et al. (*1982).

$$\textbf{Weight loss } \% = \frac{(\textbf{weight at start of storage period} - \textbf{weight at the end of storage period}) \textbf{ x 100}}{\textbf{weight at start of storage period}}$$

Economic analysis

Economic analysis was carried out to estimate the net return and the benefit cost ratio of the treatments. Cost of cultivation was calculated as sum of land rent, land preparation, seed price, irrigation, fertilizers, pest management, labor and other expenditure based on local charges for all cultivars and fertilization treatments. Gross return was obtained as the sum price of the total yield at harvesting time on the basis of local price. Net return was calculated by subtracting cost of cultivation from gross return. Benefit cost ratio was obtained by the following formula:

$$\text{Benefit cost ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

Statistical analysis

Data of the two seasons were arranged and statistically analyzed by the analysis of variances according to Snedecor and Cochran (1980) by SAS software, version 2004. Treatment means were compared using Tukey test at significance level of 0.05.

Results and Discussion

Vegetative growth

The vegetative growth parameters for onion cultivars under different fertilizers were presented in Tables 3 and 4. Data in both seasons revealed that, "Giza 20" cultivar gave the highest values of all vegetative growth parameters compared to "Giza Red" and "Giza 6 mohassan" cultivars, except for leaves number of plant that were statistically identical in all cultivars The differences in vegetative growth characteristics among cultivars might be related to the genetic make up for each cultivar. These results are in good agreement with those mentioned by Shah *et al.* (2012) and Soleymani and Shahrajabian (2012).

Table 3: Response of growth properties of onion to different treatments in both seasons

Fertilizer treatments	Plant length (cm)											
	2015/2016 season						2016/2017 season					
	Cultivars											
	Giza 20	Giza red	Giza 6	Mean	Giza 20	Giza red	Giza 6	Mean
100% C	47.00 e-i	44.33 h-j	43.33 hij	**44.89 CD**	48.67 c-f	47.00 efg	46.33 fg	**47.33 C**
100% V	52.67 cde	50.67 def	49.33 e-g	**50.89 B**	55.33 b	53.00 bc	52.00 bcd	**53.44 B**
PGPR	42.33 ij	41.00 j	40.33 j	**41.22 D**	43.00 gh	41.67 h	40.67 h	**41.78 D**
50%C+50%V	50.33 def	49.00 e-h	49.00 e-h	**49.44 B**	51.67 bcd	49.67 c-f	48.67 c-f	**50.00 C**
100% C+PGPR	51.00 def	48.33 e-h	45.33 e-i	**48.22 BC**	51.33 b-e	48.67 c-f	48.00 def	**49.33 C**
100% V+PGPR	60.33 a	58.00 abc	58.00 abc	**58.78 A**	63.67 a	61.67 a	61.33 a	**62.22 A**
50%C+50%V+PGPR	53.67 bcd	51.67 de	50.00 d-g	**51.78 B**	55.00 b	52.67 bc	51.67 bcd	**53.11 B**
RMF	63.67 a	59.00 abc	59.00 ab	**60.56 A**	65.33 a	63.00 a	62.00 a	**63.44 A**
Mean	**52.63 A**	**50.25 B**	**49.29 B**		**54.25 A**	**52.17 B**	**51.33 C**	
Leaf number/plant												
100% C	10.33 de	10.33 de	10.33 de	**10.33 B**	11.33 b-e	11.00 cde	11.33 b-e	**11.22 CD**
100% V	11.33 b-e	11.00 b-e	11.00 b-e	**11.11 AB**	12.00 a-d	11.67 a-e	11.67 a-e	**11.78 BC**
PGPR	10.33 de	9.67 e	10.00 e	**10.00 B**	11.33 b-e	10.67 de	10.00 e	**10.67 D**
50%C+50%V	10.67 cde	10.67 cde	10.67 cde	**10.67 B**	11.67 a-e	11.33 b-e	11.33 b-e	**11.44 CD**
100% C+PGPR	10.33 de	10.33 de	10.67 cde	**10.44 B**	11.33 b-e	11.33 b-e	11.33 b-e	**11.33 CD**
100% V+PGPR	12.67 ab	12.33 abc	12.33 abc	**12.44 A**	13.00 ab	12.00 a-d	11.67 a-e	**12.22 AB**
50%C+50%V+PGPR	11.00 b-e	11.33 b-e	11.33 b-e	**11.22 AB**	12.00 a-e	12.00 a-d	11.67 a-e	**11.89 AB**
RMF	13.00 a	12.33 abc	12.00 a-d	**12.44 A**	13.33 a	12.67 abc	12.67 abc	**12.89 A**
Mean	**11.21 A**	**11.00 A**	**11.04 A**		**12.00 A**	**11.58 A**	**11.46 A**	

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V= Vermicompost, PGPR= Plant Growth Promoting Rhizobacteria, RMF= Recommended Mineral Fertilizers.

Table 4: Continue response of growth properties of onion to different treatments in both seasons

Fertilizer treatments	Plant fresh weight (g)															
	2015/2016 season								2016/2017 season							
	Cultivars															
	Giza 20		Giza red		Giza 6		Mean		Giza 20		Giza red		Giza 6		Mean	
100% C	128.3	ij	126.7	j	125.3	j	**126.8**	**E**	133.3	ij	129.3	jk	128.0	jkl	**130.2**	**E**
100% V	156.7	bcd	155.7	cd	154.0	d	**155.4**	**B**	163.7	b-e	160.7	cde	156.7	ef	**160.3**	**B**
PGPR	118.3	k	117.7	k	114.0	k	**116.7**	**F**	121.7	kl	120.3	l	119.7	l	**120.6**	**F**
50%C+50%V	142.7	e	141.7	ef	140.0	efg	**141.4**	**C**	150.0	fg	147.7	gh	140.0	hi	**145.9**	**C**
100% C+PGPR	135.3	fgh	133.7	ghi	131.7	hij	**133.6**	**D**	140.3	hi	136.0	ij	133.7	ij	**136.7**	**D**
100% V+PGPR	166.3	a	165.0	a	162.3	abc	**164.6**	**A**	176.0	a	171.0	ab	168.3	abc	**171.8**	**A**
50%C+50%V+PGPR	157.7	bcd	155.7	cd	152.7	d	**155.3**	**B**	164.0	b-e	159.7	de	156.0	efg	**159.9**	**B**
RMF	166.7	a	165.7	a	163.3	ab	**165.2**	**A**	175.0	a	172.0	ab	168.0	a-d	**171.7**	**A**
Mean	**146.5**	**A**	**145.2**	**AB**	**142.9**	**B**			**153.0**	**A**	**149.6**	**B**	**146.3**	**C**		
Chlorophyll reading (SPAD)																
100% C	52.67	d-h	51.27	e-h	50.00	gh	**51.31**	**C**	58.17	fgh	55.33	gh	55.37	gh	**56.29**	**D**
100% V	59.67	bc	58.27	cd	56.67	c-f	**58.20**	**B**	65.50	b-e	62.33	ef	62.37	ef	**63.40**	**BC**
PGPR	50.67	fgh	48.67	h	48.33	h	**49.22**	**C**	56.17	gh	54.67	h	54.37	h	**55.07**	**D**
50%C+50%V	55.00	c-g	53.33	d-h	53.00	d-h	**53.78**	**BC**	66.17	b-e	63.17	def	63.37	c-f	**64.23**	**B**
100% C+PGPR	53.00	d-h	51.00	fgh	51.67	e-h	**51.89**	**C**	58.83	fgh	55.67	gh	55.70	gh	**56.73**	**D**
100% V+PGPR	66.67	a	64.67	ab	65.00	ab	**65.44**	**A**	72.50	a	69.83	ab	69.37	abc	**70.57**	**A**
50%C+50%V+PGPR	60.67	abc	58.33	cd	57.33	cde	**58.78**	**B**	60.83	efg	57.33	fgh	57.70	fgh	**58.62**	**CD**
RMF	66.00	a	64.67	ab	64.67	ab	**65.11**	**A**	72.50	a	69.33	abc	68.70	a-d	**70.18**	**A**
Mean	**58.04**	**A**	**56.28**	**B**	**55.83**	**B**			**63.83**	**A**	**60.96**	**A**	**60.87**	**A**		

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Fertilizer treatments gave significant differences of vegetative growth characteristics. Where, vermicompost + PGPR treatment gave the highest values of plant length, leaf number, plant fresh weight and chlorophyll reading, without significant differences with treatment of RMF. While, the lowest values of these characters was resulted from PGPR treatment onl. The other treatments were moderated. These results were true in the two seasons. A promotion effect of vermicompost + PGPR treatment on vegetative growth of onion plants might be attributed to that vermicompost has advantages more than compost. Vermicompost is higher in nitrate content, which is the more available form of nitrogen for plant absorption. In addition, vermicompost releases nutrients during short time compared to compost (Manivannan *et al.,* 2009; Mupondi *et al.,* 2010). Besides that, the addition of PGPR to vermicompost works to fix the atmospheric nitrogen and excrete some growth promoters (Saharan and Nehra, 2011). Thus applying vermicompost + PGPR increased the vegetative growth of onion plants to be similar to those resulted from the RMF. Similar results were reported by Shedeed *et al.* (2014), Singh and Ram (2014) and Singh *et al.* (2015).

The interaction between fertilizers and cultivars had significant effect on vegetative growth characteristics in both seasons. However, the highest values of all vegetative growth parameters were recorded by vermicompost + PGPR and RMF with all cultivars. Meanwhile, the lowest values were obtained by PGPR only with all cultivars.

Nutritional status

Data in Table 5 are presented N, P and K contents of onion leaves in both seasons. “Giza 20” cultivar had a significant superiority in the N content of leaves on the other two cultivars. The highest P and K contents of leaves were produced with “Giza 20” and “Giza Red”, whereas “Giza 6 mohassan” gave the lowest contents. This is due to differences among genotypes in the nutrient use

efficiency of different fertilizers. (Yoldas *et al.,* 2011; Shah *et al.,* 2012; Soleymani and Shahrajabian 2012).

Table 5: Response of nutritional status of onion plants to different treatments in both seasons

Fertilizer treatments	N (%)															
	2015/2016 season								2016/2017 season							
	Cultivars															
	Giza 20		Giza red		Giza 6		Mean		Giza 20		Giza red		Giza 6		Mean	
100% C	3.23	ij	3.03	jk	2.86	k	**3.04**	**E**	3.46	ij	3.30	jk	3.10	k	**3.29**	**E**
100% V	3.86	e	3.70	ef	3.54	fgh	**3.70**	**C**	4.16	ef	3.93	fg	3.67	ghi	**3.92**	**C**
PGPR	2.34	l	2.18	l	2.05	l	**2.19**	**F**	2.55	l	2.43	l	2.33	l	**2.44**	**F**
50%C+50%V	3.54	fgh	3.36	ghi	3.21	ij	**3.37**	**D**	3.77	gh	3.62	hi	3.35	jk	**3.58**	**D**
100% C+PGPR	3.44	f-i	3.24	ij	3.18	ij	**3.29**	**D**	3.65	hi	3.51	ij	3.33	jk	**3.50**	**D**
100% V+PGPR	4.55	bc	4.34	cd	4.26	d	**4.38**	**B**	4.77	bc	4.60	cd	4.40	de	**4.59**	**B**
50%C+50%V+PGPR	3.62	efg	3.43	f-i	3.29	hij	**3.45**	**D**	3.85	gh	3.68	ghi	3.42	ij	**3.65**	**D**
RMF	4.90	a	4.71	ab	4.57	bcd	**4.73**	**A**	5.07	a	4.94	ab	4.69	bc	**4.90**	**A**
Mean	**3.68**	**A**	**3.50**	**B**	**3.37**	**C**			**3.91**	**A**	**3.75**	**B**	**3.54**	**C**		
P (%)																
100% C	0.41	d-g	0.41	efg	0.38	g	**0.40**	**D**	0.43	c-f	0.41	def	0.40	f	**0.41**	**C**
100% V	0.43	a-e	0.42	b-e	0.40	efg	**0.42**	**BC**	0.44	bcd	0.43	c-f	0.42	def	**0.43**	**BC**
PGPR	0.28	h	0.28	h	0.26	hij	**0.27**	**E**	0.29	g	0.28	g	0.27	g	**0.28**	**D**
50%C+50%V	0.42	b-f	0.42	c-f	0.39	fg	**0.41**	**CD**	0.44	b-e	0.42	c-f	0.40	ef	**0.42**	**BC**
100% C+PGPR	0.44	a-d	0.44	a-e	0.42	c-f	**0.43**	**AB**	0.46	abc	0.44	bcd	0.43	b-f	**0.45**	**AB**
100% V+PGPR	0.46	a	0.46	ab	0.44	a-e	**0.45**	**A**	0.48	a	0.47	ab	0.45	abc	**0.47**	**A**
50%C+50%V+PGPR	0.45	abc	0.44	a-d	0.43	b-e	**0.44**	**AB**	0.47	ab	0.45	a-d	0.44	b-e	**0.45**	**AB**
RMF	0.43	a-e	0.43	b-e	0.41	d-g	**0.42**	**BC**	0.45	a-d	0.43	b-f	0.42	c-f	**0.43**	**BC**
Mean	**0.42**	**A**	**0.41**	**A**	**0.39**	**B**			**0.43**	**A**	**0.42**	**AB**	**0.40**	**C**		
K (%)																
100% C	3.45	ef	3.51	ef	3.33	f	**3.43**	**C**	3.60	ef	3.68	ef	3.49	f	**3.59**	**C**
100% V	3.83	bcd	3.89	abc	3.70	cde	**3.81**	**AB**	4.06	a-d	4.05	a-d	3.88	cde	**4.00**	**AB**
PGPR	2.62	g	2.65	g	2.53	g	**2.60**	**D**	2.75	g	2.77	g	2.65	g	**2.72**	**D**
50%C+50%V	3.62	de	3.68	cde	3.50	ef	**3.60**	**BC**	3.79	de	3.86	cde	3.67	ef	**3.77**	**BC**
100% C+PGPR	3.61	de	3.66	cde	3.48	ef	**3.59**	**BC**	3.79	de	3.83	cde	3.66	ef	**3.76**	**BC**
100% V+PGPR	4.05	ab	4.11	a	3.91	abc	**4.03**	**A**	4.24	ab	4.32	a	4.10	abc	**4.22**	**A**
50%C+50%V+PGPR	3.84	bcd	3.89	abc	3.70	cde	**3.81**	**AB**	4.05	a-d	4.07	a-d	3.88	cde	**4.00**	**AB**
RMF	3.80	bcd	3.85	bcd	3.67	cde	**3.77**	**B**	3.98	bcd	4.04	a-d	3.85	cde	**3.95**	**B**
Mean	**3.60**	**A**	**3.66**	**A**	**3.48**	**B**			**3.78**	**A**	**3.83**	**A**	**3.65**	**B**		

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Fertilizer applications showed significant effect on N, P and K contents of onion leaves in the two seasons. The highest N percent in leaves was preceded by RMF treatment. Vermicompost + PGPR treatment came in the second order, while PGPR treatment achieved the lowest N content. Using vermicompost + PGPR increased P content of leaves compared to RMF without significant differences with treatments of 100% compost + PGPR and 50% compost + 50% vermicompost + PGPR. As well as vermicompost + PGPR treatment gave the highest K content of leaves without significant differences with treatments of 100% vermicompost and 50% compost + 50% vermicompost + PGPR. On the other hand, PGPR treatment had the lowest P and K contents of leaves. The higher N content of onion leaves with RMF might be due to it is easy decomposition, so the plants absorb large quantities from it (Aisha *et al.,* 2007; Hernandez *et al.,* 2010; Abou-El-Hassan *et al.,* 2017). While, the superiority of vermicompost + PGPR treatment in P and K contents, may be

due to the role of vermicompost on promotion of onion plants growth and the role of PGPR on increasing the availability of these nutrients to onion plant absorption. These results are in harmony with those reported by Abdelrazzag (2002), Shaheen *et al.* (2007) and Shedeed *et al.* (2014).

Regarding the interaction between fertilizers and cultivars, in both seasons, application of RMF with "Giza 20" and "Giza Red" gave the highest N content. While, the highest P and K contents resulted from 100% vermicompost + PGPR with all cultivars. The lowest N, P and K contents was obtained by PGPR treatment with all cultivars.

Bulb yield and average bulb weight

It is clear from the data in Table 6 that there were significant differences among the various investigated treatments with regard to yield of onion. "Giza 20" cultivar produced the highest yield and average bulb weight compared to other cultivars in both seasons. There were no significant differences in yield and average bulb weight between "Giza Red" and "Giza 6 mohassan" cultivars in the first season, whereas a significant decrease was recorded in the yield and average bulb weight of "Giza 6 mohassan" down "Giza red" in the second season. This is due to differences among genotypes in their adaptability to the specific environment and nutrient use efficiency. These results are in agreement with those stated by Shah *et al.* (2012), Soleymani and Shahrajabian (2012) and Kandil *et al.* (2013).

Table 6. Response of yield and average bulb weight of onion to different treatments in both seasons

Fertilizer treatments	Yield (ton/fed.)							
	2015/2016 season				2016/2017 season			
	Cultivars							
	Giza 20	Giza red	Giza 6	Mean	Giza 20	Giza red	Giza 6	Mean
100% C	10.12 e	10.00 e	09.88 e	**10.00 D**	12.76 i	12.72 i	12.72 i	**12.72 D**
100% V	13.64 c	13.36 c	13.48 c	**13.48 B**	16.28 ef	15.44 g	15.20 g	**15.64 B**
PGPR	9.12 f	9.04 f	9.00 f	**9.04 E**	11.24 j	11.04 j	10.92 j	**11.08 E**
50%C+50%V	12.36 d	12.00 d	11.96 d	**12.12 C**	14.24 h	14.16 h	14.04 h	**14.12 C**
100% C+PGPR	12.20 de	11.96 d	11.92 d	**12.04 C**	14.40 h	14.12 h	13.88 h	**14.12 C**
100% V+PGPR	15.56 a	14.76 b	14.72 b	**15.00 A**	17.96 a	17.36 abc	16.60 cde	**17.32 A**
50%C+50%V+PGPR	13.80 c	13.60 c	13.60 c	**13.68 B**	16.44 def	15.72 fg	15.36 g	**15.84 B**
RMF	15.68 a	14.76 b	14.72 b	**15.08 A**	17.92 ab	17.16 bcd	16.60 cde	**17.24 A**
Mean	**12.80 A**	**12.440 B**	**12.40 B**		**15.16 A**	**14.72 B**	**14.40 C**	
Average bulb weight (g)								
100% C	85.3 g	82.0 g	80.7 gh	**82.7 D**	102.7 h	100.7 h	101.0 h	**101.4 D**
100% V	126.7 cd	122.3 d	119.3 d	**122.8 B**	139.7 cd	129.7 e	127.3 ef	**132.2 B**
PGPR	73.3 hi	71.3 i	71.0 i	**71.9 E**	86.3 i	83.7 i	81.7 i	**83.9 E**
50%C+50%V	110.3 e	104.7 ef	100.0 f	**105.0 C**	118.3 g	115.3 g	114.3 g	**116.0 C**
100% C+PGPR	108.3 e	104.0 ef	98.0 f	**103.4 C**	120.0 fg	115.7 g	113.0 g	**116.2 C**
100% V+PGPR	146.7 a	135.3 b	131.7 bc	**137.9 A**	157.0 a	148.3 b	140.0 cd	**148.4 A**
50%C+50%V+PGPR	126.3 cd	122.7 d	120.0 d	**123.0 B**	141.3 bc	132.0 de	128.3 e	**133.9 B**
RMF	146.7 a	135.7 b	132.0 bc	**138.1 A**	157.0 a	146.7 bc	140.7 bc	**148.1 A**
Mean	**115.5 A**	**109.8 B**	**106.6 B**		**127.8 A**	**121.5 B**	**118.3 C**	

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Fertilizer treatments had significant effect on yield and average bulb weight of onions. Using vermicompost + PGPR produced the highest yield and bulb fresh weight without significant differences with RMF. Treatment of 50% compost + 50% vermicompost + PGPR and 100% vermicompost came in the second order, 50% compost + 50% vermicompost and 100% compost + PGPR came in the third order, then 100% compost treatment, finally the lowest values of yield and average bulb weight were recorded by PGPR treatment only. The positive effect of vermicompost + PGPR treatment on yield and average bulb weight may be due to increase the uptake of N, P and K by

these plants as shown in Table 5, which improved of vegetative growth characteristics as shown in Tables 3 & 4. This resulted more stimulate of photosynthesis and metabolic processes of organic compounds in plant, thus increasing weight of blub and yield of onions. El-Shatanofy (2011), Yoldas *et al.* (2011), Soleymani and Shahrajabian (2012) and Indira and Singh (2014) indicated to similar conclusions.

The interaction between onion cultivars and fertilizer treatments had significant effects on yield and average bulb weight. The treatments of vermicompost + PGPR and RMF with "Giza 20" gave the highest yield and average bulb weight.

Bulb quality

Data in Tables 7 and 8 showed the effects of different fertilizer treatments on bulb quality for three cultivars of onion in the two seasons. The cultivar of "Giza 20" and "Giza Red" recorded the highest values of bulb diameter, firmness, TSS and dry matter. On the other hand, "Giza 6 mohassan" gave the lowest values. The differences among onion cultivars in bulb quality might be related to genetic factors as reported by Geries *et al.* (2012) and Kandil, *et al.* (2013).

Effect of different fertilizers on bulb quality, application of vermicompost + PGPR and RMF led to increase of blub diameter compared to other treatments. In contrast, these treatments decreased bulb firmness, percent of TSS and dry matter in bulb. The positive effect of vermicompost + PGPR and RMF treatments on blub diameter may be due to the superiority of these treatments in vegetable growth, which led to an increase in the process of photosynthesis and better carbohydrate build up, thus increased diameter of onion bulb. Decrease in firmness, percent of TSS and dry matter in the bulb by vermicompost + PGPR and RMF, may be due to the large size (weight and diameter) of these bulbs, since water is the major component in the cells. This effect was in conformity with the results obtained by Rizk *et al.* (2002), Shaheen *et al.* (2010), Singh and Ram (2014) and Lasmini *et al.* (2015).

Table 7: Response of onions quality to different treatments in both seasons

Fertilizer treatments	Bulb diameter (mm)															
	2015/2016 season								2016/2017 season							
	Cultivars															
	Giza 20		Giza red		Giza 6		Mean		Giza 20		Giza red		Giza 6		Mean	
100% C	5.53	def	5.37	efg	5.27	fg	**5.39**	**D**	6.47	efg	6.32	fgh	6.23	ghi	**6.34**	**D**
100% V	6.33	c	6.37	c	6.23	c	**6.31**	**B**	7.30	b	7.23	b	7.13	bc	**7.22**	**B**
PGPR	5.13	g	5.07	g	5.03	g	**5.08**	**E**	6.03	hi	6.00	hi	5.93	i	**5.99**	**E**
50%C+50%V	5.87	d	5.73	d	5.63	def	**5.74**	**C**	6.87	cd	6.67	de	6.57	d-g	**6.70**	**C**
100% C+PGPR	5.77	d	5.67	de	5.59	def	**5.68**	**C**	6.73	de	6.60	def	6.53	d-g	**6.62**	**C**
100% V+PGPR	7.03	a	6.85	ab	6.89	a	**6.93**	**A**	8.03	a	7.97	a	7.83	a	**7.95**	**A**
50%C+50%V+PGPR	6.50	bc	6.47	c	6.33	c	**6.43**	**B**	7.37	b	7.33	b	7.27	b	**7.32**	**B**
RMF	7.17	a	6.93	a	6.86	ab	**6.99**	**A**	8.10	a	8.01	a	7.80	a	**7.97**	**A**
Mean	**6.17**	**A**	**6.06**	**AB**	**5.98**	**B**			**7.11**	**A**	**7.02**	**AB**	**6.91**	**B**		
Bulb firmness (kg/cm^2)																
100% C	11.27	a-d	11.77	ab	11.05	b-e	**11.36**	**A**	10.90	a	11.03	a	10.50	a-d	**10.81**	**A**
100% V	11.11	a-d	11.55	abc	10.95	a-f	**11.20**	**A**	10.80	ab	10.93	a	10.31	a-d	**10.68**	**A**
PGPR	11.27	a-d	11.75	ab	11.09	a-d	**11.37**	**A**	10.90	a	10.96	a	10.52	abc	**10.80**	**A**
50%C+50%V	11.34	a-d	11.75	ab	11.05	a-d	**11.38**	**A**	10.80	ab	11.08	a	10.50	a-d	**10.79**	**A**
100% C+PGPR	11.41	abc	11.81	a	11.17	a-d	**11.46**	**A**	10.90	a	11.10	a	10.53	abc	**10.84**	**A**
100% V+PGPR	10.47	d-f	10.92	b-e	10.20	e-h	**10.53**	**B**	10.03	bcd	10.31	a-d	9.71	cde	**10.02**	**B**
50%C+50%V+PGPR	11.04	a-e	11.45	abc	10.86	c-f	**11.12**	**AB**	10.73	ab	10.85	ab	10.35	a-d	**10.64**	**A**
RMF	9.74	gh	10.15	fgh	9.50	h	**9.80**	**C**	9.17	e	9.66	de	8.95	e	**9.26**	**C**
Mean	**10.96**	**AB**	**11.40**	**A**	**10.73**	**B**			**10.53**	**A**	**10.74**	**A**	**10.17**	**B**		

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Table 8: Continue response of onions quality to different treatments in both seasons

Fertilizer treatments	TSS in bulb (%)							
	2015/2016 season				2016/2017 season			
	Cultivars							
	Giza 20	Giza red	Giza 6	Mean	Giza 20	Giza red	Giza 6	Mean
100% C	14.92 a	14.68 a	13.82 a	**14.47 A**	13.00 a	12.70 a	11.953 a	**12.55 A**
100% V	14.94 a	15.18 a	13.96 a	**14.69 A**	13.00 a	13.13 a	12.087 a	**12.74 A**
PGPR	14.88 a	15.02 a	13.92 a	**14.61 A**	12.83 a	13.10 a	12.047 a	**12.66 A**
50%C+50%V	15.46 a	15.05 a	13.99 a	**14.83 A**	13.80 a	13.13 a	12.120 a	**13.02 A**
100% C+PGPR	14.65 a	14.91 a	13.92 a	**14.49 A**	12.93 a	13.30 a	12.053 a	**12.76 A**
100% V+PGPR	13.46 a	13.45 a	13.12 a	**13.34 AB**	11.83 a	11.90 a	11.123 a	**11.62 AB**
50%C+50%V+PGPR	15.14 a	14.15 a	13.62 a	**14.30 A**	13.20 a	12.50 a	11.747 a	**12.48 A**
RMF	12.85 a	12.55 a	12.43 a	**12.61 B**	11.00 a	10.70 a	10.167 a	**10.62 B**
Mean	**14.54 A**	**14.37 AB**	**13.60 B**		**12.70 A**	**12.56 AB**	**11.66 B**	
Dry matter in bulb (%)								
100% C	16.52 a	16.42 a	15.73 a	**16.22 A**	15.56 a	15.43 a	14.89 a	**15.29 A**
100% V	16.59 a	16.07 a	16.06 a	**16.24 A**	15.63 a	14.99 a	15.01 a	**15.21 A**
PGPR	16.79 a	15.98 a	15.93 a	**16.24 A**	15.73 a	14.99 a	14.93 a	**15.22 A**
50%C+50%V	16.76 a	16.35 a	15.77 a	**16.29 A**	15.69 a	15.32 a	14.60 a	**15.20 A**
100% C+PGPR	16.46 a	16.39 a	15.98 a	**16.28 A**	15.47 a	15.07 a	15.00 a	**15.18 A**
100% V+PGPR	15.50 a	15.63 a	15.22 a	**15.45 AB**	14.38 a	14.56 a	14.17 a	**14.37 B**
50%C+50%V+PGPR	16.35 a	16.32 a	15.89 a	**16.19 A**	15.45 a	15.30 a	14.84 a	**15.20 A**
RMF	14.94 a	15.07 a	15.04 a	**15.01 B**	14.16 a	14.15 a	14.12 a	**14.14 B**
Mean	**16.24 A**	**16.03 AB**	**15.70 B**		**15.26 A**	**14.97 A**	**14.69 B**	

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Concerning the interaction between fertilizers and cultivars, the treatments of vermicompost + PGPR and RMF gave the highest diameter and the lowest firmness of bulbs with all cultivars. Meanwhile, there were no significant effects for interaction between all treatments and onion cultivars on bulb content of TSS and dry matter.

Storability characters

Data presented in Tables 9, 10, 11 & 12 showed the effect of different fertilizer treatments on the quality properties (TSS, dry matter, firmness and total weight loss) of onion cultivars during storage period. Generally, during storage of onion bulbs the values of TSS, dry matter and firmness were progressively increased from the first storage period, until its reach the highest values at the fourth storage period. This can be attributed to low moisture content in the bulb as the storage period increases, this led to increase the concentration of total soluble solids and dry matter in the bulb, accordingly bulb firmness is increased. This corresponding with was decided by Morsy *et al.* (2012), Kandil *et al.* (2013) and Singh and Ram (2014).

Concerning cultivars, “Giza 20” recorded the highest dry matter content of bulb compared to other two cultivars during storage periods. As well as, “Giza 20” was superior in the TSS content and firmness of bulb but without significant differences with “Giza Red”. The lowest values of these characters were resulted from “Giza 6 mohassan” cultivar in both seasons. On the contrary, “Giza 6 mohassan” cultivar gave the highest percent of weight loss compared to other two cultivars at the end of storage period. Regarding to the total weight loss after the storage period, "Giza 6 Mohassan” cv. gave the highest significant percent of total weight loss compared to other two cultivars by the end of storage period in both seasons.

Concerning fertilizer treatments during the first three storage periods, using RMF reduced TSS content of bulb compared to other treatments, except vermicompost + PGPR treatment that were statistically similar RMF and other treatments. The lowest dry matter percent of bulb were obtained

from RMF during first three storage periods, without significant differences with vermicompost + PGPR treatment in the third period.

Table 9: Response of % TSS of onions to different treatments during storage in both seasons

Property	Total soluble solids (TSS %)							
Seasons	2015/2016 season				2016/2017 season			
Periods	After 1 month	After 2 months	After 3 months	After 4 months	After 1 month	After 2 months	After 3 months	After 4 months
A: Cultivars								
Giza 20	14.52 a	15.52 a	16.48 a	17.80 a	12.57 a	13.52 a	14.49 a	15.82 a
Giza red	14.31 a	15.23 ab	16.37 a	17.55 a	12.35 ab	13.49 a	14.32 a	15.52 ab
Giza 6	13.53 b	14.54 b	15.46 b	16.58 b	11.62 b	12.54 b	13.59 b	14.79 b
B: Fertilizers								
100% C	14.44 ab	15.49 a	16.44 a	17.33 a	12.44 a	13.60 a	14.42 a	15.33 a
100% V	14.69 a	15.68 a	16.63 a	17.57 a	12.74 a	13.67 a	14.60 a	15.54 a
PGPR	14.60 a	15.53 a	16.69 a	17.36 a	12.55 a	13.78 a	14.57 a	15.35 a
50%C+50%V	14.83 a	15.62 a	16.56 a	17.50 a	12.75 a	13.61 a	14.56 a	15.59 a
100% C+PGPR	14.50 ab	15.44 a	16.39 a	17.34 a	12.75 a	13.70 a	14.54 a	15.45 a
100% V+PGPR	13.18 bc	14.30 ab	15.30 ab	17.17 a	11.33 ab	12.44 ab	13.40 ab	15.20 a
50%C+50%V+PGPR	14.30 ab	15.25 a	16.26 a	17.14 a	12.48 a	13.53 a	14.50 a	15.54 a
RMF	12.55 c	13.58 b	14.67 b	17.18 a	10.61 b	11.26 b	12.59 b	15.12 a
A x B	NS	NS	NS	NS	NS	NS	NS	NS

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Table 10: Response of % dry matter of onions to different treatments during storage in both seasons

Property	Dry matter (%)							
Seasons	2015/2016 season				2016/2017 season			
Periods	After 1 month	After 2 months	After 3 months	After 4 months	After 1 month	After 2 months	After 3 months	After 4 months
A: Cultivars								
Giza 20	17.14 a	17.72 a	18.22 a	18.57 a	16.31 a	16.78 a	17.33 a	17.65 a
Giza red	16.86 b	17.41 b	17.84 b	18.24 b	16.00 b	16.40 b	17.01 b	17.25 b
Giza 6	16.62 c	17.09 c	17.65 c	17.96 c	15.72 c	16.12 c	16.68 c	17.07 b
B: Fertilizers								
100% C	17.20 a	17.69 a	17.98 ab	18.40 a	16.25 a	16.72 a	17.15 a	17.39 a
100% V	17.18 a	17.66 a	18.11 a	18.38 a	16.32 a	16.75 a	17.19 a	17.38 a
PGPR	17.13 a	17.60 a	18.04 ab	18.33 a	16.26 a	16.65 a	17.16 a	17.38 a
50%C+50%V	17.24 a	17.71 a	18.07 ab	18.41 a	16.33 a	16.73 a	17.23 a	17.55 a
100% C+PGPR	17.22 a	17.71 a	18.16 a	18.43 a	16.24 a	16.60 a	17.12 a	17.37 a
100% V+PGPR	15.34 b	16.96 b	17.56 bc	17.81 a	15.59 b	15.04 b	16.89 ab	17.04 a
50%C+50%V+PGPR	17.15 a	17.63 a	18.08 ab	18.36 a	16.27 a	16.64 a	17.05 a	17.30 a
RMF	15.56 c	16.35 c	17.21 c	17.93 a	14.92 c	15.46 c	16.36 b	17.17 a
A x B	NS	NS	NS	NS	NS	NS	NS	NS

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Table 11: Response of onions firmness to different treatments during storage in both seasons

Property	Firmness (kg/cm^2)							
Seasons	2015/2016 season				2016/2017 season			
Periods	After 1 month	After 2 months	After 3 months	After 4 months	After 1 month	After 2 months	After 3 months	After 4 months
A: Cultivars								
Giza 20	11.39 a	11.96 a	14.42 a	15.19 a	10.84 a	11.30 a	13.61 a	14.23 a
Giza red	11.31 a	11.93 a	14.38 a	15.04 a	10.65 a	11.12 a	13.39 a	13.95 a
Giza 6	10.66 c	11.20 c	13.79 c	14.30 b	10.17 b	10.59 b	12.85 b	13.64 b
B: Fertilizers								
100% C	11.45 a	12.11 a	14.36 a	14.99 a	10.97 a	11.35 a	13.69 ab	14.02 a
100% V	11.34 a	11.93 a	14.41 a	14.85 a	10.76 a	11.25 a	13.58 ab	13.90 a
PGPR	11.46 a	12.02 a	14.42 a	14.97 a	10.93 a	11.40 a	13.66 ab	14.06 a
50%C+50%V	11.51 a	12.17 a	14.40 a	15.02 a	10.98 a	11.29 a	13.70 a	14.10 a
100% C+PGPR	11.46 a	12.15 a	14.48 a	15.09 a	10.98 a	11.33 a	13.67 ab	14.07 a
100% V+PGPR	10.60 b	10.92 b	13.94 b	14.51 a	9.91 b	10.45 b	12.37 b	13.86 a
50%C+50%V+PGPR	11.29 a	11.85 a	14.34 ab	14.73 a	10.72 a	11.21 a	13.43 ab	13.74 a
RMF	9.93 c	10.39 c	13.25 c	14.56 a	9.15 c	9.72 c	12.48 c	13.81 a
A x B	NS	NS	NS	NS	NS	NS	NS	NS

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

Table 12: Response of onions weight loss to different treatments during storage in both seasons

Fertilizer treatments	2015/2016 season				2016/2017 season			
	Cultivars							
	Giza 20	Giza red	Giza 6	Mean	Giza 20	Giza red	Giza 6	Mean
	% weight loss							
100% C	12.44 c	12.40 c	12.75 c	12.53 C	12.62 d	13.40 cd	13.92 cd	13.31 C
100% V	13.08 c	12.50 c	12.80 c	12.80 C	13.51 cd	13.59 cd	14.10 cd	13.73 C
PGPR	12.63 c	11.89 c	12.48 c	12.34 C	12.74 d	12.90 d	14.00 cd	13.21 C
50%C+50%V	12.37 c	12.70 c	12.93 c	12.67 C	12.78 d	13.08 d	14.30 cd	13.39 C
100% C+PGPR	12.12 c	12.06 c	12.88 c	12.35 C	14.53 cd	12.95 d	13.99 cd	13.82 C
100% V+PGPR	15.38 b	15.31 b	16.21 b	15.63 B	15.69 bc	15.09 bc	16.76 ab	15.85 B
50%C+50%V+PGPR	12.10 c	12.42 c	12.88 c	12.47 C	13.58 cd	13.69 cd	14.08 cd	13.78 C
RMF	20.16 a	20.28 a	20.55 a	20.33 A	18.69 a	18.23 a	18.86 a	18.59 A
Mean	13.79 B	13.70 B	14.19 A		14.27 B	14.12 B	15.00 A	

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.
C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended Mineral Fertilizers.

All treatments of non-mineral fertilizers individual or in combinations increased bulb firmness compared to RMF. No significant differences were observed in TSS, dry matter contents and firmness of bulbs in the fourth storage period. The highest values of total weight loss at the end of storage period was resulted from using RMF, 100% vermicompost + PGPR treatment came in second order. Meanwhile, the rest treatments of non-mineral fertilizers individual or in combinations recorded the lowest total weight loss by the end of the storage period without significant differences among them. This can be attributed to the large size of bulbs with mineral fertilizer treatment that content a high percentage of moisture; thus reduce TSS, dry matter contents and firmness in bulbs. High moisture is greatly reduced during the first storage periods, which leads to high weight loss. Shaheen *et al.* (2010), Geries *et al.* (2012), Singh and Ram (2014), Lasmini *et al.* (2015) and Singh *et al.* (2015) referred similar explanations.

Economic analysis

Data in Table 13 revealed that "Giza 20" cv. produced the highest total gross return, total net return and benefit cost ratio followed by "Giza Red" cv. then "Giza 6 Mohassan" cv. In regard with fertilizer treatments, application of RMF recorded the highest total gross return, total net return, and benefit cost ratio followed by application of 100% V+PGPR then 50%C+50%V+PGPR. This could be attributed to their role in increasing the total onion bulb yield. Concerning the interaction between cultivars and fertilizer treatments, "Giza 20" cv. with application of RMF or 100% V+PGPR showed the highest total gross return, total net return and benefit cost ratio, "Giza 20" was superior than other cultivars in total gross return, total net return and benefit cost ratio as it was recorded the highest total yield, consequently showed the highest value of economical parameters. This may due to its genetic factors and genetic makeup. In addition, cv. "Giza 20" with application of RMF or 100% V+PGPR exhibited the highest economical parameter it might be due its varietal response to their role in producing the highest total yield.

Table 13: Economic analysis of different treatments as total cost cultivation, total gross return, total net return and benefit cost ratio of three onion cultivars as mean for both seasons (2015/2016 and 2016/2017)

Fertilizer treatments	Cultivar							
	Giza 20	Giza Red	Giza 6 Mohassan	Mean	Giza 20	Giza Red	Giza 6 Mohassan	Mean
	Total cost cultivation (L.E./fed.)				Total Gross return (L.E./fed.)			
100% C	13440	13440	13440	**13440**	22880	22720	22600	**22733**
100%V	14590	14590	14590	**14590**	29920	28800	28680	**29133**
PGPR	12790	12790	12790	**12790**	20360	20080	19920	**20120**
50%C+50%V	14015	14015	14015	**14015**	26600	26160	26000	**26253**
100%C+PGPR	14240	14240	14240	**14240**	26600	26080	25800	**26160**
100%V+PGPR	15390	15390	15390	**15390**	33520	32120	31320	**30987**
50%C+50%V+PGPR	14815	14815	14815	**14815**	30240	29320	28960	**29507**
RMF	13080	13080	13080	**13080**	33600	31920	31320	**32280**
Mean	**14045**	**14045**	**14045**		**27965**	**27150**	**26825**	
Fertilizer treatments	Total net return (L.E./fed.)				Benefit cost ratio (%)			
100% C	9440	9280	9160	**9293**	1.70	1.69	1.68	**1.69**
100%V	15330	14210	14090	**14543**	2.05	1.97	1.97	**2.00**
PGPR	7570	7290	7130	**7330**	1.59	1.57	1.56	**1.57**
50%C+50%V	12585	12145	11985	**12238**	1.90	1.87	1.86	**1.87**
100%C+PGPR	12360	11840	11560	**11920**	1.87	1.83	1.81	**1.84**
100%V+PGPR	18130	16730	15930	**15597**	2.18	2.09	2.04	**2.01**
50%C+50%V+PGPR	15425	14505	14145	**14692**	2.04	1.98	1.95	**1.99**
RMF	20520	18840	18240	**19200**	2.57	2.44	2.39	**2.47**
Mean	**13920**	**13105**	**12780**		**1.99**	**1.93**	**1.91**	

C = Compost, V = Vermicompost, PGPR = Plant Growth Promoting Rhizobacteria, RMF = Recommended mineral fertilizers.

Conclusion

It could be concluded that using "Giza 20" cv. with vermicompost + PGPR produce good yield of onion similar to that produced with recommended mineral fertilizers with higher quality of bulbs at harvest and during storage. Application of 100% vermicompost only or 50% compost + 50% vermicompost + PGPR produce a somewhat low yield, but are higher quality of bulbs at harvest and during storage. Application of recommended mineral fertilizers or 100% vermicompost + PGPR achieved the highest total gross return, total net return and benefit cost ratio.

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