Egypt. J. Hort. **Vol. 44**, No. 2, pp. 165 - 181 (2017)

Effect of Mineral Fertilizers, Biofertilizers and Biochar Application on Production of Garlic Grown in Sandy Soil Condition

M.E.A. Youseef [*], I.A.S. Al-Easily[*] and Dalia A.S. Nawar[**]
[*]Potato and Vegetatively Propagated Vegetables, Horticulture Research Institute, Agricultural Research Centre and[**]Horticulture Department, Faculty of Agriculture, Zagazig University, Egypt.

THE main objective of this study was to produce safe and clean garlic crop.This study was carried out during 2014/2015 and 2015/2016 seasons at El-Kassasein region, Ismailia, Egypt, to investigate the effect of mineral NP fertilizers, biofertilizers and biochar on two garlic cultivars production grown in sandy soil conditions.Sids 40 cultivar recorded the highest neck and bulbdiameters, dry weight of plant parts, marketable and total yields/feddan, N and total protein contents in the bulbs. Fertilization of garlic with 75% NP + 3kg Nitrobein (Nr) + 2kg Phosphorein (Pr) + 3m^3 biochar/fed.increased all plant growth characters and yields of grades 1 and 2, marketable, exportable and total/fed., while, with 50% NP + 3m^3 biochar/fed.gave the lowest bulb nitrate content. Fertilizing the two cultivars with 75% NP + 3kg Nr + 2kg Pr + 3m^3 biochar/fed.increased dry weights of plant parts, as well as yields and its components. Fertilizing Balady plants with 100 or 75% NP + 3kg Nr+ 2kg Pr + 3m^3 biochar/fed. gave the highest net returns, followed by Sids 40 with 100% NP + 3kg Nr + 2kg Pr/fed., or with 100% NP + 3kg Nr + 2kg Pr + 3m^3 biochar/fed. It could be concluded that fertilization of garlic plants with 100 or 75% NP + 3kg Nr + 2kg Pr+ 3m^3 biochar/fed. can improve plant growth, yields and its components with a good bulb quality. Treated garlic plants with biochar positively enhanced plant growth, productivity, and bulb quality. Using previous treatments could reduce the costs, increase net return of garlic production and keep the environment out of pollution.

Keywords: *Allium sativum*, Mineral NP, Plant growth, Yield, Bulb quality, Chemical composition, Feasibility study.

Introduction

Garlic (*Allium sativum,* L.) is one of the oldest and very important vegetable crops in Egypt, due to its wide local consumption, exportation and for medicinal uses. Garlic genotype is the most important factor, which influences the growth, productivity and quality of garlic plants, especially that grown under sandy soil conditions. In this respect, Mohamed (2004) found that Sids 40 cultivar had higher values of vegetative growth and bulb characters, as well as, total yield, than Balady cultivar. Also, Osman (2015) indicated that Sids 40 cultivar produced markedly higher values of leaf number, bulb diameter, bulbing ratio and dry weight of bulb, leaves and plant, as well as, cured yield, bulb weight, also, carbohydrates, N and protein contents of bulbs than Balady cultivar. On the other hand, Balady cultivar scored higher values of plant length. Likewise, Hassan (2002), Mohamed (2004), Al-Otayk et al. (2008) and Abou El-Magd et al. (2014) mentioned that the Sids 40 plants gave the higher yield, than Balady garlic. On the contrary, El-Shabasi (2001) and Abdel-Razzak and El-Sharkawy (2013) reported that garlic yield of Balady was significantly higher than Sids 40.

Nitrogen (N) isessential for synthesisofchlorophyll, enzymes and proteins. Phosphorus (P) is essential for root growth and phosphoproteins, phospholipids, ATP and ADP formation. The use of mineral (chemical) fertilizers without rationalization maycause environmental pollution, as well as, underground watercontamination. For these reasons, there was a great attention to the usage of biofertilizers (microbial inoculation) in plant production in order to reduce the usage of mineral fertilizers,improve the soil chemical properties, and to reduce plant, soil and underground water contamination with different elements. Biofertilizers, which contain efficient strains

Corresponding author : M.E.A. Youseef, E-mail:safa_hana3@yahoo.com
DOI: 10.21608/ejoh.2017.1212.1015

of nitrogen fixing, and phosphate solubilizing bacteria could be used instead of chemical fertilizers. Furthermore, these bacterial cells increase the availability of nutrients in soil, which can be easily assimilated by plants (SubbaRao, 1993). Nitrobein is the commercial biofertilizers that give the same effect of full dose ofmineral nitrogen application (Tawfik, 2008). Furthermore, phosphorein partially overcomes the phosphate fixation problem in calcareous soil (Han and Lee, 2005).

Biochar is an organic amendment produced by the process called pyrolysis, which is the burning of plant biomass in a limited oxygen environment. Researches on field crops production system have shown promising results with biochar treatment, but the research on vegetablesis scarce. Biocharhas beenfound to reduce fertilizers need, and tomaintain or improve crop productivity. Moreover, biochar addition to mineral fertilizers significantly increased plant growth, compared to mineral fertilizer alone (Schulz and Glaser, 2012, Biederman and Harpole, 2013,Crane-Droesh et al., 2013), and also improve the water availability and retention properties of both sandy and clay soils (Jha et al., 2010, Jeffery et al., 2011 and Sun & Lu, 2014). In addition, biochar can be used for enhancing soil water storage which may increase crop productivity. In this respect, using biochar with tomato positively enhanced plant height and leaf size (Graber et al., 2010). Furthermore, addition of biochar increased the soil moisture contents, which consequently improved physiology, yield, and quality of tomato, as compared with the non biochar applications(Akhtaret al., 2014). Biochar increased the final biomass, root biomass, plant height and number of leaves of lettuce and cabbage plants (Carter et al., 2013). Biochar improves fertility of the soil, improvenutrient and water use efficiencies and also has the potential to mitigate climate change by sequestering carbon into soils (Hale, 2014).

The objectiveof this study was to determine the suitable combination of mineral NP, biofertilizers (Nitrobein and Phosphorein) and biochar to obtain high yield with good quality of garlic crop. In additionthe possibility of reducing the inputs of chemical fertilizers was studied to produce safe and clean crop of garlic under sandy soil conditions.

Material and Methods

This study was carried out during the two successive seasons of 2014/2015 and 2015/2016 at El-Kassasein Horticulture Experimental Farm, Ismailia Governorate, Egypt, Horticulture Research Institute, Agricultural Research Center to investigate the effect of the mineral NP combination, biofertilizers and biochar on the production of the two garlic cultivars; Balady and Sids 40 grown in sandy soil conditions under drip irrigation system. Random soil samples from the experimental field location, as well as the used biochar were analyzed according to the methods described by Jackson (1970) at the beginning of the experiment in the two seasons to determine the physical and chemical properties (Table 1).

TABLE 1. The physical and chemical properties of the experimental soil* and used biochar before planting.

Soil properties		Season		Biochar properties		Season	
		2014/2015	2015/2016			2014/2015	2015/2016
		Physical (%)			Chemical		
Sand		94.20	93.93	Total % (Dry weight)	C	29.8	32.7
Silt		4.02	4.22		N	0.77	0.67
Clay		1.73	1.79		S	0.09	0.07
Organic matter		0.05	0.06		P	18.6	16.9
Field capacity (F.C.)		8.22	8.87		K	305	298
Wilting point (W.P.)		3.91	4.08		Ca	609	719
Texture class		Sandy	Sandy		Mg	167	189
Chemical					Na	861	792
	N	3.32	4.29	mg/kg	Fe	66.8	75.6
Available (ppm)	P	2.98	3.36		Mn	145	166
	K	9.12	10.85		Zn	11.9	13.7
Electric conductivity (E.C.) mmhos/cm		2.97	2.82		Cu	8.28	9.77
pH (1:2.5 suspension)		8.56	8.73	pH (1:2.5 suspension)		10.21	8.98

*Soil samples were taken from 25 cm soil surface

This experiment included 24 treatments, i.e., the interaction between 2 garlic cultivars and 12 combinations of mineral NP, biofertilizers and biochar, as follows:

Garlic cultivars

- Balady(the common cultivar of garlic in Egypt).
- Sids 40 (Chinese).

Mineral NP, biofertilizers and biochar treatments

- 100% NP (120 kg N + 90 kg P_2O_5/ Feddan)fed.),whereas fed.= 4200 m^2 = 0.42 hectare).
- 100% NP + 3 kg Nitrobein (Nr) + 2 kg Phosphorein (Pr)/fed.
- 100% NP + 3 m^3biochar/fed.
- 100% NP + 3 kgNr + 2 kg Pr + 3 m^3biochar/fed.
- 75% NP (90 kgN + 67.5 kg P_2O_5/fed.).
- 75% NP + 3 kg Nr + 2 kg Pr/fed.
- 75% NP + 3 m^3 biochar/fed.
- 75% NP + 3 kg Nr + 2 kg Pr + 3 m^3biochar/fed.
- 50% NP (60 kg N + 45 kg P_2O_5/fed.).
- 50% NP + 3 kg Nr + 2 kg Pr/fed.
- 50% NP + 3 m^3 biochar/fed.
- 50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.

These treatments were arranged in a split plot design with 3 replications. The cultivars were arranged in the main plots and the combinations among mineral NP, biofertilizers and biochar were assigned in the sub plots.Garlic cloves of the 2 cultivars were selected for uniformity in the shape and size. Biofertilizers were mixed with wet cloves by adding Arabic Gum solutions before cloves planting. The treated cloves were directly planted in the same day. The used biofertilizers were Nitrobein contains *Azotobacter sp.,* as a nitrogen fixing bacteria; while Phosphorein contains *Bacillus megatherium*, as a phosphate dissolving bacteria. TheNitrobein and Phosphorein were obtained from the General Organization for Agriculture Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. All amount of biochar (3 m^3/fed.)was added during the soil preparation in the center of row and covered by sand.

The experimental unit area was 12.6 m^2 which contained 3 dripper lines (30 cm distance between drippers) with 7 m length and 60 cm between rows. One dripper line was used for the samples to measure vegetative growth and the other two dripper lines were used for yield determination. The cloves were planted on both sides of the dripper line at distance of 7.5 cm apart. The cloves were planted on 15 and 20 September of 2014/2015 and 2015/2016 seasons, respectively. Sourcesof Nand P were ammonium sulfate (20.6% N) and calcium super phosphate (15.5% P_2O_5), respectively. One third of these mineral fertilizers was added with all amount of both farmyard manure (30 m^3/fed.) and biochar (3 m^3/fed**)** during the soil preparation in the center of rows and covered by sand. Beginning one month after planting, the rest of calcium super phosphate fertilizer was divided into 7 equal amounts, and then added every 15 days intervals as a soil application and covered by sand, while, the rest amounts of ammonium sulfate fertilizer were added through the water irrigation (fertigationsystem) in20 equal dosesat7 days intervals. Other agricultural practices for commercial garlic production were carried out as recommended by the Egyptian Ministry of Agriculture.

Data Recorded

Plant growth measurements

A random sample of sixgarlic plants were taken from each plot at 135 days after planting in both seasons and the following data were recorded:Plant height,number of leaves/plant, diameter of both neck and bulb (mm),andbulbin gratio=Neckdiameter/Bulb diameter as described by (Mann, 1952). Dry weights of roots, leaves, bulband plant (dry weights of roots + leaves + bulb).

Yield and its components

At proper maturity stage of garlic bulbs (200 days after planting), bulbs in every plot wereharvested and graded into four categories according to the specification laid down by the EgyptianMinistry of Economic (1963) for garlic exportation, as follows:Grade 1: bulbs with diameter above 5.5 cm, grade 2: bulbs with diameter between 4.5 - 5.5 cm, grade 3: bulbs with diameter between 3.5 - 4.4 cm and grade 4: bulbs with diameter less than 3.5 cm. After that, each grade was separately weighed in the same day and the following data were recorded:Exportable yield = Grade 1 + Grade 2, Marketable yield = Grade 1 + Grade 2 + Grade 3, Total Yield= Grade 1 + Grade 2 + Grade 3 + Grade4 yields and average bulb fresh weight.

Bulb chemical composition

Fresh samples of 100 g of bulbs from the second season were oven dried at 70°C till constant

weight. The dry matter was finely ground and wet digested with sulfuric acid and perchloric acid (3:1). Nitrogen, phosphorus, potassium,nitrate and total carbohydrate contents were determined according to the methods described byBremner and Mulvaney (1982), Olsen and Sommers (1982), Jackson (1970), Cafado et al. (1975) and James (1995) respectively. While, total protein was calculated by multiplying total nitrogen x 6.25.

Feasibility study

The cost of production was analyzed with a view of find out the most profitable treatments. All the non-material and material input costs and interests on running capital were considered for computing the cost of production. Cost and return analysis was done in details according to the procedure of Perkins (1994). Benefit cost ratio was calculated by the following formula:
Benefit cost ratio=Gross return (Egyptian pounds (L.E.)/fed)/Total cost of production (L.E.)/fed).

Statistical Analysis

The data of this experiment were subjected to proper statistical analysis of variance according to Snedecor and Cocharan (1980) and the means separations were done using L.S.D. at 0.05 level.

Results and Discussion

Plant growth measurements

Data in Table 2 shows that garlic cv.Balady gave higher significant values of plant height in both seasons and leaf number/plant in the secondseason. On the other hand,Sids 40 cultivar gave higher significantvalues of both neck and bulb diametersin the secondseason only. However, there were no significant differences between both cultivars with respect to leaf number/plant and diameters of both neck and bulb in the firstseason and bulbing ratio in both seasons. These results might be attributed to the genetic structure of garlic cultivars (Abdel-Razzak and El-Sharkawy, 2013). Previous studies demonstrated that garlic cv. Balady gave higher values of plant length (Gad El-Hak & Abd El-Mageed, 2000, El-Shabasi, 2001,Hassan, 2002, El-Sayed, 2004, Al-Otayk et al., 2008, Hosseny & Mahmoud, 2008, Dawood, 2011, Abdel-Razzak & El-Sharkawy, 2013 and Osman, 2015), bulb diameter (El-Shabasi, 2001) and bulbing ratio (El-Sayed, 2004) than Sids 40, while Sids 40 recorded taller plants (Abou El-Magd et al., 2012) higher number of leaves/plant (Hasan, 2002, El-Sayed, 2004, Dawood, 2011, Abou El-Magd et al., 2012 and Osman, 2015), and higher values of bulb diameter (El-Sayed, 2004, Osman, 2015)than Balady cultivar. On the other hand, there were nosignificant differences between both cultivars in leaf number/plants (Hassan et al., 1990 andEl-Shabasi, 2001) and neck diameter (Osman, 2015).

Concerning the combinations among mineral NP, biofertilizers and biochar, obtained results in Table 2 indicate that fertilized garlic plants with 100% mineral NP (120kg N + 90 kg P_2O_5/ fed) + Nr+ Pr + biochar gave the highest values of plant height, leaf number/plant and diameter of both neck and bulb in both seasons, without significant differences among 100%mineral NP +Nr + Pr, 75% mineral NP + Nr + Pr and 75% NP +Nr + Pr +biochar. This result may be due to the role of the used biofertilizers in the fixing of atmospheric N and transferring insoluble P in the soil to soluble form for absorption and up take by plants (El-Shaikh, 2005 and El-Habbasha et al., 2007). Furthermore, the increments in plant growth due to biofertilizersapplication might be a result of thevital role of bacteria that present in the applied biofertilizer inproducingsome hormone substances, i.e. gibberellins, auxins and cytokinins (Tien et al., 1979, Bouton et al., 1985, Cacciari et al., 1989 and Noel etal., 1996). These phytohormones may stimulate the cell elongation and development and hence plant growth (Paleg, 1985). Moreover, the activity of these bacteria in the absorption zone of plant roots might improve soil fertility and consequently plant development by N-fixation and due to releasing of certain other nutrients, i.e. Fe, Zn and Mn (Bhande et al., 1997 and Awasthi et al., 1998) through the breakdown of organic materials in the soil and make these elements in available forms, as well as the efficient strains of bacteria that have the ability to bring insoluble phosphates in soil into soluble forms (phosphate solubilizing microorganisms) by secretic organic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphate (Sethi & SubbaRao, 1968 and Gaur & Ostwal, 1972). Microbial inoculants are carrier based preparations containing beneficial microorganisms is a viable state intended for seed or soil application and designed to improve soil fertility and help plant growth by increasing the number and biological activity of desired microorganisms in the root environment. Biochar addition to mineral fertilizer significantly increased plant growth, than chemical fertilizer alone (Schulz & Glaser, 2012, Biederman & Harpole, 2013 and Crane-Droesh, et al., 2013),

and also has the potential to significantly improve the water availability and retention properties of soils (Jha et al., 2010, Jeffery et al., 2011 and Sun & Lu, 2014). While, treated tomato plants by biochar positively enhanced plant height and leaf size (Graber et al., 2010).

As for the effect of interaction between cultivars and the combinations among mineral NP, biofertilizers and biochar, data in Table 2 illustrate that fertilizing garlic plants *cv.* Balady with 100% mineral NP + Nr + Pr + biochar gave the highest values of plant height at 135 days after planting in both seasons without significant differences among 100% mineral NP + Nr + Pr, 100% mineral NP +biochar and 75% mineral NP + Nr + Pr + biochar. Fertilized garlic plants with 100% mineral NP + Nr + Pr or75% mineral NP + Nr + pr +biochar recorded maximum values of leaf number/plant for Balady. Soil adding of100% mineral NP +Nr + Prand100 or 75% mineral NP + Nr + Pr + biocharsignificantly increased diameter of both neck and bulb for Sids 40. While, these interaction had no significant differences on leaf number, bulb diameter and bulbing ratio in the first season.

Dry weight of plant parts

Obtained results in Table 3 indicate that Sids 40 recorded higher values of dry weight of roots, bulb and whole plant, than Balady in both seasons. There were no significant differences between the two cultivars with respect to dry weight of leaves. The increases in totaldry weight were about 32.4 and 5.10% for Sids 40 over Balady cultivar in the firstand second seasons, respectively. Similar results were obtained by El-Shabasi (2001),Hassan (2002) El-Sayed (2004), Al-Otayk et al. (2008) and Osman(2015) who found that Chinese cultivar had higher dry weight of different plant parts, than Balady. On the contrary, Osman (1987)stated that dry weights of vegetative portions, bulb and whole plant of Balady were significantly higher than Sids 40.Also, Gad El-Hak and Abd El-Mageed (2000) showed that Balady cultivar showed higher values than Sids 40 in garlic plantdry weight.Besides, Hussein et al. (1995) found that Balady cultivar was the superior for leaf dry weight.

As for the effect of the combinations among mineral NP, biofertilizers and biochar,fertilized garlic plants with 100 or 75% mineral NP + Nr + Pr + biochar significantly increased dry weights of roots, bulb, leaves and whole plant in both seasons (Table 3). The increases in plant dry weight were about 15.10 and 40.48% for fertilizing with 100% mineral NP + Nr + Pr + biochar and 12.40 and 32.84% for fertilizing with 75% mineral NP + Nr + Pr + biochar in the firstand secondseasons, respectively.From the foregoing results, it could be concluded that fertilizing garlic plants grown in sandy soil with 75% mineral NP + Nr + Pr + biochar was the best treatments for enhancing height plant, number of leaves/plant, diameters of both neck and bulb, and dry weight of roots,leaves, bulb and whole plant. The effect of combinations among mineral NP, biofertilizers and biochar on dry weight of garlic plants might attributeto the increases in plant growth parameters (Table 2). Biochar induced plant growth stimulation and this can be attributed thatbiochar addition caused a shift in microbial populations towards beneficial plant growth promoting rhizobacteria or fungi as a result of either chemical and physical attributes of the biochar (Elad et al., 2011). Also, Addition of biochar to soil often results in a significant augmentation of mycorrhizal fungi plant symbiotic interactions(Warnock et al., 2007). Biochar improved dry weight of plant and this can be attributed to the direct effects via biochar supplied nutrients (Silber et al., 2010).

Concerning of the effectof the interaction between cultivars and the combinations among mineral NP, biofertilizers and biochar, obtained results in Table 3 illustrate that fertilizing of both Balady and Sids 40 cultivarwith 100 or 75% mineral NP + Nr + Pr + biochar significantly increased dry weight of roots, leaves, bulb and whole plant. The increases of total dry weight of whole plant were 18.42 and 44.52% for fertilizing Balady with 100% mineral NP + Nr + Pr +biochar in both seasons, respectively, and 52.22 and 38.87% for fertilizing Sids 40 plants with 100% mineral NP + Nr + Pr + biochar, as well as49.24 and 36.78% for fertilizing Sids 40 cultivarwith 75% mineral NP + Nr + Pr + biochar over the control (Balady with 100% mineral NP) in the firstand secondseason, respectively. From the foregoing results, it could be concluded that fertilizing with 75% mineral NP + Nr + Pr + biochar increased dry weight of roots, leaves, bulbs and whole plant for Balady and Sids 40 cultivars when grown under sandy soil conditions.

TABLE 2. Effect of cultivars, the combinations among mineral NP, biofertilizers and biochar and their interactions on some vegetative growth parameters of garlic plants grown under sandy soil conditions at 135 days after planting during 2014/2015 and 2015/2016 seasons.

Treatments	2014/2015 season					2015/2016 season				
	Plant height (cm)	Leaf number/ plant	Diameter (mm)		Bulbing ratio	Plant height (cm)	Leaf number/ plant	Diameter (mm)		Bulbing ratio
			Neck	Bulb				Neck	Bulb	
Cultivars										
Balady	84.07	7.08	16.00	50.83	0.317	80.00	7.72	14.89	56.60	0.267
Sids 40	72.46	7.72	18.04	66.40	0.277	69.52	6.95	18.22	69.71	0.265
L.S.D. at 0.05 level	**6.94**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**4.75**	**0.59**	**1.08**	**1.41**	**N.S.**
The combinations among mineral NP, biofertilizrs and biochar										
100% NP/fed.	81.42	7.50	17.93	60.35	0.305	79.00	7.67	16.95	63.45	0.267
100% NP + 3 kg Nr + 2 kg Pr/fed.	88.50	8.50	18.80	68.30	0.282	86.83	8.67	17.75	73.25	0.243
100% NP + 3 m^3 biochar/fed.	86.00	7.87	18.25	61.65	0.301	83.50	8.00	17.15	65.20	0.264
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	93.50	9.17	19.55	71.05	0.281	92.33	9.17	18.25	76.87	0.238
75% NP/fed.	62.17	6.50	14.00	47.30	0.298	58.50	5.67	15.25	53.30	0.288
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	84.50	7.89	18.40	66.67	0.282	80.17	8.17	17.45	72.50	0.241
75% NP + 3 m^3 biochar/fed.	78.50	6.83	17.55	58.35	0.304	75.00	7.50	16.15	60.95	0.266
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	89.83	8.22	19.15	69.00	0.283	88.83	9.00	18.15	74.30	0.245
50% NP/fed.	59.33	6.00	13.30	45.00	0.299	57.34	5.50	14.82	47.25	0.312
50% NP + 3 kg Nr + 2 kg Pr/fed.	75.83	6.83	16.33	55.00	0.301	72.50	6.89	15.85	59.15	0.269
50% NP + 3 m^3 biochar/fed.	68.45	6.83	15.00	49.10	0.313	62.17	5.67	15.50	54.55	0.286
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	71.17	6.67	16.00	51.65	0.317	61.00	6.17	15.40	57.10	0.272
L.S.D. at 0.05 level	**9.57**	**1.59**	**3.42**	**8.15**	**N.S.**	**6.60**	**1.20**	**1.61**	**3.81**	**0.034**
The interaction between cultivars and combination among mineral NP, biofertilizers and biochar										
Balady 100% NP/fed.	87.17	7.00	17.4	52.60	0.331	85.33	8.00	15.4	57.9	0.266
100% NP + 3 kg Nr + 2 kg Pr/fed.	97.33	8.00	18.3	60.00	0.309	95.33	9.00	16.4	66.5	0.247
100% NP + 3 m^3 biochar/fed.	95.33	7.33	17.7	53.30	0.334	93.33	8.33	15.6	59.4	0.264
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	103.00	8.67	19.3	63.30	0.310	101.00	8.67	16.7	70.9	0.237
75% NP/fed.	63.67	6.33	12.2	41.30	0.296	60.33	6.00	13.5	45.6	0.297
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	89.67	7.33	17.7	56.70	0.313	83.67	8.67	16.0	66.3	0.241
75% NP + 3 m^3 biochar/fed.	85.67	6.67	16.7	50.00	0.331	82.67	7.67	14.2	53.2	0.269
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	98.33	8.33	18.8	61.30	0.311	96.67	9.33	16.6	67.3	0.248
50% NP/fed.	62.00	6.00	11.1	40.00	0.279	59.33	6.00	12.7	44.5	0.287
50% NP + 3 kg Nr + 2 kg Pr/fed.	83.00	6.33	15.0	46.70	0.320	80.00	7.00	14.0	52.4	0.268
50% NP + 3 m^3 biochar/fed.	66.67	6.66	13.3	41.50	0.324	63.00	6.33	13.7	46.7	0.295
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	77.00	6.33	14.5	43.30	0.343	59.33	6.67	13.9	48.5	0.288
Sids 40 100% NP/fed.	75.67	8.00	18.5	68.10	0.279	72.67	7.33	18.5	69.0	0.268
100% NP + 3 kg Nr + 2 kg Pr/fed.	79.67	9.00	19.3	76.60	0.254	78.33	8.33	19.1	80.0	0.239
100% NP + 3 m^3 biochar/fed.	76.67	8.40	18.8	70.00	0.268	73.63	7.67	18.7	71.0	0.264
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	84.00	9.67	19.8	78.80	0.251	83.67	8.67	19.8	82.8	0.240
75% NP/fed.	60.67	6.66	15.8	53.30	0.300	56.67	5.33	17.0	61.0	0.279
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	79.33	8.44	19.1	76.63	0.250	76.67	7.67	18.9	78.7	0.241
75% NP + 3 m^3 biochar/fed.	71.33	7.00	18.4	66.70	0.277	67.33	7.33	18.1	68.7	0.263
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	81.33	8.11	19.5	76.70	0.255	81.00	8.67	19.7	81.3	0.243
50% NP/fed.	56.67	6.00	15.5	50.00	0.319	55.34	5.00	16.9	50.0	0.338
50% NP + 3 kg Nr + 2 kg Pr/fed.	68.67	7.33	17.6	63.30	0.281	65.00	6.67	17.7	65.9	0.290
50% NP + 3 m^3 biochar/fed.	70.22	7.00	16.7	56.70	0.301	61.33	5.00	17.3	62.4	0.277
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	65.33	7.00	17.5	60.00	0.291	62.67	5.67	16.9	65.7	0.258
L.S.D. at **0.05** level	**13.53**	**N.S.**	**4.8**	**N.S.**	**N.S.**	**9.33**	**1.70**	**2.2**	**5.4**	**0.047**

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein, and Feddan (fed.) = 4200 m^2 = 0.42 hectare.

TABLE 3. Effect of cultivars, the combinations among mineral NP, biofertilizers and biochar and their interactions on dry weights of garlic plants grown under sandy soil conditions at 135 days after planting during 2014/2015 and 2015/2016 seasons.

Treatments		2014/2015 season					2015/2016 season				
		Dry weights (g)				Realative total D.W. (%)	Dry weights (g)				Realative total D.W. (%)
		Roots	Leaves	Bulb	Total		Roots	Leaves	Bulb	Total	
											Cultivars
Balady		1.14	9.32	10.89	21.36	100.00	1.59	8.44	14.86	24.89	100.00
Sids 40		1.55	9.69	17.05	28.28	132.40	1.70	8.54	15.92	26.16	105.10
L.S.D. at **0.05** level		**0.12**	**N.S.**	**2.41**	**3.31**	-	**0.16**	**N.S.**	**0.60**	**0.51**	-
The combinations among mineral NP, biofertilizrs and biochar											
100% NP/fed.		1.39	9.79	14.38	25.56	100.00	1.71	8.29	15.16	25.15	100.00
100% NP + 3 kg Nr + 2 kg Pr/fed.		1.56	10.78	15.50	27.84	108.92	2.07	10.36	19.28	31.71	126.08
100% NP + 3 m^3 biochar/fed.		1.46	9.90	14.83	26.19	102.46	1.86	8.81	15.94	26.61	105.81
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.		1.67	11.50	16.25	29.42	115.10	2.54	12.06	20.73	35.33	140.48
75% NP/fed.		0.98	7.50	12.05	20.53	80.32	1.66	5.93	13.38	20.96	83.34
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.		1.56	10.50	15.17	27.23	106.53	1.95	9.69	17.07	28.71	114.16
75% NP + 3 m^3 biochar/fed.		1.32	9.50	13.77	24.59	96.21	1.37	8.06	14.76	24.21	96.26
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.		1.62	11.11	16.00	28.73	112.40	2.34	10.78	20.30	33.41	132.84
50% NP/fed.		1.28	7.60	11.60	20.47	80.09	1.26	5.57	11.66	18.48	73.48
50% NP + 3 kg Nr + 2 kg Pr/fed.		1.19	9.00	13.00	23.19	90.73	1.11	7.61	13.47	22.18	88.19
50% NP + 3 m^3 biochar/fed.		1.02	8.17	12.27	21.45	83.92	0.84	7.12	10.72	18.68	74.27
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.		1.14	8.72	12.83	22.69	88.77	1.02	7.66	12.22	20.90	83.10
L.S.D. at **0.05** level		**0.45**	**2.50**	**2.07**	**3.52**	-	**0.28**	**1.11**	**1.76**	**2.10**	-
The interaction between cultivars and combination among mineral NP, biofertilizers and biochar											
Balady	100% NP/fed.	1.17	9.67	10.88	21.72	100.00	1.75	8.18	15.00	24.93	100.00
	100% NP + 3 kg Nr + 2 kg Pr/fed.	1.26	10.88	11.67	23.81	109.62	2.05	10.22	18.95	31.22	125.23
	100% NP + 3 m^3 biochar/*fed*.	1.20	9.66	11.33	22.19	102.16	1.83	8.73	15.63	26.19	105.05
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	1.38	11.67	12.67	25.72	118.42	2.53	12.82	20.68	36.03	144.52
	75% NP/fed.	0.78	6.67	9.77	17.22	79.28	1.33	5.49	10.75	17.57	70.48
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	1.25	10.67	11.33	23.59	108.61	1.93	9.19	16.33	27.45	110.11
	75% NP + 3 m^3 biochar/fed.	1.12	9.33	10.67	21.12	97.24	1.22	7.95	14.26	23.43	93.98
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	1.33	11.33	12.33	24.99	115.06	2.24	10.60	19.88	32.72	131.25
	50% NP/fed.	1.63	7.33	8.86	17.83	82.09	1.21	5.30	11.33	17.84	71.56
	50% NP + 3 kg Nr + 2 kg Pr/fed.	0.93	8.67	10.67	20.27	93.32	1.09	7.49	13.31	21.89	87.81
	50% NP + 3 m^3 biochar/fed.	0.80	7.67	9.86	18.33	84.39	0.89	7.17	11.33	18.17	72.88
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	0.88	8.34	10.33	19.55	90.01	1.00	8.15	12.11	21.26	85.28
Sids 40	100% NP/fed.	1.60	9.92	17.88	29.40	135.36	1.66	8.39	15.32	25.37	101.76
	100% NP + 3 kg Nr + 2 kg Pr/fed.	1.87	10.67	19.33	31.87	146.53	2.09	10.50	19.61	32.20	129.16
	100% NP + 3 m^3 biochar/*fed*.	1.72	10..13	18.33	30.18	138.76	1.89	8.88	16.25	27.02	108.38
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	1.95	11.33	19.83	33.11	152.22	2.55	11.29	20.78	34.62	138.87
	75% NP/fed.	1.18	9.33	14.33	23.84	109.61	1.98	6.36	16.01	24.35	97.67
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	1.87	10.33	18.66	30.86	141.89	1.97	10.18	17.81	29.96	120.18
	75% NP + 3 m^3 biochar/fed.	1.52	9.67	16,87	28.06	129.01	1.52	8.17	15.29	24.98	100.20
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	1.91	10.88	19.67	32.46	149.24	2.44	10.95	20.71	34.10	136.78
	50% NP/fed.	0.92	7.86	14.33	23.11	106.25	1.30	5.83	11.99	19.12	76.69
	50% NP + 3 kg Nr + 2 kg Pr/fed.	1.45	9.33	15.33	26.11	120.05	1.12	7.72	10.11	22.47	90.13
	50% NP + 3 m^3 biochar/fed.	1.23	8.67	14.67	24.57	112.97	0.79	7.07	13.63	19.19	76.97
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	1.40	9.11	15.33	25.84	118.80	1.04	7.17	12.33	20.54	82.39
L.S.D. at **0.05** level		**0.63**	**3.53**	**2.93**	**N.S.**	-	**0.39**	**1.57**	**2.48**	**2.97**	-

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein and Feddan (fed.) = 4200 m^2 = 0.42 hectare.

Yield and its components

Data in Tables 4 and 5 show that there were no significant differences between Balady and Sids 40 cultivars with respect to yields of grades 1 and 2 and total, marketable and exportable yields in the first season and yield of grades 3 and 4 in the second season. Sids 40 cultivar recorded higher total, marketable and exportable yields in the second season and average bulb weight in both seasons, than Balady. Likewise, Hassan (2002), Mohamed (2004), Al-Otayk et al. (2008), Abou El-Magd et al. (2014) and Osman(2015)found that theSids 40 plants gave the highest yield, compared with Balady garlic. On the contrary,El-Shabasi (2001) and Abdel-Razzak and El-Sharkawy (2013) found that garlic yield of Balady was significantly higher than Sids 40.

Concerning of the effect of the combinations among mineral NP, biofertilizers and biochar, obtained results in Tables 4 and 5 indicate that fertilized garlic plants with 100 or 75% mineral NP + Nr + Pr + biochar increased yields of grades 1, 2 and 3, and total, marketable and exportable yields/fed., as well as average bulb weight without significant differences among some treatments. The increases in total yield were about 18.72 and 13.58% for fertilizing with 100% mineral NP + Nr + Pr + biochar and 15.93 and 6.02% for the fertilizing with 75% mineral NP + Nr + Pr +biochar over the control in the first and second seasons, respectively. These results may be due to the role of biofertilizers i.e., Nitrobeine which fix atmospheric N and increase the available N to plant and the role of Phosphoreinon hydrolyzing the insoluble P into soluble one (SubbaRao, 1993). These results may be due to the simulative effect of the growth promoting substances released by P-solubilizing bacteria on root initiation and formation, rather than to the effect of soluble phosphorus. The favorable effect of N and P chemical fertilizers and biofertilizers on total yield and its components could be explained through the great role of these fertilizers in enhancing plant growth rate, which exert direct effect on the yield and its components. In addition, the positive effects of biochar on the productivity could be attributed to effects of biochar on improvements of: soil cation exchange capacity (Cheng et al., 2006), P and S transformations and turnover (Deluca et al., 2009), soil physical properties including pH (Yamato et al., 2006), water and nutrient retention (Chanet al., 2007, Novak et al., 2009), nutrients supply of plants (Silber et al., 2010), neutralization of phytotoxic compounds in the soil (Wardle et al., 1998), promotionof mycorrhizal fungi (Warnock et al., 2007) and alteration of soil microbial populations and functions (Kolton et al., 2011).

As for the effect of the interaction between cultivars and the combinations among mineral NP, biofertilizers and biochar, in general, data in Tables 4 and 5 indicate thatfertilized garlic plants with 100 or 75%mineral NP + Nr + Pr + biochar increased yields of grades 1, 2 and 3, and total, marketable and exportable yields/fed. for Balady cultivarin both seasons and for sids 40 in the firstseason, with no significant differences with fertilizing with 100% mineral NP + Nr + Pr with respect to Sids 40 cultivar, whereas fertilizing with 100% mineral NP + Nr + Pr + biochar increased yields of grades 1, 2 and 3,and total, marketable and exportable yields/fed.forSids 40 in the secondseason with no significant differences with 100% mineral NP + Nr + Pr and 100% mineral NP + 3 m^3 biochar/fed. As foraverage bulb weight, generally, fertilizing Sids 40 with 100 or 75% mineral NP + Nr + Pr + biocharincreased average bulb weight without significant differences with 100% mineral NP + Nr + Pr and 100% mineralNP + 3 m^3 biochar/fed.

Bulb chemical composition

There were no significant differences between Balady and Sids 40 cultivars with respect to contents of P, K, nitrate and total carbohydrates in bulbs at the harvest time (Table 6). Sids 40 cultivargave higher values of N and total protein in bulbs, than Balady. Similar trends were obtained by Shahien (1987) and Osman(2015) who, found that that Sids 40 produced markedly higher values N, protein and total carbohydrate contents in bulb. Besides, Shahien (1987) found that K content was higher in Balady than Sids 40, and there was no difference between both cultivars in P content. Also, Osman(1987)stated that Balady and Sids 40 plants did not show any significant effectin carbohydrate and protein contents.

Concerning the effect of the combinations among mineral NP, biofertilizers and biochar, data in Table (6) shows that the combinations among mineral NP, biofertilizers and biochar had no significant effect on N, P, total protein and total carbohydrates contents in garlic bulbs at the harvest time. Fertilizing garlic plants with 100 or 75% mineral NP + Nr + Pr increased K content in the bulbs without significant differences with

100% mineral NP + biocharandwith100%mineral NP + Nr + Pr + biochar. As for nitrate content, fertilizing with 50% mineral NP and with 50% mineral NP + biochar gave the lowest values of nitrates content in the bulbs.The favorable effect of biofertilizer on chemical constituents ofbulb garlic plants may be due tothe fact that nonsymbiotic bacteria have the abilitytosupplytheplantswith N, certain micronutrientsand phytohormones that could stimulate nutrients absorption and photosynthesis and thereby increase chemical contents in different plant tissues (Bashan and Holguin, 1997). Moreover, Jagnow et al. (1991) declared that, *Azotobacter* and *Azospirillum* strains produced adequate amounts of indole-3-acetic acid (IAA) and cytokinins, which increase the surface area perunit root length responsible for root hair branching with an eventual increase in the uptake of nutrients from the soil.

Theinteractionbetween cultivars and the combinations among mineral NP, biofertilizers and biocharhad no significant effect on N, P and total carbohydrates in the bulbs (Table 6). As for nitrate content, fertilized Sids 40 plants with 50% mineral NP and 50% mineralNP + biochar gave the lowest values of nitrates content in garlic bulbs. Fertilized Sids 40 plants with 100% mineral NP + Nr + Pr, 100% mineral NP + biochar and 100% mineral NP + Nr + Pr + biochar gave the highest values of total K and protein contents in the bulbs.

Feasibility Study

Presented data in Table 7 show that fertilized garlic plants Balady cultivar with 100% mineral NP+ Nr + Pr + biochar gave the highest net returns which were 17165 and 24075 Egyptian pounds/fed., followed by the fertilizing with 75% mineral NP + Nr + Pr + biochar which were 15550 and 23414 L.E./fed. in the first and second seasons, respectively. Whereas, fertilized Sids 40 cultivar with 100% mineral NP + Nr + Pr gave the highest values of net return of 14631 and 23026 L.E./fed., followed by fertilizing with 100% mineral NP + Nr + Pr + biochar which were 14817 and 22151 L.E./fed.in the first and second seasons, consecutively. Net return and benefits ratio for all the interaction treatments were higher in the secondseason than in the firstseason, and this may be due to the price for ton in the secondseason was higher than price for ton in the first season. Previous results suggested that the continous increase in the applied biofertilizers cannot be used as substitutes for mineral NP fertilizers at all to meet the needs of plants to mineral nutrients, but they can be used to a limit extend alongside the mineral fertilizers to replace or reduce the application of mineral NP fertilizers to about 25% in order to save the high cost of chemical fertilizers, as well as to decrease the pollution of the environment and/or to produce healthy food for human.

Conclusion

Finally from the previous results, it could be concluded that fertilization of garlic plants Sids 40 or Baldy cultivargrown in sandy soil (El-Kassasein region, Ismailia Governorate, Egypt) with 100 or 75% mineral NP + 3 kg Nitrobein + 2 kg Phosphorein + 3 m^3biochar/fed.is efficienttreatment for improving plant morphological characters, dry weight, yields of grades 1 and 2, and marketable, exportable and total yields/fed.witha good bulb quality. Treated garlic plants by using biochar positively enhanced plant growth, productivity and yield quality, compared to fertilization with mineral or biofertlizers inoculation alone. In general, using suchprevious treatments could reduce the costs and increase net return of garlic production and keeps the environment out of pollution.

Acknowledgements : Very special thanks and deep gratitude to Prof. Dr. A. Bardisi Ahmad, Professor of Vegetables and Head of Horticulture Department, Faculty of Agriculture, Zagazig University, Egypt for his valuable guidance continuous encouragements and going throughout the manuscript of this research.

Funding statements

The authors received no external funding for this study and have no conflicts of interest to declare. But, the authors are grateful to El-Kassasein Horticulture Experimental Station, Ismailia Governorate, Egypt, Horticulture Research Institute, Agricultural Research Center for providing research facilities to carry out this present work at its farm and laboratory.

Conflicts of interest

The authors agree that there is no conflict of interest to any destinations or personal up the date of publication of this research.

TABLE 4.Effect of cultivars, the combinations among mineral N P, biofertilizers and biochar and their interactions on yield and its components of garlic plants grown under sandy soil conditions during 2014/2015 season.

Treatments		2014/2015 season								
		Average bulb Weight (g)	Yield and its components (ton/fed.)							Relative Total Yield (%)
			Grade 1	Grade 2	Grade 3	Grade 4	Total Yield	Marketable	Exportable	
Cultivars										
Balady		45.33	1.580	2.463	1.740	1.445	7.225	5.781	4.040	100.00
Sids 40		60.41	1.606	2.502	1.478	1.694	7.280	5.586	4.107	100.76
L.S.D. at 0.05 level		**2.84**	**N.S.**	**N.S.**	**0.192**	**0.106**	**N.S.**	**N.S.**	**N.S.**	**-**
The combinations among mineral NP, biofertilizrs and biochar										
100% NP/fed.		53.98	1.717	2.518	1.304	1.530	7.067	5.538	4.234	100.00
100% NP + 3 kg Nr + 2 kg Pr/fed.		57.11	2.410	2.963	1.259	1.204	7.836	6.632	5.373	110.80
100% NP + 3 m^3 biochar/fed.		55.48	1.603	2.606	1.771	1.550	7.530	5.980	4.209	106.55
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.		62.44	2.451	2.693	2.027	1.220	8.390	7.170	5.144	118.72
75% NP/fed.		46.67	0.995	2.296	1.629	2.077	6.997	4.920	3.291	99.00
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.		56.31	1.700	2.839	1.131	1.357	7.027	5.670	4.539	99.43
75% NP + 3 m^3 biochar/fed.		51.98	1.615	2.754	1.683	1.654	7.706	6.052	4.369	109.04
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.		58.75	2.116	2.672	2.097	1.308	8.193	6.885	4.788	115.93
50% NP/fed.		43.00	0.800	1.976	1.769	2.233	6.778	4.545	2.776	95.91
50% NP + 3 kg Nr + 2 kg Pr/fed.		51.14	1.455	2.205	1.895	1.754	7.309	5.555	3.660	103.42
50% NP + 3 m^3 biochar/fed.		47.96	0.998	2.345	1.485	1.509	6.339	4.828	3.343	89.69
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.		49.69	1.237	1.924	1.262	1.441	5.863	4.423	3.161	82.96
L.S.D. at **0.05** level		**9.23**	**0.217**	**0.261**	**0.349**	**0.260**	**0.916**	**0.467**	**0.320**	**-**
The interaction between cultivars and combination among mineral NP, biofertilizers and biochar										
Balady	100% NP/fed.	46.43	1.852	2.472	1.359	1.492	7.175	5.683	4.324	100.00
	100% NP + 3 kg Nr + 2 kg Pr/fed.	48.11	2.570	2.754	1.092	1.567	7.656	6.416	5.324	106.70
	100% NP + 3 m^3 biochar/fed.	47.62	1.880	2.674	1.800	1.358	7.712	6.354	4.554	107.48
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	56.30	2.260	2.990	2.072	1.276	8.598	7.322	5.250	119.83
	75% NP/fed.	39.19	0.940	2.271	1.985	1.765	6.961	5.196	3.211	97.02
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	47.52	1.940	2.688	1.191	1.079	6.898	5.819	4.628	96.14
	75% NP + 3 m^3 biochar/fed.	44.72	1.450	2.931	1.877	1.431	7.689	6.258	4.381	107.16
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	50.21	1.948	2.983	1.987	1.074	7.992	6.918	4.931	111.39
	50% NP/fed.	37.18	0.750	1.990	2.093	1.885	6.718	4.833	2.740	93.63
	50% NP + 3 kg Nr + 2 kg Pr/fed.	43.82	1.160	2.073	2.015	1.542	6.790	5.248	3.233	94.63
	50% NP + 3 m^3 biochar/fed.	40.16	0.950	2.047	1.886	1.653	6.536	4.883	2.997	91.09
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	42.75	1.223	1.688	1.526	1.542	5.979	4.437	2.911	83.33
Sids 40	100% NP/fed.	61.52	1.582	2.563	1.248	1.240	6.960	5.393	4.145	97.00
	100% NP + 3 kg Nr + 2 kg Pr/fed.	66.10	2.250	3.172	1.425	1.168	8.015	6.847	5.422	111.70
	100% NP + 3 m^3 biochar/fed.	63.34	1.325	2.539	1.743	1.742	7.348	5.606	3.864	102.41
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	68.58	2.642	2.395	1.981	1.164	8.182	7.018	5.037	114.03
	75% NP/fed.	54.15	1.050	2.320	1.273	2.389	7.032	4.643	3.370	98.00
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	65.10	1.460	2.990	1.072	1.634	7.156	5.522	4.450	99.74
	75% NP + 3 m^3 biochar/fed.	59.23	1.780	2.577	1.489	1.876	7.722	5.846	4.357	107.62
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	67.29	2.284	2.361	2.207	1.542	8.394	6.852	4.645	116.99
	50% NP/fed.	48.81	0.850	1.962	1.445	2.580	6.837	4.257	2.812	95.29
	50% NP + 3 kg Nr + 2 kg Pr/fed.	58.45	1.750	2.336	1.775	1.966	7.827	5.861	4.086	109.09
	50% NP + 3 m^3 biochar/fed.	55.75	1.047	2.643	1.083	1.365	6.138	4.773	3.690	85.55
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	56.64	1.250	2.160	0.999	1.339	5.748	4.409	3.410	80.11
L.S.D. at **0.05** level		**13.05**	**0.307**	**0.369**	**0500**	**0.368**	**0.643**	**0.660**	**0.452**	**-**

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein and Feddan (fed.) = 4200 m^2 = 0.42 hectare.

TABLE 5.Effect of cultivars, the combinations among mineral N P, biofertilizers and biochar and their interactions on yield and its components of garlic plants grown under sandy soil conditions during 2015/2016 season.

Treatments		2015/2016season								
		Average bulb Weight (g)	Yield and its components (ton/fed.)							Relative Total Yield (%)
			Grade 1	Grade 2	Grade 3	Grade 4	Total Yield	Marketable	Exportable	
Cultivars										
Balady		44.24	1.390	1.741	2.034	1.582	6.747	5.165	3.131	100.00
Sids 40		59.68	1.549	2.123	1.995	1.497	7.136	5.639	3.644	105.76
L.S.D. at **0.05** level		**2.18**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.18**	**0.414**	**0.393**	-
The combinations among mineral NP, biofertilizrs and biochar										
100% NP/fed.		53.72	1.535	1.953	2.030	1.591	7.108	5.518	3.488	100.00
100% NP + 3 kg Nr + 2 kg Pr/fed.		57.71	1.720	1.960	2.305	1.479	7.630	6.152	3.847	107.34
100% NP + 3 m^3 biochar/fed.		54.38	1.458	2.350	2.163	1.470	7.274	5.804	3.641	102.34
100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.		61.35	1.887	2.198	2.690	1.299	8.073	6.775	4.085	113.58
75% NP/fed.		46.30	1.165	1.574	1.589	1.781	7.777	4.328	2.739	109.41
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.		53.94	1.511	2.181	2.155	1.325	7.172	5.847	3.692	100.90
75% NP + 3 m^3 biochar/fed.		50.69	1.490	1.952	1.990	1.569	7.000	5.432	3.442	98.48
75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.		56.73	1.787	2.128	2.274	1.348	7.536	6.188	3.914	106.02
50% NP/fed.		42.18	1.170	1.430	1.465	1.830	5.895	4.065	2.600	82.93
50% NP + 3 kg Nr + 2 kg Pr/fed.		50.34	1.409	1.871	1.880	1.646	6.805	5.160	3.279	95.73
50% NP + 3 m^3 biochar/fed.		47.75	1.218	1.695	1.775	1.594	6.282	4.688	2.913	88.38
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.		48.44	1.289	1.892	1.855	1.545	6.413	4.869	3.014	90.22
L.S.D. at **0.05** level		**4.20**	**0.218**	**0.500**	**0.258**	**0.480**	**0.381**	**0.324**	**0.287**	-
The interaction between cultivars and combination among mineral NP, biofertilizers and biochar										
Balady	100% NP/fed.	45.83	1.540	1.681	1.959	1.670	6.850	5.180	3.221	100.00
	100% NP + 3 kg Nr + 2 kg Pr/fed.	49.89	1.728	1.462	2.010	1.617	7.150	5.533	3.523	104.38
	100% NP + 3 m^3 biochar/fed.	46.23	1.220	2.383	2.013	1.597	6.880	5.283	3.270	100.44
	100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.	54.81	1.953	2.166	2.670	1.387	8.176	6.789	4.119	119.36
	75% NP/fed.	38.89	1.050	1.360	1.858	1.682	5.950	4.268	2.410	86.86
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	43.23	1.321	2.052	1.767	1.270	6.410	5.140	3.373	93.58
	75% NP + 3 m^3 biochar/fed.	43.27	1.520	1.728	1.990	1.512	6.750	5.238	3.248	98.54
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	47.12	1.843	2.150	2.433	1.534	7.960	6.426	3.993	116.20
	50% NP/fed.	36.94	0.990	1.260	1.730	1.770	5.750	3.980	2.250	83.94
	50% NP + 3 kg Nr + 2 kg Pr/fed.	42.80	1.267	1.691	1.880	1.662	6.500	4.838	2.958	94.89
	50% NP + 3 m^3 biochar/fed.	40.56	1.100	1.510	2.050	1.563	6.223	4.660	2.610	90.85
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	41.28	1.148	1.450	2.044	1.718	6.360	4.642	2.598	92.85
Sids 40	100% NP/fed.	61.61	1.530	2.225	2.100	1.512	7.367	5.855	3.755	107.54
	100% NP + 3 kg Nr + 2 kg Pr/fed.	65.52	1.711	2.459	2.600	1.340	8.110	6.770	4.170	118.39
	100% NP + 3 m^3 biochar/fed.	62.52	1.695	2.317	2.312	1.343	7.667	6.324	4.012	111.93
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	67.88	1.820	2.230	2.710	1.210	7.970	6.760	4.050	116.35
	75% NP/fed.	53.71	1.280	1.788	1.320	1.880	6.268	4.388	3.068	91.50
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	64.65	1.700	2.310	2.544	1.380	7.934	6.554	4.010	115.82
	75% NP + 3 m^3 biochar/fed.	58.12	1.460	2.175	1.990	1.625	7.250	5.625	3.635	105.84
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	66.33	1.730	2.105	2.115	1.624	7.112	5.950	3.835	103.82
	50% NP/fed.	47.41	1.350	1.600	1.200	1.890	6.040	4.150	2.950	88.18
	50% NP + 3 kg Nr + 2 kg Pr/fed.	57.88	1.550	2.050	1.880	1.630	7.110	5.480	3.600	103.79
	50% NP + 3 m^3 biochar/fed.	54.94	1.336	1.880	1.500	1.624	6.340	4.716	3.216	92.55
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	55.59	1.430	2.333	1.665	1.372	6.467	5.095	3.430	94.41
L.S.D. at **0.05** level		**5.94**	**0.308**	**0.707**	**0.385**	**0.679**	**0.539**	**0.459**	**N.S.**	-

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein and Feddan (fed.) = 4200 m^2 = 0.42 hectare.

TABLE 6.Effect of cultivars, the combinations among mineral N P, biofertilizers and biochar and their interactions on the chemical composition of bulbs at harvest time of garlic plants grown under sandy soil conditions during 2015/2016 season.

Treatments		2015/2016 season					
		Mineral content (%)			Nitrate content (mg/kg F.W.)	Total protein (g/100 g D.W.)	Total carbohydrates (g/100 g D.W.)
		N	P	K			
							Cultivars
Balady		1.89	0.304	1.65	1165.4	11.80	57.08
Sids 40		2.18	0.302	1.76	1157.3	13.65	52.01
L.S.D. at **0.05** level		**0.29**	**N.S.**	**N.S.**	**N.S.**	**2.03**	**N.S.**
The combinations among mineral NP, biofertilizrs and biochar							
100% NP/fed.		2.23	0.318	1.83	1264.0	12.87	52.58
100% NP + 3 kg Nr + 2 kg Pr/fed.		2.17	0.344	2.00	1146.5	14.63	62.58
100% NP + 3 m^3 biochar/fed.		2.23	0.332	1.91	1190.7	13.91	60.54
100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.		2.38	0.318	2.08	1340.5	14.88	63.60
75% NP/fed.		1.71	0.301	1.35	1245.2	10.71	48.77
75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.		2.20	0.321	1.96	1139.5	13.75	62.28
75% NP + 3 m^3 biochar/fed.		2.08	0.295	1.80	1240.5	13.00	54.17
75% NP + 3 kg Nr + 2 kg Pr+ 3m^3 biochar/fed.		2.05	0.338	1.67	1284.6	12.82	54.17
50% NP/fed.		1.62	0.251	1.27	976.0	10.13	51.27
50% NP + 3 kg Nr + 2 kg Pr/fed.		1.98	0.287	1.65	1093,5	12.35	49.27
50% NP + 3 m^3 biochar/fed.		1.87	0.283	1.42	960.0	11.66	43.88
50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.		1.92	0.251	1.51	1055.0	12.00	52.80
L.S.D. at **0.05** level		**N.S.**	**N.S.**	**0.21**	**166.8**	**N.S**	**N.S**
The interaction between cultivars and combination among mineral NP, biofertilizers and biochar							
Balady	100% NP/fed.	1.86	0.318	1.84	1155	11.62	54.78
	100% NP + 3 kg Nr + 2 kg Pr/fed.	2.12	0.341	2.04	1162	13.25	68.25
	100% NP + 3 m^3 biochar/*fed.*	2.05	0.327	1.96	1123	12.81	66.14
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	2.12	0.357	2.05	1370	13.25	68.94
	75% NP/fed.	1.56	0.268	1.22	1215	9.75	50.31
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	2.08	0.332	1.98	1153	13.00	67.40
	75% NP + 3 m^3 biochar/fed.	1.94	0.312	1.80	1261	12.13	53.18
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	1.92	0.342	1.60	1325	12.00	52.87
	50% NP/fed.	1.47	0.246	1.37	1049	9.19	51.19
	50% NP + 3 kg Nr + 2 kg Pr/fed.	1.89	0.278	1.56	1061	11.81	52.43
	50% NP + 3 m^3 biochar/fed.	1.79	0.278	1.28	1010	11.19	44.10
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	1.86	0.246	1.32	1100	11.63	55.23
Sids 40	100% NP/fed.	2.59	0.317	1.82	1373	14.12	50.38
	100% NP + 3 kg Nr + 2 kg Pr/fed.	2.23	0.346	1.96	1131	16.00	56.91
	100% NP + 3 m^3 biochar/*fed.*	2.40	0.337	1.86	1258	15.00	54.94
	100% NP + 3 kg Nr + 2 kg Pr+3 m^3 biochar/fed.	2.64	0.278	2.10	1311	16.50	58.26
	75% NP/fed.	1.87	0.333	1.48	1275	11.67	47.23
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	2.32	0.309	1.94	1126	14.50	57.16
	75% NP + 3 m^3 biochar/fed.	2.22	0.278	1.80	1220	13.88	55.16
	75% NP + 3 kg Nr + 2 kg Pr+ 3 m^3 biochar/fed.	2.18	0.333	1.74	1244	13.63	52.77
	50% NP/fed.	1.77	0.256	1.16	903	11.06	51.34
	50% NP + 3 kg Nr + 2 kg Pr/fed.	2.06	0.295	1.73	1126	12.88	46.10
	50% NP + 3 m^3 biochar/fed.	1.94	0.287	1.56	910	12.13	43.66
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	1.98	0.256	1.70	1010	12.38	50.38
L.S.D. at **0.05** level		**N.S.**	**N.S.**	**0.30**	**236**	**4.33**	**N.S.**

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein, and Feddan
(fed.) = 4200 m^2 = 0.42 hectare.

TABLE 7. Feasibility study for the effect of the interaction between cultivars and the combinations among mineral NP, biofertilizers and biochar applications of garlic plants grown under sandy soil conditions during 2014/2015 and 2015/2016 seasons.

Cultivars	Treatments: The combinations among mineral NP, biofertilizers and biochar	Treatment cost (Egyptian pounds/fed.)	Total production cost (Egyptian pounds/fed.)	Total cost (Egyptian pounds/fed.)	Total yield (ton/fed.)	Price (Egyptian pounds/ton)	Gross return (Egyptian pounds/fed.)	Net return (Egyptian pounds/fed.)	Benefit ratio
		2014/2015 season							
Balady	100% NP/fed.	814.2	7500	8314.2	7.175	3000	21525	13211	2.59
	100% NP + 3 kg Nr + 2 kg Pr/fed.	814.2	7500	8314.2	7.656	3000	22968	14654	2.76
	100% NP + 3 m^3 biochar/*fed.*	1054.2	7500	8554.2	7.712	3000	23136	14582	2.70
	100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.	1129.2	7500	8629.2	8.598	3000	25794	17165	2.99
	75% NP/fed.	610.7	7500	8110.7	6.961	3000	20883	12772	2.57
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	685.7	7500	8185.7	6.898	3000	20693	12507	2.53
	75% NP + 3 m^3 biochar/fed.	850.7	7500	8350.7	7.689	3000	23067	14716	2.76
	75% NP + 3 kg Nr + 2 kg Pr+ 3m^3 biochar/fed.	925.7	7500	8425.7	7.992	3000	23976	15550	2.85
	50% NP/fed.	407.1	7500	7907.1	6.718	3000	20154	12247	2.55
	50% NP + 3 kg Nr + 2 kg Pr/fed.	482.1	7500	7982.1	6.790	3000	20370	12388	2.55
	50% NP + 3 m^3 biochar/fed.	647.1	7500	8147.1	6.536	3000	19608	11461	2.41
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	722.1	7500	8222.1	5.979	3000	17937	9715	2.18
Sids 40	100% NP/fed.	814.2	8600	9414.2	6.960	3000	20880	11466	2.22
	100% NP + 3 kg Nr + 2 kg Pr/fed.	814.2	8600	9414.2	8.015	3000	24045	14631	2.55
	100% NP + 3 m^3 biochar/fed.	1054.2	8600	9654.2	7.348	3000	22044	12390	2.29
	100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.	1129.2	8600	9729.2	8.182	3000	24546	14817	2.52
	75% NP/fed.	610.7	8600	9210.7	7.032	3000	21096	11885	2.29
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	685.7	8600	9285.7	7.156	3000	21468	12182	2.31
	75% NP + 3 m^3 biochar/fed.	850.7	8600	9450.7	7.722	3000	23166	13715	2.45
	75% NP + 3 kg Nr + 2 kg Pr+ 3m^3 biochar/fed.	925.7	8600	9525.7	8.394	3000	25182	15656	2.64
	50% NP/fed.	407.1	8600	9007.1	6.837	3000	20511	11504	2.28
	50% NP + 3 kg Nr + 2 kg Pr/fed.	482.1	8600	9082.1	7.827	3000	23481	14399	2.58
	50% NP + 3 m^3 biochar/fed.	647.1	8600	9247.1	6.138	3000	18414	9167	1.99
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	722.1	8600	9322.1	5.748	3000	17244	7922	1.85
L.S.D. at **0.05** level		-	-	-	**0.643**	-	**3886**	**3886**	**0.45**
		2015/2016 season							
Balady	100% NP/fed.	814.2	7500	8314.2	6.850	4000	27400	19086	3.29
	100% NP + 3 kg Nr + 2 kg Pr/fed.	814.2	7500	8314.2	7.150	4000	28600	20286	3.44
	100% NP + 3 m^3 biochar/fed.	1054.2	7500	8554.2	6.880	4000	27520	18966	3.22
	100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.	1129.2	7500	8629.2	8.176	4000	32704	24075	3.79
	75% NP/fed.	610.7	7500	8110.7	5.950	4000	23800	15689	2.93
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	685.7	7500	8185.7	6.410	4000	25640	17454	3.13
	75% NP + 3 m^3 biochar/fed.	850.7	7500	8350.7	6.750	4000	27000	18649	3.23
	75% NP + 3 kg Nr + 2 kg Pr+ 3m^3 biochar/fed.	925.7	7500	8425.7	7.960	4000	31840	23414	3.78
	50% NP/fed.	407.1	7500	7907.1	5.750	4000	23000	15093	2.91
	50% NP + 3 kg Nr + 2 kg Pr/fed.	482.1	7500	7982.1	6.500	4000	26000	18018	3.26
	50% NP + 3 m^3 biochar/fed.	647.1	7500	8147.1	6.223	4000	24892	16745	3.06
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	722.1	7500	8222.1	6.360	4000	25440	17218	3.10
Sids 40	100% NP/fed.	814.2	8600	9414.2	7.367	4000	29468	20054	3.13
	100% NP + 3 kg Nr + 2 kg Pr/fed.	814.2	8600	9414.2	8.110	4000	32440	23026	3.44
	100% NP + 3 m^3 biochar/*fed.*	1054.2	8600	9654.2	7.667	4000	30668	21014	3.18
	100% NP + 3 kg Nr + 2 kg Pr+3m^3 biochar/fed.	1129.2	8600	9729.2	7.970	4000	31880	22151	3.28
	75% NP/fed.	610.7	8600	9210.7	6.268	4000	25072	15861	2.72
	75% NP + mineral NP + 3 kg Nr + 2 kg Pr/fed.	685.7	8600	9285.7	7.934	4000	31736	22450	3.42
	75% NP + 3 m^3 biochar/fed.	850.7	8600	9450.7	7.250	4000	29000	19549	3.07
	75% NP + 3 kg Nr + 2 kg Pr+ 3m^3 biochar/fed.	925.7	8600	9525.7	7.112	4000	28448	18922	2.99
	50% NP/fed.	407.1	8600	9007.1	6.040	4000	24160	15153	2.68
	50% NP + 3 kg Nr + 2 kg Pr/fed.	482.1	8600	9082.1	7.110	4000	28440	19358	3.13
	50% NP + 3 m^3 biochar/fed.	647.1	8600	9247.1	6.340	4000	25360	16113	2.74
	50% NP + 3 kg Nr + 2 kg Pr + 3 m^3 biochar/fed.	722.1	8600	9322.1	6.467	4000	25868	16546	2.77
L.S.D. at **0.05** level			-	-	**0.539**	-	**2156**	**2156**	**0.36**

N.S.: Not significant, 100% NP: 120 kg N + 90 kg P_2O_5, 75% NP: 90 kg N + 67.5 kg P_2O_5, 50% NP: 60 Kg N + 45 kg P_2O_5/fed., Nr: Nitrobein, Pr: Phophorein, and

Feddan (fed.)= 4200 m^2 = 0.42 hectare.

References

Abdel-Razzak, H.S. and El-Sharkawy, G.A. (2013) Effect of biofertilizer and humic acid applications on growth, yield, quality and storability of two garlic (*Allium sativum,* L.) cultivars. *Asian J. Crop Sci.,* **5** (1), 48 - 64.

Abou El-Magd, M.M., Zaki, M.F., Abo Sedera S.A. and El-Shorbagy, T.T. (2014) Evaluation of five garlic (*AlliumSativum,* L.) cultivars underbid-chemical and mineral fertilization. *Middle East J. Agric. Res.,* **3** (4), 926 - 935.

Abou El-Magd, M.M., El-Shourbagy, T. and Shehata, S.M. (2012) A comparative study on the productivity of four Egyptian garlic cultivars grown under various organic materials in comparison to conventional chemical fertilizer. *Aust. J. Basic & Appl. Sci.,* **6** (3), 415 - 421.

Akhtar, S.S., Li, G., Andersen, M.N. and Liu, F. (2014) Biochar enhances yield and quality of tomato under reduced irrigation. *Agric. Water Manag.,* **138**, 37- 44.

Al-Otayk, S., El-Shinawy, M.Z. and Motawei, M.I. (2008) Variation in productive characteristics and diversity assessment of garlic cultivars and lines using DNA markers. *Met., Env., Arid Land & Agric. Sci.,* **20** (1), 63 - 79.

Awasthi, R.P., Godara, R.K. and Kalth, N.S. (1998) Interaction effect of VA-*mycorrhiza* and *Azotobacter* inoculation on micro-nutrient uptake by peach seedlings. *Hort. J.,* **11** (2), 1-5. (C.F. Hort. Abstr., **66** (11), 9461.

Bashan, Y. and Holguin, G. (1997) *Azosprillium* plant relationship. *Environ. & Physiol. Adv. Can. J. Microbial,* **43**, 103-121.

Bhande, S.R., Sharma, S.B. and Chougule, A.B (1997) Effect of biofertilizer in combination with nitrogen through organic and inorganic sources on yield and quality of onion. *Natl. Hort. Res. Dev. Found.,* **17** (2), 1-3.

Biederman, L.A. andHarpole,W.S. (2013)Biochar and its effects on plant productivity and cycling: a meta-analysis. *G.C.B. Bioenergy,* **5**, 202 - 214.

Bouton, J.H., Albracht, S.L. and Zuberer, D.A. (1985) Screening and selection of plants for rootassociated bacteria nitrogen fixation. *Field Crop Res.,* **11** (2),131-140.

Bremner, J.M. and Mulvaney, C.S. (1982)Total nitrogen. In: Page, A.L.R.H. Miller and D.R. Keeney (Ed.)", *Methods of Soil Analysis*, Madison, W.I. U.S.A., pp.:595 - 624.

Cacciari, D.L., Pietrosanti, T. and Pietrosanti, W. (1989) Phytohormoneslike substances produced by single and mixed diazotrophic cultures of *Azospirillum* and *Arthrobacter*. *Plant & Soil,* **115**, 151-153.

Cafado, D.A., Haroon, M., Sharder, L.E. and Youn, V.L. (1975) Rapid colorimetric determination of nitrate in plant tissues by nitrification of salicylic acid comm. *Soil Plant Anal.,***6**,71-80.

Carter, S., Shackley, S., Sohi, S., BounSuy, T. and Haefele, S. (2013)The impact of biochar application on soil properties and plant growth of pot grown lettuce (*Lactuca sativa*) and Cabbage (*Brassica chinensis*). *Agron.,* **3**, 404 - 418.

Chan, K.Y., Van Zwieten, L., Meszaros, I., Downie, A. and Joseph, S. (2007) Agronomic values of greenwaste biochar as a soil amendment.*Australian J. Soil Res.,* **45**, 629 -634.

Cheng, C.H., Lehmann,J., Thies, J.E.,Burton,S.D. and Engelhard, M.H. (2006) Oxidation of black carbon by biotic and a biotic processes.*Organic Geochem.,***37**, 1477 - 1488.

Crane-Droesch, A., Abiven, S., Jeffery, S. and Torn, M.S. (2013) Heterogeneous global crop yieldresponse to biochar: a meta-regression analysis.*Environ. Res. Letters,* **8**, 1 - 8.

Dawood, A.R.A. (2011) A comparative study of growth, yield and storability of some garlic cultivars and clones under Assiut conditions M.Sc. *Thesis*, Fac. Agric., Assiut Univ., Egypt.

Deluca, T.H., MacKenzie, M.D. and Gundale, M.J. (2009) Biochar effects on soil nutrient transformations. In: Biochar for Environmental Management: *Sci. & Tech.* (Lehmann J., Joseph, S. ed.), *Earthscan*, London, U.K., pp.:251 - 270.

Elad, Y., Cytryn, E., Harel,Y.M., Lew,B.and Graber,E.R. (2011)The Biochar Effect: plant resistanceto biotic stresses. *Phytopathol Mediterr,* **50**, 335 - 349.

El-Habbasha, S.F., Hozayn,M. and Khalafallah,M.A. (2007) Integration effect between phosphoruslevels and biofertilizers on quality and quality yield of faba bean (*Viciafaba*, L.) in newly cultivated sand soils. *Res. J. Agric. Biol. Sci.,* **3** (6), 966 - 971.

El-Sayed, M.A.A. (2004) Studies on productivity of some garlic cultivars under Sinai conditions. M.Sc. *Thesis*, Fac. Agric., Cairo Univ., Egypt.

El-Shabasi, M.S.S. (2001) Effect of potassium and boron fertilizers on growth, yield, bulb quality andbulb storageability on garlic.*The 5th Arabian Horti.Conf., Ismailia, Egypt, March.,* 35 - 48.

El-Shaikh, K.A. (2005) Growth and yield of onion as affected by biofertilization, application of nitrogen and phosphorus fertilizers under south valley conditions.*Assiut J. Agric.Sci.,***36**(1), 37- 50

Gad El-Hak, S.H. and Abd El-Mageed,Y.T. (2000) Effect of nitrogen source on growth, yield, nitrate content and storage ability of two garlic cultivars. *El-Minia J. Agric. Res. Dev.,***20**(1), 115 -139.

Gaur, A.C. and Ostwal, K.P. (1972) Influence of phosphate dissolving bacilli on yield and phosphate uptake of wheat crop. *Indian J. Exp. Biol.*, **10**, 393- 394.

Graber, E.R., Harel, Y.M., Kolton, M., Cytryn, E., Silber, A., David, D.R.,Tsechansky, L., Borenshtein, M. and Elad,Y. (2010) Biochar impact on development and productivity of pepper and tomato grown in fertigated soilless media. *Plant Soil,***337**, 481- 496.

Hale, L.E. (2014) Biochar and plant growth promoting *Rhizobacteria* as soil amendments. *Ph. D. Thesis*, Univ. California Riverside, U.S.A.

Han, H.S. and Lee, K.D. (2005) Phosphate and potassium solubilizing bacteria effect on mineral uptake, soil availability and growth of eggplant. *Res. J. Agric. & Biol. Sci.,* **1** (2), 176 - 180.

Hassan, E.M.A. (2002) Studies on the effect of fertilization by chemical organic and biofertilizers ongrowth yield and quality of garlic (*Allium sativum,* L.) under new reclaimed soil. Ph.D. *Thesis*, Fac. Agric., Assiut Univ., Egypt.

Hassan, M.A.M., Osman, A.Z. and Abd El-Hamid, A.M. (1990) Studies on intercropping cultivar andplanting date of garlic. *El-Minia J. Agric. Res. Dev.,* **12** (2), 1065 - 1082.

Hosseny, M.H. and Mahmoud, Y.M. (2008) Evaluation of thirteen garlic ecotypes in newly reclaimed land underSohag condition. *Assiut J. Agric. Sci.,***5**, 93 - 106.

Hussein, M.S., El-Saeid, H.M. and Omar, E.A. (1995) Development of growth and yield of some lines of Chinese garlic. *Egypt. J. Hort.,* **22** (1), 19 - 30.

Jackson, M.L. (1970) Soil chemical analysis.Prentic Hall, Englewood Ceiffs, N.J.

Jagnow,G. Hoflhct, Grande Hoffman, K.H. (1991) Inoculation of non-Symbioticrhizosphere bacteria: Possibilities of increasing and stabilizing yields. *Angew Botanik,* **65**, 97-126.

James, C.S. (1995) Analytical chemistry of foods. *Blokie Acad. & Professional*, London.

Jeffery, S., Verheijen, F.G.A.,Van der Velde,M. andBastos, A.C. (2011) A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis. *Agric. Ecosystem. &Environ.,***144**(1),175 - 187.

Jha, P., Biswas, A.K., Lakaria,B.L. andRao,A.S. (2010) Biochar in agriculturepros pects and relatedimplications.*Curr. Sci.,***99**, 1218 - 1225.

Kolton, M., Meller Harel,Y., Pasternak, Z., Graber, E.R., Elad,Y.and Cytryn,E. (2011) Impact of biochar application to soil on the rootassociated bacterial community structure of fully developed greenhouse pepper plants. *Appl. & Enviro. Microbiol.,***77,** 4924 - 4930.

Mann, L.K. (1952) Anatomy of garlic bulb and factors affecting bulb development. Hilgardia,**21**(8), 95- 231.

Ministry of Economy (1963) Garlic exported guidance. Ministerial Oder No. 652.

Mohamed, S.I.A. (2004) Some studies to improve garlic productivity. Ph.D. *Thesis*, Fac. Agric., El-Minia Univ., Egypt.

Noel, T.C., Sheng, C., Yost, C.K., Pharis, R.P. and Hynes, M.E. (1996) *Rhizobium leguminosarum* as a plant growth promoting *Rhizobacterium* direct growth promotion of canola and lettuce. *Can. J. Microbiol,* **42** (3), 279-283.

Novak, J.M., Busscher,W.J., Laird, D.L., Ahmedna, M., Watts, D.W. and Niandou, M.A.(2009) Impact of biochar amendment on fertility of a southeastern coastal plain soil. *Soil Sci.,***174**, 105 - 112.

Olsen, S.R. and Sommers, L.E. (1982) Phosphorus In: Page, A.L., R.H. Miller and D.R. Keeney (Eds.). Methods of soil analysis. Part 2. *Amr. Soc. Agron.,* Madison, WI, U.S.A., 403 - 430.

Osman, A.Z. (1987) The effect of some agricultural treatments on yield and quality of garlic (*Alliumsativum,* L.). Ph.D. *Thesis*, Fac. Agric., El-Minia Univ., Egypt.

Osman, Y.M.M. (2015) Effect of some foliar application on yield, quality and storability of garlic. *M.Sc. Thesis*, Fac. Agric., Ain Shams Univ., Egypt.

Paleg, L.G. (1985) Physiological effects of gibberellins. *Ann. Rev. Plant Physiol.,* **16**, 291-322.

Perkins, F.(1994) Practical cost benefit analysis: basic concepts and applications. Macmillan Education, San Marino.

Schulz, H. and Glaser, B. (2012) Effects of biochar compared to organic and inorganic fertilizers on soilquality and plant growth in a greenhouse experiment. *J. Plant Nutri. & Soil Sci.,* **175** (3), 410 -422.

Sethi, R.P. and Subba Rao, N.S. (1968) Solubilization of tricalcium phosphate and calcium phytate by soil fungi. *J. Gen. Appl. Microbiol,* **14**, 329-331.

Shahien, A.H.M. (1987) Effect of some agricultural treatments on garlic yield. M.Sc. *Thesis*, Fac. Agric., Zagazig Univ., Egypt.

Silber A., Levkovitch,I. and Graber,E.R. (2010) pH-Dependent mineral release and surface properties of corn straw biochar: Agronomic implications. *Enviro. Sci. Tech.,* **44** (24), 9318 - 9323.

Snedecor, G.W. and Cocharn, W.G.(1980) *Statistical Methods*, 7thed., Iowa State Unv., Press, Ames., Iowa, U.S.A.

Subba Rao, N.S. (1988) Biofertilizers in agriculture. Oxford and TBH Publ. Co. Ltd. New Delhi, Bombay, *Calcutta,* 134 -141.

Subba Rao, N.S. (1993) *Biofertilizers in Agriculture*, 3rded., Oxford and TBH Publ. Co. Ltd., New Delhi, Bombay, *Calcutta,* 219 p.

Sun, F. and Lu, S. (2014) Biochar improve aggregate stability, water retention and porespace properties of clayey soil. *J. Plant Nut. Soil Sci.,***177** (1), 26 -33.

Tawfik, K.M. (2008) Evaluating theseofrhizobacterin on cowpea plants grown under saltstress. *Res.J. Agric. & Biol. Sci.,* **4** (1), 26- 33.

Tien, T.M., Gaskins, M.H. and Hubble, D.H. (1979) Plant growth substancesproduced by *Azospirillumbarsilense* and their effect on growth of plants. *Appl. Environ. Microbiol.,* **37** (5), 1016 - 1024.

Wardle, D.A., Zackrisson, O. and Nilsson, M.C. (1998) The charcoal effect in Boreal forests: mechanisms and ecological consequences. *Oecologia*, **115** (3), 419 - 426.

Warnock, D.D., Lehmann, J., Kuyper, T.W. and Rillig, M.C. (2007) Mycorrhizal responses to biochar in soilconcepts and mechanisms.*Plant & Soil,* **300**, 9 - 20.

Yamato, M., Okimori, Y.Wibowo,I.F., Anshori,S. and Ogawa, M. (2006) Effects of the application of charred bark of Acacia mangiumon the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Sci. & Plant Nutr.,* **52** (4), 489 - 495.

(*Received* 11/06/2017;
accepted 14/12/2017)

تأثير إضافة الأسمدة المعدنية والمخصبات الحيوية والفحم الحيوي على إنتاج أصناف الثوم النامية تحت ظروف الأراضي الرملية

***محمد السيد عبدالسلام يوسف، *إبراهيم عبدالله سليم العسيلي و**داليا أحمد سامي نوار**
*قسم بحوث البطاطس والخضر خضرية التكاثر-معهد بحوث البساتين - مركز البحوث الزراعية
و**قسم البساتين - كلية الزراعة - جامعة الزقازيق – مصر.

إن الهدف الرئيسي من هذه الدراسة هو إنتاج محصول آمن ونظيف من الثوم؛لذلك أجريت هذه الدراسة خلال موسمى ٢٠١٥/٢٠١٤ و ٢٠١٦/٢٠١٥ بمنطقة القصاصيين (الإسماعيلية – مصر) لدراسة تأثير إضافة التوليفات المختلفة من الأسمدة المعدنية (النيتروجين والفوسفور)، والمخصبات الحيوية (النيتروبين والفوسفورين)، والفحم الحيوي (النباتي) علي إنتاج صنفين من الثوم النامي تحت ظروف الأرض الرملية. حيثسجل الصنف سدس ٤٠ أعلي القيم لقطرى البصلة وعنقها، والوزن الجاف لأجزاء النبات، والمحصول القابل للتسويق والكلى للفدان، وكذلك محتوى النيتروجين والبروتين في البصلة. وعند تسميد نباتات الثوم بإستخدام ٧٥٪ السماد المعدني النيتروجيني والفوسفاتي (٩٠ كجم ن + ٦٧,٥ كجم فو٢أ٥/فدان) + ٣ كجم نيتروبين + ٢ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان، أعطى أعلى القيم للنمو الخضري، والوزن الجاف لأجزاء النبات، ومحصول الفدان من أبصال الدرجة الأولى والثانية، والقابل للتسويق والتصدير والمحصول الكلي للفدان.أما التسميد بإستخدام ٥٠٪ سماد معدني (٦٠ كجم ن + ٤٥ كجم فو٢أ٥/فدان) + ٣ كجم نيتروبين+ ٢ ٪ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان فقد سجل أقل محتوى نيترات في الأبصال. كذلك، فقد أدى تسميد صنفي الثوم بإستخدام ٧٥٪ سماد معدني + ٣ كجم نيتروبين + ٢ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان إلى زيادة الوزن الجاف لأجزاء النبات، وكذلك المحصول ومكوناته. إن تسميد الصنف البلدي بإستخدام ١٠٠٪ سماد معدني (١٢٠ كجم ن + ٩٠ كجم فو٢أ٥/فدان)أو ٧٥٪ سماد معدني + ٣ كجم نيتروبين + ٢ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان سجل أعلى قيم لصافي العائد الكلي للفدان، يليه تسميد الصنف سدس ٤٠ بإضافة ١٠٠٪ سماد معدني + ٣ كجم نيتروبين+ ٢ كجم فوسفورين/فدان، ثم تسميد نفس الصنف بـ ١٠٠٪ سماد معدني + ٣ كجم نيتروبين + ٢ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان، على التوالى. لذلك،يمكن التوصية بتسميد نباتات الثوم بـ ١٠٠ أو٧٥٪ سماد معدني (نيتروجين وفوسفور) + ٣ كجم نيتروبين + ٢ كجم فوسفورين + ٣ م٣ فحم نباتي/فدان؛ حيث ثبت زيادة في النمو الخضري، والإنتاجية، وكذلك جودة الأبصال الناتجة. وأن إضافة الفحم النباتي للأرض المنزرعة بنباتات الثوم زاد النمو الخضري، وإنتاجية،وجودة الأبصال، وخفض تكاليف الإنتاج الكلية، ورفع قيمة العائد الكلى لزراعة الثوم، مع الحفاظ على البيئة من التلوث،مقارنة بمعاملات التسميد المعدني، أوالمخصبات الحيوية معا أومفردة.