35 *Egypt. J. Hort.* **Vol. 42,** No. 2, pp. 531- 543 (2015)

Influence of Compost, Humic Acid and Effective Microorganisms on Organic Production of Red Cabbage

S. A. Abd El-Aziz[*] and M. Z. El-Shinawy[**]
[*]*Central Lab of Organic Agriculture, Horticulture Research Institute, Agricultural Research Centre and* [**]*Horticulture Department, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.*

AN EXPERIMENT was conducted during the two successive winter seasons of 2012/2013 and 2013/2014, in the experimental farm of Arid Land Agricultural Research and Service Center (ALARC), Fac. of Agriculture, Ain Shams University, Cairo, Egypt. The present work aims to study the influence of humic acid and effective microorganisms (EM) on organic production of red cabbage (Lisa F_1 Hybrid) under sandy soil conditions. The rates of compost (100 and 150% as recommended dose of nitrogen) with and without additions of humic acid and effective microorganisms (EM) individually or in combinations, were investigated comparing to recommended dose of NPK as mineral fertilizer (control) on growth, yield and quality of red cabbage. The results showed that the rates of 100 and 150% compost + humic acid + EM and 150% compost + EM only gave significantly superior in growth, yield and some quality of red cabbage compared to recommended dose of NPK as mineral fertilizer. It is recommended that good organic production of red cabbage in sandy soil can be performed successfully using rate of 150% of compost plus EM with or without addition of humic acid or using 100% compost plus humic acid and EM.

Keywords: Red cabbage, Organic production, Compost, Humic acid, Effective microorganisms (EM).

Red cabbage is usually consumed fresh as an ingredient of coleslaws and mixed salads. Cabbage, a member of cruciferae, is one of the vegetables and an important source of food globally, it is a rich source of vitamin A and C (FAO, 2000). Consumption of cruciferous vegetables, such as cabbage, is known to reduce the risk of several cancers, especially lung, colon, breast, ovarian and bladder cancer. Research also reveals that crucifers provide significant cardiovascular benefits (Beecher, 1994).

Organic farming products are becoming very necessary in today's world to manage ecosystem health and to impart related human health benefits, world over there is growing demand for organic products. The organic areas in the whole world reached to 37.5 million hectares, whereas the cultivated organic area in Egypt is about 82000 hectares (FiBL and IFOAM, 2014). In the near future, the export of vegetable will focus on the organic production. Organic fertilizers can therefore be used to reduce the amount of toxic compounds (such as nitrates) produced from mineral fertilizers particularly in the fresh vegetables and improving the quality of leafy vegetables produced as well as human health (Worthington, 2001 and Mahmoud *et al.,* 2009). Fundamentals of organic farming technology is producing healthy fruits without the use of chemical fertilizers, synthetic hormones and pesticides, the means of achieving this target are through the soil becomes fertile by using compost and microorganisms to improve soil helping crops grow healthy and sturdy (Wakui, 2009).

The use of compost as organic fertilizer allows improvement in soil fertility, in addition to being excellent soil conditioner, improving their physical, chemical and biological, such as water retention, aggregation, porosity, increased the cation exchange capacity, increased fertility and improve life soil microbial, however, the value compound fertilizer depends on the material used as raw material (Miyasaka *et al.,* 1997, Ahmad *et al.,* 2008 and Fiorentino & Fagnano, 2011).

Humic acid has an essential role in agricultural processes. It increases cation exchange capacity and enhances soil fertility (Chen and Aviad, 1990), converting the mineral elements into forms available for plants (Stevenson, 1994). Humic substances lead to a greater uptake of nutrients into the plant root and through the cell membrane (Tipping, 2002). Humic substances may possibly enhance the uptake of minerals through the stimulation of microbiological activity (Mayhew, 2004).

The effective microorganisms (EM) inoculants are liquid microbial concoctions containing yeasts, actinomycetes, lactic acid and photosynthetic bacteria (Daly and Stewart, 1999). Most of the species in EM inoculants are heterotrophic and require organic sources of carbon and nitrogen for their nutrition. Therefore, EM inoculation has been more effective when applied in combination with organic materials to provide both carbon and nitrogen (Yamada and Xu, 2000). The microorganisms contained in the concoctions reportedly produce plant hormones, beneficial bioactive substances and antioxidants while solubilizing nutrients (Higa and Parr, 1994). The application of EM increases soil organisms those are beneficial for plant growth, resulting in more rapid mineralization of organic matter, suppression of soil-borne pathogens and increased crop yield and quality (Asia-Pacific Natural Network, 1995). Other studies have shown that inoculation of the agroecosystem with EM leads to an improvement in soil and crop quality in addition to higher crop yields (Higa and Parr, 1994, Li and Ni, 1995, Yan and Xu, 2002, Javaid, 2006, Khaliq *et al.,* 2006, Chantal *et al.,* 2010, Javaid & Mahmood, 2010, Javaid, 2011 and Ncube *et al.,* 2011). Therefore this work aimed to evaluate the ability of enhancing organic production of red cabbage by humic acid and effective microorganisms in presence of compost under sandy soil conditions.

Materials and Methods

The experiment was carried out in the experimental farm of the Arid Land Agricultural Research Center (ALARC), Faculty of Agriculture, Ain Shams

University, Egypt, during the two successive seasons of 2012/2013 and 2013/2014. The red cabbage (*Brassica oleracea* var. *capitata rubra*) seeds (Lisa F_1 Hybrid) were sown in the nursery on 11 and 7 November in the first and second seasons, respectively. The seeds were placed in the seedling trays, which were filled with peat moss and vermiculite 1:1 (v:v). Then the plants were transplanted in sandy soil on 13 and 11 of December in the first and second seasons, respectively. The experimental trial was conducted in washed sand in cement plots (1 m^2). Each plot included 6 plants in two lines, the distance between plants was 30 cm, were irrigated by drip irrigation. Emitter discharge rate was 4 L/hr. Chemical analyses of the experimental soil are in Table 1.

TABLE 1. Chemical analyses of the experimental soil.

pH 1:5	EC 1:10 dS/m	Cations meq/L				Anions meq/L			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{-}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.58	0.82	1.55	0.32	1.36	0.58	-	1.63	1.81	1.14

Two rates of compost 100 and 150% from nitrogen recommended dose in sandy soil at 70 kg N/feddan (fed = 0.4 ha) with and without addition of humic acid and effective microorganisms (EM) individually or in combinations were investigated for organic production of red cabbage comparing to conventional production (recommended dose of NPK) by mineral fertilizer (control). The compost was produced by Arid Land Agricultural Research and Service Center, Faculty of Agriculture, Ain Shams University. The chemical analyses of the used compost are illustrated in Table 2. The mineral fertilizers of NPK were applied according to Ministry of Agriculture and Land Reclamation (2009) as follow: 70 kg N/fed as 340 kg ammonium sulphate (20.5% N), 45 kg P_2O_5/fed as 290 kg calcium super phosphate (15.5% P_2O_5) and 48 kg K_2O/fed as 100 kg potassium sulphate (48% K_2O). Calcium super phosphate was added as one dose during soil preparation, whereas ammonium sulphate and potassium sulphate were added at three equal portions, during soil preparation, after 3 and 6 weeks from transplanting. Each quantity of compost (6.25 and 9.38 ton/fed as 100 and 150% of N recommended dose) were added as one dose during soil preparation. The diluted humic acid was prepared by adding 3 ml / L water. EM was produced by Ministry of Agriculture on liquid microbial concoction containing yeasts, actinomycetes, lactic acid and photosynthetic bacteria. The diluted EM was prepared by adding 2 ml concentrated EM with 2 ml molas / L water without chlorine for 24 hours (Yadav, 2002). The diluted solutions of humic acid and EM individually or in combinations were applied to the soil surface beside plants at 4 times after 2, 4, 6 and 8 weeks from transplanting as 2 liters for plot.

TABLE 2. Chemical analyses of the compost.

pH 1:5	EC 1:10 dS/m	O.M (%)	Macro elements (%)					Micro elements (ppm)			
			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu
7.74	5.32	32.40	1.12	0.71	1.40	1.26	0.63	3165	96	238	146

The Experimental Treatments
- Recommended dose of NPK as mineral fertilizers (RDMF) (control).
- 100% compost (100% C)
- 100% compost + humic acid (100% C + HA)
- 100% compost + EM (100% C + EM)
- 100% compost + humic acid + EM (100% C +HA + EM)
- 150% compost (150% C)
- 150% compost + humic acid (150% C + HA)
- 150% compost + EM (150% C + EM)
- 150% compost + humic acid + EM (150% C + HA + EM)

The experimental treatments were arranged in a completely randomized block design, with three replicates for each treatment, each replicate included 6 plants.

After 90 days from transplanting, the plants were harvested and total yield was recorded for each plot. Three plants were randomly chosen from each plot to measure fresh and dry shoot weight, stem diameter (under the first bottom leaf directly), stem length, outer leaf number, surround, length and weight of head. Also, head firmness and percentage of total soluble solids (TSS) were measured by using Pressure Tester and Digital Refractometer, respectively. Vitamin C in red cabbage heads was determined as described in FAO (1980). As well as, anthocyanin content was determined using spectrophotometer according to Geza *et al.* (1984). Red cabbage head content of macronutrient (N, P, K and Ca), micronutrient (Fe, Zn, Mn and Cu), and nitrate were determined in dry matter of head. Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). The K, Ca, Fe, Zn, Mn and Cu were determined spectrometrically using Phillips Unicum Atomic Absorption Spectrometer as described by Chapman and Pratt (1961). Nitrate content was determined using Brucine method reported by Holty and Potworowski (1972).

Data were statistically analyzed by the analysis of variance using one way ANOVA according to Snedecor and Cochran (1980) with using SAS package. Comparison of treatment means was done using Tukey test at significance level 0.05.

Results and Discussion

Plant growth

Data in Table 3 showed that 150% compost + HA + EM treatment gave the highest fresh and dry weights of red cabbage plants compared to other treatments. The treatments of 100% compost + HA + EM and 150% compost + EM ranked the second order with superior on recommended dose of mineral fertilizer treatment (control). The treatments of recommended dose, 100% compost + EM and 150% compost + HA came in the third order. The lowest fresh and dry weights of plants were obtained by 100% compost treatment only in both seasons. This trend was true in stem diameter property. On the other hand, there weren't significant differences among the treatments of recommended dose of mineral fertilizer, 100% compost + HA + EM and 150% compost + EM. Concerning properties of stem length and outer leaf number, there were no significant differences among all treatments. Generally, application of 150% compost + EM with or without HA and 100% compost + HA + EM significantly increased plant growth for red cabbage plants compared to the recommended dose of mineral fertilizer treatment. These effects could be a result of using high rate of compost with HA due to improving physical, chemical and biological properties of the soil (Chen & Avaid, 1990, Miyasaka *et al.,* 1997, Mayhew, 2004, Ahmad *et al.*, 2008 and Fiorentino & Fagnano, 2011). As well as, EM inoculation has more effect when applied in combination with organic materials to provide both carbon and nitrogen which are important for their nutrition (Yamada and Xu, 2000). Effective microorganisms produce plant hormones and beneficial bioactive substances that led to increase the plants growth (Higa & Parr, 1994, Chantal *et al.*, 2010 and Javaid, 2011).

TABLE 3. Effect of compost, HA and EM on fresh and dry weight of shoot (F & DWS), stem diameter, stem length and outer leaf number of red cabbage plants during 2012/2013 and 2013/2014 seasons.

Treatments	FWS kg / plant	DWS g / plant	Stem diameter (cm)	Stem length (cm)	outer leaf No
	First season				
RDMF (control)	1.18c	113c	3.38bc	4.13a	22.67a
100% compost	0.91e	87e	2.80e	3.97a	22.33a
100% compost + HA	1.08d	101d	3.12d	4.07a	22.67a
100% compost + EM	1.13cd	108cd	3.23cd	4.00a	22.00a
100% compost +HA + EM	1.31b	124b	3.43b	4.27a	22.67a
150% compost	1.06d	103d	3.17d	4.07a	21.67a
150% compost + HA	1.17c	114c	3.17d	4.17a	21.67a
150% compost + EM	1.27b	123b	3.55b	4.28a	23.67a
150% compost +HA + EM	1.42a	135a	3.86a	4.18a	23.33a
Second season					
RDMF (control)	1.26bc	115c	3.68bc	4.72a	23.40a
100% compost	0.97d	88e	3.02f	4.73a	22.91a
100% compost + HA	1.16c	102d	3.23ef	4.74a	23.26a
100% compost + EM	1.20c	108d	3.55cd	4.56a	23.19a
100% compost +HA + EM	1.37ab	126b	3.75bc	4.83a	24.07a
150% compost	1.22bc	104d	3.42de	4.64a	23.22a
150% compost + HA	1.26bc	115c	3.56cd	4.75a	23.72a
150% compost + EM	1.46a	124b	3.86b	4.86a	24.42a
150% compost +HA + EM	1.51a	137a	4.15a	4.87a	24.75A

Means in same column followed by similar letters are not statistically different at 0.05 level according to Tukey test.
RDMF = Recommended Dose Of Mineral Fertilizer
HA = Humic Acid
EM = Effective Microorganisms

Macro and micronutrients

Macronutrients content of red cabbage plants is shown in Table 4. The highest concentrations of N, P and K were produced by 150% compost plus EM with or without HA treatments followed by the recommended dose of mineral fertilizer and 100% compost + HA + EM treatments (Table 4). On the other hand, the lowest percentages of N, P and K in red cabbage plants were found with 100% compost without adding HA or EM treatment. While 150% compost with HA and EM individually or in combinations, recommended dose of mineral fertilizer and 100% compost + HA + EM treatments resulted in the highest percentages of Ca in red cabbage plants. On the contrary, 100% compost only gave the lowest Ca%.

TABLE 4. Effect of compost, HA and EM on macronutrient percent of red cabbage plants during 2012/2013 and 2013/2014 seasons.

Treatments	N (%)	P (%)	K (%)	Ca (%)
	First season			
RDMF (control)	3.42b	0.445cd	2.45bc	1.61ab
100% compost	2.23f	0.248g	1.32f	0.86f
100% compost + HA	2.50e	0.334f	1.67e	1.18e
100% compost + EM	3.08c	0.384e	2.03d	1.29d
100% compost +HA + EM	3.41b	0.435cd	2.45bc	1.59b
150% compost	2.87d	0.422d	2.29c	1.44c
150% compost + HA	3.23c	0.453c	2.35c	1.63ab
150% compost + EM	3.68a	0.516b	2.61ab	1.66ab
150% compost +HA + EM	3.73a	0.553a	2.78a	1.68a
	Second season			
RDMF (control)	3.55b	0.457b	2.52b	1.63b
100% compost	2.30f	0.255f	1.37e	0.88f
100% compost + HA	2.59e	0.343e	1.73d	1.20e
100% compost + EM	3.20d	0.395d	2.14c	1.41d
100% compost +HA + EM	3.55b	0.451bc	2.58b	1.62bc
150% compost	3.10d	0.424c	2.46b	1.55c
150% compost + HA	3.38c	0.466b	2.52b	1.67ab
150% compost + EM	3.85a	0.514a	2.81a	1.70ab
150% compost +HA + EM	3.91a	0.535a	2.99a	1.72a

Means in same column followed by similar letters are not statistically different at 0.05 level according to Tukey test.
RDMF = Recommended Dose Of Mineral Fertilizer
HA = Humic Acid
EM = Effective Microorganisms

Data in Table 5 indicated that applying 150% compost with or without HA or EM increased micronutrients content (Fe, Zn, Mn and Cu). Conversely, applying 100% compost without HA or EM decreased Fe and Zn content. Whereas, there were no significant differences among 100% compost without HA or EM treatments and recommended dose of mineral fertilizer treatment in plants content of Mn and Cu. These effects approximately were true in the two seasons. These results might be due to the beneficial effects of compost which increase cation exchange capacity of sandy soil to maintain nutrients in available form for plants (Miyasaka *et al*., 1997, Ahmad *et al*., 2008 and Fiorentino & Fagnano, 2011). Moreover, positive effects of humic acid and EM may increase the stimulation of microbiological activity and enhance the nutrients uptake by plant roots through solubilizing of nutrients (Stevenson, 1994, Higa & Parr, 1994, Tipping, 2002, Mayhew, 2004 and Ncube *et al*., 2011).

TABLE 5. Effect of compost, HA and on micronutrient concentration (ppm) of red cabbage plants during 2012/2013 and 2013/2014 seasons.

Treatments	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
First season				
RDMF (control)	111.87c	29.50c	26.67b	10.37c
100% compost	68.50e	20.43d	22.43b	8.20c
100% compost + HA	85.67d	22.53d	25.43b	9.37c
100% compost + EM	95.77d	23.37d	25.40b	9.03c
100% compost +HA + EM	109.87c	24.57d	26.10b	9.67c
150% compost	111.87b	30.50bc	36.27a	13.00b
150% compost + HA	140.77a	35.20a	38.27a	15.23ab
150% compost + EM	140.10a	34.17ab	37.00a	15.07ab
150% compost +HA + EM	143.37a	36.43a	38.93a	16.40a
Second season				
RDMF (control)	118.94bc	30.34cd	27.96b	10.74cd
100% compost	68.88e	21.01f	22.85c	8.50d
100% compost + HA	88.09d	23.17ef	26.66bc	9.71d
100% compost + EM	98.48d	24.03ef	26.63bc	9.36d
100% compost +HA + EM	113.18c	27.09de	27.36b	11.02cd
150% compost	128.77b	31.97bc	38.02a	13.54bc
150% compost + HA	146.78a	35.82ab	40.12a	15.90ab
150% compost + EM	147.62a	36.90a	38.79a	15.73ab
150% compost +HA + EM	151.07a	38.19a	40.81a	17.12a

Means in same column followed by similar letters are not statistically different at 0.05 level according to Tukey test.
RDMF = Recommended Dose of Mineral Fertilizer
HA = Humic Acid
EM = Effective Microorganisms

Yield and head quality

Data in Tables 6 and 7 revealed that 150% compost + HA + EM treatments gave the highest values of total yield, weight, surround and length of head compared to other treatments. The treatments of 100% compost + HA + EM and 150% compost + EM came in the second order that were superior compared to the recommended dose of mineral fertilizer treatment. The lowest values of total yield, weight, surround and length of head were obtained by 100% compost without HA or EM treatments in both seasons. These effects might be due to that most of microorganism species in EM inoculants are heterotrophic and require organic sources of carbon and nitrogen for their nutrition. Therefore, EM inoculation has more effect when applied in combination with organic materials (Yamada and Xu, 2000).

TABLE 6. Effect of compost, HA and EM on yield, weight, surround and length of red cabbage heads during 2012/2013 and 2013/2014 seasons.

Treatments	yield kg/m^2	Head weight kg	Head surround cm	Head length cm
	First season			
RDMF (control)	4.50cd	0.747c	39.33bc	18.50bcd
100% compost	3.47f	0.580e	35.33d	16.00f
100% compost + HA	4.12e	0.687d	37.33cd	17.17e
100% compost + EM	4.31de	0.720cd	38.67cd	18.00de
100% compost +HA + EM	5.01b	0.843ab	41.33ab	19.00abc
150% compost	4.11e	0.680d	37.67cd	18.17cd
150% compost + HA	4.53c	0.760c	39.67bc	18.50bcd
150% compost + EM	5.00b	0.840b	41.33ab	19.33ab
150% compost +HA + EM	5.27a	0.883a	43.33a	19.67a
Second season				
RDMF (control)	4.72c	0.836c	41.60c	18.90bc
100% compost	3.58f	0.629e	37.00e	16.20f
100% compost + HA	4.30e	0.753d	38.96d	17.47e
100% compost + EM	4.52d	0.783d	40.42cd	18.43d
100% compost +HA + EM	5.27b	0.905b	43.37b	19.28b
150% compost	4.32e	0.746d	39.63d	18.57cd
150% compost + HA	4.73c	0.834c	41.73c	18.86c
150% compost + EM	5.35b	0.933ab	44.06ab	19.85a
150% compost +HA + EM	5.55a	0.961a	45.117a	20.00a

Means in same column followed by similar letters are not statistically different at 0.05 level according to Tukey test.
RDMF = Recommended Dose of Mineral Fertilizer
HA = Humic acid
EM = Effective Microorganisms

TABLE 7. Effect of compost, HA and EM on firmness, TSS, vitamin C, anthocyanin and nitrate of red cabbage heads during 2012/2013 and 2013/2014 seasons.

Treatments	Firmness	TSS	Vit. C	Anthocyanin	NO_3
	Kg/cm^2	%	mg/100g	%	%
	First season				
RDMF (control)	6.50b	5.20bc	33.27cd	0.308de	0.340a
100% compost	5.27d	3.77e	32.07g	0.296h	0.062d
100% compost + HA	5.53cd	4.07e	32.47fg	0.300gh	0.067cd
100% compost + EM	6.13bc	4.63d	32.57ef	0.302fg	0.072cd
100% compost +HA + EM	6.70ab	5.60ab	33.67bc	0.312cd	0.079cd
150% compost	5.77cd	4.87cd	32.93de	0.304ef	0.091c
150% compost + HA	6.13bc	5.13bcd	33.80bc	0.313bc	0.117b
150% compost + EM	6.70ab	5.73a	34.23a	0.317ab	0.123b
150% compost +HA + EM	7.23a	5.93a	34.63a	0.321a	0.132b
	Second season				
RDMF (control)	6.32bc	5.10cd	32.99c	0.304b	0.350a
100% compost	5.05e	3.66g	31.67f	0.291e	0.062d
100% compost + HA	5.40de	3.95g	32.16e	0.295de	0.068d
100% compost + EM	5.96c	4.53f	32.40de	0.296cd	0.073cd
100% compost +HA + EM	6.48b	5.34bc	33.53b	0.307b	0.083cd
150% compost	5.52d	4.73ef	32.63d	0.299c	0.092c
150% compost + HA	6.05c	4.99de	33.49b	0.308b	0.118b
150% compost + EM	6.58ab	5.64ab	34.00a	0.314a	0.125b
150% compost +HA + EM	6.94a	5.77a	34.26a	0.316a	0.130b

Means in same column followed by similar letters are not statistically different at 0.05 level according to Tukey test.
RDMF = Recommended Dose of Mineral Fertilizer
HA = Humic Acid
EM = Effective Microorganisms

Application of 150% compost + EM with or without HA and 100% compost + HA + EM increased head firmness of cabbage, while 100% compost with or without HA and 150% compost only decreased head firmness, whereas other treatments were mediated. This effect could be resulted from the reduction of calcium concentration in the plant tissues that treated by100% compost with or without HA and 150% compost only (Table 4) where this element in plant tissue is located in the middle lamella, which give the strength to the cell wall, thus lead to an increase in head firmness as was reported by Marschner (1995). The same trend approximately was true with TSS, vitamin C and anthocyanin content in red cabbage heads in the two seasons. As increasing the rate of compost to 150% with HA and EM individually or in combinations increased TSS, vitamin C and anthocyanin content in red cabbage heads.

Generally, increasing of compost rate to 150% with addition of HA and EM significantly increased plant growth, yield and quality for red cabbage. The positive influences of this treatment may be due to the availability of nutrients in the soil, which lead to an increase in vegetative growth of plants (Table 3), that may result in accumulation of more carbohydrates enhancing yield and head quality. These results were supported by Li & Ni (1995), Asia-Pacific Natural Network (1995) on natural agriculture, Yan & Xu (2002) on peanut, Javaid (2006) on pea, Chantal *et al.* (2010) on cabbage, Javaid & Mahmood (2010) on soybean and Ncube *et al.* (2011) on tomato.

Concerning nitrate content in red cabbage heads in both seasons, all compost with or without HA and EM treatments reduced NO_3 content of red cabbage heads significantly comparing with the recommended dose of mineral fertilizer treatment. This explains that applying organic fertilizer decrease nitrate accumulation in vegetables as were found by El-Shinawy *et al.* (1999) and Abou-El-Hassan & Desoky (2013) on lettuce, Worthington (2001) on vegetables, Mahmoud *et al.* (2009) on cucumber and Shehata *et al.* (2010) on celery.

Conclusions

It could be concluded that organic production of red cabbage in sandy soil can be enhanced successfully by applying 150% of compost as recommended dose of nitrogen + EM with or without humic acid or using 100% compost + humic acid and EM to produce good yield, quality and healthy of red cabbage.

References

Abou-El-Hassan, S. and Desoky, A.H. (2013) Effect of compost and compost tea on organic production of head lettuce. *J. Appl. Sci. Res.,* **9** (11), 5650-5655.

Ahmad, R., Shehzad, S.M., Khalid, A., Arshad, M. and Mahmood, M.H. (2008) Growth and yield response of wheat and maize to nitrogen and L tryptophan enriched compost. *Pak. J. Bot.,* **39**(2), 541-549.

Asia-Pacific Natural Agriculture Network (1995) EM application manual for APNAN countries. M. Shintani (ed). Asia-Pacific Natural Agriculture Network Bangkok, Thailand. http://www.agriton.nl/apnanman.html.

Beecher, C. (1994) Cancer preventive properties of varieties of Brassica oleracea a review. *Am. J. Clin. Nutr.,* **59**, 1166S.

Chantal, K., Xiaohou, S. Weimu, W. and IroOngor, B.T. (2010) Effects of effective microorganisms on yield and quality of vegetable cabbage comparatively to nitrogen and phosphorus fertilizers. *Pak. J. Nutr.,* **9** (11), 1039-1042.

Chapman, H.D. and Pratt, P.F. (1961) *Methods of Analysis for Soil, Plant and Water,* Division of Agric. Sci., Calif. Univ.

Chen, Y. and Aviad, T. (1990) Effects of humic substances on plant growth. In: McCarthy P, Calpp CE, Malcolm RL. Bloom, Readings.ASA and SSSA, Madison, WI. pp. 161-186.

Daly, M.J. and Stewart, D.C.P. (1999) Influence of effective microorganisms on vegetable production and carbon mineralization a preliminary investigation. *Sust. Agr.,* **14**, 15-28.

El-Shinawy, M.Z., Abd-Elmoniem, E.M. and Abou-Hadid, A.F. (1999) The use of organic manure for lettuce plants grown under NFT conditions. *Acta Hort.*, **491**, 315-318.

FAO (Food and Agriculture Organization) (1980) Soil and Plant Analysis. *Soils Bulletin,* **38** (2) 250.

FAO (Food and Agriculture Organization) (2000) Statistical database food and Agricultural Organization of the United Nations, Rome, Italy.

FiBL and IFOAM (2014) The World of Organic Agriculture, Statistics and Emerging Trends.

Fiorentino, N. and M. Fagnano, (2011) Soil fertilization with composted solid waste: short term effects on lettuce production and mineral N availability. *Geophysical Research Abstracts,* Vol. **13**, p. 10520.

Geza, H., Parsons, G.F. and Maattick, L.R. (1984) Physiological and biochemical events during development and maturation of grape berries. *Am. J. Enol. Vitic.,* **35** (4), 220-227.

Higa, T. and Parr, J.F. (1994) Beneficial and effective microorganisms for a sustainable agriculture and environment.International Nature Farming Research Center, Atami, Japan. http://www.agriton.nl/higa.html.

Holty, J.G. and Potworowski, H.S. (1972) Brucine analysis for high nitrate Concentrations. *Enviro. Sci. Tech.***,** **8** (6), 835- 837.

Javaid, A. (2006) Foliar application of effective microorganisms on pea as an alternative fertilizer. *Agronomy for Sustainable Development,* **26**, 257-262.

Javaid, A. (2011) Effects of biofertilizers combined with different soil amendments on potted rice plants. *Chil. J. Agr. Res.,* **71** (1), 157-163.

Javaid, A. and Mahmood, N. (2010) Growth and nodulation response of soybean to biofertilizers. *Pakistan J. of Botany,* **42**, 863-871.

Khaliq, A., Abbasi, M.K. and Hussain, T. (2006) Effect of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan. *Bioresource Technology,* **97**, 967-972.

Li, W. and Ni, Y. (1995) Research and application of EM (effective microorganisms). *Chin. J. Ecol.,* **14**, 58-62.

Mahmoud, E.K., Abd EL-Kader, N., Robin, P., Akkal-Corfini, N. and Abd El-Rahman, L. (2009) Effects of different organic and inorganic fertilizers on Cucumber Yield and Some Soil Properties. *World J. Agric. Sci.,* **5** (4), 408-414.

Marschner, H. (1995) "*Mineral Nutrition of Higher Plants*" 2^{nd} ed., Academic press. New York. pp. 243-244.

Mayhew, L. (2004) Humic substances in biological agriculture [Online].Available at www.acresusa.com/toolbox/reprints/Jan04_Humic%20Substances.pdf.

Ministry of Agriculture and Land Reclamation (2009) Symptoms of nutrient deficiency on some field and horticultural crops. Soils, Water and Enviro. Res. Inst., Agric. Res. Center.

Miyasaka, S., Nakamura, Y. and Okamoto, H. (1997) Yield and nutrient absorption by lettuce by liming and fertilization mineral and organic soil. *Brazilian Horticulture,* **8** (2), 6-9.

Ncube, L., Mnkeni, P.N.S. and Brutsch, M.O. (2011) Agronomic suitability of effective micro-organisms for tomato production. *Afr. J. Agric. Res.,* **6**(3), 650-654.

Shehata, S.M., Abdel-Azem, H.S., Abou El-Yazied, A. and El-Gizawy, A.M. (2010) Interactive effect of mineral nitrogen and biofertilization on the growth, chemical composition and yield of celeriac plant. *European Journal of Scientific Research,* **47** (2), 248-255.

Snedecor, G.W. and Cochran, (1980) "*Statistical Methods*", 6^{th} ed., Iowa state university press, Ames., Iowa, U.S.A.

Stevenson, F.J. (1994) Humus Chemistry: Genesis, composition, reactions, 2^{nd}edition, John Wiley and Sons, Inc, New York.

Tipping, E. (2002) Cation binding by humic substances. Cambridge University Press, Cambridge, U.K.

Wakui, Y. (2009) Organic farming technology in Japan. The Japan Agricultural Exchange Council. Nikken Align Bldg. Nishi-Kamata, Ota-ku, Tokyo, Japan.

Watanabe, F.S. and Olsen, S.R. (1965) Test of an ascorbic acid method for determining phosphorus in water and Na HCO_3 extracts from soil. *Soil Sci. Soc. Amer. Proc.,* **29**, 677 – 678.

Worthington, V. (2001) Nutritional quality of organic versus conventional fruits, vegetables and grains. *J. Alternative Complent. Med.,* **7**, 161-173.

Yadav, S.P. (2002) Performance of effective microorganisms (EM) on growth and yields of selected vegetables. *Nature Farming & Environment*, **1**, 35-38.

Yamada, K. and XU, H.L. (2000) Properties and applications of an organic fertilizer inoculated with effective microorganisms. *Crop Prod.*, **3**, 255-268.

Yan, P.S. and Xu, H.L. (2002) Influence of EM Bokashi on nodulation, physiological characters and yield of peanut in nature farming fields. *J. Sus. Agric.*,**19**, 105-112.

(*Received* 8/10/2014;
accepted 10/2/2015)

تأثير الكمبوست وحمض الهيوميك والكائنات الحية الدقيقة النشطة على الإنتاج العضوى للكرنب الاحمر

سعد أبو الحسن عبد العزيز* و محمد زكى الشناوى**
*المعمل المركزى للزراعة العضوية - مركز البحوث الزراعية و**قسم البساتين - كلية الزراعة - جامعة عين شمس - القاهرة - مصر.

أجريت التجربة خلال موسمى شتاء متتاليين فى ٢٠١٣/٢٠١٢ و ٢٠١٤/٢٠١٣. فى المزرعة البحثية التابعة لمركز بحوث وخدمات الزراعة فى المناطق القاحلة بكلية الزراعة – جامعة عين شمس – جمهورية مصر العربية . يهدف هذا العمل لدراسة تأثير حمض الهيوميك والكائنات الحية الدقيقة النشطة على الإنتاج العضوى للكرنب الاحمر (هجين ليزا) تحت ظروف التربة الرملية.

تم دراسة استخدام الكمبوست بمعدلات ١٠٠ و ١٥٠ ٪ (من المعدل الموصى به من عنصر النيتروجين) مع او بدون اضافة حمض الهيوميك والكائنات الحية الدقيقة النشطة منفردة او مخلوطة ومقارنتها باستخدام المعدل الموصى به من الاسمدة الكيماوية لعناصر النيتروحين والفوسفور والبوتاسيوم من حيث النمو والمحصول وبعض صفات الجودة باالكرنب الاحمر.

أوضحت النتائج المتحصل عليها أن معاملات الكمبوست بمعدل ١٠٠ و١٥٠٪ مع اضافة حمض الهيوميك والكائنات الحية الدقيقة النشطة ومعاملة ١٥٠٪ كمبوست مع اضافة الكائنات الحية الدقيقة النشطة فقط اعطت تفوق معنوى فى النمو الخضرى والمحصول وبعض صفات الجودة فى رؤوس الكرنب الاحمر مقارنة بمعاملة المعدل الموصى به من السماد المعدنى (المقارنة).

توصى هذه الدراسة بامكانية الانتاج العضوى الجيد للكرنب الاحمر فى التربة الرملية باستخدام ١٥٠٪ من معدل الكمبوست الموصى به مع اضافة الكائنات الحية الدقيقة النشطة مع او بدون اضافة حمض الهيوميك. او باستخدام ١٠٠٪ كمبوست مع اضافة حمض الهيوميك والكائنات الحية الدقيقة النشطة.