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Assessing Organic Manure Efficiency Versus Mineral Fertilization with and without *Mycorrhiza* on Yield and Properties of Globe Artichoke (*Cynara scolymus* L.) Grown on a Clay Alluvial Soil in Egypt Delta

Nahla M. Morsy
Department of Sustainable Development of Environment and it's projects Management, Environmental Studies & Research Institute (ESRI), EL-Sadat City University, Egypt.
E-mail address: Nahla.morsy@esri.usc.edu.eg

ABSTRACT

A field experiment was conducted for two successive seasons (2015/2016 and 2016/2017) on globe artichoke (*Cynara scolymus* L.) cv. Fransawy in a randomized complete block, factorial. Factor 1 was manuring (M) treatments of mineral nutrients " as a reference treatment" "RT" (M1), farmyard manure "FYM" (M2), vermicompost "VC" (M3), chicken manure "CM" (M4) and biogas compost "BC" (M5). Factor 2 was Arbuscular mycorrhiza (A) with treatments of none (A0) and mycorrhiza (A1). Mineral fertilizations (kg ha^{-1}) were 124 N+65 P+200 K. Organic fertilization was on basis of applying 124 kg total N ha^{-1} of each source with the associated P and K in each. Rates of sources (kg ha^{-1}) were 34972.1 FYM, 4124.6 CM, 6887.9 BC and 7614.9 VC (as an average in both seasons). RT gave greater values of number of leaves, number of off-shoots, plant height as well as NPK contents and yield than any of the organic manures with relative yield production efficiency of 80.9, 76.7, 68.2 and 66.7 % for VC, CM, FYM and BC respectively relative to RT. Vesicular Arbuscular Mycorrhizal (VAM) caused increases in all parameters only under conditions of organic manuring.

Keywords: artichoke, mycorrhiza, farmyard manure, vermicompost, chicken manure, biogas, productivity

INTRODUCTION

Globe artichoke (*Cynara scolymus* L.) is an important vegetable crop in Egypt (Shams, 2014). Its immature inflorescence (head) is the edible part (Rouphael *et al.*, 2017). It is rich in inulin and vitamins (Frutos *et al.*, 2019), fibers, minerals (Lattanzio *et al.*, 2009), polyphenols (Fratianni *et al.*, 2007) and antioxidants (Liorach *et al,* 2002). Thus, it gained a high importance for export to the European markets (Barno *et al.*, 2011).

Although inorganic soluble fertilizers are commonly used for vegetable crops (Lampkin, 1990) in view of their quick utilization by plants (Vernon, 1999; Duhan *et al.*, 2017). However, the extensive fertilization contributed in environmental pollution (Abdelhafez *et al.*, 2012) besides their high cost of application (Horton and Manner, 2018). On the other hand, biofertilizers and organic amendments and fertilizers can be used as environment-friendly sources for plant nutrients although they may not be as efficient in crop production as chemical fertilizers (Farid *et al.*, 2014; Abdelhafez *et al.*, 2017; Alshaal *et al.*, 2019; Bassouny and Abbas, 2019; Wakindiki *et al.*, 2019). Organic manures such as compost are thought to improve the soil structure, aeration and support plants with slow release nutrient (Uddin *et al.*, 2009); however, the immature compost might have negative impacts on soils and plants (Duggan and Jones, 2016). Composting using worms is also thought to be a suitable alternative (Kumar *et al.*, 2015). This product has lower pH value and narrower C/N ratio as compared with the compost (Duggan and Jones, 2016). Biogas is another organic amendment that can increase soil fertility; hence improve the growth of plants (Farid *et al.*, 2018). Farmyard manure can increase enrich soil with nutrients (Nest *et al.*, 2016). All such organic amendments can enrich soil with nutrients (Abdelhafez *et al.*, 2018; Mupambwa and Mnkeni, 2018) and stimulate the microbial biomass activities in soil (Sradnick *et al.*, 2018). Mixed applications of these amendments can be more efficient in improving plant growth and yield (Farid *et al.*, 2018).

Phosphorus (P) affects plant productivity particularly in soil where its fixation occurs easily, such as many soils in Egypt (El-Katkat, 1992). Organic amendments can release P slowly upon their decomposition (Ahmed *et al.*, 2013). However, application of the organic treatments with no other amendments might not be the optimum solution to improve the availability of P. In this concern, mycorrhiza is one of the promising bio-techniques that can improve P uptake by plants (Ardakani *et al,* 2011and Mohamed *et al.*, 2019) such as artichokes (Ezz El-Din *et al,* 2010). This takes place through different mechanisms such as solubilizing soil P (Rai, 2006). Extended mycorrhiza hyphae can penetrate soil and increasing the absorption area of the plant roots (Wiedenhoeft, 2006). Applying VAM can increase N utilization by plants (Verzeaux *et al.*, 2017; Vadeboncoeur *et al.*, 2015 and Zhang *et al.*, 2018). The current study is aiming at assessing the effect of different organic amendments vermicompost, chicken manure, biogas compost or farmyard manure applications with or without VAM on yield and properties of Globe artichoke grown on a clay alluvial soil in Egypt Delta.

MATERIALS AND METHODS

Materials:

Both soils of the experimental fields were clay non-saline slightly alkaline alluvial soils; the main properties of the soils are given in Table 1. The manures and VAM fungi (*Glomus mosseae*) were obtained from Ain Shams University, Faculty of Agriculture. The main properties of the manures are given in Table 2.

Table 1. Main properties of soils of the fields of the experiment

Season	Sand	Silt	Clay	Texture	pH	EC	O.M	$CaCO_3$	N	P%	K
	%					(dS m^{-1})	gkg^{-1}				
2015	21.06	25.16	53.78	Clay	8.2	1.03	10.1	153	1.2	3.1	1.1
2016	21.25	26.21	52.54	Clay	8.5	0.95	11.3	144	1.4	4.2	1.3

pH in soil:water suspension (1:2.5), EC in soil paste extract

Table 2. Main properties of organic manures used in the experiment

Organic manure	Season 1				Season 2			
	Farmyard manure (FYM)	Chicken manure (CM)	Biogas manure (BC)	Vermi-compost (VC)	FYM	Chicken manure (CM)	Biogas manure (BC)	Vermi-compost (VC)
Total N (g kg^{-1})	3.0	31	19	15.7	4.3	29.0	17.0	16.8
Total P (g kg^{-1})	6.5	9.4	7.5	12.7	7.0	9.2	7.0	12.3
Total K (g kg^{-1})	5.5	10.0	6.0	5.9	5.7	9.0	5.8	5.7
Organic matter (g kg^{-1})	124	406	448	432	101	357	488	401
C/N ratio	25:1	8:8	10:3	10:7	23:1	9:1	10:5	11:1
Density kg m^{-3}	750	200	285	715	760	220	285	710
Organic manure (kg ha^{-1}) = 123.6 kg N/ha	41200.0	3987.1	6505.3	7872.6	28744.2	4262.1	7270.6	7357.1

The Field experiments:

A field experiment was carried out during the two successive seasons of 2015/2016 and 2016/2017 (one experiment for each season) in a private farm at Damalo village, Benha, Qalubia Governorate. Old crowns of globe artichoke (*Cynara scolymus* L.) cv. Fransawy (taken from the previous plants) were used as plant materials for propagation. The design was a randomized complete block, factorial (2 factors) with 3 replicates. Factor 1 was manuring (M) with the following treatments: mineral nutrients treatment " as a reference treatment" "RT" (M_1), farmyard manure "FYM" (M_2), vermicompost "VC" (M_3), chicken manure "CM" (M_4) and biogas compost "BC" (M_5) respectively. Factor 2 was Arbuscular mycorrhiza (A) with treatments of none (A_0) and mycorrhiza (A_1). Plants were planted at end of August. The plot included four ridges, 1 m wide and 4.0 m long with an area of 16 m^2. Three ridges were planted while the fourth was left without planting as a guard between plots. The old crowns were planted at a distance of 1 m apart on one side. The reference treatment was given mineral N at 124 kg N ha^{-1} as ammonium sulphate (206 g N kg^{-1}) + 65 kg P ha^{-1} as calcium superphosphate (68 g P kg^{-1}) + 200 kg K ha^{-1} as K-sulphate (400 g K kg^{-1}). Each of the organic manure treatments were given the manure so as to provide a total of 124 kg Nha^{-1}. Rates of organic manure applications "kg ha^{-1}" (based on their total N) were thus 34972.1 FYM, 4124.6 CM, 6887.9 BC and 7614.9 VC (as an average in both seasons); given during land preparation. Mineral N and K were given in three equal splits, 2, 3 and 4 months after planting while P was given with land preparation.

Data recorded:

1. Vegetative growth characteristics:

Five plants were randomly taken from each plot for determination of plant height, number of leaves and offshoots per plant at start of blooming (120 days after planting). Samples of leaves were oven dried at 70 C for 48 h, weighed, ground, then digested in a mixture. For determination of P and K, samples were digested in a mixture of conc. sulphuric and perchloric acids (2:1 ratio), and for N determination samples were digested with conc. sulphuric acid (Kjeldahl method). Laboratory analyses were carried out according to methods of AOAC (2000) Jackson (1973) and Black et al (1982), respectively.

2. Head yield and quality:

Five heads were taken randomly from each plot during every harvest period (early – late) in both seasons of study for measuring the head fresh weight and the average edible part fresh weight. Samples of the edible parts of heads were taken at beginning and end of harvest and dried 70 ^{O}C. Inulin concentration was determined according to Winton and Winton (1958) while fibers were determined according to AOAC (2000).

3. Statistical analysis

Analysis of variance (ANOVA) was performed using the SPSS program (2006). Significant differences between means were determined by Duncan's multiple range test at 5% according to Gomez and Gomez (1984).

RESULTS

Vegetative growth:

Table 3 reveals that application of mineral nutrients (RT) gave greater values of number of leaves, number of off shoots, plant height as well as NPK contents than any of the organic manure treatments. Treatments of the organic manure showed that vermicompost (VC), was the highest followed by chicken manure (CM) then farmyard manure (FYM) and the lowest was by biogas compost (BC). All treatments receiving VAM showed positive response. The positive effect of mycorrhiza occurred only where organic manures were applied, but not where mineral fertilization was given. Therefore, the effect of mineral fertilization was very pronouncing to show any response to the mycorrhiza addition.

Early and total yield:

Data in Table 4 show that application of the reference treatment (RT) of mineral nutrients combined with VAM gave the highest yields, surpassing the lowest yield given by FYM by 91.7 and 86.6% for early yield in seasons 1 and 2 respectively. The main effect of fertilization treatments shows that RT gave yields greater than any of the organic manures. The VC manure gave the highest of the organic manures followed by CM then FYM or BC. Relative total yields given by VC, CM, BC and FYM as compared with the RT yield were 80.9, 76.7, 68.2 and 66.7 % respectively (averages of the two seasons). The efficiency of the organic manures was particularly marked under conditions of VAM. The main effect of VAM shows that the mycorrhiza caused an average increase of 23.2% in early yield over the two seasons. The effect was pronounced under conditions of organic manuring. Where mineral fertilization was given, the VAM effect was very slight. The pattern of response regarding the total yield was rather similar to that of the early yield

Head weight:

Data in Table 4 show that RT combined with VAM gave the highest head weight surpassing the lowest head weight of the FYM treatment 6.4 and 7.0% for early yield in seasons 1 and 2 respectively. The main effect of fertilization treatments shows that RT gave weight per head greater than any of the organic manures. Among the organic manures, the VC source gave the highest head weight followed by CM then FYM and BC gave the lowest.

Table 3. Effect of mineral nutrients and organic manures with and without mycorrhiza on artichoke growth and its N, P and K contents

Organic manuring (M)	Arbuscular *mycorrhiza* (A)											
	Season 1			Season 2			Season 1			Season 2		
	A_0	A_1	Mean	A_0	A_1	Mean	A_0	A_1	Mean	A_0	A_1	Mean
	Number of leaves plant^{-1}						Plant height (cm)					
M_1	36.9a	37.6a	37.3A	38.5a	38.5a	38.6A	91.5 ab	94.2a	92.9A	92.2 abc	94.0a	93.1A
M_2	23.2c	31.6 ab	27.4C	27.6e	34.2abcde	31.0B	71.9f	85.4 bcd	78.6D	68.2e	85.9abcd	77.1C
M_3	28.8 bc	36.0a	32.4B	29.4bcde	35.9 ab	32.6B	83.0 cde	93.3a	88.1B	84.2 bcd	89.9 abc	87.1B
M_4	27.8bc	33.7 ab	30.7BC	28.9 cde	35.3 abc	32.1B	83.0 de	86.9abcd	85.0 BC	82.8 cd	89.4 abc	86.1B
M_5	25.4c	32.0 ab	28.7 BC	28.4 de	34.4abcd	31.4B	77.48 ef	88.5abcd	83.0C	79.7d	89.2abcd	84.5B
Mean	28.4B	34.2A		30.5B	35.7A		81.4B	89.7A		81.5B	89.7A	
	Number of offshoots plant^{-1}						N %					
M_1	1.32abcd	1.66abcd	1.49A	2.01 abc	2.08 ab	2.04A	1.499 b	1.766 a	1.632 A	1.510 b	1.664 a	1.587 A
M_2	0.39e	1.67abcd	1.03B	1.01 d	1.97 abc	1.49B	1.059 e	1.258 cd	1.158 D	1.071 f	1.295 cd	1.183 C
M_3	1.28 bcd	1.79 ab	1.54A	2.02 abc	2.23a	2.12A	1.280 cd	1.425 b	1.352 B	1.218 de	1.359 c	1.288 B
M_4	1.12 cd	1.92a	1.52A	1.84 bc	2.28a	2.06A	1.183 d	1.298 c	1.240 C	1.150 ef	1.368 c	1.259 B
M_5	1.12d	1.32abcd	1.22 AB	1.64c	1.96 abc	1.80AB	1.065 e	1.229 cd	1.147 D	1.074 f	1.296 cd	1.185 C
Mean	1.05B	1.67A		1.70B	2.10A		1.217 B	1.395 A		1.204 B	1.396 A	
	P %						K %					
M_1	0.265def	0.566 a	0.415 A	0.299cde	0.560 a	0.429 A	1.134 de	2.036 a	1.585 A	1.629 ab	1.904 a	1.766 A
M_2	0.211 f	0.291cde	0.251 D	0.202 f	0.314bcd	0.258 C	1.098 e	1.763abc	1.430 A	1.315 bc	1.140 c	1.227 C
M_3	0.292cde	0.383 b	0.337 B	0.242def	0.400 b	0.321 B	1.359bcde	1.779 ab	1.569 A	1.105 c	1.658 ab	1.381BC
M_4	0.246def	0.347 bc	0.296 C	0.275def	0.384 bc	0.329 B	1.315cde	1.745abc	1.530 A	1.372 bc	1.760 ab	1.566AB
M_5	0.224 ef	0.312bcd	0.268CD	0.215 ef	0.323bcd	0.269 C	1.328bcde	1.588abcd	1.458 A	1.349 bc	1.680 ab	1.514 B
Mean	0.247 B	0.379 A		0.246 B	0.396 A		1.246 B	1.782 A		1.354 B	1.628 A	

Notes: M_1, M_2, M_3, M_4 and M_5 are mineral nutrients (reference treatment 'RT'), farmyard manure (FYM), vermicompost (VC), Chicken manure (CM) and biogas compost (BC) respectively. A_0 and A_1 are none and mycorrhiza respectively.

Relative values of weight per head given by VC, CM, BC and FYM as compared with that given by the mineral source RT were 95.6, 93.8, 91.9 and 90.7 % respectively (averages of the two seasons). This pattern occurred particularly under conditions of VAM. The main effect of VAM shows that the mycorrhiza caused an average increase of 5.2 % for the early yield over the two seasons. Such positive effect of VAM occurred only where organic manuring was given; under conditions of mineral fertilization, there was no difference between the VAM and no VAM treatments. The pattern of response with regard to the total yield was rather similar to that of the early yield.

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Table 4. Effect of mineral nutrients and organic manures with and without mycorrhiza on artichoke yield

Organic manuring (M)	Arbuscular *mycorrhiza* (A)											
	First season			Second season			First season			Second season		
	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean
	Early yield (kg plant^{-1})						Total yield (kg plant^{-1})					
M_1	1.451ab	1.459 a	1.455 A	1.852ab	2.068 a	1.960 A	6.339ab	6.534 a	6.436 A	6.462ab	7.091 a	6.777 A
M_2	0.761 i	1.336 b	1.048 B	1.108 g	1.848abc	1.478 B	3.579 g	5.189cd	4.384 C	3.820 e	5.554 c	4.687 C
M_3	1.009 f	1.127def	1.068 B	1.442defg	1.593bcdef	1.517 B	4.595de	5.772bc	5.183 B	4.743 d	6.260bc	5.502 B
M_4	0.873ghi	1.134cde	1.0035b	1.431efg	1.751abcde	1.591 B	4.222 ef	5.937ab	5.080 B	4.019de	6.102bc	5.061BC
M_5	0.787 hi	1.021 ef	0.904 C	1.311 fg	1.471cdefg	1.391 B	3.926 fg	4.583de	4.255 C	3.751 e	5.761 bc	4.756 C
Mean	0.976 B	1.215 A		1.428 B	1.746 A		4.532 B	5.603 A		4.559 B	6.153 A	
	Weight head^{-1} (g)											
	Early yield						Late yield					
M_1	283.0 a	282.2 a	282.6 A	285.2 abc	290.8 a	288.0 A	259.5 a	260.6 a	260.1 A	245.7 ab	249.2 a	247.5 A
M_2	265.6 e	272.4 c	269.0 D	271.2 f	276.9 def	274.1 D	224.7 e	245.1 bcd	234.9 C	221.3 d	230.1 cd	225.7 B
M_3	271.6 c	281.7 a	276.7 B	277.9 def	287.8 ab	282.9 AB	243.7 cd	256.8 ab	250.3 AB	230.3 cd	238.9 abc	234.6 B
M_4	268.3 d	277.0 b	272.7 C	276.1 ef	283.7 bcd	279.9 BC	236.1 de	250.2 abc	243.2 BC	223.3 d	242.1 abc	232.7 B
M_5	268.5 d	276.1 b	272.3 C	274.9 ef	278.9 cde	276.9 CD	226.7 e	248.5 abc	237.6 C	224.7 d	233.3 bcd	229.0 B
Mean	271.4 B	277.8 A		277.1 B	283.6 A		238.1 B	252.2 A		229.1 B	238.7 A	
	Weight of edible part head^{-1} (g)											
	Early yield						Late yield					
M_1	82.71 ab	84.47 a	83.59 A	82.69 abc	91.68 a	87.18 A	69.26 a	70.68 a	69.97 A	74.22 ab	78.80 a	76.51 A
M_2	64.34 e	71.84 c	68.09 C	73.50 c	79.86 bc	76.68 B	53.81 e	62.99 cd	58.40 C	61.33 d	69.21 bc	65.27 C
M_3	67.74 cde	78.61 b	73.17 B	75.03 c	86.80 ab	80.91 A	62.72 cd	67.75 ab	65.23 B	71.22 bc	74.24 ab	72.73 AB
M_4	68.10 cde	70.04 cd	69.07 C	76.84 c	80.60 bc	78.72 B	60.73 d	65.39 bc	63.06 B	65.10 cd	75.92 ab	70.51 BC
M_5	66.03 de	71.88 c	68.95 C	73.38 c	80.20 bc	76.79 B	54.14 e	63.95 cd	59.04 C	66.93 cd	71.32 bc	69.12 BC
Mean	69.78 B	75.37 A		76.29 B	83.83 A		60.13 B	66.15 A		67.76 B	73.90 A	

***See notes of Table 3 for designation of treatments**

Weight of edible part per head

The highest weight of edible part per head (Table 4) was given by RT+VAM. The lowest was given by FYM in season 1 and by CM in season 2 for early yield. For the late yield the lowest was given by FYM in both seasons. For the early yield, the highest value surpassed the lowest by 31.3% for season 1 and 24.9% for season 2. Comparable percentages for the late yield were 31.5 for season 1 and

28.5% for season 2. The VC source gave the highest edible part per head among the organic sources, followed by CM then FYM and BC gave the lowest. This was particularly true where VAM was applied. Over the two seasons, VAM caused an average increase of 9.0 % for the early yield and 9.0 for the late yield. Higher positive effect of VAM occurred only where organic manuring was given since no such significant effect was obtained under conditions of mineral fertilization

Fiber and inulin contents in head:

The highest fibers and inulin were due to RT (Table 5). The lowest fiber content was given by VC or BC. For the early yield, the highest value surpassed the lowest by 14.3% for season 1 and 26.8% for season 2. The pattern of inulin content followed that of the fiber content. Application of VAM caused greater contents of fiber as well as inulin with average increase of 38.7 and 31.4% for seasons 1 and 2 respectively in early yield. In the late yield VAM caused lower increases of 6.3 and 5.4% in seasons 1 and 2, respectively

Table 5. Effect of mineral nutrients and organic manures with and without mycorrhiza on contents of fibers and inulin in artichoke (*Cynara scolymus*, L.)

Organic manuring (M)	Arbuscular *mycorrhiza* (A)											
	First season			Second season			First season			Second season		
	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean
	Fibers content (g kg^{-1} DW)											
	Early yield						Late yield					
M_1	2.20a	2.19a	2.20 A	2.29a	2.25a	2.27A	2.11a	2.31a	2.21 AB	2.15a	2.28a	2.21 A
M_2	2.16 ab	2.15 ab	2.16 AB	2.21 ab	2.18 ab	2.20A	2.24a	2.28a	2.26 AB	2.26a	2.26a	2.26 A
M_3	1.84 de	1.86 de	1.85B	1.80d	1.78d	1.79B	2.23a	2.12a	2.18A	2.22a	2.14b	2.18B
M_4	1.93 cd	1.94 cd	1.94B	1.97c	2.01c	1.99B	2.19a	2.24a	2.22 AB	2.21a	2.22a	2.22A
M_5	1.80e	2.04 bc	1.92B	1.81d	2.09 bc	1.95B	2.20a	2.24a	2.22B	2.23a	2.20a	2.21 A
Mean	1.99B	2.03A		2.02B	2.06A		2.19 A	2.24 A		2.21 A	2.22 A	
	Inulin content (g kg^{-1} DW)											
	Early yield						Late yield					
M_1	3.18c	4.34b	3.76B	3.24 de	4.22c	3.73D	2.44c	2.51 bc	2.48C	2.47 bc	2.58 ab	2.53A
M_2	3.01c	3.04c	3.03C	3.12e	3.15e	3.13 A	2.21e	2.28 de	2.25 AB	2.23e	2.30 de	2.27A
M_3	3.04c	5.38a	4.21 A	3.35d	5.44a	4.40B	2.34d	2.68a	2.51A	2.36 cd	2.65a	2.51A
M_4	3.21c	4.34b	3.78B	3.33d	4.43b	3.88B	2.54b	2.58b	2.56A	2.56 ab	2.60a	2.58A
M_5	3.21c	4.28b	3.75B	3.35d	4.33 bc	3.84C	2.44c	2.67a	2.56B	2.47 bc	2.64a	2.56A
Mean	3.10B	4.30A		3.28B	4.31A		2.39 A	2.54 A		2.42B	2.55 A	

***See notes of Table 3 for designation of treatments**

DISCUSSION

Application of the mineral fertilizer shows superiority in improving the nutritional status of artichoke as well as the growth parameters and yield components over the organic sources. This probably indicates that the readily soluble nutrients are still more preferable for artichoke use than the slow release organic sources in the clayey soils. Generally, the investigated soils are low in their organic matter content. Thus, application of organic amendments probably raised their content in soil of organic matter and this might in turn improve soil-water retention (Abdelhafez *et al.*, 2017), enrich soils with nutrients and increase the availability of non-labile forms of soil nutrients (Farid *et al.*, 2014 and 2018). Moreover, these amendments stimulate the activities of soil microorganisms (Sheng Mao, 2006) which in turn increase phytohormones, and; therefore, affect positively plant growth. Results obtained herein revealed that vermicompost is more preferable than the other organic sources for improving the growth and yield components of artichoke. This might take place because of its high content of nutrients as well as plant growth promoting substances (Bhattacharya and Chattopadhyay, 2002). Also, its low C:N ratio (Table, 2) guarantee rapid decomposition in soil while minimizes the competition between the microorganisms of organic matter and plant roots on the uptake of the available nutrients (Rai, 2006).

The favorable effect of VAM on increasing vegetative growth, NPK content in leaves, early and total yield beside of improving the quality of heads of artichoke is mainly attributed to its ability to increase the solubility of soil phosphorus; while, on the other hand, increases the surface area of absorption of soil nutrients by plant roots (Mohamed *et al.*, 2019), consequently produces activation energy to be utilized in metabolites and building the cells, as well as development of the plant (Rai, 2006). The obtained results are in accordance with those reported by Mohsen (2011) on garlic plants, Shams (2014) and Abdel Nabi *et al.* (2017) on artichoke as they found that early and total yield were enhanced by application of VAM to the soil, as compared with the un-inoculation plants.

Also, the superiority of Mycorrhiza may be due to symbiosis through greater and faster root structure development as well as through numerous mechanisms such as greater water absorption and a higher resistance to both parasite attacks on the root structure and different types of stress (Ezz El-Din *et al.*, 2010; Mohamed *et al.*, 2019). These effect are in good accordance with those of Shams (2014) on artichoke, and Gmaa (2015) on tomato.

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تقييم كفاءة السماد العضوي مقابل التسميد المعدني مع أو بدون الميكوريزا على المحصول وخصائص الخرشوف (*Cynara scolymus* L.) المنزرع فى تربة طميية طينية في دلتا مصر

نهلة مختار مرسى

قسم التنمية المتواصلة للبيئة وإدارة مشروعاتها ـ معهد الدراسات والبحوث البيئية – جامعة مدينة السادات – مصر

أجريت تجربة حقلية لموسمين متتاليين (٢٠١٦/٢٠١٥ و ٢٠١٧/٢٠١٦) على الخرشوف الفرنساوى *Cynara scolymus* L. حيث تم تنفيذ التجربة إحصائياً فى تصميم قطاعات كامل العشوائية وكان العامل الأول هو معاملة السماد من العناصر الغذائية المعدنية "كمعاملة مرجعية، السماد البلدى، الفيرمي كمبوست، سماد الدواجن و سماد البيوجاز وكان العامل الثانى هو الميكورهيزا الداخلية حيث تم معاملة النباتات إما بإضافة أو عدم إضافة الميكروهيزا. تم التسميد المعدني بمعدل ١٢٤كجم نيتروجين+ ٦٥ كجم فوسفات + ٢٠٠كجم بوتاسيوم للهكتار. كان التسميد العضوي على أساس إضافة ١٢٤ كجم نيتروجين للهكتار من كل مصدر من مصادر السماد العضوى مع الفوسفور والبوتاسيوم المصاحب في كل منهما. وكانت معدلات كل من السماد البلدى، سماد الدواجن، البيوجاز والفيرمى كمبوست هى (٣٤٩٧٢.١ ، ٤١٢٤.٦، ٦٨٨٧.٩، ٧٦١٤.٩ كجم للهكتار كمتوسط للموسمين، على التوالى. أعطت المعاملة المرجعية (السماد المعدنى) قيمًا أكبر لعدد الأوراق، عدد الخلفات، إرتفاع النبات، المحتوي من عناصر النيتروجين، الفسفور والبوتاسيوم وقد حقق السماد العضوى عائد من إنتاجى بلغ ٨٠.٩ %، ٧٦.٧ %، ٦٨.٢ %و ٦٦.٧٪ للفرمى كمبوست والدواجن والسماد البلدى والبيوجاز على الترتيب وذلك عند المقارنة بالمعاملة المرجعية. كما وجد أن استخدام الميكورهيزا حقق زيادات في جميع المعاملات فقط في ظل ظروف مصادر التسميد العضوي.

الكلمات المفتاحية: الخرشوف ، الميكوريزا ، السماد البلدى ، الفيرمي كمبوست ، سماد الدجاج ، سماد البيوجاز، الانتاجية.