Effect of NPK Rates and Inoculation with Mycorrhizal Fungi on Chamomile (*Matricaria chamomilla* L.) Plant in Sandy Soils

Abdallah, S. A. S.; M. A. M. Ali and T. O. M. El-Kashef
Plant Production Department, Faculty of Environmental Agricultural Sciences, Arish University

Received: *17/9/2018*

Abstract: This study was carried out during the winter seasons of 2014-15 and 2015-16 at The Experimental Farm of Environmental Agricultural Sciences Faculty, Arish University, North Sinai Governorate, Egypt. The aim of this work was to study the effect of different NPK rates (0.00, 22.4, 44.8 and 67.2 Kg/fed) and different Mycorrhizal fungi concentrations (0.00, 28, 56 and 84 g/fed) and their interactions on growth and chemical content of dry leaves (nitrogen, phosphorus, potassium), and fresh leaves content of chlorophyll A and B as well as dry flower content of oil of chamomile (*Matricaria chamomilla* L.) under sandy soil conditions. A Split plot design was used NPK rates were randomly arranged in main plots and the mycorrhizal fungi concentrations were randomly distributed in the sub plots, Drip irrigation was used. Distance between lines was 50 cm and between plants in the same row was 30 cm (28000 plant per fed). The obtained results showed that the highest values of vegetative growth (plant height, stem diameter, number of branches, fresh and dry weight of herb, root length, and root fresh and dry weight), flower traits (number of folwer/plant, flower fresh and dry weight, and flower diameter), chemical constituents (N, P, K), chlorophyll content (a & b), and essential oil percentage were achieved when chamomile plants treated with 67.2 kg NPK/fed or 84g/fed mycorrhizal fungi. The interaction results indicated that the highest values of all previous traits were recorded with plants fertilized with 67.2 kg NPK/fed and inoculated with mycorrhizal fungi at 84 g/fed.

Keywords: *Matricaria chamomilla*, Mycorrhizal fungi, NPK fertilization

INTRODUCTION

Chamomile (*Matricaria chamomilla* L.) has been widely grown in Europe and Iran and it is belongs to family Asteraceae (Farkoosh *et al*., 2011). In Egypt, the high quality of chamomile flowers and its production during the winter and the early spring months give the crop great opportunities for export to most Europe countries, especially, Germany. Thus, more efforts should be directed toward increasing the productivity of chamomile plant to meet the increment in exports by increasing the cultivated area especially in the promising lands such as North Sinai province.

Application of NPK fertilizer at optimum levels play a key role in growth and development of most physiological processes in the plant as described by Lambers *et al*. (2000)**.** Nitrogen has an essential role in plants as constituent of proteins, amino acids, nucleic acids, chlorophyll and growth hormones as reported by Russel (1988). The lack of nitrogen used by plants caused depressed of protein synthesis and as a result the plant growth is affected. Phosphorus plays specific roles in the conservation and transfer energy in plants. Also Phosphorus involved in root development processing (Yagodin, 1982). Potassium is known to be linked with carbohydrates metabolism, sugar translocation and cell division and development. Also, potassium increases the resistance of plants versus the drought, pests and diseases (Mengel and Kirkby, 1987).

The influences of NPK on different medicinal plants, however, was reported by Gomaa and Youssef (2007) on fennel, Anwar *et al*. (2010) on mint, Sabra (2014) on Khella, Hassan *et al*. (2015) on basil, Khalid and Shedeed (2015) on black-cumin, Milica *et al.* (2015) on coriander, anise and caraway. With regard to Asteraceae family, Ahmad *et al*. (2011) showed that application of NPK rates at 15:10:10 g m^{-2} caused the maximum values of plant height, flowers length, flowers fresh weight and flowers diameter for marigold plant. The similar results were in family Asteraceae by Massoud *et al*. (2016), Ahmed *et al*. (2017) and Ayemi *et al*. (2017) who found that NPK fertilization improved growth characteristics and essential oil of yarrow, chrysanthemum and gerbera plants, respectively.

The mutual relationship between the plant species and Arbuscular Mycorrhizal (AM) fungi improves the growth of plant especially under the adverse conditions (Farkoosh *et al*., 2011). This symbiotic association helps host plants to increase the uptake from immobile nutrient elements such as phosphorus, nitrogen, zinc and copper. Also, improve the resistance against the biotic and abiotic stress by induce plant hormones production such as cytokinins and gibberelins (Sharma, 2003). In addition, the symbiosis increases the resistance of AM plants to pathogens such as nematodes (Thangaswamy and Padmanbhan, 2006). Several studies concluded the properties of using the AM fungi in the cultivation of medicinal plants (Al-Amri *et al.,* 2016; Heidari and Deljou, 2014; Yaghoub and Weria, 2013; Zubek *et al*., 2012). Until now there are scarce studies for using AM fungi on chamomile plants. However, Farkoosh *et al*. (2011) found that chamomile plants inoculation with AM fungi significantly increased the vegetative growth, flower characteristics and oil yield and content compared with non-inoculated ones.

The aim of this work was to study the effect of NPK fertilization and arbuscular mycorrhizal (AM) fungi and their interaction on vegetative growth, some chemical constituents and essential oil percentage of chamomile (*Matricaria chamomilla* L.) plant under North Sinai conditions.

MATERIALS AND METHODS

This study was conducted during 2014/2015 and 2015/2016 seasons in the Experimental Farm of

Environ. Agric. Sci. Fac., Arish University, North Sinai Governorate under sandy soil conditions using drip irrigation system to study the effect of NPK rates combined with arbuscular mycorrhizal fungi concentrations on plant growth, essential oil percentage and some chemical constituents in *Matricaria chamomilla* L. plant.

The seeds of *Matricaria chamomilla* L. were sown in the nursery at September 1st in both seasons. Uniform seedlings (about 10 cm length) were transplanted at November 14th. Drip irrigation system was used. The chemical analysis of soil and underground water used for irrigation were carried out using Atomic Absorption Spectrophotometer according to Page (1982) and presented in Table 1.

This experiment included 16 treatments which were the combination of four NPK fertilization rates and four mycorrhizal fungi concentrations. Treatments were arranged in a split plot design with three replicates, where fertilization rates were randomly arranged in the main plots and mycorrhizal fungi concentrations were randomly arranged in the sub plots.

NPK fertilization was applied at rates of 0.00, 22.4, 44.8 and 67.2 kg/fed using a compound NPK fertilizer (20:20:20). The amount of chemical fertilizer treatments were divided into eight equal doses, the first dose was applied after two weeks from transplanting, whereas, the other seven doses were applied once every two weeks.

Mycorrhizal fungi vaccine was brought from Agriculture Research Center (ARC), Cairo, Egypt as a powder, mixed with sugar solution (as recommended on package), then added at rates of 0.00, 28.0, 56.0 and 84.0 g/fed before planting in seedlings hills.

The experimental unit area was 10.5 m^2 (21m long × 0.5 m wide), every treatment contained three dripper lines. The distance between lines was 50 cm and between drippers was 30 cm (between seedlings). Every experimental unit contained 50 plants (about 28000 plant per fed).

Table (1): Mechanical and chemical analysis of soil and underground water

Properties	Soil		Water
	1st season (2014/2015)	2nd season (2015/2016)	
Mechanical analysis	**Particular size distribution (%)**		
Clay	1.80	1.60	-
Silt	3.10	3.40	-
Fine sand	76.30	76.20	-
Coarse sand	18.80	18.80	-
Soil texture	Sandy soil	Sandy soil	-
Chemical analysis	**Soluble ions (meq.l^{-1}) (soil past extract)**		
Ca^{++}	3.03	2.10	18.10
Mg^{++}	2.11	2.20	20.18
Na^{+}	1.18	4.49	17.70
K^{+}	0.48	0.31	0.24
Cl^{-}	1.02	2.30	38.38
Co_3^{--}	-	-	-
Hco_3^{-}	2.00	2.40	6.23
So_4^{--}	3.78	4.40	11.61
EC(dsm^{-1})	0.68	0.91	5.62
pH (1:2.5)	8.10	8.20	6.69
Organic carbon (g.kg^{-1})	0.93	1.22	-
Organic matter (g.kg^{-1})	1.16	2.10	-
Ca CO_3 (g.kg^{-1})	3.95	3.95	-

Three randomly selected plants from each experimental unit were taken at harvest (started at September and finished at April) and the following data were recorded:

A) Vegetative growth characters; viz, plant height (cm), root length (cm), number of branches /plant, herb fresh and dry weight (g), root fresh and dry weight (g) and stem diameter (mm). B) Floral traits; viz, number of flowers, flower fresh and dry weight (g), and flower diameter (mm). C) Essential oil percentage (EO%) in the dry flower heads (it was determined in the second season by water distillation methods according to British Pharmacopoeia (1963). D) Chemical constituents; viz, Chlorophyll a and b (mg/gm) in fresh leaf samples according to Moran (1982), Also, nitrogen, phosphorus and potassium percentages in leaves of the dried herb were determined following the methods of Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Brown and Lilleland (1946).

All collected data were analyzed with analysis of variance (ANOVA) procedure using the General Linear Models (GLMs) procedures using SAS (SAS, 2004). Differences between means were compared by using Duncan multiple range test at 0.05 level (Duncan, 1955).

RESULTS AND DISCUSSION

1. Effect of NPK fertilizer rates:

1.1 Vegetative growth characteristics:

Data in Table (2) indicated that NPK rates affected significantly all vegetative growth traits in both seasons. The highest NPK fertilizer rate (67.2 kg/fed) resulted in the highest values of plant height, stem diameter, number of branches, herb fresh and dry weight compared with the control and other NPK treatments in both seasons, without significant difference than (44.8 kg/fed) NPK for number of branches in both season. The enhancing effect of NPK on plant growth may be due to that NPK play key role in increasing the phytotosynethetic corresponding to the increases of carboxylation rate and maximum electron transport rate (Mengel and Kirkby, 1987). Also, NPK increased the meristemaic activities and consequently the growth of plants (Lambers *et al*., 2000). The obtained results in the present study, generally, agreed with many researchers who indicated that the high rates of NPK resulted in higher values of different plants. Khalid and Shedeed (2015) reported that the application of high levels of NPK fertilizer (3:3:3) enhanced the vegetative growth expressed by plant height, leaf number, branch number and herb dry weight in *Nigella sativa* plant. Also, Massoud *et al*. (2016) showed that NPK at the rate of 3 g /pot was the most effective treatment in terms of average shoot length, plant fresh weight and plant dry weight compared with NPK at rates 1 or 2 g/pot in *Achillea millefolium*. In addition, Ayemi *et al*. (2017) indicated that the application of NPK ratio at 17:25.5:34 g/m^2 in Gerbera plant achieved the highest plant height, number of leaves/plant and plant spread compared to the control and other NPK rates. Other findings on chamomile plant indicated that the highest plant height resulted with application of NPK fertilizers at rates of 100:60:40 kg/ha in compared with non fertilizer plants Upadhyay *et al*. (2016), the maximum plant height, fresh and dry weight were obtained by using 200 kg urea/ha Hadi *et al.* (2015).

Table (2): Effect of NPK rates on vegetative growth of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / NPK(kg/fed)	Plant height(cm)	Stem diameter (mm)	No. branches	Herb fresh weight (g)	Herb dry weight (g)
			First Season		
Control	61.33 c	6.59 d	32.67 b	40.82 d	14.50 d
22.4	63.91 c	7.30 c	34.33 b	51.01 c	17.16 c
44.8	70.91 b	7.80 b	36.67ab	62.05 b	19.62 b
67.2	77.16 a	8.21 a	51.25 a	69.01 a	21.27 a
			Second Season		
Control	62.66 d	6.43 c	33.67 b	47.05 c	15.91 d
22.4	66.33 c	6.91 b	41.17 b	53.19 b	17.82 c
44.8	74.25 b	7.13 b	55.25 a	58.39 b	20.58 b
67.2	81.41 a	8.16 a	64.58 a	66.36 a	22.08 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

1.2 Root parameters:

Data in Table (3) indicated a significant effect for NPK treatments on root length (cm), root fresh and dry weight. Application of 67.2 kg/fed NPK had the highest value in all traits in both seasons, without significant difference than (44.8 kg/fed) NPK for root length and root dry weight in the first season. The promotive effect of NPK fertilizer on roots characteristics may be due to the key role of nitrogen in improving cell division and elongation which reflected on root elongation (Yagodin, 1982). The previous results appeared to be in general accordance with those reported by Vembu *et al*. (2010) who indicated that the application of NPK fertilizer at 30: 40: 40 kg/ha resulted in maximum root length, root fresh and dry weight in *Catharanthus roseus* plants. Also, Omotoso and Shittu (2007) on Okra reported that the highest root length was achieved with using NPK fertilizer at the rate of 150 kg/ha compared with unfertilizer plants or 300 kg/ha NPK.

Table (3): Effect of NPK rates on root parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / NPK(kg/fed)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
		First Season	
Control	11.16 b	4.04 d	2.05 b
22.4	11.75 b	4.61 c	2.35 b
44.8	12.66 a	5.54 b	2.74 a
67.2	12.91 a	6.12 a	3.04 a
		Second Season	
Control	9.75 c	3.22 c	1.65 c
22.4	10.91 b	4.57 b	1.83 bc
44.8	11.75 b	4.91 b	2.19 b
67.2	12.75 a	5.64 a	2.94 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

1.3 Flower parameters:

Data presented in Table (4) indicated that there were significant increases on all studies parameters; i.e., number of flowers/plant, flower fresh weight, flower dry weight and flower diameter due to the application of NPK treatments. Application of 67.2 kg/fed NPK had the highest value in all traits, without significant difference than applying 44.8 or 22.4 kg/fed NPK for flower diameter, while the control treatment had the lowest values in both seasons. The increase in flower parameters according to the application of NPK fertilizer may be due to their stimulatory effect on reserve growth which enhanced reserve food accumulation necessary for flowering and buds initiation. The obtained results seemed to be in general agreement with those reported by Ahmed *et al*. (2017) who indicated that the maximum plant height, number of flowers, flowers length, flowers weight as well as flowers diameter were recorded with NPK at a rate of 150:75: 135 kg/ha in the chrysanthemum plant. Also, Ayemi *et al*. (2017), they found that application of NPK fertilizer at the rate of 20:30:40 g /m^2had the highest number of flowers/plant and flower diameter in Gerbera plant. Moreover, Massoud *et al*. (2016) reported that increases of fresh and dry weight of inflorescences (g/plant) of yarrow plant were with application of NPK at a rate of 3 g /pot.

Table (4): Effect of NPK rates on flower parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / NPK(kg/fed)	No. Flowers/plant	Flower fresh weight (g)	Flower dry weight (g)	Flower diameter (mm)
		First Season		
Control	39.16 d	8.043 d	1.31 d	7.96 b
22.4	58.83 c	11.64 c	1.76 c	8.18 ab
44.8	65.83 b	12.50 b	2.09 b	8.42 ab
67.2	73.50 a	14.13 a	2.43 a	8.69 a
		Second Season		
Control	51.83 d	8.40 d	1.47 c	7.55 b
22.4	56.00 c	10.93 c	1.56 c	7.64 ab
44.8	68.50 b	12.51 b	2.17 b	7.74 ab
67.2	76.50 a	14.61 a	2.49 a	8.12 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

1.4 Chemical constituents and essential oil:

Data listed in Table (5) indicated a significant effect for NPK treatments on all studied traits; viz., dry leaves content of nitrogen, phosphorus, potassium, and fresh leaves content of chlorophyll (a and b) as well as flowers content of essential oil. There were no significant difference between the application of 44.8 kg/fed and 67.2 kg/fed of NPK fertilizer in both seasons on N content in both seasons, P content in the second season, and K content in the first and second season. As regard to chlorophyll content there were no significant differences among the three NPK rates in both seasons. This may suggest that nitrogen, phosphors and potassium play an important role in the physiological processes leading to the synthesis of leaf pigments.

Table (5): Effect of NPK rates on chemical constituents of *Matricaria chamomilla* leaves during 2014/2015 and 2015/2016 seasons and essential oil percentage in the second season (2015/2016)

Parameters / NPK(kg/fed)	N %	P %	K %	Chl. A	Chl. B	EO %
			First Season			
Control	0.320 c	0.017 c	1.88 c	2.02 b	6.83 b	-
22.4	0.369 b	0.020 b	1.99 bc	2.19 ab	6.98 ab	-
44.8	0.418 a	0.021 b	2.17ab	2.30 ab	7.08 ab	-
67.2	0.433 a	0.023 a	2.25 a	2.42 a	7.26 a	-
			Second Season			
Control	0.405 c	0.021 c	2.22 b	1.64 b	6.74 b	0.54 b
22.4	0.425 bc	0.024 b	2.41ab	1.89 ab	7.20 ab	0.51 b
44.8	0.461 ab	0.025 ab	2.48 a	2.05 a	7.45 a	0.47b
67.2	0.477 a	0.027 a	2.62 a	2.14 a	7.51 a	0.64 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

The obtained results matched well with those of Sarhan *et al*. (2002) on *Taxodium distichum* who demonstrated that NPK fertilization at the level of 9 g/pot (25:15:15) had a higher chlorophyll b, N and P in leaf contents. He added that the highest K content was obtained in plants supplied with 25:15:15 at the rate of 9 g/pot NPK. Also, Ahmad *et al*. (2011) stated that fertilizing marigold plants with NPK at the rates of 15:20:10, 5:20:10, and 10:20:10 g m^{-2} led to increase the content of nitrogen, phosphorus, and potassium in leaves. However, chlorophyll contents were higher in plants fertilized with 15:20:10 g m^{-2} NPK. Moreover, Janaki *et al*. (2016) found that the highest N, P and K contents in wild thyme (*Thymus serpyllum*) plants were produced with NPK at the rates of N (150 Kg urea /ha), P (250 kg phosphorus/ha) and K (150 kg potassium/ha). On the other side, Kozera *et al*. (2013) reported that the application of NPK at rates of 103.9, 209.8, 314.7 kg/ha significantly decreased the content of phosphorus and potassium in caraway fruits.

Results indicated that the highest essential oil percentage was recorded by application of 67.2 kg/fed NPK rate. This result was probably due to that nitrogen fertilization enhanced volatile oil, through playing direct or indirect role in the biosynthesis processes. The obtained results seemed to be in general agreement with those reported by Karami *et al*. (2008) on *Chamomilla recutita* who found that the cultivated plants fertilized with 90 kg/ha NPK had the maximum oil content, while, in the wild species the highest oil content was in control plants. Also, Massoud *et al*. (2016) found that the essential oil percentage reached the maximum values as a result to application of NPK at 3 g /pot. On the other side, Kozera *et al*. (2013) indicated that the application of NPK at rates of 103.9, 209.8, 314.7 kg/ha significantly decreased essential oil content in caraway fruits.

2. Effect of mycorrhizal fungi treatments:

2.1 Vegetative growth:

Data presented in Table 6 indicate significant effects for arbuscular mycorrhizal inoculation on all studied traits; viz., plant height, stem diameter, number of branches, herb fresh and dry weight. Application of 84 g/fed treatment had the highest value in all parameters in both seasons. The positive effects of the AM fungi on vegetative growth may be due to the increases of nutrient and water uptake, and photosynthesis process, production of growth regulating substances. The previous results are in a general accordance with those reported by Asrar and Elhindi (2011) who found that seedlings of marigold had higher highest values of plant height and shoot dry weight under well-watered and water-stressed plants due to the effect of AM fungi than non-mycorrhizal seedlings. Also, Siddur and Garampalli (2016) stated that the inoculation of *Centella asiatica* plants with three AM fungi encouraged higher number of leaves, shoot length and shoot weight in compared with non-mycorrhizal plants.

Table (6): Effect of mycorrhizal fungi on vegetative growth of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / A.M.(g/fed)	Plant height (cm)	Stem diameter (mm)	No. branches	Herb fresh weight (g)	Herb dry weight(g)
		First Season			
Control	49.58 d	6.13 d	24.67 b	28.74d	10.36 d
28	66.75 c	7.06 c	39.75 ab	52.47 c	15.08 c
56	75.08 b	7.74 b	43.00 a	60.50b	20.89 b
84	81.91 a	8.98 a	47.50 a	81.19 a	26.22 a
		Second Season			
Control	49.33 d	6.00 d	33.42 c	32.95d	12.49 d
28	67.08 c	6.87 c	56.08 ab	51.73 c	15.43 c
56	75.83 b	7.64 b	45.17 bc	63.68b	22.11 b
84	92.41 a	8.11 a	60.00 a	76.63 a	26.36 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

2.2 Root parameters:

Data illustrated in Table (7) indicated significant effect for AM fungi treatment on all studied traits; viz., root length, root fresh and dry weight. Application of 84 g/fed had the highest value in all traits parameters in both seasons. The increase in all traits of roots in this study may be due to that AM fungi enhanced plant growth. Also, mycorrhizal fungi caused plants' root system development by increasing microbial count, nutrient absorption and soil aggregate stability (Milleret *et al.,* 2009). The previous findings are in the same direction with those reported by Yadav *et al*. (2013) who observed that the root length and root fresh and dry weight of micropropgated *Glycyrrhiza glabra* plants significantly improved when inoculated with different AM fungi sources at the beginning of the acclimatization stage. Also, Zou *et al*. (2014) observed that, inoculation with AM fungi of *Poncirus trifoliate* significantly increased the root length and root projected area compared with non-mycorrhizal plants. Moreover, Heidari and Deljou (2014) stated that the maximum root dry weight was achieved with the inoculation of 5% AM fungi in Zinnia plants.

2.3 Flower parameters:

Data presented in Table (8) clarify significant effect for AM fungi treatment on all studied traits; viz., number of flowers/plant, flower fresh weight, flower dry weight and flower diameter. Application of 84 g/fed treatment had the highest value in all parameters in both seasons, without significant difference than 56 g/fed for flower diameter in the first season. The increases of flower parameters of plants could be attributed to the increase their absorption of nutrient elements such as phosphorus which is effective in plant blooming (Heidari and Deljou, 2014).These results are in harmony with those of Puschel *et al.* (2014) who found that AMF inoculation significantly increased number of flowers in *Gazani arigens* plants. Also, Asrar and Elhindi (2011) and Heidari and Deljou (2014) found that AM fungi inoculation increased the number of flowers in *Tagetes erecta* and zinnia plants, respectively.

Table (7): Effect of mycorrhizal fungi on root parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / A.M.(g.fed^{-1})	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
	First Season		
Control	9.75 d	2.80 d	0.92 d
28	11.91 c	3.84 c	1.73 c
56	12.91 b	6.20 b	3.33 b
84	13.91 a	7.47 a	4.19 a
	Second Season		
Control	7.58 d	2.46 d	0.85 d
28	11.08 c	3.27 c	1.55 c
56	12.16 b	5.31 b	2.50 b
84	14.33 a	7.30 a	3.73 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test

Table (8): Effect of mycorrhizal fungi on flower parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

Parameters / A.M.(g/fed)	No. Flowers/plant	Flower fresh weight (g)	Flower dry weight(g)	Flower diameter (mm)
		First Season		
Control	25.75d	4.59 d	0.55 d	6.83 c
28	47.75 c	8.85 c	1.16 c	8.19 b
56	67.58b	13.56 b	2.44 b	8.84 ab
84	96.25 a	19.30 a	3.44 a	9.40 a
		Second Season		
Control	20.58 d	3.99 d	0.80 d	5.94 c
28	51.66 c	9.60 c	1.55 c	7.91 b
56	84.00 b	13.91b	2.09 b	8.20 b
84	96.58 a	18.97 a	3.24 a	8.99 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

2.4 Chemical constituents and essential oil percentage:

Data presented in Table (9) showed significant effects for inoculation with mycorrhizal fungi on all studied traits; viz., nitrogen, phosphorus, potassium, chlorophyll (a and b) and essential oil percentage. Application of 84 g/fed treatment had the highest value of all parameters in both seasons, without significant difference than 56 g/fed for content of potassium and content of chlorophyll A in the first season. This result may be due to that AM fungi affects pigments and phosphorous content of host plant positively as reported by Asrar and Elhindi (2011)**.** The results also indicated that AM fungi treatment support a higher chlorophyll concentration and these results may be occurred by improving Mg^{+2} uptake (Giri *et al.,* 2003).

Table (9): Effect of mycorrhizal fungi on chemical constituents of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons and essential oil percentage in the second season (2015/2016)

Parameters / A.M.(g/fed)	N %	P %	K %	Chl. A	Chl. B	EO %
			First Season			
Control	0.245 d	0.015 d	1.33 c	1.53 c	5.97 d	-
28	0.282 c	0.019 c	2.05 b	2.04 b	6.90 c	-
56	0.419 b	0.021 b	2.37 a	2.64 a	7.42 b	-
84	0.595 a	0.026 a	2.53 a	2.72 a	7.86 a	-
			Second Season			
Control	0.368 d	0.019 d	1.79 d	1.10 c	6.13 c	0.50 bc
28	0.417 c	0.022 c	2.32 c	1.94 b	7.15 b	0.43c
56	0.456 b	0.026 b	2.59 b	2.19 b	7.61ab	0.59 ab
84	0.527 a	0.029 a	3.03 a	2.48 a	8.02 a	0.61a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test

The previous results are in harmony with those of Selvaraj *et al*. (2009) who observed that inclusion seven different AM fungi species significantly increased N, P, K and chlorophyll contents, as compared to non-inoculation of patchouli plants. Also, Yadav *et al*. (2013) indicated that the highest values of the leaves chlorophyll content in plants treated with AM fungi compared with untreated ones of *Glycyrrhiza glabra* plants. In addition, Karagiannidis *et al.* (2012) showed that the inoculated Mentha and Origanum plants with AM fungi had the higher N, P, K and contents compared with noninoculated plants.

Concerning essential oil percentage, the results indicated that application of 84 g/fed treatment had the highest value of essential oil percentage without no significant difference than 56 g/fed in the second season. These results are in the same line with those of Selvaraj *et al*. (2009) who found that the highest essential oil percentage content in the leaves were achieved with the inoculation of AM fungi in Patchouli plants compared with the non- inoculated plants. On the other hand, Badawy (2015) reported that the oil percentage had non significant change due to inoculation mycorrhiza in anise plant compared with no-inoculation plants.

3. Effect of interaction between NPK rates and mycorrhizal fungi on *M. chamomilla* plant:

3.1 Vegetative growth:

Data presented in Table (10) illustrate a significant effect for interaction between NPK rates and mycorrhizal fungi on all studied traits; viz., plant height, stem diameter, number of branches, herb fresh and dry weight. Application of 67.2 kg/fed NPK with 84 g/fed of AM fungi had the tallest plants, stem diameter, herb fresh and dry weight. The highest number of branches were recorded in plants treated with 44.8 kg/fed NPK with 84 g/fed of AM fungi without significant difference than 67.2 kg/fed NPK with 56 g/fed of AM fungi in the first season. These results are in harmony with those of Badawy (2015) on anise found that the highest plant height, plant fresh weight and plant dry weight were obtained in plants inoculation with AM fungi and 50% NPK fertilizer compared with control plants. Also, Chukwuka *et al.* (2017) proved that inoculation of cassava plants with 30 g of AM fungi plus 60 g of NPK significantly gave the highest plant height.

Table (10): Effect of interaction between NPK rates and Mycorrhizal fungi rates on vegetative growth of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons

NPK (kg/fed)	A.M.(g/fed) / Parameters	Plant height (cm)	Stem diameter (mm)	No. branches	Herb fresh weight (g)	Herb dry weight (g)
First Season						
Control	Control	42.33 I	5.36 h	29.00 bc	22.43 f	9.18 k
	28	60.00 fg	6.45 fg	23.33 bc	38.55 e	12.59 hi
	56	68.66 e	7.17def	19.33 c	41.88 e	15.22 fg
	84	74.33 cd	7.39 de	27.00 bc	60.42 d	21.01 e
22.4	Control	45.33 I	5.92 gh	30.33 bc	27.21 f	10.32 jk
	28	64.33 ef	6.83 ef	46.67abc	46.16 e	14.08 gh
	56	69.33 de	7.31 de	33.00 bc	57.94 d	21.17 de
	84	76.66 c	9.14 bc	49.00abc	72.75 bc	23.07 d
44.8	Control	52.33 h	6.40 fg	36.00bc	27.99 f	10.75 ijk
	28	67.33 e	7.47 de	37.33bc	61.49 d	16.57 f
	56	78.00 c	7.86 d	24.00bc	64.97 cd	21.72 de
	84	86.00 ab	9.48 ab	74.67 a	93.76 a	29.43 b
67.2	Control	58.33 g	6.83 ef	35.33 bc	37.33 e	11.17 ij
	28	75.33 c	7.48 de	30.00 bc	63.68 d	17.10 f
	56	84.33 b	8.62 c	70.33 a	77.23 b	25.43 c
	84	90.66 a	9.91 a	54.33 ab	97.83 a	31.37 a
Second Season						
Control	Control	35.33 h	5.07 h	30.67cde	24.29 j	9.21 j
	28	61.66 e	6.56 ef	38.00b-e	47.23 ghi	12.26 hi
	56	68.00 d	6.89def	21.67 e	52.74 e-h	19.39 e
	84	85.66 bc	7.22cde	43.33b-e	63.93 b-e	22.80 cd
22.4	Control	47.33 g	5.67 gh	26.67 de	29.14 j	11.20 ij
	28	60.66 e	6.68 ef	49.33bcd	48.94 fgh	16.26 f
	56	68.00 d	7.29cde	50.67bcd	61.23 c-f	21.00 de
	84	89.33 b	7.99abc	97.67a	73.45 bc	22.83 cd
44.8	Control	54.33 f	5.71 gh	33.33cde	36.05 ij	13.68 gh
	28	62.33 e	6.34 fg	37.00b-e	53.80 e-h	16.36 f
	56	83.33 c	7.96abc	54.33 bc	68.92 bcd	23.54 c
	84	97.00 a	8.50 a	56.00 bc	74.79 b	28.76 b
67.2	Control	60.33 e	7.58bcd	44.00b-e	42.32 hi	15.86 fg
	28	83.66 c	7.90abc	40.33b-e	56.98 d-g	16.87 f
	56	83.00 bc	8.44 ab	94.33 a	71.83 bc	24.53 c
	84	97.66 a	8.72 a	61.33 b	94.34 a	31.05 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test

3.2 Root parameters:

Data presented in Table (11) showed a significant effect for the interaction between NPK rates and mycorrhizal fungi rates on all studied traits; viz., root length, root fresh and dry weight. Regarding root length, application of 67.2 kg/fed NPK with 84 g/fed AM fungi had the highest record with no significant difference than 67.2 kg/fed NPK with 56 g/fed AM fungi in both seasons. Regarding root fresh weight, the highest value was with applying 67.2 kg/fed NPK with 84 g/fed AM fungi without significant difference than 44.8 kg/fed NPK with 84 g/fed AM fungi and 67.2 kg/fed NPK rates with 56 g/fed AM fungi in both seasons. Concerning root dry weight, there was no differences between application of 67.2 kg/fed NPK with 84 g/fed AM fungi and 67.2 kg/fed NPK treatments with 56 g/fed AM fungi in the first season and between 67.2 kg/fed NPK with 84 g/fed AM fungi, 44.8 kg/fed NPK with 84 g/fed AM fungi and 67.2 kg/fed NPK treatments with 56 g/fed AM fungi in the second season.

These results are in agreement with those of Abo-Rekab *et al*. (2010) who examined the effect of AM fungi and NPK fertilizer at rates of 1.5, 2.0 and 2.5 g/l on the date palm plantlets after one year from acclimatization stage. They found that the highest root length and number of roots were in plants treated with 2.5 g/l NPK with mycorrhiza compared with the control and other treatments.

Table (11): Effect of interaction between NPK rates and mycorrhizal fungi rates on root parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons.

NPK(kg/fed)	A.M.(kg/fed) / Parameters	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
First Season				
Control	Control	9.33 h	2.56 g	0.51 g
	28	11.00e-h	3.30 fg	1.46 def
	56	11.33 d-g	3.93 ef	2.91 c
	84	13.00 bcd	6.36 cd	3.31 bc
22.4	Control	9.66 gh	2.63 g	0.87 fg
	28	12.00 def	3.59 fg	1.59 def
	56	12.33 cde	5.81 d	3.16 bc
	84	13.00 bcd	6.43 cd	3.76 b
44.8	Control	9.66 gh	2.95 fg	1.07 efg
	28	12.33 cde	3.77 ef	1.78 de
	56	14.00 abc	7.18 bc	3.35 bc
	84	14.66 ab	8.25 a	4.75 a
67.2	Control	10.33 fgh	3.05 fg	1.23 efg
	28	12.33 cde	4.72 e	2.09 d
	56	14.00 abc	7.88 ab	3.90 b
	84	15.00 a	8.84 a	4.96 a
Second Season				
Control	Control	6.33 h	1.56 g	0.63g
	28	9.66 g	2.67 f	1.37d-g
	56	10.00 fg	3.86 de	1.78 de
	84	13.00 bcd	4.78 cd	2.83 bc
22.4	Control	6.66 h	2.68 f	0.63 g
	28	10.66 efg	3.20 ef	1.54 def
	56	12.33 cde	4.93 c	1.96 de
	84	14.00 abc	7.45 b	3.17 b
44.8	Control	7.66 h	2.74 f	0.92 fg
	28	11.66 def	3.54 ef	1.55 def
	56	13.00 bcd	5.30 c	2.16 cd
	84	14.66 ab	8.06 ab	4.16 a
67.2	Control	9.66 g	2.84 ef	1.21 efg
	28	12.33 cde	3.65 ef	1.73 def
	56	13.33 bcd	7.14 b	4.09 a
	84	15.66 a	8.92 a	4.75 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

3.3 Flower parameters:

Data presented in Table (12) showed a significant effect for interaction between NPK and mycorrhizal fungi on all studied traits; viz., flowers number/plant, flower fresh weight, flower dry weight and flower diameter. Application of 67.2 kg/fed NPK with 84 g/fed AM fungi had the highest values of all traits without significant difference than 44.8 kg/fed NPK with 84 g/fed AM fungi with for flower diameter in the first season. In this concern Ali and El-Mekawey (2006) indicated that the highest fresh and dry weight of yearly yield of inflorescence (g/plant) resulted in plants fertilizer with NPK fertilization plus farm yard manure of *Matricaria chamomilla* compared with the control plants.

Table (12): Effect of interaction rates between NPK fertilization and mycorrhizal fungi on flower parameters of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons.

NPK(kg/fed)	A.M.(g/fed) / Parameters	No. Flowers/plant	Flower fresh weight (g)	Flower dry weight (g)	Flower diameter (mm)
First Season					
Control	Control	19.66 h	2.68 I	0.40 I	6.72 e
	28	40.33 fg	4.74 h	0.73 ghi	7.95 cde
	56	46.66 fg	10.34 f	1.89 de	8.39 bcd
	84	50.00 ef	14.40 d	2.24 cd	8.77 abc
22.4	Control	22.66 h	4.69 h	0.48 I	6.75 e
	28	41.66 fg	7.56 g	1.20 fgh	8.13 cde
	56	66.33 d	14.04 d	1.91 de	8.77 abc
	84	104.66b	20.28 b	3.45 b	9.09 abc
44.8	Control	23.66 h	5.34 h	0.63 hi	6.92 de
	28	50.33 ef	10.78 f	1.22 fg	8.16 b-e
	56	78.33 c	13.33 de	2.68 c	8.92 abc
	84	111.0 ab	20.55 ab	3.85 ab	9.70 ab
67.2	Control	37.00 g	5.68 h	0.69 ghi	6.92 de
	28	58.66 de	12.34 e	1.52 ef	8.52 abc
	56	79.00 c	16.54 c	3.29 b	9.29 abc
	84	119.3 a	21.97 a	4.23 a	10.03 a
Second Season					
Control	Control	9.33 j	3.04 I	0.43 f	5.71 c
	28	39.66 h	8.15 g	1.31 de	7.83 b
	56	76.00 ef	9.85 efg	1.45 de	7.97 b
	84	82.33 de	12.57 d	2.68 bc	8.68 ab
22.4	Control	12.33 j	3.18 I	0.49 f	5.87 c
	28	39.66 h	9.38 fg	1.44 de	7.84 b
	56	76.00 ef	11.58 de	1.49 de	8.12 b
	84	96.00 bc	19.60 b	2.81 bc	8.73 ab
44.8	Control	24.66 I	4.57 hi	1.05 e	6.04 c
	28	58.00 g	9.85 efg	1.60 de	7.87 b
	56	88.33 cd	14.52 c	2.44 c	8.18 b
	84	103.0 ab	21.11 ab	3.59 a	8.87 ab
67.2	Control	36.00 h	5.17 h	1.21 e	6.15 c
	28	69.33 f	11.01 def	1.85 d	8.11 b
	56	95.66 bc	19.69 b	2.99 b	8.53 b
	84	105.0 a	22.58 a	3.90 a	9.70 a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

3.4 Chemical constituents and essential oil percentage:

Data presented in Table (13) showed a significant effect for interaction between NPK treatment and mycorrhizal fungi on all studied traits; viz., nitrogen, phosphorus potassium, chlorophyll and essential oil percentage. The highest contents of N, P, K and chlorophyll a & b were recorded with application of 67.2 kg/fed NPK and inoculation with 84 g/fed AM fungi without significant difference than 67.2 kg/fed NPK and 56 g/fed AM fungi for potassium percentage and chlorophyll a & b in both seasons. These results are in corroborate with Badawy (2015) who reported that plants treated with mycorrhiza plus 50 or 75% of NPK fertilizer had the highest N, P, K leaf content of anise plants. Also, Chukwuka *et al.* (2017) found that the highest chlorophyll contents were obtained with AM fungi plus NPK fertilizer at rates of 30 g compared with the control plants in cassava plants.

It was noticed that, the highest value of essential oil percentage was achieved by 67.2 kg/fed NPK plus 84 g/fed AM fungi. This result is in agreement with those of Badawy (2015) who concluded that the highest oil yields/fed were resulted in plants treated with mycorrhiza plus 50 or 75% of NPK fertilizer in anise plant. Also, Ali and El-Mekawey (2006) observed that the highest volatile oil percentage and volatile oil yield (l/fed) were in *M. chamomilla* plants were recorded with fertilized NPK fertilization plus farm yard manure.

CONCLUSION

In conclusion, addition of chamomile plants with NPK fertilizer at the rate of 67.2 kg/fed plus inoculation of AM fungi at a rate of 84 g/fed gave the highest vegetative growth, flower characteristic, number of roots, root lengt and essential oil percentage under sandy soil of El-arish region.

Table (13): Effect of interaction between NPK rates and mycorrhizal fungi on chemical constituents of *Matricaria chamomilla* plant during 2014/2015 and 2015/2016 seasons and essential oil percentage in the second season (2015/2016)

NPK(kg/fed)	A.M.(g/fed) Parameters	N %	P %	K %	Chl. A	Chl. B	EO %
				First Season			
Control	Control	0.229 g	0.014 h	1.14 f	1.31 e	5.79 g	-
	28	0.268efg	0.017efg	1.80cde	1.50 de	6.72 c-f	-
	56	0.331 e	0.019def	2.20abc	2.56 ab	7.06 bc	-
	84	0.452 cd	0.020cde	2.41 a	2.70 a	7.77 ab	-
22.4	Control	0.241 fg	0.014 h	1.27 f	1.46 de	5.96 fg	-
	28	0.269efg	0.020def	1.87bcd	2.00bcd	6.81cde	-
	56	0.409 d	0.020cde	2.30 ab	2.61 ab	7.32abc	-
	84	0.555 b	0.026 b	2.50 a	2.70 a	7.84 ab	-
44.8	Control	0.249 fg	0.015 gh	1.38 ef	1.50 de	6.03efg	-
	28	0.289efg	0.020def	2.25abc	2.28abc	6.91 cd	-
	56	0.455 cd	0.021 cd	2.45 a	2.69 a	7.52abc	-
	84	0.679 a	0.028 b	2.60 a	2.73 a	7.87 ab	-
67.2	Control	0.259 fg	0.017fgh	1.55def	1.84cde	6.12d-g	-
	28	0.301 ef	0.020def	2.27abc	2.37abc	7.15abc	-
	56	0.480 c	0.023 c	2.55 a	2.71 a	7.80 ab	-
	84	0.693 a	0.032 a	2.60 a	2.76 a	7.97 a	-
			Second Season				
Control	Control	0.355 f	0.017 h	1.67 g	0.75f	5.52 g	0.48g
	28	0.389def	0.019fgh	2.17 ef	1.69 cd	6.76 c-f	0.32i
	56	0.413 c-f	0.023def	2.30def	1.73 bcd	6.92 b-f	0.50fg
	84	0.462bcd	0.026 cd	2.75a-d	2.37 a	7.77 abc	0.68c
22.4	Control	0.363 ef	0.018 gh	1.70 g	1.06 ef	6.26 fg	0.63d
	28	0.409c-f	0.022d-g	2.30def	1.77bcd	6.94 b-f	0.53ef
	56	0.444b-e	0.026 cd	2.59b-e	2.29 ab	7.54 abc	0.51fg
	84	0.485 bc	0.028 bc	3.03 ab	2.43 a	8.05 a	0.42h
44.8	Control	0.374def	0.020e-h	1.71 g	1.26 def	6.35 efg	0.65cd
	28	0.438b-f	0.023d-g	2.40 c-f	2.09 abc	7.41 a-e	0.63d
	56	0.459bcd	0.027bcd	2.62b-e	2.36 a	7.97 ab	0.55e
	84	0.573 a	0.031 ab	3.19 a	2.49 a	8.08 a	0.72b
67.2	Control	0.378def	0.021e-h	2.06 fg	1.34 de	6.41 d-g	0.40h
	28	0.431b-f	0.025cde	2.40 c-f	2.21 abc	7.47 a-d	0.56e
	56	0.509 ab	0.028 bc	2.87abc	2.39 a	8.01 ab	0.32i
	84	0.588 a	0.0344a	3.15 a	2.62 a	8.17 a	0.76a

Values having the same alphabetical letters did not significantly different at 0.05 levels of significant according to Duncan's multiple rang test.

REFERENCES

Abo-Rekab, Z. A., R. S. S. Darwesh and N. Hasan (2010). Effect of arbuscular mycorrhizal fungi, NPK complete fertilizers on growth and concentration nutrients of acclimatized date plam plantlets. Mesopotomia Journal of Agriculture, 38:1-11.

Ahmad, I., M. Asif, A. Amjad and S. Ahmad (2011). Fertilization enhances growth, yield, and xanthophyll contents of marigold. Turkey Journal of Agriculture, 35: 641-648.

Ahmed, R., M. J. Hussain, S. Ahmed, M. R. Karim and M.A. Siddiky (2017). Effect of N, P and K fertilizer on the flower yield of Chrysanthemum. The Agriculturists, 15(1): 58-67.

Al-Amri, S. M., K. M. Elhindi and A. F. Sharaf El-Din (2016). Effects of arbuscular mycorrhizal fungus Glomus mosseae and phosphorus application on plant growth rate, essential oil content and composition of coriander (*Coriander sativum* L.). Progress in Nutrition, 18(4): 443-454.

Ali, M. A. M and M. A. El-Mekawy (2006). Effect of some fertilizer types and drip irrigation rates on productivity of *Matricaria chamomilla* L. plant under El-arish region conditions. Agriculture Research Journal, suez Canal University, 6: 108-120.

Anwar, M., S. Chand and D. Patra (2010). Effect of graded levels of NPK on fresh herbage yield, oil yield and oil composition of six cultivars of menthol mint (*Mentha arvensis* L.). Indian J. Nat Prod. Resour., 1: 74-79.

Asrar, A. A. and K. M. Elhindi (2011). Alleviation of drought stress of marigold (*Tagetes erecta*) plants by using Arbuscular mycorrhizal fungi. Saudi Journal of Biological Sciences, 18: 93–98.

Ayemi, T. J., D. Singh and U. Fatmi (2017). Effect of NPK on plant growth, flower quality and yield of gerbera (*Gerbera jamesonii* L. cv. ruby red) under naturally ventilated polyhouse conditions. Int.J.Curr. Microbiol. App. Sci., 6(8): 1049-1056.

Badawy, M. Y. M. (2015).Studying the possibility of cultivating *Pimpinella anisum* plant under Sinai conditions by using chemical fertilization and mycorrhiza. Egyptian J. Desert Res., 65 (2): 215-232.

Bremner, J. M. and C. S. Mulvaney (1982). Nitrogen total. P. 595-624. In A. L. Page (ed.), Methods of Soil Analysis. Agron. No. 9, Part 2: Chemical and microbiological properties, 2nd ed., Am. Soc. Agron., Madison, WI, USA.

British Pharmacopoeia (1963). Determination of Volatile Oil in Drugs. The Pharmaceutical Press, London.

Brown, J. D. and O. Lilleland (1946). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Proc. Amer. Soc. Hort. Sci., 48: 341-364.

Chukwuka, K. S., R. U. Okechukwu, B. O. Umukoro and M. C. Obiakara (2017). Arbuscular mycorrhiza fungi, NPK (15-15-15) and cow dung interaction in sustainable cassava production and food security. Adv. Plants Agric. Res., 7(4): 328335.

Duncan, B. D. (1955). Multipe ranges and multiple F test. Biometrics, 11: 1-42.

Farkoosh, S. S., M. R. Ardakani, F. Rejali, M. T. Darzi and A. H. Faregh (2011). Effect of mycorrhizal symbiosis and *Bacillus coagolance* on qualitative and quantitative traits of *Matricaria chamomilla* under different levels of phosphorus. Middle-East J. Sci. Res., 8(1): 1-9.

Giri, B., R. Kapoor and K. G. Mukerji (2003). Influence of arbuscular mycorrhizal fungi and salinity on growth, biomass and mineral nutrition of *Acacia auriculiformis*. Biol. and Fertility of Soils, 38: 170-175.

Gomaa, A. O. and A. S. M. Youssef (2007). Bio-fertilizers as a partial alternative to chemical NPK fertilization and its influence on the productively of fennel plants (*Foeniculum vulgare*, Miller).The third Conf. of Sustain. Agric. Develop. Fac. of Agric., Fayoum Univ., 327-352.

Hadi, M. R. H. S., M. A. Fallah and M. T. Darzi (2015). Influence of nitrogen fertilizer and vermicompost application on flower yield and essential oil of chamomile (*Matricaria chamomil*e L.). J. Chemical Health Risks, 5(3): 235-244.

Hassan, M. R. A., A. H. M. El-Naggar, E. H. Shaban and M. E. A. Mohamed (2015). Effect of NPK and bio-fertilizers rates on the vegetative growth and oil yield of *Ocimum basillicum* L. Plants. Alexandria Science Exchange Journal, 36: 58-72.

Heidari, Z. and M. J. N. Deljou (2014). Improvement of morpho-physiological traits and antioxidant capacity of zinnia (*Zinnia elegance* 'Dreamland Red') by arbuscular mycorrhizal fungi (*Glomus mosseae*) inoculation. Int. J. Adv. Biol. Biom. Res. 2(10): 2627-2631.

Janaki P., R. S. Adhikari and J. S. Negi (2016). Effect of Nitrogen, Phosphorus and Potassium on Growth and Green Herb Yield of *Thymus serphyllum.* Int.J.Curr. Microbiol.App.Sci. 5(1): 406-410.

Karagiannidis, N., T. Thomidis, E. Panou-Filotheou, C. Karagiannidou (2012). Response of three mint and two oregano species to Glomusetunicatum inoculation. Austr. J. Crop Sci., 6: 164-169.

Karami, A., M. Khush-Khui and F. Sefidkon (2008). Effects of nitrogen, phosphorus and potassium on yield, essential oil content and composition of cultivated and wild population of *Chamomilla recutita* L. Rauschert, Journal of Medicinal and Aromatic Plant Sciences, 30: 1-4.

Khalid, K. A. and M. R. Shedeed (2015). Effect of NPK and foliar nutrition on growth, yield and chemical constituents in *Nigella sativa* L. J. Mater. Environ. Sci., 6(6): 1709-1714.

Kozera, W., E. Majcherczak and B. Barczak (2013). Effect of varied NPK fertilisation on the yield size, content of essential oil and mineral composition of caraway fruit (*Carum carvi* L.). J. Elem., 2: 255–267.

Lambers, H., F. S. Chapin and T. L. Pons (2000). Plant Physiological Ecology. Springer-Verleg, New York. Inc.

Massoud, H. Y., H. H. Abdel-Kader, F. R. Ibrahim and A. M. Ibrahi (2016). Effect of Mineral Fertilizer and Compost on Vegetative Growth and Essential Oil Content of Yarrow (*Achillea millefolium* L.) Plant. J. Plant Production, Mansoura Univ., 7(6): 559–565.

Mengel, K. and A. Kirkby (1987). Principles of Plant Nutrition 4th Ed. International Potash. Institute. Bern. Switzerland.

Milica, G. A., K. D. Zeljke, I. O. Snezana, D. K. Dusan and V. O. Mico (2015). Effect of organic and mineral fertilizers on essential oil content in caraway, anise and coriander fruits. Acta Sci. Pol., Hortorum Cultus, 14(1): 95-103.

Milleret, R., R. C. Le Bayon and J. M. Gobat (2009). Root mycorrhiza and earthworm interactions: their effects on soil structuring processes, plant and soil nutrient concentration and plant biomass. Plant and Soil., 316(1): 1-12.

Moran, R. (1982). Formula for determination of chlorophyllous pigments extracted with N,N-Dimethylformamide. Plant Physiol., 69:1376-1381.

Olsen, S. R. and L. E. Sommers (1982). Phosphorus. In: Page, A.L., Miller, R.H., Keeney, D.R. (Eds.). Methods of Soil Analyses, Part 2, chemical and microbiological properties, 2nd ed. American Society of Agronomy, Madison, WI, USA, pp. 403–430.

Omotoso, S. O. and O. S. Shittu (2007). Effect of NPK fertilizer rates method of application in growth and yield of Okra (*Abelmoschus esculensus* L. moench) at Ado-Ekiti, South Western Nigeria. International Journal of Agricultural Research, 2: 614–619.

Page, A. L. (1982). Methods of Soil Analysis. Part2: chemical and microbiological properties. (2nd ed.) Amer. Soc. Agron., In Soil Sci. Amer. Inc, Madison, Wisconsin, USA.

Puschel, D., J. Rydlova and M. Vosatka (2014). Can mycorrhizal inoculation stimulate the growth and flowering of peat-grown ornamental plants under standard or reduced watering? Applied Soil Ecology, 80: 93-99.

Russel, E. W. (1988). "Soil Condition and Plant Growth" 11th ed Language Soc. Longman, London.

Sabra, M. M. (2014). Physiological studies on khella (*Ammi visnaga*) plant. M.Sc. Thesis, Fac. Agric., Fayoum University.

Sarhan, A., T. Abou-Dahab, A. M. Abdel-Dayem and A. R. Rabie (2002). NPK fertilization of *Taxodium distichum* seedlings.proc. 2nd. Inter Conf. Hort Sci., 10-12 Sept. Kafr El-Sheikh, Tanta Univ., Egypt: 1342-1358.

SAS (2004). SAS/STAT User's Guide. SAS Institute Inc., Cary, N.C.

Selvaraj, T., M. Nisha and S. Rajeshkumar (2009). Effect of indigenous arbuscular mycorrhizal fungi on some growth parameters and phytochemical constituents of *Pogostemon patchouli* Pellet. MaejoInt J. Sci. Tech., 3: 222-234.

Sharma, A. K. (2003). Biofertilizers for Sustainable Agriculture. Agrobios, India, p.: 407.

Siddur, S. H. and R. H. Garampalli (2016). Efficacy of three arbuscular mycorrhizal fungi on growth of *Centella asiatica* L. (Urban). Asian J. Plant Sci. Res., 6(3):11-16.

Thangaswamy, S. and C. H. Padmanbhan (2006). Arbuscular mycorrhizae: Adiverse personality. Journal of Central European Agriculture, 7: 349-58.

Upadhyay, R. K., V. R. Singh and S. K. Tewari (2016). New agro-technology to increase productivity of chamomile (*Matricaria chamomilla* L.). Industrial Crops and Products, 89: 10–13.

Vembu, G., R. Singaravel and S. KAmaraj (2010). Effect of NPK levels on the growth and yield of *Catharanthus roseus* in coastal sandy soil. Asian J. Soil Sci., 5(1): 97-99.

Yadav, K., A. Aggarwal and N. Singh (2013). Arbuscular mycorrhizal fungi induced acclimatization and growth enhancement of *Glycyrrhiza glabra* L.: A Potential Medicinal Plant. Agric Res., 2(1): 43–47.

Yaghoub, R. and W. Weria (2013). Arbuscular mycorrhizal fungi associated with some aromatic and medicinal plants. Bull Environ, Pharmacol. Life Sci., 2: 129–138.

Yagodin, B. A. (1982). Agricultural Chemistry, Part 1. Mir Publishers. Moscow, USSR. Minneapolis, Minnesota, USA.

Zou,Y., Q. S. WU, Y. Li and Y. M. Huang (2014). Effects of arbuscular mycorrhizal fungi on root system morphology and sucrose and glucose contents of *Poncirus trifoliate*. Chinese Journal of Applied Ecology, 25(4): 1125-1129.

Zubek, S., A. M. Stefanowicz, J. Blaszkowski, M. Niklinska and K. Seidler-lozykowska (2012). Arbuscular mycorrhizal fungi and soil microbial communities under contrasting fertilization of three medicinal plants. Appl. Soil Ecol., 59: 106–115.

تأثير مستويات من التسميد الكيماوي و الميكوريزا علي نبات شيح البابونج تحت ظروف الأراضي الرملية

سونيا عطيه شحاته عبد الله - محمد احمد محمود علي – تقي عمر مصطفي الكاشف
قسم الإنتاج النباتي – كلية العلوم الزراعية البيئية – جامعة العريش – مصر

أجريت هذه الدراسة بالمزرعة البحثية لكلية العلوم الزراعية البيئية – جامعة العريش خلال موسمين متتاليين (٢٠١٤/٢٠١٥، و٢٠١٥/٢٠١٦م) بهدف دراسة تأثير معدلات من التسميد الكيماوي و التلقيح بفطر الميكوريزا علي النمو الخضري والتزهير وبعض المكونات الكيمائية ونسبه الزيت الطيار لنبات شيح البابونج. استخدم في التجربة نظام القطع المنشقة مرة واحدة في ثلاث مكررات حيث تم توزيع معدلات التسميد الكيماوي (NPK) (كنترول، و ٢٢.٤، و ٤٤.٨ ، و٦٧.٢ كجم/فدان) عشوائيا في القطع الرئيسية. وتم توزيع معدلات التلقيح بالميكوريزا (بدون تلقيح، و ٢٨، و ٥٦، و ٨٤ جم/فدان) عشوائيا في القطع المنشقة. نتجت أعلى القيم لصفات النمو الخضري (طول النبات، و قطر الساق، وعدد الأفرع، والوزن الطازج والجاف للعشب، طول الجذر، الوزن الطازج والجاف للجذر)، وصفات التزهير (عدد الأزهار/ نبات، والوزن الطازج للأزهار، والوزن الجاف للأزهار، وقطر الزهرة)، ومحتوى الأوراق من العناصر الغذائية (النيتروجين، الفسفور، البوتاسيوم)، والكلورفيل (أ،ب)، ونسبه الزيت الطيار في الأزهار الجافة عند التسميد الكيماوي بمعدل ٦٧.٢كجم/فدان مع التلقيح بفطر الميكوريزا بمعدل ٨٤ جم/فدان. وكانت نتائج التفاعل في نفس الاتجاه (بنفس تأثير المعاملات السابقة).