PHYSIOLOGICAL EFFECTS OF MYCORRHIZAE ON GROWTH, CHEMICAL COMPOSITION, OIL YIELD AND ITS COMPONENTS OF *OCIMUM BASILICUM* (L.) PLANTS GROWING UNDER DIFFERENT LEVELS OF CHEMICAL FERTILIZATION

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ABSTRACT:

Two pot experiments were carried out at the Central Laboratory for Agriculture Climate (CLAC), Agricultural Research Centre, Dokki, Giza, Egypt, during 2012 and 2013 summer seasons. The objective of this work was to study the effect of Mycorrhizae on vegetative growth, oil production and chemical characters of basil plant. Treatments were arranged in complete randomized design (CRD) with three replicates in both seasons. As the NPK level was increased vegetative growth characters (plant height, number of branches, leaf area and leaves number) of basil plant were significantly increased in both seasons. In addition, they significantly increased as a result of the applied mycorrhizae when compared to un-treated plants in both seasons. The highest values for growth characters were obtained when treated with the combination of NPK recommended dose with mycorrhizae. Application of NPK fertilization tended to increase mineral concentration including N, P, K, Ca, Fe, Zn, Mn as well as protein, total carbohydrates and oil yield as well as major ingredients of essential oil of basil plants. Also mycorrhizae treatments tended to increase the same attributes when compare with un-treated plants. Similar trend was obtained for N, P, K, Ca, Fe, Zn, Mn as well as protein and total carbohydrates in both herb and roots of plants. Generally, the maximum herb fresh and dry yield and essential oil yield were obtained with the integrated application of mycorrhizae and recommended dose of NPK. As well as, treatment of inoculated basil plants with mycorrhizae with half dose of NPK was significantly higher than treatment in which plants fertilized only with 100% of NPK. It might be concluded that applying mycorrhizae might improve nutritional status of basil plants leading to higher plant productivity.

Key words: basil plants, mycorrhizae, NPK, chemical fertilization

INTRODUCTION:

Herbal medicines are in great demand in both developed and developing countries as a source of primary health care owing to their attributes having

wide biological and medicinal activities, high safety margins and lesser costs. Herbal molecules are safe and would overcome the resistance produced by the pathogens as they exist in a combined form or in a pooled form of more than one molecule in the protoplasm of the plant cell (Lai and Roy, 2004; Tapsell *et al*., 2006).

Basil (*Ocimum basilicum* L.) is a medicinal plant traditionally used for the treatment of respiratory and intestinal problems and kidney malfunction (Lorenzi& Matos, 2008). Basil is economically important due to the use of its essential oil in hygiene and cleaning products, perfumes, and cosmetics and as a local anesthetic and antiseptic (Liber, *et al*. ,2011) Furthermore, basil essential oil has been tested in the control of plant pests (Erler, *et al*. 2006), and has been shown to act as an antioxidant (Politeo *et al*.,2006). It is widely cultivated for the production of essential oils and is also marketed as an herb, either fresh, dried or frozen (Putievsky & Galambosi, 1999). The intensive use of manufactured nitrogen fertilizers increased the crops productivity but with low quality which is not acceptable for export (Lain *et al*., 1996; Wang *et al*., 1996).

Effective agriculture, sanitary, safety treatments and collection practices for medicinal and aromatic plants is only the first step in quality assurance, on which the safety and efficacy of herbal medicinal and aromatic products directly depend upon (WHO guidelines). Lately, the safe agriculture is one of the main attitudes in the world (El-Kouny, 2002).

A combination of organic and mineral nutrients has been advocated (Prabu *et al*., 2003). As the integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Bocchi&Tano, 1994).

In many environments, plant growth is limited by inadequate nutrient supply (Elser *et al* 2007, Hell and Hellibrand 2001. This condition is alleviated by a mutualistic association with soil fungi of the order Glomeromycota which provide the plant host with diverse mineral nutrients in exchange for assimilates (Smith and Read 2008). This symbiosis, referred to as arbuscular mycorrhizae (AM), emerged approximately 450 Ma ago, and is thought to have facilitated the colonization of land by early vascular plants (Brundrett 2002. The fungal mycelium emanating from the root system reaches far beyond the rhizosphere and therefore can acquire nutrients from soil volumes to which roots have no access (friese& Allen 1991). Furthermore, fungal hyphae are much thinner than roots (Azcón-Aguilar *et al* 1998), allowing them to explore small cracks in the micrometer range that are inaccessible to roots.Mycorrhizae are important for the establishment growth and survival of seedling, particularly in marginal habitats, where the symbiosis improves stress tolerance as well as conserves soil structures (Sharma, 2002).Many researchers studied the effect of mycorrhizae on plants productivity their data showed significantly increased in

plant productivity and chemical compositions by using mycorrhizae(Cabello *et al*. 2005) on *Mentha piperita* plants, Zolfaghari *et al* 2013 on sweet basil and Weisany *et al*. 2015 on dill plants.

The objective of this study was to investigate the effect of mycorrhizae on growth characters , herb fresh and dry weight productavity, essential oil production and its componenets of basil (*Ocimum basilicum* L.) plants growing under different levels of NPK.

MATERIALS AND METHODS

This study was carried out at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Centre, Dokki, Giza governorate, Egypt during two successive seasons of 2012 and 2013. Seeds of (*Ocimum basilicum*) country of origin Italy obtained from national research center was used in this study. Seeds were sown on 15th and 18th of March 2012 and 2013, respectively for seedling preparation. 15 cm Fresh transplants were transplanted. Transplants were placed into pots filled with 9 kg of sand: clay (1:1) 25 cm in diameter.Mycorrhizal inoculation was done at sowing by applying 1g/seedling of mycorrhizal inoculums. By using Mycorrhizeen from SEKEM Company. Treatments were arranged in completely randomized design with three replicates in both seasons.

The soil chemical properties were determined according to Jackson, (1973). (Table1)

Table (1): some physical and chemical analysis of experimental soil:

Property	**value**	**Cations (me./l)**	**value**	**Anion (me./l)**	**value**	**PH (soil paste**	**EC (ds/m)at 25^{o} c**
Sand%	49%	Ca^{++}	8.8	CO_3^{--}	0	8.6	2
Silt%	26%	Mg^{++}	1.08	HCO_3^{-}	3.6		
Clay %	24.4	Na^{+}	5.8	Cl^{-}	4.1		
		K+	2.22	SO_4^{--}	10.2		

The treatments were as follows:

* Recommended dose of NPK (control).
* Recommended dose of NPK with mycorrhizae.
* 50% of recommended dose of NPK with mycorrhizae.
* Mycorrhizae without adding NPK.
* 50% of recommended dose of NPK.

Recorded Data:

Three cuts were taken from each labeled plant at the early bloom stages (on 20th and 22nd August, 24th and 21st of October, 10th and 12ndof December 2012 and 2013, respectively in the two seasons). The following data were recorded and statistically analyzed.

Vegetative growth parameters:

Plant height (cm).

Number of leaves/plant
Number of branches/ plant.
Leaf area(cm^2) of the fifth leave above.
Herb fresh weight(g/plant).
Air dry weight of herb (g/plant).
Root fresh weight(g/plant) (were taken after third cut).
Root dry weight(g/plant) (were taken after third cut).

The yield:

Yield fresh weight (g/plant) total of all fresh weight of the three cuts.
Yield dry weight (g/plant) total of all dry weight of the three cuts.
Essential oil percentage.

Chemical analysis:

Chemical constituents in herb and root were presented intotal carbohydrates content, mineral nutrients (N, P, K, Ca, Zn, Mn, Fe), and oil components. Total nitrogen was determined by Kjeldah method described by Bremner and Mulvaney (1982).Phosphorous concentration in acid digested was determined by colorimeter method (ammonium molybdate) using spectrophotometer according to Jackson (1967). Potassium content was determined using Flame photometer as described by Chapman and Pratt (1961) and the results were represented as gm/100 gm D.W. of plant.Calcium content and Micro nutrients (Mn, Zn, and Fe) elements content were determined using atomic absorption spectro-photometer, D.P.3300 Parkenvelemer.While the content of carbohydrates in dried leaves samples were determined using the method described by Dubois *et al*. (1956). Pigments content including Chlorophyll a, b and carotenoids were determined in fresh leaves samples (mg/gm F.W.) according to Lichtenthaler &Wellburn, 1983

Essential Oil Percentage in the Fresh Herb:

The oil percentage was determined in fresh herb in both seasons using the hydro-distillation method by Clevenger apparatus according to Guenther 1974. A known weight of fresh herb (100 g) was placed in a flask of 1 L capacity for distillation and an adequate amount of water was added. A proper essential oil trap and condenser were attached to the flask and enough water was added to fill the trap. The distillation continued for three hours until no further increase in the oil was observed. After finishing the distillation process the apparatus was left to be cooled and dried by sodium sulphate anhydrous.Chemical analysis for essential oil was conducted using the gas-chromatography (GC) coupled to mass spectrometry (MS).The essential oil percentage was estimated as follows:

Essential oil %= Essential oil vol./weight of samples *100

Biological data:

* Estimation of mycorrhizal infection were determined using the method described by Giovanetti & Mosse(1980)

Infection %= No. of infected roots/total No. of roots x 100

* Estimation of **mycorrhizal spores** using the wet sieving and decanting technique (Gerdemann& Nicolson 1963), and **mycorrhizal dependency** was defined as the ratio of the herb dry weight of AM seedlings and non-AM seedlings (Graham &Syvertsen 1985).

Statistical Analysis:

A randomize complete block design with two factors was used for analysis all data with three replications for each parameter. The treatment means were compared by least significant difference (L.S.D.) test as given by **Snedecor and Cochran (1994)** by using Assistat program.

RESULTS AND DISCUSSION

Vegetative Growth:

The obtained results of plant growth characters revealed that, recommended dose of NPK inoculated with mycorrhizae treatment significantly increased all growth characters(plant height, number of branches, leaf area, leaves number/plant,root length and root fresh and weight g /plant) in both seasons of basil plants compared to the control treatment (plants receiving the recommended NPK dose) as shown in (Table 2 and 3). From data it is clear that, inculated plant with mycorrhizae under half dose of NPK treatment was significantly higher than control treatment (plant received full dose of NPK). The favorable effects of the combination between chemical fertilizer and mycorrhizae may be explained based on the positive effect of interaction between mycorrhizae and chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Bocchi &Tano, 1994). Mycorrhizae are important for the establishment growth and survival of seedling, particularly in marginal habitats, where the symbiosis improves stress tolerance as well as conserves soil structures (Sharma, 2002). The benefits of arbuscular mycorrhizal fungi are usually attributed to the improved plant nutrition De la Rosa-Mera *et al*. 2011as well as physiological changes Pozo *et al*. 2002. Our finding is in line with Khankandi *et al*., 2013 who mentioned that, The significantly promoted growth and development of basil plants were observed in mycorrhizal fungi and/or amino acid treated plants as it was indicated by the higher leaf numbers, area and dry weight as well as improved root system (higher root length, dry mass and numbers) compared with control. And Freitas *et al*. (2004) indicated that inoculation of *Mentha arvensis* with mycorrhiza resulted in increased plant height, also Copetta *et al* (2006) have shown that inoculation of plants with mycorrhiza can result in a significant change in number of branches and number of follicles per plant.

Table (2): plant height, number of branches, leaves number and leaf area, of basil plants as effected by inoculated with mycorrhizae under different levels of NPK in 2012 and 2013.

Treatments	Cut	Plant hight(cm)		No. of branch/plant		Leaves No.		Leaf area cm^2	
		1stseason	2ndseason	1stseason	2ndseason	1stseason	2ndseason	1stseason	2ndseason
Recommended dose of NPK (control)	1st	30.33	28.83	31.33	34.33	208.33	229.33	22.82	22.37
	2nd	32.27	30.67	36.67	40.67	210.33	231.33	23.05	26.45
	3rd	36.23	34.43	35.33	39	204.33	225	22.36	26.72
mean		32.94 c	31.31 c	34.44 c	38 c	207.66 c	228.55 c	22.74 b	25.18 a
Mycorrhizae	1st	19.43	18.47	9.67	10.67	60.67	66.67	11.43	11.2
	2nd	22.07	21	13	14	61.67	67.67	11.45	11.31
	3rd	24.77	23.5	13	14	59	65	11.19	10.97
mean		22.09 e	20.99 e	11.89 e	13.89 e	60.45 e	66.45 e	11.36 d	11.16 c
50% of recommended dose of NPK	1st	19.67	18.7	13.33	14.67	103.67	114	17.36	17.01
	2nd	24.03	22.83	15.33	17	104.67	115	17.53	21.93
	3rd	30.63	29.1	15.33	17	101.67	112	17	22.15
mean		24.78 d	23.54 d	14.66 d	16.22 d	103.34 d	113.67 d	17.30 c	20.36 b
Mycorrhizae +%50 NPK	1st	33.67	32	35	38.3	261.67	288	21.62	21.18
	2nd	39.73	37.73	39	43	264.67	291	21.83	21.4
	3rd	47.20	44.83	38.67	42.67	257.67	286.33	21.18	20.75
mean		40.2 b	38.19 b	37.56 b	41.32 b	261.34 b	288.44 b	21.54 b	21.11 b
Mycorrhizae with recommended dose of NPK	1st	42.20	40.13	53.67	59	379.67	417.67	25.62	25.11
	2nd	48.10	45.67	57.33	63.3	383.67	422.33	25.88	25.36
	3rd	51.90	49.33	59.67	65.87	371.67	408.67	25.1	24.6
mean		47.4a	45.04 a	56.89a	62.72 a	378.34 a	416.22 a	25.53 a	25.02 a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (3): Effect of inculation with mycorrhizae under different levels of NPK on root length ,fresh and dry weight in 2012 and 2013.

Treatments	Root length cm		Root fresh weight g/plant		Root dry weight g/plant	
	1stseason	2ndseason	1stseason	2ndseason	1stseason	2ndseason
Recommended dose of NPK (control)	5.10 lc	6.12c	12.76b	11.34c	9.64c	8.59c
Mycorrhizae	3.9d	4.68d	6.54c	7.33d	4.96d	5.55d
50% of recommended dose of NPK	3.17e	3.8e	6.5c	6.43e	4.93d	4.87e
Mycorrhizae +%50 NPK	6.43b	7.72b	12.26b	14.76b	14.76b	11.19b
Mycorrhizae with recommended dose of NPK	10.23a	10.6a	20.54a	22.62a	22.62a	17.11a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

3.2. Chemical analysis

As mentioned of growth characters data, the results of chemical analysis (micro and macro elements in herb (Table 4) and in root (table 5), Pigments and total carbohydrates and protein, essential oil percentage in herb (table 6) have the same conclusion where, all parameters significantly increased as a

result of recommended dose of NPK inoculated with mycorrhizae treatment compared to control plants (plants received the recommended NPK dose). Going along with other treatments, it was obvious that, in both seasons treatments of the combination of 50% of NPK inculated with mycorrhizae significantly increased all chemical characters of basil plants over the recommended dose of NPK alone.

This could be resulted from the modified relations between source and sink tissues as well as the enhanced photosynthesis rates due to mycorrhizae inculation. These results are convenience with those reported by Kuntal *et al*, 2007 who showed that the yield and nutrient content of stevia plant affected by applied chemical fertilizers NPK and bio-fertilizers (Vesicular Arbuscular Mycorrhiza, phosphorus solubilizing bacteria and Azospirillium as sole and in combinations) and have been increased significantly.

3.3.The yield:

Data in table (7) shown that,recommended dose of NPK inoculated with mycorrhizae treatment significantly increased herb fresh and dry weight/ fadden and essential oil productivity /fadden in both seasons of basil plants compared to the control treatment (plants received the recommended NPK dose). Moreover,using mycorrhizae with half dose of NPK significantly increased yield of basil plant more than control plants. Mycorrhizae increase the growth rate because of the increase in water and mineral uptake such as nitrogen and phosphorus, which leads to the biomass yield improvement.The observed promoted yield in the treated plants could be attributed to the enhanced leaf number and area, raised root system and nutrition as well as stimulated chlorophyll content and photosynthesis.This finding is in accordance with the previous observations on sweet basil (*Ocimum basilicum*) (Zolfaghari *et al*. 2013) as well as on dill plant (Weisany *et al*. 2015).

Essential oil composition:

The content of essential oil in the fresh herb of all treatments of basil plants was extracted. 9 compounds were determined in the essential oil obtained from all treatments (table 8). From data it noticed that, The essential oil of basil plants is characterized by high amount of linalool (42.04 -45.15%) The highest amount of linalool was increased (45.15 %) with mycorrhizae under full recommended dose of NPK treatment as compared with the control treatment (full recommended dose of NPK) (42.04%). The same trend observed with estragole, 1.8-cineole, Bornyl acetate and Eugenol while α- terpineol, Trans-a'bergamotene, Germacrene-D and Alfa-copaene recorded the highest amount of them with the control plants and the lowest amount of them noticed with the mycorrhizae treatment.The variations in essential oil content and composition could be due to the effect of different treatments on enzymes activity and metabolism improvements. These finding is in line with Shajari *et al*. 2016who mentioned that the application of biological fertilizer especially mycorrhizae

had a significant effect on improving quantitative and qualitative yield of Coriander. Furthermore, Studies of *Ocimum basilicum* (Khaosaad *et al*., 2006) and *Artemisia annua* (Kapoor *et al*., 2007)have shown that root colonization by AMF increased essential oil content and quality.

Table (4): Effect of inoculation with mycorrhizae under different levels of NPK on macro and micro elements content in herb of basil plant in 2012 and 2013.

Treatments	Cut	N%		P%		K%		Ca mg/g		Fe ppm		Mn ppm		Zn ppm	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	3.09	3.4	0.38	0.42	0.93	1.02	3.06	3.37	935.65	1029.22	129.08	141.99	58.96	64.86
	2nd	3.11	3.42	0.42	0.46	0.94	1.04	3.08	3.39	943.9	1038.29	130.37	143.4	59.55	65.5
	3rd	3.06	3.37	0.41	0.45	0.95	1.04	3.03	3.33	926.67	1019.66	126.47	139.11	57.76	63.54
mean		3.09 c	3.40c	0.40c	0.44	0.94c	1.03c	3.06c	3.36c	935.41c	1029.06c	128.64c	141.50c	58.76c	64.63c
Mycorrhizae	1st	2.78	3.06	0.44	0.48	0.46	0.51	2.75	3.03	819.9	901.66	129.1	142.01	51.85	57.04
	2nd	2.79	3.07	0.48	0.53	0.46	0.5	2.76	3.04	827	909.7	130.39	143.43	52.37	57.6
	3rd	2.75	3.03	0.47	0.52	0.54	0.6	2.73	3	748	823.75	126.49	139.13	50.8	55.87
mean		2.77d	3.05d	0.46d	0.51d	0.49d	0.54d	2.75d	3.02d	798.30d	878.37d	128.66d	141.52d	51.67d	56.84d
50% of recommended dose of NPK	1st	2.49	2.74	0.3	0.33	0.64	0.7	2.47	2.72	900.93	991.03	110.19	121.2	51.09	56.2
	2nd	2.5	2.76	0.33	0.36	0.47	0.62	2.48	2.73	908.83	999.72	111.29	122.42	51.6	56.76
	3rd	2.47	2.7	0.33	0.36	0.53	0.58	2.45	2.7	823.5	905.85	107.95	118.75	50.05	55.06
mean		2.49e	2.73e	0.32e	0.35e	0.55e	0.63e	2.47e	2.72e	877.75e	965.53e	109.81e	120.79e	50.91e	56.01e
Mycorrhizae +%50 NPK	1st	4.32	4.76	0.55	0.6	1.06	1.2	4.28	4.7	1028.47	1131.31	144.84	159.32	60.48	66.53
	2nd	4.35	4.79	0.6	0.66	1.06	1.17	4.31	4.75	1037.67	1141.43	146.29	160.92	61.09	67.2
	3rd	4.26	4.69	0.59	0.64	1.04	1.15	4.22	4.65	938.53	1032.39	141.9	156.09	59.25	65.18
mean		4.31b	4.75b	0.58b	0.63b	1.05b	1.17b	4.27b	4.70b	1001.56 b	1101.71 b	144.34b	158.78b	60.27b	66.30b
Mycorrhizae with recommended dose of NPK	1st	4.92	5.41	0.85	0.93	1.33	1.47	4.88	5.37	1213.33	1334.67	151.27	166.4	68.77	75.64
	2nd	4.95	5.44	0.93	1.03	1.33	1.5	4.91	5.4	1224.37	1346.8	152.79	168.07	69.45	76.4
	3rd	4.85	5.3	0.91	1	1.36	1.46	4.81	5.29	1195.3	1215.83	148.2	163.02	67.37	74.1
mean		4.91a	5.38a	0.90a	0.99a	1.34a	1.48a	4.87a	5.35a	1181a	1299.10a	150.75 a	165.83a	68.53a	75.38a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (5): Effect of inculation with mycorrhizae under different levels of NPK on macro and micro elements content in root of basil plant in 2012 and 2013.

Treatments	N%		P		K		Ca		Fe		Mn		Zn	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	3.11c	3.42c	0.33d	0.4c	1.04c	1.14c	3.08c	3.39c	315.17b	346.99b	151.28c	166.41c	57.76c	63.54c
Mycorrhizae	2.79d	3.07d	0.39c	0.43c	0.61d	0.67d	2.77d	3.04d	254.62d	280.08d	151.31c	166.44c	50.8d	55.87d
50% of recommended dose of NPK	2.5e	2.76e	0.27e	0.33d	0.57d	0.63d	2.48e	2.75e	279.99c	307.99c	129.14d	142.05d	50.05d	55.06d
Mycorrhizae +%50 NPK	4.35b	4.79b	0.48b	0.53b	1.25b	1.38b	4.31b	4.75b	319.1b	351.01b	169.74b	186.72b	59.25b	65.18b
Mycorrhizae with recommended dose of NPK	4.96a	5.45a	0.75a	0.83a	1.61a	1.77a	4.92a	5.41a	375.8a	413.38a	177.29a	195.02a	67.27a	74.1a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different

Table (6): Effect of inculation with mycorrhizae under different levels of NPK on pigments , total carbohydrates protein and essential oil percentge of basil plants in 2012 and 2013

Treatments	Cut	Total carbohydrates		protein		Chlorophyll a.		Chlorophyll b		caroteinoids		E.O%	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	4.46	5.35	19.33	21.27	1.65	1.63	0.31	0.35	0.147	0.16	0.22	0.218
	2nd	4.37	5.24	19.4	21.38	1.68	1.65	0.32	0.348	0.148	0.163	0.21	0.205
	3rd	4.17	4.98	19.43	21.375	1.6	1.58	0.3	0.334	0.142	0.157	0.21	0.20
mean		4.33b	5.19b	19.39c	21.34c	1.64b	1.62b	0.31b	0.34b	0.15b	0.16b	4.33d	5.19d
Mycorrhizae	1st	4.59	5.5	17.37	19.1	1.23	1.19	0.23	0.249	0.107	0.123	0.15	0.148
	2nd	4.53	5.39	17.43	19.18	1.26	1.19	0.23	0.25	0.101	0.118	0.13	0.126
	3rd	4.27	5.12	17.4	19.175	1.19	1.16	0.22	0.238	0.095	0.114	0.13	0.13
mean		4.46b	5.34b	17.40d	19.15d	1.23e	1.18e	0.23e	0.25e	0.10e	0.12d	4.46c	5.34c
50% of recommended dose of NPK	1st	3.18	3.81	15.6	17.16	1.25	1.24	0.26	0.282	0.111	0.121	0.13	0.129
	2nd	3.13	3.74	15.63	17.2	1.38	1.35	0.26	0.28	0.119	0.134	0.12	0.118
	3rd	2.93	3.55	15.628	17.186	1.31	1.3	0.25	0.271	0.117	0.128	0.12	0.114
mean		3.08c	3.70c	15.62e	17.18e	1.31d	1.30d	0.26d	0.28d	0.12d	0.13d	3.08e	3.70e
Mycorrhizae +%50 NPK	1st	5.27	6.32	27.03	29.74	1.51	1.47	0.28	0.308	0.132	0.144	0.23	0.227
	2nd	5.17	6.2	27.22	29.96	1.57	1.48	0.26	0.312	0.131	0.147	0.22	0.22
	3rd	4.9	5.89	27.231	29.955	1.47	1.43	0.27	0.297	0.128	0.141	0.22	0.217
mean		5.11a	6.14a	27.16b	29.89b	1.52c	1.46c	0.27c	0.31c	0.13c	0.14c	5.11b	6.14b
Mycorrhizae with recommended dose of NPK	1st	5.46	6.55	30.73	33.81	1.84	1.79	0.34	0.378	0.161	0.176	0.31	0.3
	2nd	5.37	6.42	30.9	33.99	1.92	1.81	0.35	0.381	0.163	0.179	0.3	0.29
	3rd	5.07	6.1	30.87	34	1.79	1.74	0.33	0.367	0.142	0.172	0.29	0.287
mean		5.30a	6.36a	30.83a	33.93a	1.85a	1.78a	0.34a	0.38a	0.16a	0.18a	0.3a	0.29a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (7) :Effect of inculation with mycorrhizae under different levels of NPK on herb fresh and dry weight, yield of fresh and dry herb/faddan and essential oil yield /faddan of basil plant in 2012 and 2013:

Treatments	Herb fresh weight g/plant		Herb dry weight g/plant		Yield fresh weight Ton/fad.		Yield dry weight ton/fad.		E.O yield l/faddan	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	129.63b	127.63b	27.23c	26.7c	3.564b	3.493b	0.75c	0.734c	7.69b	7.77b
Mycorrhizae	61.53e	60.3e	16.03e	15.7e	1.692e	1.658e	0.44e	0.43e	2.31d	2.22d
50% of recommended dose of NPK	100.7d	98.7d	21.17d	20.73d	2.769d	2.714d	0.58d	0.57d	3.42c	3.45c
Mycorrhizae +%50 NPK	110.5c	122c	32.43b	31.8b	3.039c	3.357c	0.89b	0.874b	7.69b	7.37b
Mycorrhizae with recommended dose of NPK	180.3a	198.43a	52.43a	51.4a	4.958a	5.457a	1.44a	1.412a	16.53a	15.83a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (8): Effect of inculation with mycorrhizae under different level of NPK on the essential oil components of basil plants.

Treatment	1.8-cineole	linalool	α- terpineol	Bornyl acetate	estragole	Trans-a'bergamotene	Germacrene-D	Alfa-copaene	Eugenol
Control	12.6	43	1.57	1.03	16.4	5.19	2.2	5.3	7.57
50%NPK	12.31	42.5	1.54	0.98	16.21	5.14	2.17	5.09	7.4
Mycorrhizae	13.04	44.1	1.21	2.04	18	4.5	1.46	2.98	8
Mycorrhizae+50% NPK	13.18	44.37	1.26	2.26	18.02	4.62	1.54	3.09	8
Mycorrhizae+100%NPK	13.24	44.98	1.23	2.09	18	4.57	1.5	3	8.1

Bilogical data:

From table (9) it is clear that all inoculated plants were succeed in infection with mycorrhizae. The mycorrhizae fungal colonized the host plants successfully with high percentage. Data reviled that, applying high dose of NPK significantly increased the mycorrhizal infection for the inoculated plants while it recorded (27 and 27.9 %) in first and second seasons respectively while inoculated plants under un-fertilized conditions significantly recorded the lowest mycorrhizal infection in both seasons (18.3 and 17.3 %) respectively.

According to mycorrhizae spores data in table (9) showed that, the same trend of mycorrhizal infection obtained in mycorrhizal spores, the full recommended dose of NPK treatment had significantly the highest amount of spores in 100 gram of soil in both growing seasons (905 and 910 spores/100 g soil) respectively, while inculated plants under un-fertilized condition significantly had the lowest amount of spores 850 and 853/100g soil in both seasons respectively.

Mycorrhizal dependency was defined as the ratio of the yield of dry weight of mycorrhizal seedlings and non-mycorrhizal seedlings. Our results showed that, basil plants catagorized as Obligatorily mycorrhizal plants while the mycorrhizal dependency ranged from 92.5% under full recommended dose of NPK, 53.2% under half dose of NPK and 66.5% with plants didn't receive NPK fertilization.

The sweet basil plants appeared to have high dependency on mycorrhizae which improved plant growth, photosynthetic efficiency.this results in harmony with the previous work on sweet basil plants (Elhindi *et al* 2017).

Table (9): Effect of inculation with mycorrhizae under different level of NPK on infection, mycorrhizal spores and mycorrhizal dependency of basil plants in 2012 and 2013.

Treatments	infection		Mycorrhizal spores		Mycorrhizal dependency %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Mycorrhizae	18.3c	17.6c	850c	853c	66.45b	66.49b
Mycorrhizae +%50 NPK	19.2b	19b	903b	900b	53.1c	53.40c
Mycorrhizae with recommended dose of NPK	27a	27.9a	905a	910a	92.5a	92.51a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

4. Conclusion:

This study confirmed the role of AM fungi in the productivity performance of basil plants; all the mycorrhizae inoculated plants demonstrated an increase in biomass, as already reported by previous studies in the literature. We noticed that, inoculated basil plants with mycorrhizae with half dose of NPK significantly improved the quantitative and qualitative yield of basil plants. The inoculation with AM fungi can reflect a friendly strategy to enhance the sustainability of the agricultural practices and the production of bioactive molecules in basil plants. Therefore, it appears that application of mycorrhizae could be promising in the production of basil by the reduction of chemical fertilizer application; it seems

using this mycorrhizae in agroecosystems could increase water uptake by its positive effects on root parameters.

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التأثيرات الفسيولوحية للميكورهيزا على النمو والتركيب الكيماوى ومحصول الزيت ومكوناته فى نبات الريحان النامية تحت مستويات مختلفة من التسميد الكيماوى

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** المعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية بالجيزة

اجريت تجربتي اصص فى المعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية بالدقى- محافظة الجيزة خلال موسمي ٢٠١٢، ٢٠١٣. وكان الهدف من البحث هو دراسة تاثير الميكورهيزا على النمو الخضرى وانتاج الزيت العطرى والتركيب الكيماوى لنباتات الريحان. تم توزيع المعاملات فى قطاعات تامة العشوائية بثلاث مكررات فى الموسمين. وكانت المعاملات السماديه التي عومل بها نبات الريحان هي :إضافة نصف الجرعه من السماد الكيماوي، إضافة جرعه كاملة من السماد الكيماوي (الكونترول)، التلقيح بالميكورهيزا فقط، نصف الجرعه من السماد الكيماوي NPK مع التلقيح بالميكورهيزا، جرعه كاملة من السماد الكيماويNPK مع التلقيح بالميكورهيزا، تشير النتائج الى انه بزيادة مستوى التسميد الكيماوى ادى الى زيادة معنوية فى كلا من الصفات الخضرية (ارتفاع النبات، عدد الافرع، مساحة سطح الورقة، وعدد الاوراق للنبات) وذلك خلال الموسمين. كان تاثير الميكورهيزا على كل الصفات المذكورة تاثير ايجابى مقارنة بالنباتات الغير ملقحة بالميكورهيزا. سجلت النباتات الملقحة بالميكورهيزا والمسمدة تسميد كامل من التسميد الكيماوى أعلى القيم. وبالنسبة للتركيب الكيماوى لنبات الريحان سواء فى العشب او الجذر: ادى التسميد بالجرعة الموصى بها من السماد الكيماوى مع التلقيح بالميكورهيزا الى زيادة تركيز العناصر المعدنية (نيتروجين، فسفور، بوتاسيوم، كالسيوم، حديد، زنك، منجنيز) فى العشب والجذر وكذلك الكربوهيدرات الكلية والبروتين ونسبة الزيت العطرى والمكونات الاساسية للزيت العطرى. وعموما، زاد محصول العشب الطازج والجاف وحصول الزيت باستخدام الميكورهيزا مع التسميد الكيماوى الموصى به. وكذلك أظهرت النتائج تفوق النباتات الملقحة بالميكورهيزا مع نصف جرعة التسميد الكيماوى الموصى به عن النباتات المسمدة بالجرعة الكاملة من التسميد الكيماوى فقط. ومن ثم فانه يمكن استنتاج ان استخدام الميكورهيزا ربما يؤدى الى تحسين الحالة الغذائية لنبات الريحان والتى تؤدى الى زيادة انتاجية النبات(كما وجودة).