Egypt. J. of Appl. Sci., 36 (9-10) 2021 *114-127*

UTILIZATION OF MYCORRHIZA AND YEAST FOR PRODUCING RED CABBAGE

Saad Abou-El-Hassan[1] ; A. M. H. Hawash[2] ; M.M. El-Dolify[2] and Manal M.H. Gad El-Moula[2]

1- Central Lab of Organic Agriculture, Agricultural Research Center, Egypt.

2- Central Laboratory for Agricultural Climate, Agricultural Research Center, Egypt.

*** E-mail-Hawwash_Hawash78@yahoo.com**

ABSTRACT

A field experiment was designed at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Giza, Egypt during 20118/2019 and 20119/2020 seasons. This experiment was aimed to evaluate the effectiveness of mycorrhiza and yeast extract to produce red cabbage (Lisa F_1) under a low level of chemical fertilizers. Individual and combination treatments of arbuscular mycorrhizal fungi (AMF) and yeast extract combined with 50% of chemical fertilizers were compared with 50 and 100% of chemical fertilizers. The application of 50% chemical fertilizers + AMF + yeast extract gave the highest values of vegetative growth, yield and head properties of red cabbage. The treatment of 50% chemical fertilizers + yeast extract came in second order and produced a similar yield to the yield obtained from 100% chemical fertilizers. The plants treated by 50% chemical fertilizers only produced the lowest values of all studied traits. This study demonstrated the possibility of applying AMF and yeast extracts with the use of half dose of chemical fertilizers to produce good yield and quality of red cabbage.

Key Words: Red cabbage, arbuscular mycorrhizal fungi, yeast extract, low level of chemical fertilizers.

INTRODUCTION

Red cabbage is usually eaten fresh as an ingredient of coleslaw and mixed vegetable salads. Cabbage is a vegetable of the cruciferous family and an important source of fresh food worldwide. It is a rich source of vitamin A and C (**FAO, 2000**). It is known that the habit of eating cruciferous vegetables like cabbage, reduces the risk of many types of cancer, especially lung, colon, breast, ovarian and bladder cancer. Researchers have also revealed that cruciferous vegetables strengthen the heart and blood vessels (**Beecher, 1994**).

Fertilizer is a key part to obtain a good vegetable production, the requirement of fertilizer for vegetables is very high due to its high yielding in a short period. Accordingly, nutrition with appropriate levels of N, P and K had a major role in improving the growth and yield of vegetable crops (**Jilani *et al.,* 2009; Eifediyi and Remison, 2010;**

Feleafel *et al.,* 2014 and Naik *et al.,* 2019). However, excessive fertilizer with N, P and K leads to pollute of the agricultural ecosystem through groundwater pollution with nitrates and increased nitrate content in agricultural products, causing destructive effects on human health, as well as reducing soil fertility and activity of microorganisms (**Mahdi *et al.,* 2010**). More likely, plants do not benefit from the large amounts of mineral fertilizers that are added to the soil annually. Where, about 50% of these fertilizers are lost due to atmospheric volatilization or leaching into the soil, which causes an increase in greenhouse gases, groundwater pollution and soil salinization (**Simpson *et al*., 2011**).

Arbuscular mycorrhizal fungi (AMF) establish symbiotic associations with most different plants. Fungal hyphae of mycorrhiza often penetrate within the cortex cell walls of the root to form a common root network inside and between root cells, which serve as major points of nutrient exchange between the plant and the fungus (**Parniske, 2008; Smith and Read, 2008**). As a consequence, mycorrhizal fungi provide the plant with soil nutrients such as N, P, K, Zn, Fe and water, in turn the fungi take from the plant a part of the products of photosynthesis (**Egerton-Warburton *et al.,* 2007; Ortas, 2012; Abdullahi and Sheriff, 2013**). Importantly, mycorrhiza increases the root absorption surface, thus increasing the absorption of water and nutrients **(Cavagnaro *et al*., 2006; Smith and Read, 2008; Wu *et al*., 2010 and Hameed *et al*., 2014)**. Application of AMF can compensate for the reduction in chemical fertilizers, offering a more optimal growth and yield (**Solaiman *et al*., 2010; Ziane *et al.,* 2017; Yusif *et al*., 2018; Farhan and Khalifa, 2019**).

Yeast is rich in nitrogen, which is an essential nitrate for plant growth. Yeast also produces beneficial substances such as growth regulators (particularly cytokinins), amino acids and vitamins (particularly B complex) that improve plant cell division and growth, thus enhancing plant growth and productivity (**Amer, 2004; El-Tohamy, *et al*., 2008; Mahmoud, *et al*., 2013; Nassef, *et al*., 2016 ; Abdelaal, *et al*., 2017**). Many studies reported that application of the yeast extract led to improve growth and productivity of vegetable crops such as **Tartoura (2001)** on pea, **El- Tohamy and El-Greadly (2007)** on beans, **Ahmed *et al.* (2011)** on potato and **Sarhan *et al.* (2011)** on cucumber. Other studies reported that application of the yeast extract led to increase quality and yield of many vegetable crops such as **Abou El-Nasr *et al.* (2001)** on squash, **Kabeel *et al.* (2005)** on cucumber, **Fawzy (2007)** on head lettuce and **Alsaady *et al.* (2020)** on cabbage. Some studies reported that yeast played an important role in enhancing of plant nutrient status and increasing the growth of plant (**Mahmoud, *et al*., 2013** on pea; **Abou-El-Hassan and El-Batran, 2020** on sweet corn).

Therefore, this study investigated the possibility of utilizing arbuscular mycorrhizal fungi and yeast extracts to produce red cabbage under low level of chemical fertilizers.

MATERIAL AND METHODS

Field experiment on red cabbage was carried out at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Giza, Egypt during 2018/2019 and 2019/2020 seasons. This experiment was performed to evaluate the effectiveness of mycorrhiza and yeast extract to produce red cabbage (Lisa F_1) under a low level of chemical fertilizers.

Plant Material

Seeds of red cabbage were sown in the nursery on first week of October in both seasons. The seeds were placed in the seedling trays, which were filled with peat moss and vermiculite 1:1 (v:v). The plants were transplanted in the field on the first week of November in both seasons. The experimental area was prepared into ridges after plowing and leveling; each plot contained three ridges of 0.6 m width and 3 m length. The transplanting were planted at a distance of 0.30 m in one row on ridge. The plants were irrigated three times a week using drip hoses (flow rate 4 l / h); physical and chemical properties of the experimental soil were presented in Table 1. The experiment was designed in complete randomized blocks with three replicates. The plot area was 5.40 m^2 (3 m length and 1.8 m width).

Table 1. Physical and chemical properties of the experimental soil

Clay %	Silt %	Sand %	Texture	pH	EC dS/m	Cations meq/l				Anions meq/l		
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO_4^{=}$
47.71	40.74	11.55	Silte clay	7.78	1.13	2.12	1.15	4.53	1.54	2.27	4.75	2.83

The Experimental Treatments

1- 100% Chemical fertilizers of N, P and K (F) as control treatment
2- 50% F
3- 50% F + arbuscular mycorrhizal fungi (AMF) as *Glomus mosseae*
4- 50% F + yeast extract (Y)
5- 50% F + AMF + Y

Quantities of application

The control treatment as a chemical fertilizers of N, P and K were applied as follow 51.25 kg N/fed as 250 kg ammonium sulphate (20.5% N), 31 kg P_2O_5/fed as 200 kg calcium super phosphate (15.5% P_2O_5) and 48 kg K_2O/fed as 100 kg potassium sulphate (48% K_2O). Calcium super phosphate was added as one dose during soil preparation, whereas ammonium sulphate and potassium sulphate were added at three equal portions, during soil preparation, after 3 and 6 weeks from transplanting.

Arbuscular mycorrhizal fungi (*Glomus mosseae*) was used as mixture of vermiculite and soil (1:1) containing spores and hyphae of mycorrhiza. These fungi were placed (on 5 cm depth) into rows of planting just before cultivation the red cabbage transplanting at rate 1 kg/feddans according to **Xavier and Germida (2003)**. Yeast extract was prepared by adding 1 kg of dry yeast with 1 liters of molasses and adding water to a volume of 20 liters. These ingredients were transported to a non-completely sealed (100 liters container) and left for 12 hours, then water was added to 100 liters final volume. Yeast extract were applied to the derange soil after one and four weeks of planting at a rate of 100 l/fed.

Table 2. Chemical analysis of activated yeast (mg/100g dry weight).

Mineral		Amino acid	
Total N	7.23	Arginine	1.99
P	51.68	Histidine	2.63
K	34.39	Isoleiucine	2.31
Mg	5.76	Leucine	3.09
Ca	3.05	Lysine	2.95
Si	1.55	Methionine	0.72
So2	0.49	Phrnylalanine	2.01
Fe	0.92	Theronine	2.09
Mn	81.3	Tryptophan	0.45
Zn	335.6	Valine	2.19
NaCl	0.30	Glutamic acid	2.00
Co	67.8	Serine	1.59
Pd	438.6	Aspartic acid	1.33
		Praline	1.53
		Tyrosine	1.49

Data Recorded

After 90 days from transplanting, the plants were harvested and total yield was recorded for each plot. Three plants were randomly chosen from each plot to measure head fresh weight, stem diameter (under the first bottom leaf directly), outer leaf number, circumference and weight of head. Also, head firmness and percentage of total soluble solids (TSS) were measured by using Pressure Tester and Digital Refractometer, respectively. As well as, anthocyanin content was determined using spectrophotometer according to **Geza *et al.* (1984)**. Red cabbage head content of nutrient (N, P and K) and nitrate were determined in dry matter of head. Total nitrogen, phosphorus and potassium were determined by Micro Kjeldahl, Spectrophotometer and Flame photometer respectively according to **FAO (1980)**. Nitrate content was determined using Brucine method reported by **Holty and Potworowski (1972)**.

Statistical analysis

Data of the two seasons were arranged and statistically analyzed by the analysis of variances according to **Snedecor and Cochran (1980)** with SAS software, version 2004. Treatment means were compared using Tukey test at significance level 0.05.

RESULTS AND DISCUSSION

Vegetative growth of red cabbage (head fresh weight, stem diameter and outer leaf number) in response to mycorrhiza and yeast extract in both seasons is shown in Table 3. Results showed that the treatment of mycorrhiza + yeast extract under 50% of chemical fertilizers gave the highest values in all growth characteristics of plants compared to other treatments. While, treatment of yeast extract with using 50% of chemical fertilizers came the second order without significant differences with treatment of 100% chemical fertilizers. Growth characteristics of the mycorrhiza treatment with the addition of 50% chemical fertilizers ranked third order. The lowest values in all growth characteristics were obtained from using 50% chemical fertilizers only. Enhancement in the growth of red cabbage plants with using mycorrhiza and yeast extract may be due to the role of micorrhiza in nutrient releasing and increasing the absorptive surface of roots **(Cavagnaro *et al*., 2006; Smith and Read, 2008; Wu *et al*., 2010; Hameed *et al*., 2014).** As well as the role of yeast extract in improving the vegetative growth of plant. Where, yeast extract contains high levels of nitrogen, produces beneficial substances like growth regulators (especially cytokinins), amino acids and vitamins (especially B-complex) that work to increase the division and growth of plant cells leading to improve plant growth (**Tartoura, 2001; Amer, 2004; El-Tohamy and El-Greadly, 2007; Ahmed *et al.,* 2011; Sarhan *et al.,* 2011; Mahmoud, *et al*., 2013; Abdelaal, *et al*., 2017**).

Table 3. Effect of mycorrhiza and yeast extract on vegetative growth characteristics of red cabbage plants during 2018/2019 and 2019/2020 seasons

Treatment	head fresh weight/ kg		Stem diameter/cm		Outer leaf No	
	First season	Second season	First season	Second season	First season	Second season
100% F	1.74 b	1.84 b	3.30 b	3.30 b	14.67 b	15.00 b
50% F	1.07 d	1.12 d	2.47 c	2.47 c	11.67 c	11.67 d
50% F + AMF	1.50 c	1.56 c	3.20 b	3.23 b	14.00 b	14.00 c
50% F + Y	1.72 b	1.82 b	3.27 b	3.30 b	14.67 b	15.00 b
50% F + AMF + Y	1.85 a	1.93 a	3.47 a	3.53 a	16.33 a	16.67 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

F= Chemical fertilizers AMF= Arbuscular mycorrhizal fungi (Glomus mosseae)

Y= Yeast extract

Effects of different treatments on yield and head characteristics of red cabbage in both seasons are presented in Table 4 and 5. The results clearly showed that treatment of 50% chemical fertilizers + AMF + yeast extract produced the highest yield per plot and feddan as well as gave the best head characteristics compared to other treatments. The treatment of 50% chemical fertilizers + yeast extract came in second order and produced a yield similar to the yield produced by 100% chemical fertilizers without significant differences between them. Whereas, the plants treated by 50% chemical fertilizers only produced the lowest values of yield and head characteristics. The superiority of 50% chemical fertilizer + AMF + yeast extract treatment in the yield and head characteristics can be attributed to its superiority in stimulating vegetable growth of plants as shown in Table 2, resulting in an increase in photosynthesis and better carbohydrate construction, thus improved yield and head characteristics of red cabbage. These results are consistent with those obtained by **Solaiman *et al.* (2010), Ziane *et al.* (2017), Yusif *et al*. (2018*)*** and **Farhan & Khalifa (2019)** on arbuscular mycorrhizal fungi; **Abou El-Nasr *et al.* (2001), Kabeel *et al.* (2005), Fawzy (2007)** and **Alsaady *et al.* (2020)** on yeast extract. They found that application of mycorrhiza or yeast extract lead to the production of plants better in the productivity and yield quality.

Table 4. Effect of mycorrhiza and yeast extract on yield of red cabbage during 2018/2019 and 2019/2020 seasons

Treatment	Yield/plot (5.40 m^2) kg		Yield t/fed.	
	1st season	2nd season	1st season	2nd season
100% F	42.04 b	44.08 b	31.14 b	32.65 b
50% F	25.70 d	26.34 d	19.03 d	19.51 d
50% F + AMF	36.06 c	37.56 c	26.71 c	27.82 c
50% F + Y	41.29 b	43.92 b	30.59 b	32.53 b
50% F + AMF + Y	44.83 a	47.09 a	33.21 a	43.88 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

F = Chemical fertilizers AMF = Arbuscular mycorrhizal fungi (*Glomus mosseae*)

Y = Yeast extract

Table 5. Effect of mycorrhiza and yeast extract on head characteristics of red cabbage during 2018/2019 and 2019/2020 seasons

Treatment	Head weight kg		Head circumference cm		Head firmness kg/cm^2	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% F	1.17 b	1.22 b	40.67 b	41.67 b	13.40 d	13.267 c
50% F	0.71 d	0.73 d	26.67 d	27.33 d	15.53 a	15.467 a
50% F + AMF	1.00 c	1.04 c	36.33 c	37.33 c	15.27 a	15.133 a
50% F + Y	1.15 b	1.22 b	40.33 b	42.00 b	14.67 b	14.467 b
50% F + AMF + Y	1.25 a	1.31 a	42.67 a	43.67 a	14.17 c	14.233 b

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

F = Chemical fertilizers AMF = Arbuscular mycorrhizal fungi (*Glomus mosseae*)

Y = Yeast extract

Data in Table 6 are mentioned that the highest concentration of N was found in plants that treated by 100% chemical fertilizers compared to other treatments followed by 50% chemical fertilizers + yeast extract with or without AMF. While, P and K contents of plants were the highest with treatment of 50% chemical fertilizers + AMF + yeast extract followed by 100% chemical fertilizers. On the other hand, the lowest concentrations of N, P and K in plants treated by 50% chemical fertilizers only. There were not significant differences in P content of plants between treatments of 100% chemical fertilizers and 50% chemical fertilizers + AMF, as well as no significant differences in K content of plants between treatments of 100% chemical fertilizers and 50% chemical fertilizers + yeast extract. The high N content of plants that treated by 100% chemical fertilizers might be due to N chemical fertilizer is easy decomposition, so the plants absorb N from it in large quantities. These results are in agreement with those obtained by **Singh & Chauhan (2009**) and **Mitova & Stancheva (2013)**. The enhancement of nutrient contents in plants that treated by of 50% chemical fertilizers + AMF + yeast extract might be due to the role of micorrhiza in nutrient releasing, especially phosphorus and expanding the absorptive area of roots from soil nutrients **(Wu *et al*., 2010; Hameed *et al*., 2014)**. As well as, yeast extract contains high levels of nitrogen, produces beneficial substances like growth regulators, amino acids and vitamins (**Amer, 2004; El-Tohamy, *et al*., 2008; Mahmoud, *et al*., 2013; Abdelaal, *et al*., 2017**). All these beneficial effects improved vegetative growth and nutrient uptake, thus increasing the plant's nutrient content. These results are in harmony with those obtained by **Hart *et al.* (2015), Hijri (2016), Bona *et al.* and Chen *et al.* (2017)** on arbuscular mycorrhizal fungi, **Mahmoud *et al.* (2013), Abdelaal *et al.* (2017**) and **Abou-El-Hassan & El-Batran (2020)** on yeast extract. They found that application of mycorrhiza or yeast extract lead to the production of plants vigor growth and higher nutrient uptake.

Table 6. Effect of mycorrhiza and yeast extract on nutritional status of red cabbage plants during 2018/2019 and 2019/2020 seasons

Treatment	N		P		K	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% F	3.677 a	3.707 a	0.447 b	0.460 b	2.447 b	2.477 b
50% F	2.230 d	2.250 d	0.250 d	0.247 d	1.320 d	1.353 d
50% F + AMF	3.143 c	3.290 c	0.427 b	0.440 b	2.250 c	2.267 c
50% F + Y	3.347 b	3.437 b	0.383 c	0.403 c	2.347 bc	2.403 b
50% F + AMF + Y	3.460 b	3.527 b	0.517 a	0.527 a	2.610 a	2.673 a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

F = Chemical fertilizers   AMF = Arbuscular mycorrhizal fungi (*Glomus mosseae*)

Y = Yeast extract

Data in Table 7 have illustrated the effects of different treatments on head compositions of red cabbage in two seasons. The results indicated that application of 50% chemical fertilizers + AMF + yeast extract increased head compositions of TSS and anthocyanin compared to other treatments without significant differences with the treatment of 100% chemical fertilizers in the TSS content of the head. This result may be attributed to the positive role of mycorrhiza and yeast extract in improving vegetable growth (Table 2) and nutritional status (Table 3) of red cabbage plants, which led to increase photosynthesis products that translocation to cabbage heads. These results are in harmony with those reveled by **Hart *et al.* (2015), Hijri (2016), Bona *et al.* and Chen *et al.* (2017)** on arbuscular mycorrhizal fungi, as well as are consistent with those reported by **El-Tohamy *et al.* (2008), Mahmoud *et al.* (2013) and Abdelaal *et al.* (2017)** on yeast extract. Concerning nitrate content in red cabbage heads in both seasons; all treatments treated with 50% chemical fertilizers reduced NO_3 content of red cabbage heads significantly compared to 100% chemical fertilizers treatment. This may be attributed to the lack of nitrogen availability, which reduced the accumulation of nitrate in the cabbage heads, while the high nitrogen availability led to an increase in the accumulation of nitrate. In the same vein, the reduction of chemical nitrogen fertilizer led to decrease nitrate accumulation in heads of lettuce (**Abou-El-Hassan & Desoky 2013; Shahein *et al.*, 2013)** and red cabbage (**Abou-El-Hassan and El-Shinawy, 2015)**.

Table 7. Effect of mycorrhiza and yeast extract on the head composition of red cabbage during 2018/2019 and 2019/2020 seasons

Treatment	TSS (%)		Anthocyanin (%)		NO_3 (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% F	8.467 ab	8.333 a	0.830 b	0.833 b	0.330 a	0.337 a
50% F	7.267 d	7.200 d	0.643 d	0.657 d	0.063 d	0.067 d
50% F + AMF	7.867 c	7.800 c	0.737 c	0.747 c	0.090 cd	0.093 c
50% F + Y	8.333 b	8.300 b	0.813 b	0.823 b	0.117 bc	0.120 b
50% F + AMF + Y	8.800 a	8.700 a	0.887 a	0.887 a	0.137 b	0.137 b

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

F = Chemical fertilizers AMF = Arbuscular mycorrhizal fungi (*Glomus mosseae*)

Y = Yeast extract

CONCLUSION

It could be concluded possibility applying AMF and yeast extracts with the use of half dose of chemical fertilizers to produce good yield and quality of red cabbage.

ACKNOWLEDGEMENTS

This work has been supported by Central Laboratory of Organic Agriculture (CLOA), Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center.

REFERENCES

Abdelaal, K.A.A. ; Y.M. Hafez ; A. El Sabagh and H. Saneoka (2017). Ameliorative effects of abscisic acid and yeast on morpho-physiological and yield characteristics of maize plant (*Zea mays* L.) under water deficit conditions. Fresenius Environ. Bulletin, 26(12): 7372-7383.

Abdullahi, R. and H.H. Sheriff (2013). Effect of arbuscular mycorrhizal fungi and chemical fertilizer on growth and shoot nutrients content of onion under field condition in Northern Sudan Savanna of Nigeria. IOSR J. Agri. Veter. Sci., 3(5): 85-90.

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

Abou-El-Hassan, S. and M.Z. El-Shinawy (2015). Influence of compost, humic acid and effective microorganisms on organic production of red cabbage. Egypt. J. Hort., 42(1): 533- 545.

Abou-El-Hassan, S. and H.S. El-Batran (2020). Integration of some bio compounds with compost tea to produce sweet corn without mineral fertilizers. Middle East J. of Agric. Res., 9(3): 645-652.

Abou El-Nasr, M.E. ; R.A. El-Shabrawy and M.M. Abd El- Rahman (2001). Effect of bread yeast application and some nutrient elements on squash (*Cucurbita pepo* L) plant growth, yield and fruit quality under conditions of the early summer planting. J. Agric. Sci. Mansoura Univ., 26(7): 4451-4464.

Ahmed, A.A. ; M.M.H. Abd El-Baky ; M.F. Zaki and F.S. Abd El-Aal (2011). Effect of foliar application of active yeast extract and zinc on growth, yield and quality of potato plant (*Solanum tuberosum* L). J. of Appl. Sci. Res., 7(12): 2479-2488.

Alsaady, M.H.M. ; H.A. Salim ; A.K. Abdulrazzaq ; U.N. Saleh ; N.H. Jassim ; A.R. Hamad ; J.A. Attia ; J.J. Darwish and A.F. Hassan (2020). Response of cabbage plants to foliar application of yeast suspension and nitrogen fertilizer. Eco. Env. & Cons., 26(2): 832-836.

Amer, S.S.A., 2004. Growth, green pods yield and seeds yield of common bean (*Phaseolus vulgaris* L.) as affected by active dry yeast, salicylic acid and their interaction. J. Agric. Sci. Mansoura Univ., 29(3): 1407-1422.

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

Bona, E. ; S. Cantamessa ; N. Massa ; P. Manassero ; F. Marsano and A. Copetta (2017). Arbuscular mycorrhizal fungi and plant growth-promoting pseudomonads improve yield, quality and nutritional value of tomato: A field study. Mycorrhiza, 27: 1-11.

Cavagnaro, T.R. ; L. Jackson ; J. Six ; H. Ferris ; S. Goyal ; D. Asami and K. Scow (2006). Arbuscular mycorrhizas, microbial communities, nutrient availability, and soil aggregates in organic tomato production. Plant Soil, 282: 209–225.

Chen, S. ; H. Zhao ; C. Zou ; Y. Li ; Y. Chen and Z. Wang (2017). Combined inoculation with multiple arbuscular mycorrhizal fungi improves growth, nutrient uptake and photosynthesis in cucumber seedlings. Front. Microbiol., 8: 25-16.

Egerton-Warburton, L.M. ; J.I. Querejeta and M.F. Allen (2007). Common mycorrhizal networks provide a potential pathway for the transfer of hydraulically lifted water between plants. J. Exp. Bot., 58: 1473-1483.

Eifediyi, E.K. and S.U. Remison (2010). Growth and yield of cucumber (*Cucumis sativum* L.) as influenced by farmyard manure and inorganic fertilizer. J. Plant Breeding and Crop Sci., 2(7): 216-220.

El-Tohamy, W.I.A. and N.H.M. El-Greadly (2007). Physiological responses, growth, yield and quality of snap beans in response to foliar application of yeast, vitamin E and zinc under sandy soil conditions. Australian J. of Basic and Appl. Sci., 1(3): 294-299.

El-Tohamy, W.A. ; H.M. El-Abagy and N.H.M. El-Greadly (2008). Studies on the effect of putrescine, yeast and vitamin C on growth, yield and physiological responses of eggplant (*Solanum melongena* L.) under sandy soil conditions. Australian J. of Basic and Appl. Sci., 2(2): 296-300.

Farhan, M.J. and K.M. Khalifa (2019). Effect of inoculation with the mycorrhiza and the level of the phosphate fertilization in the growth and development of the okra in gypsiferous soil. Plant Archives, 19(2): 3951-3956.

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

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

Fawzy, Z.F. (2007). Increasing productivity of head lettuce by foliar spraying of some bio- and organic compounds. Egypt. J. Appl. Sci., 22(10A): 237-247.

Feleafel, M.N. ; Z.M. Mirdad and A.S. Hassan (2014). Effect of NPK fertigation rate and starter fertilizer on the growth and yield of cucumber grown in greenhouse. J. Agri. Sci., 6(9): 81-92.

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

Hameed, A. ; Q.S. Wu ; E.F. Abd_Allah ; A. Hashem ; A. Kumar ; H.A. Lone and P. Ahmad (2014). Role of AM fungi in alleviating drought stress in plants. In: Miransari, M. (Ed.), Use of Microbes for the Alleviation of Soil Stresses. Springer Science, Business Media, New York.

Hart, M. ; D.L. Ehret ; A. Krumbein ; C. Leung ; S. Murch and C. Turi (2015). Inoculation with arbuscular mycorrhizal fungi improves the nutritional value of tomatoes. Mycorrhiza, 25: 359-376.

Hijri, M. (2016). Analysis of a large dataset form field mycorrhizal inoculation trials on potato showed highly significant increase in yield. Mycorrhiza, 2: 209-214.

Holty, J.G. and H.S. Potworowski (1972). Brucine analysis for high nitrate concentrations. Environ. Sci. Technol., 8(6): 835-837.

Jilani, M.S. ; A. Bakar ; K. Waseem and M. Kiran (2009). Effect of different levels of NPK on the growth and yield of cucumber (*Cucumis sativus*) under the plastic tunnel. J. Agric. Soc. Sci., 5(3): 99-101.

Kabeel, M.M. ; S.M.A. Kabeel and M.A. Fayza (2005). Effect of organic and biofertilizer on growth, yield and fruit quality of cucumber grown under clear polyethylene low tunnels. J. Agric. Sci. Mansoura Univ., 30(5): 2827-2841.

Mahdi, S.S. ; G.I. Hassan ; S.A. Samoon ; H.A. Rather ; S.A. Dar and B. Zehra, (2010). Bio-fertilizers inorganic agriculture. J. Phytol., 2(10): 42-54.

Mahmoud, A.R. ; M. EL-Desuki ; M.M. Abdel-Mouty and A.H. Ali (2013). Effect of compost levels and yeast extract application on the pea plant growth, pod yield and quality. J. App. Sci. Res., 9(1):149-155.

Mitova, I. and I. Stancheva (2013). Effect of fertilizer source on the nutrients biological uptake with garden beans production. Bulgarian J. of Agric. Sci., 19(5): 946-950.

Naik, H.P. ; P.C. Mali ; V.D. Kapse ; K.P. Vaidya ; R.V. Dhopavkar ; N.A. Meshram and S.S. More (2019). Response of F_1 hybrids of cucumber (*Cucumis sativus* L.) to different levels of fertilizers under Konkan agro climatic condition. The Pharma Innovation J., 8(12): 429-430.

Nassef, D.M.T. and H.M. El-Aref (2016). Response of Cucumber to Yeast and Royal Jelly Foliar Applications. Assiut J. Agric. Sci., 47: 633-648.

Ortas, I. (2012). The effect of mycorrhizal fungal inoculation on plant yield, nutrient uptake and inoculation effectiveness under long-term field conditions. Field Crops Res., 125: 35–48.

Parniske, M. (2008). Arbuscular mycorrhiza: the mother of plant root endosymbioses. Nature Reviews Microbiol., 6: 763–775.

Sarhan, T.Z. ; S.T. Ali and S.M.S. Rasheed (2011). Effect of bread yeast application and seaweed extract on cucumber (*Cucumis sativus* L.) plant growth, yield and fruit quality. Mesopotamia J. of Agric., 39(2): 26-32.

Shahein, M.M. ; S. Abou El Hassan and A.A. Ragab (2013). Reduction of mineral fertilizers in lettuce production by using microbial inoculation, Potassium Humate and Potassium Silicate. Hortscience J. Suez Canal University, 1: 77-84.

Simpson, R.J. ; A. Oberson ; R.A. Culvenor ; M.H. Ryan ; E.J. Veneklaas ; H. Lambers ; J.P. Lynch ; P.R. Ryan ; E. Delhaize ; F.A. Smith ; S.E. Smith ; P.R. Harvey and A.E. Richardson (2011). Strategies and agronomic interventions to improve the phosphorus-use efficiency of farming systems. Plant and Soil, 349: 89–120.

Singh, N.I. and J.S. Chauhan (2009). Response of french bean (*Phaseolus Vulgaris* L.) to organic manures and inorganic fertilizer on growth and yield parameters under irrigated condition. Nature and Sci., 7(5): 52-54.

Smith, S.E. and D.J. Read (2008). Mycorrhizal Symbiosis. 3rd ed. Academic Press New York, USA.

Snedecor, G.W. and W.G. Cochran (1980). Statistical methods. Sixth Edition, Iowa state university press, Ames., Iowa, U.S.A.

Solaiman, Z.M. ; P. Blackwell ; L.K. Abbott and P. Storer (2010). Direct and residual effect of biochar application on mycorrhizal root colonisation, growth and nutrition of wheat. Soil Res., 48: 546–554.

Tartoura, E.A.A. (2001). Response of pea plants to yeast extract and two sources of N-fertilizers. J. Agric. Sci., Mansoura Univ., 26(12): 7887-7901.

Wu, Q.S. ; Y.N. Zou ; W. Liu ; X.F. Ye ; H.F. Zai and L.J. Zhao (2010). Alleviation of salt stress in citrus seedlings inoculated with mycorrhiza: changes in leaf antioxidant defense systems. Plant Soil Environ., 56: 470-475.

Xavier, L.J.C. and J.J. Germida (2003). Selective interaction between arbuscular mycorrizal fungi and *Rhizobium leguminosarum* bv. *viceae* enhance pea yield and nutrition. Biol. Fertil. Soils, 37: 262-267.

Yusif, S. ; M. Dare ; O. Babalola ; A. Popoola ; M. Sharif and M. Habib (2018). The roles of biochar and arbuscular mycorrhizal inoculation on selected soil biological properties and tomato performance. FUTY J. Environ., 12: 1–8.

Ziane, H. ; A. Meddad-Hamza ; A. Beddiar and S. Gianinazzi (2017). Effects of arbuscular mycorrhizal fungi and fertilization levels on industrial tomato growth and production. Int. J. Agric. Biol., 19: 341–347.

الإستفادة من الميكورهيزا والخميرة لإنتاج الكرنب الأحمر

سعد أبو الحسن عبد العزيز[1] – أحمد محمود حسن حواش[2] –
محمد رشاد مصطفى الضليفى[2] – منال محمد حسنى عبد المولى[2]

1- المعمل المركزى للزراعة العضوية – مركز البحوث الزراعية – الجيزة – مصر.

2- المعمل المركزى للمناخ الزراعى – مركز البحوث الزراعية – الجيزة – مصر.

أجريت تجربة حقلية في المعمل المركزي للمناخ الزراعي (CLAC) ، مركز البحوث الزراعية ، الجيزة ، مصر خلال موسمي 2019/20118 و 2020/20119. تهدف هذه التجربة إلى تقييم فعالية فطريات الميكورهيزا ومستخلص الخميرة لإنتاج الكرنب الأحمر (هجين ليزا) تحت مستوى منخفض من الأسمدة الكيماوية. تمت مقارنة معاملات فردية ومجتمعة من

فطريات الميكورهيزا ومستخلص الخميرة بالاضافة الى 50٪ من الأسمدة الكيماوية مع إستخدام 50٪ و 100٪ من الأسمدة الكيماوية.

أعطت إضافة 50٪ من الأسمدة الكيماوية + فطريات الميكورهيزا + مستخلص الخميرة أعلى القيم من النمو الخضري والمحصول وخصائص الرأس للكرنب الأحمر. وجاءت معاملة 50٪ من الأسمدة الكيماوية + مستخلص الخميرة في المرتبة الثانية وأنتجت محصولاً مشابهًا للمحصول المتحصل عليه من 100٪ أسمدة كيماوية دون وجود فروق معنوية بينهما. النباتات التي عوملت بنسبة 50٪ من الأسمدة الكيماوية فقط أنتجت أقل القيم فى جميع الصفات المدروسة. أوضحت هذه الدراسة إمكانية تطبيق فطريات الميكورهيزا ومستخلص الخميرة مع إستخدام نصف جرعة الأسمدة الكيماوية لإنتاج محصول جيد وذو جودة عالية من الكرنب الأحمر.