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The Effect of Increasing Mycorrhiza Applications on Nutrition of Pak Choi (*Brassica rapa* L. *subsp. chinensis* L.) Plant

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Abstract: The study was done to determine the effect of increasing mycorrhiza application on some macro and micro nutrient element contents of pak choi (*Brassica rapa* L. *subsp. chinensis* L.) plant. According to the experiment results, important increases in some macro and micro nutrient element contents of pak choi plant were determined with increasing mycorrhiza applications. The contents were determined as P (0.38 %, 0.42 %, 0.45 %, 0. 49 % and 0.51 %), K (4.01 %, 4.30 %, 4.41 %, 4.56 % and 4.70 %), Ca (1.83 %, 2.01 %, 2.06 %, 2.20 % and 2.36 %), Mg (0.14 %, 0.15 %, 0.15 %, 0.16 % and 0.16 %), Fe (309 mgkg^{-1}, 417 mgkg^{-1}, 678 mgkg^{-1}, 1009 mgkg^{-1}and 1696 mgkg^{-1}), Cu (5.49 mgkg^{-1}, 6.10 mgkg^{-1}, 6.53 mgkg^{-1}, 7.05 mgkg^{-1}and 7.63 mgkg^{-1}), Mn (45.90 mgkg^{-1}, 52.23 mgkg^{-1}, 60.20 mgkg^{-1}, 70.40 mgkg^{-1}and 80.00 mgkg^{-1}) and Zn (32.23 mgkg^{-1}, 35.40 mgkg^{-1}, 37.00 mgkg^{-1}, 40.70 mgkg^{-1}and 46.86 mgkg^{-1}) at I. dose, (control): 0 ml plant^{-1}, II. dose: 15 ml plant^{-1}, III. dose: 20 ml plant^{-1}, IV. dose: 30 ml plant^{-1} and V. dose: 40 ml plant^{-1}, respectively. These P, K, Ca and Mg contents increases were determined significant at the level of $P<0.05$, statistically. The highest nutrient element contents of pak choi plant were obtained V. dose: 40 ml plant^{-1}applications for P, K, Ca, Mg, Fe, Cu, Mn and Zn nutrient elements.

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1. Introduction

As a highly rated leafy variety of vegetables and a marvelous food alternative, brassicas is grown for its enlarged, edible, terminal buds; and is preferably eaten almost everywhere in the world as well [1]. This green vegetable was made known around the world by the efforts of the travelers and immigrants [2-4].

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Pak choi name was given syn. *Brassica chinensis* L. (1759), *Brassica campestris* L. subsp. *chinensis* (L.) [5], *Brassica rapa* L. subsp. *chinensis* (L.) [6] in China. This vegetable which has been known since the 5th A. D. and grown widely in China and Taiwan is classified within the group which is identified as Chinese vegetables [7, 8]. Its leaves are edible and it has 50-60 days of vegetation approximately [9, 10].

A greenhouse experiment was made for the effect of increasing mycorrhiza application on the some nutrient element contents of maize plant (*Zea mays* L.) [11]. According to the research results, N, K, Fe and Cu contents of maize plant increased with increasing mycorrhiza application.

The effect of salt (0 and 100 mg Na Cl kg^{-1}) and increasing zinc applications (0, 25, 50 mg Zn kg^{-1}) application on phosphorus and zinc uptake of maize (*Zea mays* L.) plant with mycorrhiza and non-mycorrhiza conditions. At the end of the experiment it was determined that mycorrhiza inoculated applications provided a significant increase in fresh weight, dry weight, phosphorus and zinc contents compared to the non-mycorrhiza applications [12].

The research was done to determine the effect of increasing mycorrhiza application on some macro and micro nutrient element contents of pak choi plant.

2. Material and Methods

Using high tunnel cold greenhouse covered by polyetilen (PE) with UV additive which belongs to Namik Kemal University, Vocational College of Technical Sciences, Plant and Animal Production Department, the experiments were carried out autumn in Tekirdag city (40°98' N, 27°48' E) Turkey in 2016.

Research was designed as three replications according to randomized block experimental design. The white mini variety of Pak Choi (Zengarden Firm) was used for the research (Figure 1). Seeds were sown in multi-celled trays filled with peat (Klasmann-Deilmann, Potground H, Germany) in October. Some properties of the used peat are: 160-260 mgl^{-1} N, 180-280 mgl^{-1} P_2O_5, 200-150 mgl^{-1} K_2O, 80-150 mgl^{-1} Mg, pH: 6, 70 % organic matter and 35 % C. When the seedlings became 2 to 3 true leaves (21th days for pak choi after seed sowing) they were planted to pre-prepared places in high tunnel cold greenhouse with 10x10 cm intervals and 10 plants in each parcel.

Then five mycorrhiza doses (I. dose, (control): 0 mlplant^{-1}, II. dose: 15 mlplant^{-1}, III. dose: 20 mlplant^{-1}, IV. dose: 30 mlplant^{-1}and V. dose: 40 mlplant^{-1}were applied before a month from harvesting time and plants were harvested 54 days after seed sowing. Some macro and micro nutrient elements (P, K, Ca, Mg, Fe, Cu, Mn and Zn) contents of plants were determined via ICP-OES instrument [13]. Then experiment analysis results were evaluated SPSS 21 statistically program. ANOVA variance analysis was done and Duncan multiple comparison tests were done on this research results.

Some chemical properties of the soil samples which used in this experiment it can be seen in Table 1. The some climate data measured inside the tunnel during the growing of the plants it can be seen in Table 2. Since there were no diseases and pests, no pesticides was used during the growing period.

Figure 1. A general view from pak choi experiment and post-harvested plant (Original).

According to the Table 1, pH value alkaline, salt less, low organic matter content, little lime, medium available phosphorus, exchangeable K, Ca and Mg sufficient, also, micro element (Mn, Cu, Fe and Zn) contents are sufficient of experiment area soil

Table 1. Some chemical properties of soil samples

Soil properties	Results
pH	8.01
Salinity (%)	0.07
CaCO3 (%)	2.74
Organic matter (%)	1.35
Ca (%)	0.54
P ($mgkg^{-1}$)	36.40
K ($mgkg^{-1}$)	253.80
Mg ($mgkg^{-1}$)	473.10
Mn ($mgkg^{-1}$)	5.68
Cu ($mgkg^{-1}$)	0.81
Fe ($mgkg^{-1}$)	7.43
Zn ($mgkg^{-1}$)	0.97

Table 2. Average some climate data in unheated greenhouse during the experiment period.

Month	Average temperature (^{0}C)	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Average humidity (%)
October	16.50	19.03	14.01	87
November	12.30	15.01	9.60	89
December	7.40	10.50	4.30	90

3. Results and Discussion

The effect of increasing mycorrhiza application on some macro nutrient element content of pak choi plant is given in Table 3. According to the Table 3, phosphor content of pak choi plant was obtained 0.38 % and 0.51 % for I. dose and V. dose, respectively. Potassium content of pak choi plant was obtained 4.01 % and 4.70 % for I. dose and V. dose, respectively.

Calcium content of pak choi plant was obtained 1.83 % and 2.36 % for I. dose and V. dose, respectively. Magnesium content of pak choi plant was obtained 0.14 % and 0.16 % for I. dose and V. dose, respectively.

P, K, Ca and Mg contents of pak choi plant increased with increasing mycorrhiza application (Table 3). These increases were found statistically significant at the level of $p<0.05$. These results were found to be some earlier researchers [11, 14].

Table 3. The effect of increasing mycorrhiza application on some macro nutrient element contents of pak choi plant, (%)

Mycorrhiza doses	P	K	Ca	Mg
I.dose (Control)	0.38±0.31**c**	4.01±0.18**d**	1.83±0.77**d**	0.14±0.07**a**
II. dose	0.42±0.13**b**	4.30±0.30**c**	2.01±0.29**c**	0.15±0.21**ab**
III. dose	0.45±0.08**b**	4.41±0.51**bc**	2.06±0.11**c**	0.15±0.13**ab**
IV. dose	0.49±0.09**a**	4.56±0.73**ab**	2.20±0.99**b**	0.16±0.15**a**
V. dose	0.51±0.06**a**	4.70±0.59**a**	2.36±0.62**a**	0.16±0.80**a**

*: values are average of three replications,
**: each parameter evaluated individually,
***: $p<0.05$

The effect of increasing mycorrhiza application on some micro nutrient element content of pak choi plant is given in Table 4. According to the Table 4, iron content of pak choi plant was obtained 309 mgkg^{-1} and 1696 mgkg^{-1}for I. dose and V. dose, respectively. Cupper content of pak choi plant was obtained 5.49 mgkg^{-1}and 7.63 mgkg^{-1}for I. dose and V. dose, respectively.

Zinc content of pak choi plant was obtained 32.23 mgkg^{-1}and 46.86 mgkg^{-1}for I. dose and V. dose, respectively. Manganese content of pak choi plant was obtained 45.90 mgkg^{-1}and 80.00 mgkg^{-1}for I. dose and V. dose, respectively.

Fe, Cu, Zn and Mn contents of pak choi plant increased with increasing mycorrhiza application according to the Table 4. These increases were found statistically significant at the level of $p<0.05$. These results were found to be some earlier researchers [15-17].

Table 4. The effect of increasing mycorrhiza application on some micro nutrient element contents of pak choi plant, $mgkg^{-1}$

Mycorrhiza doses	Fe	Cu	Zn	Mn
I.dose (Control)	309±4.3**d**	5.49±0.02**d**	32.23±0.10**d**	45.90±0.4**d**
II. dose	417±3.9**d**	6.10±0.02**c**	35.40±0.10**c**	52.23±0.2**d**
III. dose	678±5.5**c**	6.53±0.01**c**	37.00±0.02**c**	60.20±0.4**c**
IV. dose	1009±19.3**b**	7.05±0.08**b**	40.70±0.10**b**	70.40±0.1**b**
V. dose	1696±4.9**a**	7.63±0.04**a**	46.86±0.30**a**	80.00±0.5**a**

*: values are average of three replications,
**: each parameter evaluated individually,
***: $p<0.05$

Mycorrhiza could also enhance crop quality not only by enrichment in macronutrients (like P) [18, 19] and in micronutrients [20-22]. Mycorrhiza yield mineral element contents are decreasing, compromising the nutritional value of food. The use of beneficial bacteria results in an increase in the concentration or availability of mineral elements in the production. Micro nutrient is regarded as a promising strategy to overcome malnutrition in terms of nutrition [20, 23]. Beneficial bacteria use, macro and micronutrient element affects the soil intake positively [24, 25]. According to Gianinazzi and Gollotte, 2010 [26] increasing mineral nutrient and water uptake by plants. And promote plant growth while reducing fertilizer requirement.

4. Conclusion

According to this greenhouse experiment results, increasing doses of mycorrhiza application was increased some macro (N, P, K, Ca and Mg) and micro (Fe, Cu, Zn and Mn) element contents of pak choi plant. These increases were found to be statistically significant at the level of $p<0.05$. This result is very important nutrition and quality of pak choi plant. Because, excess chemical fertilizers application to the agricultural soils was destroyed soil fertility and quality. Therefore, mycorrhiza, another different microbial fertilizers, other organic fertilizers and organic materials should be applied to the agricultural soils for quality plant production and sustainable soil fertility. Also, according to the earlier research result, mycorrhiza applications were improved of some physical, chemical and biological properties of the agricultural soils.

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