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The effect of increasing leonardit applications on dry matter yield and some nutrient elements contents of rye (*Secale cerale* L.) plant

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Abstract

This research was done determine the effect of increasing leonardite applications on dry matter yield and some nutrient element contents of rye (*Secale cerale* L.) plant. For this purpose a pot experiment was done in greenhouse conditions with three replications. Five leonardite doses (L0: 0 kg da^{-1}, L1: 50 kg da^{-1}, L2: 100 kg da^{-1}, L3: 150 kg da^{-1} and L4: 200 kg da^{-1}) were applied to pots before a one month sowing. Nitrogen (14 kg N da^{-1}), phosphorus (8 kg P_2O_5 da^{-1} and potassium (5 kg K_2O da^{-1}) applied to the each pot as NH_4NO_3 and KH_2PO_4 form. Rye (*Secale cerale* L.) plants were harvested 60 day after planting and dry matter yield and some macro and trace element (N, P, K, Ca, Mg, Fe, Cu, Zn and Mn) contents of plants were determined. According to the results, statistically significant increases of dry matter yield of plants were determined with increasing leonardite applications. On the other hand, increasing leonardite applications on N and Fe contents of rye (*Secale cerale* L.) plants were found statistically significant at the level of 5 %. But the effects of leonardite applications on other nutrient element contents were not found statistically significant.

Keywords: Leonardite, macro element, trace element, rye.

Özet

Bu araştırma artan miktarlarda leonardit uygulamasının çavdar bitkisinin (Secale cerale L.) verimi ve bazı bitki besin elementi içerikleri üzerindeki etkisini belirlemek amacıyla yapılmıştır. Bu amaçla sera koşullarında üç paralelli bir saksı denemesi yapılmıştır. Denemede beş doz leonardit (L0: 0 kg da^{-1}, L1: 50 kg da^{-1}, L2: 100 kg da^{-1}, L3: 150 kg da^{-1} ve L4. 200 kg da^{-1}) tohum ekiminden bir ay önce uygulanmıştır. Saksılara eşit miktarda olacak şekilde 14 kg N da^{-1}, 8 kg P_2O_5 kg da^{-1} ve 5 kg K_2O da^{-1} NH_4NO_3 ve KH_2PO_4 gübrelerinden uygulanmıştır. Çavdar bitkileri ekimden 60 gün sonra hasat edilmiş ve kuru madde miktarları ile birlikte bazı makro ve mikro bitki besin elementi içerikleri (N, P, K, Ca, Mg, Fe, Cu, Zn ve Mn) belirlenmiştir. Elde edilen bulgulara göre, artan miktarlarda leonardit uygulamaları ile birlikte çavdar bitkisinin kuru madde miktarı üzerinde önemli artışlar saptanmıştır. Ayrıca leonardit uygulamaları ile birlikte bitkinin N, Fe ve Zn içeriklerinde de istatistiksel olarak % 5 düzeyinde önemli artışlar belirlenmiştir. Leonardit uygulamalarının bitkinin diğer besin elementi içerikleri üzerindeki etkileri istatistiksel olarak önemli bulunamamıştır.

Anahtar kelimeler: Leonardit, makro besin elementi, mikro besin elementi, çavdar

Introduction

Today, the intense search for a solution to humanity's nourishment problem has been going on. However, with the wrong agricultural applications, the sustainable soil fertility and natural sources have been severely destroyed. Moreover, with these incorrect applications, unqualified and unhealthy nutrient consumption has appeared to be a big problem. As a result, serious health problems have occurred.

With the unconscious and excessive nitrogenous chemical fertilizer applications to cultigens, some macro and micro nutrient elements of the plant together with its yield and some biological characteristics are affected negatively. This causes the deterioration of the quality of the product and threatens the human health consequently (Addiscott, 2005).

Besides the quality deterioration of the plant, soil quality and fertility are destroyed with the excessive chemical fertilizer applications (Gollany et al, 2004, Beman et al, 2005, Zand-Parsa et al. 2006). This causes the accumulation of the compounds that are dangerous for human health within vegetables (Ruiz. Et al. 1999).

In a study in which TKI product has been used as a source of organic fertilizer, humic and fulvic acid by Gezgin et al. (Gezgin, et al. 2012), wheat, walnut, cherry, and olive plants have been growth and significant increases in yield and quality of the plants are observed. It has also been emphasized the necessity of the use of organic fertilizers on the lands of our country which have inadequate organic matter contents.

Kumbul (Kumbul et al. 2000) who is working on algea extracts that have been used increasingly in agriculture, explained that thanks to the use of algea extracts by farmers high yield and quality have been gained especially in soybean, cauliflower, cucumber, tomato, potato and strawberry plants.

In a research conducted by Alagöz et al. (Alagöz et al. 2006), the increasing doses of poultry manure, garbage compost and leonardite are applied. At the end of a seven-month incubation experiment which was made under greenhouse conditions, it has been concluded that these three organic materials have positive effects on soil's organic matter amount, KDK value, salt and total N content, and pH levels, and these fertilizers should be used in agriculture.

In a research in which the increasing doses of leonardite have been applied to wheat plant (Yazıcı, 2001), it is concluded that there are significant improvements in the plant's yield and nutrient elements with the leonardite applications.

In a study conducted by Yılmaz and Gülser plant (Yılmaz ve Gülser, 2012), the effects of Gidya and chemical fertilizer applications on pepper plant (*Capsicum annuum* L.) growth, some biological characteristics and some nutrient element contents have been analyzed. According to the results, significant increases in the plant fresh sprig weight, dry sprig weight, sprig length, number of leaves, fresh root weight, dry root weight and root diameter, and N, Ca, Mg, Fe, P and Mn contents have occurred. These increases have been considered 5 % significant statistically.

In a greenhouse study (Karaman, 2012), the effects of the increasing doses of humic acid applications on tomato plant's quality and yield were investigated. For this purpose, 0, 60, and 120 mg/kg doses of humic acid were applied to the plants. According to the results, significant increases in the nutrient element contents, dry matter amounts, and dry matter weight of tomato plant have occurred.

In an experiment, the mineralized grape pulp as a source of humic acid has been applied to soils that have different chemical characteristics as 0, 4, 8 and 16 ton da^{-1} doses. According to the results which are gathered at the end of a six-month incubation experiment, the pH levels of the soils appear to be different from each other. However, the application of the increasing doses of grape pulp decreases the EC levels of soil samples, and enhances the organic matter amounts, total N, available P and exchangeable K and Ca

contents. The effects of grape pulp on the chemical features of the soils have been considered significant statistically (Adiloğlu et al. 2012).

A study conducted by Sağlam et al. (Sağlam et al. 2012) analyzed the effects of leonardite and mineral nitrogen fertilizer on the corn plant (Zea mays L.) nitrogen uptaken. Five doses of leonardite (L) (0, 50, 100, 150, 200 kg da^{-1}) and 4 doses of nitrogen (0, 5, 10, 15 N kg da^{-1}, 33 % N ammonium nitrate fertilizer) have been applied to the pots. The results reveal that with the mineral nitrogen fertilizer applications together with leonardite, the highest level of increase in the plant height has been obtained in 100 kg leonardite da^{-1-1}5 kg N da^{-1}, and the highest increase in the nitrogen level of the plant has been obtained in 200 kg leonardite da^{-1-1}5 kg N da^{-1} applications.

In a greenhouse study conducted to determine the effects of aquaculture wastes and vermicompost on lettuce plant (*Lactuca sativa* L. var. crispa) yield, 1 control and 4 doses (I. dose: 0 g/m2, II. dose: 50 g/m2, III. dose:100 g/m^2, IV. dose:150 g/m^2) of aquaculture application and 1 control and 4 doses (I. dose: 0 kg da^{-1}, II. dose: 400 kg da^{-1}, III. dose: 800 kg da^{-1}, IV. dose: 1200 kg da^{-1}) of vermicompost have been applied. Lettuce plants were harvested 30 days after planting, and the results reveal that aquaculture and vermicompost applications increased of the yield, fresh weight, plant diameter, leaf number, leaf height and width of the lettuce plant. While aquaculture application does not affect the plant's Fe and Mn contents, with the vermicompost application Fe and Mn contents increase in 5 % significance statistically (Adiloğlu et al. 2015).

In this study, the effect of increasing leonardit applications on dry matter yield and some nutrient elements contents of rye (Secale Cerale L.) plant was investigated.

Material and Method

A soil sample taken from NKU Faculty of Agriculture research fields and rye (*Secale Cerale* L.) plant that was grown under greenhouse conditions have been taken in a pot experiment. In the experiment 3 kg plastic pots have been used. Five leonardite doses (L0: 0 kg da^{-1}, L1: 50 kg da^{-1}, L2: 100 kg da^{-1}, L3: 150 kg $da^{-1}$and L4: 200 kg da^{-1}) have been applied to the pots as three replications. The organic fertilizer was applied to the pots a month before the planting by mixing it with the soil. After 30 days, rye (Secale Cerale L.) seeds were planted to the pots, and according to soil analysis results, Nitrogen (14 kg N da^{-1}), phosphorus (8 kg P_2O_5 kg da^{-1} and potassium (5 kg K_2O da^{-1}) were applied to the each pot. NH_4NO_3 and KH_2PO_4 were used as fertilizer sources.

Twenty rye (Secale Cerale L.) seeds were planted in each pot and 15 homogenously developed plants were left in each pot after germination. After a two months development process, the plants were harvested and some of its macro (N, P, K, Ca, Mg) and micro (Fe, Cu, Zn, Mn) nutrient elements with their dry matter yield were determined. The results were evaluated statistically and the effects of the increasing doses of leonardite application on the macro and micro nutrient elements were determined.

Some physical and chemical properties of the leonardite organic matter that was used in the experiment as pH: 5.20; organic matter: 60.60 %; moisture: 42.90 %; total (hümic + fulvic) acide: 59.10 %.

In the soil sample used in the experiment, pH, salt, lime content, organic matter amount, available phosphorus, exchangeable potassium, calcium, magnesium (Sağlam, 2012), some available trace nutrient elements (Fe, Cu, Zn, Mn) (Lindsay and Norvell, 1978) and texture (Tuncay, 1994) analyses were made. Nitrogen, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents of the plant samples were determined according to Kacar and İnal (Kacar and İnal, 2010) in a solution obtained upon wet digestion. Variance analyses (MSTAT 3.00/EM) were made within statistical package program while evaluating the experiment results, and the differences between the averages have been determined in 5 % significance level considering the LSD test (Düzgüneş et al. 1987).

Results and Discussion

Some physical and chemical properties of the experiment soil sample

Some physical and chemical properties of the soil sample from the experiment field are presented in the Table 1. It can be concluded from the table that the soil has neutral pH, no salt, low lime content, inadequate organic matter amount, average level of available phosphorus content, low exchangeable potassium content, adequate exchangeable Ca, Mg content and available Fe, Cu and Mn contents, inadequate available Zn content, and it was determined that its texture class is clay (C).

Table 1. Some chemical and physical properties of the soil sample

Soil property	Analysis value
pH	7.23
EC x 10^6	241
Lime, %	2.80
Organic matter, %	0.71
Available phosp., P_2O_5, kg da^{-1}	9.25
Exch. potassium, K_2O, kg da^{-1}	41.68
Exchangeable Ca, %	1.51
Exchangeable Mg, %	0.18
Available Mn, mg kg^{-1}	12.32
Available Cu, mg kg^{-1}	3.74
Available Fe, mg kg^{-1}	4.83
Available Zn, mg kg^{-1}	0.41
Texture class	Kil (C)

The effects of leonardite application on dry matter amount of the rye plant

The effects of the increasing doses of leonardite application on rye (*Secale cerale* L.) plant dry matter yield are presented in the Table 2.

Table 2. The effect of leonardite application on dry matter yield of rye plant, *, **

Leonardite dose	Dry matter yield, gr pot^{-1}
L_0: 0 kg da^{-1}	2.26 b
L_1: 50 kg da^{-1}	4.18 b
L_2: 100 kg da^{-1}	7.20 a
L_3: 150 kg da^{-1}	9.70 a
L_4. 200 kg da^{-1}	9.81 a

*: values average of three replications, **: significant at the level of 5 %

It can be observed from the Table 2 that the increasing doses of leonardite application enhance the dry matter yield of rye (*Secale cerale* L.) plant and this has been considered 5 % significant. This result is expectable, because organic matter amount of the sample soil is inadequate and dry matter yield of the plant samples increased with the application of the increasing doses of leonardite.

In previous researches, it was also proven that with the increasing doses of leonardite and organic material application to the soils, dry matter amount of the plants increased (Sağlam et al. 2012, Stumpe et al. 2000).

Effects of the leonardite application on some macro nutrient element contents of rye plant

The effects of the increasing doses of leonardite application on rye (*Secale cerale* L.) plant some macro nutrient element contents are presented in the Table 3.

Table 3. The effects of leonardite application on some macro element (N, P, K, Ca, Mg) contents of rye plant, %, *, **, ***

Leonardite dose	N	P	K	Ca	Mg
L_0: 0 kg da^{-1}	2.83 c	0.23	5.33	0.96	0.10
L_1: 50 kg da^{-1}	3.20 b	0.26	5.42	0.97	0.13
L_2: 100 kg da^{-1}	3.36 b	0.27	5.50	1.00	0.14
L_3: 150 kg da^{-1}	3.35 b	0.28	5.59	1.06	0.12
L_4. 200 kg da^{-1}	3.63 a	0.30	5.56	1.03	0.15

*: values average of three replications, **: each element was evaluated individually, ***: significant at the level of 5 %.

It can be observed from the Table 3 that the effects of the increasing doses of leonardite application on N, P, K, Ca and Mg content of rye (*Secale cerale* L.) plant vary and the increasing doses of fertilizer application generally increase the nutrient element contents of the plant.

However, only the nitrogen contents of the plants were obtained 5 % significant statistically, because of the fact that nitrogen is a mobile nutrient in soils. The effects of the increasing doses of leonardite application on P, K, Ca and Mg contents of the plant were not obtained significant statistically. The most important reason is that the experiment duration is short and these nutrient elements' mobility is not as high as nitrogen's, and their availability levels are usually adequate.

Many researches similar to this study reveal that the increasing doses of organic aquaculture application on nitrogen contents of the vegetables plants were increased (Adiloğlu et al. 2015, Graber and Junge, 2009).

Effects of the leonardite application on some micro nutrient element contents of rye plant

The effects of the increasing doses of leonardite application on some micro nutrient element contents (Fe, Cu, Zn and Mn) of rye (*Secale cerale* L.) plant are presented in the Table 4.

Table 4. The effects of leonardite application on some micro element (Fe, Cu, Zn ve Mn) contents of rye plant, mg kg^{-1}, *, **, ***

Leonardite dose	Fe	Cu	Zn	Mn
L_0: 0 kg da^{-1}	39.33 b	8.83	12.82 b	80.37
L_1: 50 kg da^{-1}	63.15 a	10.65	22.45 a	96.09
L_2:100 kg da^{-1}	61.86 a	9.38	21.99 a	91.68
L_3: 150 kg da^{-1}	67.76 a	10.35	28.34 a	93.36
L_4. 200 kg da^{-1}	66.40 a	10.78	30.96 a	93.80

*: values average of three replications, **: each element was evaluated individually, ***: significant at the level of 5 %.

It can be observed from the Table 4 that the effects of the increasing doses of leonardite application on micro element contents (Fe, Cu, Zn and Mn) of rye plant (*Secale cerale* L.) vary and the increasing doses of fertilizer application generally increase the nutrient element contents of the plant.

The effects of the leonardite doses on Fe and Zn contents the plants were determined 5 % significant compared to the control, however, it was not identified any difference between the increasing doses. The effects of the increasing doses of leonardite application on Cu and Mn contents of the plants were not obtained significant statistically, because of the adequacy available Cu and Mn contents of soil sample.

In a research conducted in Chile in order to reveal the effects of the organic fertilizers on some micro nutrient elements of plants, significant increases in Fe, Zn, Mn micro nutrient elements contents of plants were determined upon the organic fertilizer application (Celis and Sandoval, 2010).

In another research on the same subject (Adiloğlu et al. 2015) it was revealed that the application of various organic materials to the lettuce plant caused significant increases in some micro nutrient elements of the plant, such as Fe and Mn.

Conclusion

According to the results of this study, with the increasing doses of leonardite application to rye plant (Secale cerale L.) 5 % significant increases were determined in the dry matter yield of plants. On the other hand, the effects of these organic materials some macro nutrient element contents on rye plant are different from each other.

Five % significant increases were determined N contents of the plant with the increasing doses of leonardite applications. However, similar applications' effects on P, K, Ca and Mg contents of plant were not considered significant.

The effects of the increasing doses of leonardite applications on some trace nutrient elements of rye plant vary. With the increasing doses of leonardite 5 % significant increases were identified Fe and Zn contents of the rye plant. However, the effects of leonardite doses on Cu and Mn contents of the rye plant were not determined as significant.

The use of organic fertilizers in order to meet the nutrient element needs of the plants have been increasing recently. The excessive use of chemical fertilizers has caused the deformation of the nutrient balances of the soils, and has seriously threatened human health by producing unhealthy products.

It has been a necessity to use organic materials such as leonardite in agriculture in order to increase organic matter amounts of the soils. These kinds of applications help developing the organic matter amounts of the soils in our country while improving some quality parameters of the plants.

This study provides the fact that leonardite organic material can be used with rye (*Secale cerale* L.) plant in agriculture. Considering our agricultural lands' inadequacy of organic matter, the necessity of using such organic materials should be realized.

There should be a wide range of field and greenhouse experiments on the usability of leonardite organic material on different agricultural areas of our country together with different kinds of plants. With the increase in the use of organic fertilizers in agriculture less chemical fertilizers will be used, product yield will develop, the degenerated nutrient levels will be recovered and the sustainable fertility of the soils will be protected as a result.

Competing interests and Acknowledgements

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