Scientific Papers. Series A. Agronomy, Vol. LX, 2017
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

IMPROVEMENT OF Ca AND Mg UPTAKE BY APPLICATION OF DOLOMITE AND DOLOMITE + LEONARDITE

Ali COSKAN[1], Kemal DOGAN[2], Ahmet DEMIRBAS[3], Ibrahim ERDAL[1], Ismail HORZUN[1], Emin Cagdas OK[1]

[1]Suleyman Demirel University, Faculty of Agriculture, Isparta, Turkey
[2]Mustafa Kemal University, Faculty of Agriculture, Hatay, Turkey
[3]Cumhuriyet University, Sivas MYO Plant and Animal Production Department, Sivas, Turkey

Corresponding author email: alicoskan@sdu.edu.tr

Abstract

This study was carried out as a pot experiment to determine the effects of dolomite alone or together with leonardite on Ca and Mg uptake of pepper plants. The doses of 8 and 16 g.pot^{-1} of dolomite which were equivalent to 4000 and 8000 kg.ha^{-1} incorporated to soil as either alone or together with 8 and 16 g.pot^{-1} of leonardite. Each pot fertilized by 200 mg.kg^{-1} N, 150 mg.kg^{-1} P_2O_5 and 150 mg.kg^{-1} K_2O. Results revealed that application of neither dolomite nor dolomite + leonardite applications were effective on root dry matter development; however, 4000 kg.ha^{-1} dolomite + 4000 kg.ha^{-1} leonardite incorporation yielded the highest shoot dry weight. Ca concentrations of plants were increased by increasing doses of dolomite and leonardite. Dolomite incorporation alone at the dose of 4000 kg.ha^{-1} improved plant Mg concentration, all other applications was reduced plant Mg contents compared to non-treated (NT) variant. Zn and Mn concentration were also measured in this study. Zn concentration was 96 mg.kg^{-1} at non-treated variant which was reached its highest value as 221 mg.kg^{-1}Zn at 4000 kg.ha^{-1} dolomite dose. The lowest obtained value within the dolomite and dolomite + leonardite applied pots was 143 mg.kg^{-1}Zn which was still 49% higher than NT. Mn concentration was gradually increased by increasing dose of both applications, starting from 80 mg.kg^{-1}Zn in NT to 192 mg.kg^{-1}Mn at the highest application doses of dolomite and dolomite + leonardite. Stimulating effect of leonardite was observed in shoot dry wegiht, Ca, Cu and Mn concentration whereas Mg and Zn concentration was diminished by leonardite addition to the dolomite.

Key words: *dolomite, leonardite, calcium, magnesium, plant nutrition.*

INTRODUCTION

Calcium and magnesium deficiencies are two common problems on greenhouse vegetable production especially in alkaline soils. Addition of the deficient nutrients to soil and increasing the availability of existing elements via organic matter incorporations are the two of the possible approaches to improve plant nutrition. Organic matter incorporation has an indirect effect as stimulating biological activity of the soils which Turgay et al. (2004) reported higher CO_2 formation in leonardite application. Microorganisms in soils are releasing phytohormones, small molecules or volatile compounds, which may act directly or indirectly to regulate plant growth. Humic substances have beneficial effects on plants by improving soil fertility by influencing nutrient uptake (Trevisan et al., 2010). Visser (1985) reported 200 times more microorganism number in case of 30 mg L^{-1} humic and fulvic acid (HFA) applications.

Mg deficiency leads to prevent photosynthates transport from leaves to roots (Cakmak et al., 1994) which may cause less root development, consequently insufficient micronutrients uptake. Moreover, crop tolerance to the stresses factors increasing by Mg; therefore, Mg demand is depended by growth conditions (Gransee and Fuhrs, 2013). The deficiency of Ca causes physiological disorder as blossom end rot, whereas, increasing Ca concentration increased leaf and fruit Ca contents (Bar-Tal et al., 2001). Kirkby and Pilbeam (1984) reported the cause of Ca deficiencies as poor Ca distribution rather than restriction of Ca uptake. Bar-Tal et al., (2001) reported less blossom end occurrence in case of frequent irrigation along with Ca fertilization.

In this research dolomite as Ca and Mg containing natural material was used to provide those two elements to the soil. Leonardite was selected as bio-stimulant agent to improve availability of Ca and Mg.

MATERIALS AND METHODS

The experiment was carried out under greenhouse conditions as a pot experiment using the soil that taken from the Suleyman Demirel University Research Farm. Three kg of soil placed to each pot. The texture class, organic carbon contents, total organic nitrogen, $CaCO_3$ content, pH and salt contents of the experimental soils were SiC, 0.64%, 0.029%, 25%, 8.1 and 0.015%, respectively.

The detail of applications and doses are presented in Table 1.

Table 1. Detail of applications

Abbreviation	Description
NT	Non-treated – control
D1	8 g of dolomite to each pot which equivalent to 4000 kg ha^{-1}
D2	16 g of dolomite to each pot which equivalent to 8000 kg ha^{-1}
DL1	8 g dolomite + 8 g leonardite which equivalent to 4000 kg ha^{-1} dolomite + 4000 kg ha^{-1} leonardite
DL2	16 g dolomite + 16 g leonardite which equivalent to 8000 kg ha^{-1} dolomite + 8000 kg ha^{-1} leonardite

Prior transferring the seedlings, dolomite or dolomite + leonardite incorporated to each pot homogenously.

The CaO, MgO and Fe_2O_3 contents of the dolomite were 32%, 21% and 0.28 whereas the humic + fulvic acid content of leonardite was 40%. Each pot fertilized by with 200 mg kg^{-1} N, 150 mg kg^{-1} P_2O_5 and 150 mg kg^{-1} K_2O using ammonium nitrate, NH_4NO_3, $NH_4H_2PO_4$ (Mono Ammonium Phosphate) and potassium sulphate K_2SO_4 fertilizers.

At the end of 2 months growing period, shoot and root were removed, washed thoroughly by demineralised water. Before grinding, plant materials are dried out at 65 °C until they reach constant weight.

Dry biomass development as root and shoot were weighed using analytical balance. The Ca, Mg, Zn, Cu and Mn concentrations were determined using atomic absorption spectrophotometer following the procedures described by Kacar and Inal (2010). Moreover, the total element uptake from the soil was calculated for every single element considering biomass development and plant nutrient concentrations (Jarrell and Beverly, 1981). Those values are presented in related figures as a line chart.

RESULTS AND DISCUSSIONS

The root and shoot biomass developments were presented in Figure 1. No statistical differences observed among root dry weights ($p>0.05$), whereas the shoot weights are statistically influenced from the applications ($p<0.05$). The highest shoot weight determined in DL1 application. Shoot weight was not affected from D1 application which no differences were observed between NT and D1. However, when leonardite accompany to dolomite (DL1), synergistic effects become visible; therefore shoot dry weight reached the highest value. Although it is not statistically significant, increasing leonardite dose reduced shoot weight when D2 and DL2 are compared. The negative effects of higher levels of leonardite in certain circumstances are reported earlier (Leventoglu and Erdal, 2014; Erol and Coskan, 2016).

The results in Figure 1 proved once again that the higher dose of leonardite application is either limiting the beneficial effects of leonardite or even cause adverse effects. On the other hand, leonardite incorporation was sustained shoot/root ratio (Table 2) which was diminished by high dose of dolomite application.

Cakmak et al. (1994) used shoot/root ratio to evaluate plant nutritional status, they reported close relationship between shoot/root dry weight ratios and relative distribution of total carbohydrates (sugars and starch) in shoot and roots.

The main purpose of this experiment was to improve Ca and Mg uptake which both are causing deficiency problems in greenhouse vegetable production especially in the high relative humid conditions. A number of factors are affecting Ca and Mg uptake, which the main challenge is sustaining availability of the nutrients.

The Ca and Mg concentrations as well as their uptake amount are presented in Figures 2 and 3 respectively.

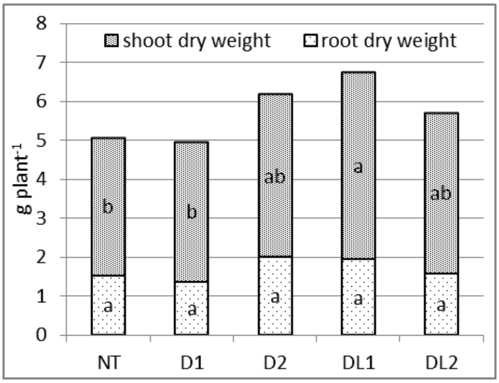

Figure 1. Root and shoot biomass development

Table 2. Shoot: root ratio of pepper plant

	NT	D1	D2	DL1	DL2
S:R ratio	2.26	2.59	2.05	2.44	2.57

Dolomite applications alone were not effective as dual applications of dolomite and leonardite. Although the highest solely dolomite applications dose slightly improved Ca concentration, the lowest dolomite application without leonardite (D1) did not improved Ca in the plant. The highest Ca concentration observed at the highest combination of dolomite and leonardite (DL2); however, DL1 application provided the highest Ca uptake. These results clearly proved that the dolomite can be used as a Ca source, but the higher dose of application may further increase pH, that resulting micronutrient deficiency. To overcome this phenomenon leonardite can be used to enhance Ca uptake at lower dolomite applications. The mechanism of this enhance effect of leonardite is not clear; however, Sozudogru et al. (1996) reported no effects of leonardite on Ca uptake. Positive effect in this study can be associated with improved soil microorganisms where Visser (1985) reported 200 times more microorganism number in case of 30 mg L^{-1} HFA applications.

As clearly seen in Figure 3, increasing dolomite doses - reduced Mg uptake, and leonardite application did not alter this effect. The highest Mg concentration was reached in D1 application, whereas the lowest was in D2 which the plant Mg concentration was even lower than the non-treated variant. The reason of negative effect of increasing dolomite dose most likely associated with pH increment due to the liming effect. When Ca and Mg results considered together, it is hard to recommend optimum dose for both -nutrients uptake; however, if the dolomite application is the only option available, the lower doses along with leonardite applications are seem to be more promising practice.

The Zn, Cu and Mn concentration as well as uptake amounts are presented in Figures 4, 5 and 6, respectively. The idea behind Zn, Cu and Mn evaluation was to determine possible negative impact of dolomite incorporation on uptake of these micronutrients due to the pH increas. Zn deficiency is one of the most common nutrition disorders due to two third of the soils in Turkey has Zn insufficiency problem (Eyuboglu et al., 1998). Results revealed that all applications improved Zn concentration and Zn uptake compared to control. This was not expected because of dolomite incorporation to soil is increasing pH (Toth, 2010), and Zn availability is reducing 100 times by increasing pH at 1 unit (Havlin et al., 1998). Contrary to results presented here, Toth (2010) reported either no influence or reduction on Zn concentration by means of dolomite applications. Although the increment in zinc concentration as a result of dolomite application was gradually decreased, yet Zn concentrations were higher even in 8000 kg ha^{-1} dose than the control. The tested dose of 8000 kg ha^{-1} was possibly higher than the highest dose that farmers follow in Turkey. Considering the Zn uptake, any of D1, D2 or DL1 applications may be recommended in fertilizer program.

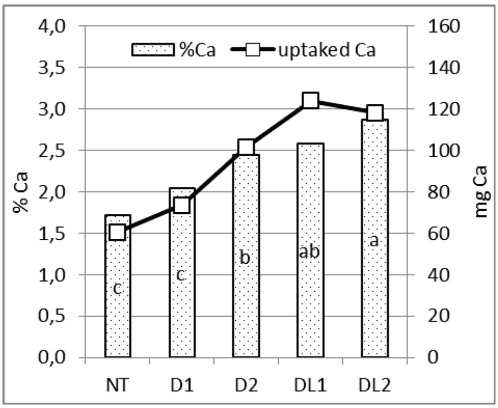

Figure 2. Ca concentrations and Ca uptake

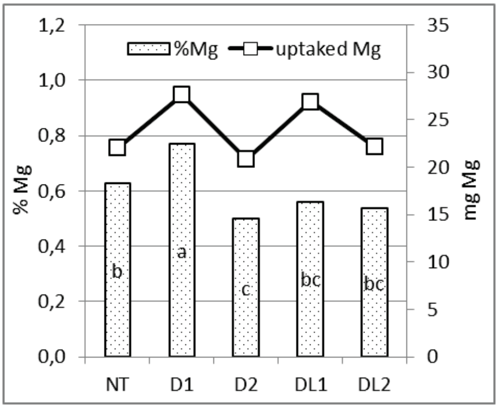

Figure 3. Mg concentrations and Mg uptake

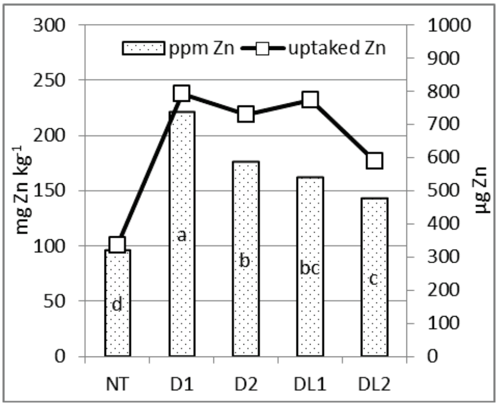

Figure 4. Zn concentrations and Zn uptake

Similarly to Zn concentration, Cu concentration (Figure 5) was positively influenced from dolomite applications; however, no tendency as a function of dolomite dose was observed. All applications were improved Cu uptake of the plants, whereas the lowest Cu concentration was in NT. While the highest value obtained in DL2, no differences was exist between D2 and DL1 variants.

The copper element has a distinctive feature among the all elements analysed. Copper accumulation has recently been mentioned in the soil in Turkey due to the fact that it is cheap and allowed in organic farming; therefore, it is the most used substrate as a fungicide in the region. In this research the Cu values determined within the adequate Cu threshold values of 25-75 mg Cu kg^{-1} which Jones (2012) reported. But DL2 application increased both Cu contents and Cu uptake by 67% and 94% respectively. Taking this into consideration, it is concluded that the application of dolomite does not cause Cu toxicity in the short term, but caution should be exercised when applying dolomite in areas containing high Cu contents. On the other hand, plants are more resistant to Cu deficiency comparing to Zn and Mn (Yu and Rengel, 1999). Cu uptake was in accordance of Cu concentration, besides Cu uptake was more influenced in leonardite + dolomit applied pots.

Mn content (Figure 6) was the only element showing tendency. Both increasing doses of dolomite and dolomite + leonardite, increased Mn concentration as well as Mn uptake. Leonardite has the stimulation effect on Mn uptake as expected whereas dolomite + leonardite applications provided the higher Mn nutrition. The relations between the parameters are presented in Table 3. Strong relation was determined between Mn and Ca concentrations ($p<0.001$). Increasing root dry weight was increased shoot dry weight whereas Ca concentration was positively influenced from shoot dry weight ($p<0.01$). The other relations were found to be insignificant ($p>0.05$).

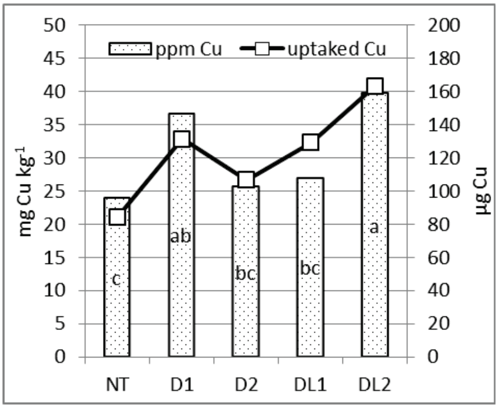

Figure 5. Cu concentrations and Cu uptake

CONCLUSIONS

No doubt dolomite was the one of the potential Ca and Mg source for plant production considering the results presented here. However, most probably due to the further increasing pH in alkaline soils, higher dose of dolomite is preventing uptake of zinc which is already one of the nutritional disorders in Turkey. In this research dolomite application improved Ca uptake in every additional dose, while Mg concentration was negatively affected by increasing amount of dolomite. The highest Mg concentration was achieved on the lowest dolomite dose. Even in this lower dose, leonardite incorporation was further reduced Mg concentration. Leonardite was considered as an agent to stimulate nutrient uptake by improving soil biologic activity; nevertheless, it was not encourage Mg uptake. Consequently, to improve Mg uptake the lower dolomite dose should be recommended whereas the higher dolomite + leonardite doses should be selected for stimulate Ca uptake.

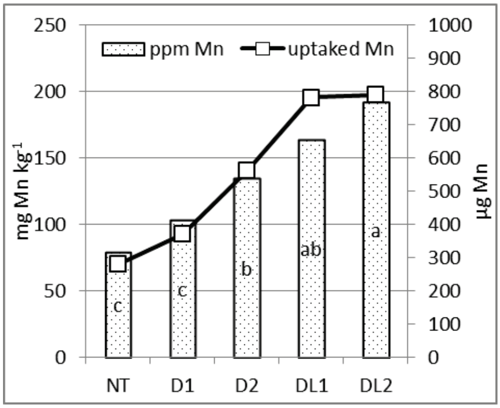

Figure 6. Mn concentrations and Mn uptake

Table 3. Correlation coefficients between the parameters tested

	mg Cu kg^{-1}	*mg Mn kg^{-1}*	*mg Zn kg^{-1}*	*%Mg*	*%Ca*	*shoot dry w.*
mg Mn kg^{-1}	0.2824					
mg Zn kg^{-1}	0.3854	0.0953				
%Mg	0.2910	-0.4256	0.3436			
%Ca	0.4087	0.8475 ***	0.0707	-0.3466		
shoot dry w.	0.2584	0.3835	0.1104	-0.3405	0.5576 **	
root dry w.	-0.1668	0.2111	-0.0779	-0.4194	0.3433	0.6225 **

** $p<0.01$ *** $p<0.001$

REFERENCES

Bar-Tal A., Keinan M., Aloni B., Karni L., Oserovitz Y., Gantz S., Hazan A., Itach M., Tratakovski N., Avidan A., Posalski I., 2001. Relationships between Blossom- End Rot and Water Availability and Ca Fertilization in Bell Pepper Fruit Production. Acta Hortic. 554, p. 97-104.

Cakmak I., Hengeler C., Marschner H., 1994. Partitioning of Shoot and Root Dry Matter and Carbohydrates in Bean Plants Suffering from Phosphorus, Potassium and Magnesium Deficiency. J. Exp. Bot. 45 (9): p. 1245-1250.

Erol H., Coskan A., 2016. Effect of Humic + Fulvic Acid Application at Different Doses on Biological Activity of Different Region Soils. Scientific Papers. Series A. Agronomy, Vol. 59, p. 69-74.

Eyuboglu F., Kurucu N., Talaz S., 1998. General Situation of Plant Available Micronutrients Elements (Fe, Cu, Zn, Mn) of Turkish Soils. The Republic of Turkey, Soil and Fertilizer Research Institute, Ankara (in Turkish).

Gransee A., Fuhrs H., 2013. Magnesium mobility in soils as a challenge for soil and plant analysis, magnesium fertilization and root uptake under adverse growth conditions. Plant and Soil 368: p. 5-21.

Havlin J.L., Beaton J.D., Tisdale S.J., Nelson W.L., 1998. Soil Fertility and Fertilizer, An Introduction to Nutrient Management. 6th Edition. Pearson Education Inc. ISBN: 9780136268062.

Jarrell W.M., Beverly R.B., 1981. The Dilution Effect in Plant Nutrition Studies. Advances in Agronomy, 34: p. 197-224.

Jones Jr. J.B., 2012. Plant Nutrition and Soil Fertility Manual, Second ed. CRC Press. ISBN 9781439816097.

Kacar B., Inal A., 2010. Plant Analyses, Nobel Academic Press. ISBN: 9786053950363 (in Turkish).

Kirkby E.A., Pilbeam D.J., 1984. Calcium as a plant nutrient. Plant, Cell & Env. 7: p. 397-405.

Leventoglu H., Erdal I., 2014. Effect of High Humic Substance Levels on Growth and Nutrient Concentration of Corn under Calcareous Conditions. Journal of Plant Nutrition, 37: p. 2074-2084.

Sozudogru S., Kutuk A.C., Yalcin R., Usta S., 1996. Humik Asitin Fasulye Bitkisinin Gelisimi ve Besin Maddeleri Alimi Uzerine Etkisi. Ankara Universitesi Ziraat Fakultesi Yayin No: 1452. Bilimsel Arastırma ve Incelemeler: 800, Ankara.

Toth T., 2010. Effect of Zinc and Dolomite Treatments on the Chemical Composition of Acid Sandy Soil and Bean Crop. Communications in Soil Science and Plant Analysis, 41: p. 2568-2576.

Trevisan S., Francioso O., Quaggiotti S., Nardi S., 2010. Humic substances biological activity at the plant-soil interface-From environmental aspects to molecular factors. Plant Signaling & Behavior 5:6, p. 635-643.

Turgay O.C., Tamer N., Türkmen C. ve Karaca A., 2004. Gidya ve Ham Linyit materyallerinin Topragin Biyolojik Ozelliklerine Etkisini Degerlendirmede Toprak Mikrobiyal Biyokutlesi. 3. Ulusal Gubre Kongresi Bildiri Kitabi, 1. Cilt, s; p. 827- 836, Tokat.

Visser S.A., 1985. Physiological Action of Humic Substances on Microbial Cells. Soil Biology and Biochemistry, 17(4): p. 457-462.

Yu Q., Rengel Z., 1999. Micronutrient Deficiency Influences Plant Growth and Activities of Superoxide Dismutases in Narrow-leafed Lupins. Ann. Bot. 83(2): p. 175-182.