AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
ISSN : 2597-8713 (Online) - 2598-5167 (Print)
Available on :
http://agriscience.scientific-work.org/index.php/agriscience

Cucumber (*Cucumis Sativus* L.)Growth and Nutrient Content Response to Applications of Leonardite and Phosphorus Fertilizer

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Article History: Received: June 18, 2021; Accepted: Agustus 10, 2021

ABSTRACT

Leonardite is a common mineral that contains a lot of organic matter. It may have a beneficial influence on plant growth and nutritional content. The objective of the present study was to determine the effect of four different leonardite doses (0, 20, 35, and 50 g kg^{-1}), three different phosphor rates (0, 50, 100, and 150 mg kg^{-1} P), on plant growth, and nutrient uptake of Cucumber (*Cucumis sativus* L.). plants. The experiment was conducted in a plastic house. Increasing the leonardite dose statistically increased the concentrations of N, P, K, Mg, Cu, and Mn in the cucumber leaves, but Zn content (34.711 a) mg kg^{-1} of the leaves was significantly higher only with the (20 gm) of leonardite. The highest phosphor application (150 mg kg^{-1}) increased leaf N, P, K, Ca, Mg, and Mn concentrations compared with the other three doses and also the leaf Zn levels statistically did not increase as the P applications increased from (control to 150 mg kg^{-1}). Based on the number of fruits per plant, the best interaction among leonardite doses and phosphor rate were a combination of the (35gm×100 mg kg^{-1}) increasing the numbers of cucumber per plant (48.000a).

Keywords: Leonardite, Phosphor inorganic fertilizer, Cucumber plant.

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a popular vegetable all over the world. It is the most well-known member of the Cucurbitaceae family (Thoa, 1998). Cucumber is a native plant and one of the earliest vegetables grown by early man (Eifediyi and Remison, 2010). Economically, after tomato, cabbage, and onion, it is the fourth most important crop in Asia. In Europe, it ranks second only to tomatoes (Eifediyi and Remison, 2010). It has been cultivated for almost 3,000 years (Okonmah, 2011). Cucumber is a main source of vitamins, minerals, fiber, and water content in fruits, all of which are essential for human nutrition (Slavin and Lloyd, 2021). Cucumber is grown on fertile soils because infertile soils provide lower-quality fruits that are not widely accepted by customers (Eifediyi and Remison, 2010).

One of the most popular techniques for increasing the productivity of agricultural lands and achieving a greater yield per unit area is to use fertilizers to replenish the shortage of plant nutrients in the soil. Inorganic fertilizers are the most frequent method. However, relying solely on inorganic fertilizers may have negative consequences for human health and the environment

ISSN : 2597-8713 (Online) - 2598-5167 (Print)
Available on :
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(Kumar et al., 2019). To offset the negative impacts of inorganic fertilizers, the use of organic fertilizers, either alone or in combination with inorganic fertilizers, has been growing in the soil (Chen, 2006).

To maintain healthy soil and minimize soil degradation, this organic matter must be replenished. Humic substances (well-decomposed and highly stable organic material, such as humic acid, fulvic acid, and humins) make up a significant portion of soil organic matter, improve soil fertility and physical integrity, and boost nutrient availability (Akinremi et al, 2000).

Humic acid and other humic substances enhance root and shoot growth, increase available plant nutrients and soil nutrient absorption, and improve plant tolerance to biotic and abiotic stresses. (Ünlü et al., 2010; Akinremi et al., 2000; Serenella et al., 2002; Dursun et al., 2002; Cimrin and Yilmaz, 2005).

Humic substance aids in the stabilization of soil temperatures and the delaying of water evaporation. It has also been observed that humic acid treatment improves the physical plant characteristics of plants growing in a salty environment (Turkmen et al., 2004; Turkmen et al., 2005).

As a result, humic acid and humic substances promote root and shoot growth (Cimrin and Yilmaz, 2005). Furthermore, they improve plant resilience to biotic and abiotic stress factors by increasing soil organic matter, plant nutrients, and nutrient absorption from the soil (Unlu et al, 2010). As a result, leonardite may be utilized as a soil supplement since it increased tomato, potato, and maize plant growth and yields (Sanli et all, 2013) & (Eyheraguibel et al, 2008).

Leonardite is a natural organic substance, brownblack formed by the breakdown of organic matter over billions of years (Akinrinde, 2006). It is sedimentary peat, plankton, and plant–animal waste deposition, contains the high amount humic acids, fulvic acids, and plant nutrients with the appearance of coal but not the compaction (Erkoc, 2009) and (Ratanaprommanee et al, 2016).

Leonardite, also known as humat, organic humat, humalit, or humus in various countries, is one of these organic fertilizers (Akinremi et al., 2000). When leonite contains 30 to 80 percent humic acids, it can be utilized as a soil amendment (Schnitzer, 1992; Akinremi et al., 2000; Erkoc, 2009; Sugier et al., 2013) The use of humic compounds has been shown in several studies to boost plant growth and agricultural yield (Paksoy et al., 2010; Aisha et al., 2014; Shafeek et al., 2015).

It also decreases the pH of the soil around the roots and aids in the conversion of inaccessible nutrients into plant-accessible forms (Vaughan and Donald, 1976). Because it releases nutrients slowly and avoids nutrient loss owing to leaching and evaporation, leonardite could be utilized as a soil amendment (Sibanda and Young, 1989).

The leonardite has numerous advantages, according to many researchers' studies on various crops, thus having it as a component can help increase nutrient availability, crop output, and play a key role in microelement transfer and availability. As a result, leonardite is a promising component for improving supplement accessibility and yield growth (Nisak et al., 2017). It assumes a role in the transportation and accessibility of micronutrients, which are more concentrated in soils with a higher pH. Scientists have identified several beneficial effects of leonardite on various crops. It is mostly absorbed by plant roots, but it is also translocated to shoots and other plant components, and it improves plant growth responses (Verlinden et al., 2009)

As a result, the goal of this study was to see how different dosages of leonardite, alone or in combination with inorganic P fertilizers, affected the morphology, yield, nutritional content, of Cucumber plants.

2. MATERIALS AND METHODS

The current study was conducted at the horticulture and landscape design department, Technical Institute of Bakrajo, Sulaimani Polytechnic University, Sulaimani /Iraq, during the growth period 2017-2018 under plastic house conditions.

The leonardite minerals utilized in this investigation were readily available in Kahramanmaraş/ Turki. The effects of leonardite and phosphor treatments on Cucumber plant development were investigated using four different leonardite doses (0, 20, 35, and 50 g kg^{-1}), three different phosphor rates (0, 50, 100, and 150 mg kg^{-1} P), and three replications. characteristics of the leonardite sources used in the study: Organic Matter (%), Total Humic and Fulvic Acid (%), Available Boron (mg kg^{-1}), pH and Maximum moisture content (%) were (45% , 40% , 0.96 mg kg^{-1} , 5-7 and 35%) respectively.

To make up the four application rates of 0, 20, 35, and 50 g kg-1 leonardite, the leonardite was mixed manually at each application rate until the leonardite – 8 kg soil mixture was homogeneous for each pot.

In two split applications, phosphor was applied as triple super phosphate (46 percent P) at four rates (0, 50, 100, and 150 mg kg^{-1} P). Nitrogen was applied as urea $(CO(NH_2)_2$ 46 percent N in two split dosages of 70 mg kg^{-1} to all pots in addition to phosphor. 90 days after sowing, the plants were harvested. The biomass (leaves) was then dried at 60-80°C in an oven.

The plant samples were digested using an HNO3/HClO4 combination to determine the amounts of P, K, Ca, Mg, Mn, Zn, and Cu (Jones and Case, 1990). The vanadomolybdophosphoric acid method was used to identify total plant P. (Kuo, 1996). Total N was assessed using the

ISSN: 2597-8713 (Online)
ISSN: 2598-5167 (Print)
Agricultural Science

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ISSN : 2597-8713 (Online) - 2598-5167 (Print)
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Kjeldahl procedure (Bremner, 1996), and total K, Ca, Mg, Mn, Zn, and Cu were determined in the digest using an atomic absorption spectrophotometer (Perkin Elmer, 3110).

The Physical and chemical properties of the soil used in the study: was shown in (Table 1) defined by (Ali and Majeed,2017).The soil utilized in the study is typical of the area, with high lime content, alkaline pH, low organic matter, low available Zn and P, and high available Ca and Mg.

Table 1: The properties of the soil used in the study

P	**K**	**Mg**	**Ca**	**Zn**	**Cu**	**Mn**	**Fe**	**OM**	**pH**	**$CaCO_3$**	**E.C.**
(mg kg^{-1})								**(%)**		**(%)**	**dSm^{-1}**
2.37	255	153.7	5485	0.85	1.06	35.16	7.8	2.30	7.65	32.1	1.56

This study employed a factorial experiment (4×4×3) with three replications in a randomized complete block design (RCBD) to assess the effects of leonardite dosages and phosphor treatment with interactions. The data was compared with the observed using the XLSTAT software 2020 Advanced Statistics version 2020.1 software to achieve this purpose. When the F-value was significant at $p \leq 0.05$, the Duncan's Multiple Comparison tests were used in this software for the primary impacts of treatments that differed. When the means differed significantly, letters were allocated to separate the groups. When the means within a column do not differ considerably when the same letters are used.

3. RESULTS AND DISCUSSION

In generally, the research done so far have shown that leonardite has a wide range of effects. Leonardite enhanced the nutrient content, yields and changed the structure of products in a few experiments.

Duncan's multiple comparison tests revealed that the leaves of cucumber plants grown in leonardit-amended soils removed more nitrogen than those grown in unamended. Increasing the leonardite dose increased the concentrations of N, P, K, Mg, Cu and Mn in the cucumber leaves (Table 2). The leonardite applications increased significantly increase the leaf K and Mg content compared to the control, but statistically there was not differences when used (35 or 50 gm) leonardit. The Zn content (34.711 a) mg kg^{-1} of the leaves was significantly higher only with the (20 gm) leonardite application rate, and Ca content the result (5.004 a) percent of the leaves was higher affected from the (35gm) applications of leonardit.

ISSN: 2597-8713 (Online)
ISSN: 2598-5167 (Print)
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Table 2: The effect of leonardit doses (gm/kg) on leaf nutrient content

Leonardit doses	N	P	K	Ca	Mg	Cu	Zn	Mn
(gm/kg)	(%)					($mg\ kg^{-1}$)		
0**	0.868 d	0.287 d	0.600 c	3.826 d	0.284 c	12.128 d	25.515 b	79.312 d
20	1.576 c	0.323 c	0.727 b	4.102 c	0.314 b	13.953 c	34.711 a	82.558 c
35	2.293 b	0.366 b	0.933 a	5.004 a	0.362 a	14.994 b	27.665 b	85.823 b
50	3.950 a	0.409 a	0.876 a	4.707 b	0.373 a	15.731 a	28.433 b	87.980 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p \leq 0.05$ according to
Duncan's Multiple Range Test. Note. 0**: Control or not add the leonardite.

According to the observations, applying leonardite doses mixed with soil had a good effect on increasing macro-micro nutrient on the cucumber plant, due largely to the positive effects of leonardite on the physical and chemical properties of soil, high available water holding and adsorption capacities, and improved nutrient use efficiency by increasing the availability and uptake of macro and micro nutrients. Many authors have observed improved plant development as a result of adequate nutrient availability and soil moisture (Mahmoud and Hafez, 2010).

Influences of humic acid fertilizers on nutrient absorption addict to humic acid resources like leonardite, concentration, practice type, plant species, and cultivars, according to Chen and Aviad, 1990.
As per David et al., 1994 leonardite increases soluble nitrogen as well as other plant nutrients like K.

Many studies working on diverse plants from various areas have discovered that increasing the dosages of leonardite treatment causes a significant increase in the N, P, K, Ca, Mg, and S content of the plants. (Topcuoglu and Onal, 2006; Saglam et al., 2012; Turan et al., 2012; Kucukyumuk et al., 2014). And these results are similar to our research.

Highest phosphor application (150 mg kg^{-1}) increased leaf N,P,K,Ca,Mg and Mn concentrations compared with the other three doses and the leaf Zn levels statistically did not increased as the P applications increased from (control to 150 mg kg^{-1}) Table 3. The results show in table 10, the effect of phosphor applications on some macro and micro nutrient concentrations of cucumber plant in leonardite there were significant differences for all nutrients of cucumber plant shoots except Zn. Although, the amount of P, K and Mg statistical there was not differences when

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treated with (100 or 150) mg kg^{-1} phosphor fertilizers, it means the 100 mg kg^{-1} phosphor application had a good result to increase P, K and Mg nutrients (0.385 a, 0.891 a and 0.388 a) mg kg^{-1} respectively.

Table 3: The effect of Phosphor doses (mg kg^{-1}) on leaf nutrient content.

Phosphor Doses	**N**	**P**	**K**	**Ca**	**Mg**	**Cu**	**Zn**	**Mn**
(mg kg^{-1})	**(%)**					**(mg kg^{-1})**		
0*	1.482 d	0.276 c	0.617 c	3.768 d	0.263 c	10.537 d	32.128	77.442 d
50	1.996 c	0.313 b	0.737 b	4.256 c	0.282 b	13.458 c	26.437	82.623 c
100	2.364 b	0.385 a	0.891 a	4.573 b	0.388 a	16.719 a	28.487	86.531 b
150	2.844 a	0.410 a	0.891 a	5.042 a	0.400 a	16.091 b	29.271	89.077 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p \leq 0.05$ according to
Duncan's Multiple Range Test. Note. 0*: Control or not add the phosphor fertilizer.

The main effects of all the treatments were significant for the dry weights, plant height and number of fruits per plant of cucumber plants (Table 4). Duncan's multiple comparison tests indicated that the dry matter of the cucumber plants grown in the soils amended with the leonardit were higher than those grown in the control. Increasing the leonardit dose increased the dry weights, plant height and number of fruits per plant. When the phosphor applications rising statistically dry weights, and number of fruits per plant was increased. According to Chen and Aviad, 1990; Nardi, et al., 2002; Escobar, et al., 1996 leonardite may have direct and indirect effects on the plant growth. Direct effects are those, which require uptake of humic matters into the plant tissue resulting in diverse biochemical effects.

According to Akinremi et al. (2000), leonardite treatment improved nutrient absorption in canola. They also found that when leonardite was applied to canola, the dry matter grew linearly. Cucumber, maize, wheat, cabbage, and potato yields were increased when leonardite or humic compounds were applied. (El-Shabrawy et al., 2010; Ayuso et al., 1996; Delfine et al., 2005; Hopkins and Stark, 2003 respectively). According to Saha et al. (2014), the combined application of humic acid and manure had a significant impact on rice grain production. Seyedbagheri (2010) discovered that increasing leonardite dosages improved tuber production from 11.4 percent to 22.3 percent.

Table 4: The effect of Phosphor and Leonardit (main effect) doses on the dry mass of the leaf, plant high and No. of fruit per plant

Phosphor Doses ($mg\ kg^{-1}$)	**Dry weights (gm)**	**Plant height (cm)**	**No. of fruit per plant**
0*	3.546 d	159.887 a	34.833 c
50	4.119 c	168.118 b	38.000 b
100	4.595 b	171.628 ab	40.083 a
150	4.930 a	175.646 a	41.333 a
Leonardit Doses (gm/kg)			
0**	3.288 d	155.638 d	33.583 d
20	3.706 c	160.775 c	37.417 c
35	4.595 b	173.837 b	39.667 b
50	5.600 a	185.029 a	43.583 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p \leq 0.05$ according to Duncan's Multiple Range Test. Note. 0*: Control or not add the phosphor fertilizer, and 0**: Control or not add the leonardite.

According to the maximum means, the best interactions among leonardite doses and phosphor rate was (50gm × 150 $mg\ kg^{-1}$) for gets the hay value of N and P (5.089 a %, and 0.490 a%) respectively. However, the best combination among leonardtit and phosphor doses was (35gm×100 $mg\ kg^{-1}$) to increasing Ca, Mg, and Mn (5.957 a ,0.435 a , and 93.803 a) respectively. Then, Based on the Number of fruit per plant, the best interaction between leonardite doses and phosphor rate, was a combination of the (35gm×100 $mg\ kg^{-1}$) increasing the numbers of cucumber per plants (48.000a).

Table 5: The best interaction between the (Leonardit and phosphor doses) in the experiment.

	N	**P**	**K**	**Ca**	**Mg**	**Cu**	**Zn**	**Mn**
	(%)					**($mg\ kg^{-1}$)**		
Interactions Maximum Mean	50 × 150 5.089 a	50 × 150 0.490 a	35 × 100 1.107 a	35 ×150 5.957 a	35 × 150 0.435 a	35 ×100 17.997 a	20 × C 56.900 a	35 × 150 93.803 a

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Interactions Minimum Mean	0** × 0* 0.775 g	0** × 0* 0.215 e	0**× 50 0.575 h	0** × 0* 3.178 i	0** × 0* 0.218 h	0** × 0* 8.140 h	0** × 0* 22.853 b	20 × 0* 73.712 j
	Dry weights (gm)		**Plant height (cm)**		**No. of fruit per plant**			
Interactions Maximum Mean	50 × 100 6.363 a		50 × 100 193.533 a		35 × 100 48.000 a			
Interactions Minimum Mean	0** × 150 3.187 g		0** × 0* 151.467h		0** × 0* 30.000 h			

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p \leq 0.05$ according to Duncan's Multiple Range Test. Note. 0*: Control or not add the phosphor fertilizer, and 0**: Control or not add the leonardite.

Finally, there have been several reports of enhanced yields using leonardite in greenhouses, due to the leonardite powder's layer structure, along with its high organic matter and nutrient content, could be suitable to microbial development, increase water holding capacity, increase availability of plant nutrients, and the chemical characteristics of leonardite revealed that it has a great potential for application as a soil conditioner to increase soil fertility and agricultural output. As these experiments were conducted under ideal growth conditions, the effects of leonardite may differ in the field, where there is a complicated interplay between soil, climate, and other variables. As a result, when identical experiments are done under other conditions, the results from greenhouse research may not be reproduced.

4. CONCLUSIONS

Significant increases in N, P, K, Ca, Mg, Cu, and Mn nutrient were determined as compared to the control group in the current study, which aims to investigate the effects of increasing doses of leonardite application with phosphor fertilizer on the cucumber plant with regard to some macro and micronutrients of the content. In addition, leonardite treatment enhanced plant height, dry weights, and the quantity of fruits per plant, showing that higher rates of administration might boost crop nutrient absorption. Organic fertilizers and soil improvers, such as leonardite, have been increasingly popular in recent years in agriculture. As a result, excessive and unintentional usage of chemical fertilizers in agriculture has resulted in significant quality issues with agricultural goods. More research on the application of leonardite to soils is needed in the future for more detailed observations of different plants.

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