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المجلة العراقية لبحوث السوق
وحماية المستهلك

RESPONSE OF CABBAGE PLANTS TO APPLICATION OF NATURAL ZEOLITE, ORGANIC AND MINERAL FERTILIZERS

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ABSTRACT

This experiment was conducted in one of fields belong to College of Agricultural Engineering Sciences/ University of Baghdad –Station Research (F) in Jadriya. to find out effect of natural zeolite, organic fertilizer (poultry manure) and mineral fertilizers and their interactions, "Dounia" cabbage growth and yield, a field experiment was carried out in fall season 2021and the number of plants in the experimental unit was 20 plants. Treatments were replicated three times at factorial design in a RCBD. Factors of study experiment included addition of three levels of natural zeolite (without addition (Z0), 5 Mg.ha^{-1} (Z5), and 10 Mg.ha^{-1} (Z10)), while poultry manure was added with three levels; without addition (O_0) , 5 Mg.ha^{-1} (O5), and 10 Mg.ha^{-1} (O10), As for mineral fertilizer treatments, they were added in three levels (50%, 75%, and 100% of complete fertilizer recommendation), which were 100 kg ha^{-1} N, 150 kg ha^{-1} P, and 150 kg ha^{-1} K, which are denoted by symbols M50, M75, and M100, respectively. The experimental results showed that natural zeolite at 10 Mg. ha^{-1} (Z10) significantly increased in shoot dry weight of 113.74 gm plant^{-1}, root dry weight of 37.07 gm plant^{-1} and total yield of 27.66 Mg. ha^{-1}. Results also shows that poultry manure at 10 Mg. ha^{-1} (O10) gave highest shoot dry weight of 105.33 g. plant^{-1}, highest root dry weight of 31.38 g. plant^{-1}, highest leaf chlorophyll content of 174.37 mg 100 g plant^{-1} and highest total yield of 27.98 Mg ha^{-1}. As for addition of mineral fertilizers, data cleared that, addition at 100% of complete fertilizer recommendation (M_{100}) gave highest shoot dry weight of 109.24 g. plant^{-1}, highest root dry weight of 33.02 g. plant^{-1} , highest leaf chlorophyll content of 172.07 mg 100 g plant^{-1} and highest total yield of 27.94 Mg ha^{-1}.

Keywords: Cabbage Plants, Natural Zeolite, Mineral Fertilizers.

استجابة محصول اللهانة لأضافة الزيولايت الطبيعي والأسمدة العضوية والمعدنية

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الخلاصة

أجريت هذه التجربة في أحد الحقول التابعة لكلية علوم الهندسة الزراعية، جامعة بغداد- محطة البحوث (F) في الجادرية. لمعرفة تأثير الزيولايت الطبيعي والسماد العضوي (مخلفات الدواجن) والأسمدة المعدنية وتداخلاتها في بعض خصائص التربة ونمو وحاصل اللهانة صنف "دنيا" أجريت تجربة حقلية في فصل الخريف 2021. صممت التجربة تحت تصميم القطاعات الكاملة المعشاة وبتصميم التجربة العاملية RCBD. وبثلاث مكررات اذ تضمنت عوامل تجربة

الدراسة إضافة ثلاثة مستويات من الزيولايت الطبيعي (بدون إضافة (Z_0) ، 5 ميكاغرام هـ$^{-1}$ (Z_5) ، 10ميكاغرام هـ $^{-1}$ (Z_{10})، بينما أضيفت مخلفات الدواجن بثلاثة مستويات. بدون إضافة (O_0) و 5 ميكاغرام هـ $^{-1}$ (O_5) و 10 ميكاغرام هـ$^{-1}$ (O_{10}) أما معاملات الأسمدة المعدنية فقد تمت إضافتها على ثلاثة مستويات (50% ، 75% ، 100%) من التوصية السمادية الكاملة، والتي كانت 100 كغم N هـ $^{-1}$و 150 كغم هـ $^{-1}$و 150 كغم Kهـ$^{-1}$، والتي يشار إليها بالرموز M50 وM75 و M100 بالتتابع. أظهرت نتائج التجربة أن الزيولايت الطبيعي عند 10 ميكاغرام هكتار (Z_{10}) زاد معنوياً في الوزن الجاف للنبات عند 113.74 غرام نبات $^{-1}$ والوزن الجاف للجذور 37.07 غرام نبات $^{-1}$ والحاصل الكلي 27.66 ميكا غرام هكتار$^{-1}$. أظهرت النتائج أيضًا أن مخلفات الدواجن عند 10 ميكاغرام هكتار (O_{10}) أعطى أعلى وزن جاف للمجموع الخضري بمقدار 105.33 غم نبات $^{-1}$، وأعلى وزن جاف للجذور بلغ 31.38 غم نبات $^{-1}$، وأعلى محتوى من الكلوروفيل للأوراق بلغ 174.37 ملغم 100 غم. نبات $^{-1}$ وأعلى حاصل بلغ 27.98 ميكاغرام هـ$^{-1}$. أما بالنسبة لإضافة الأسمدة المعدنية ، فقد بينت النتائج أن الإضافة بنسبة 100٪ من التوصية الكاملة للأسمدة (M100) أعطت أعلى وزن جاف للنبات 109.24 غم نبات $^{-1}$، وأعلى وزن جاف للجذور 33.02 غم نبات$^{-1}$، وأعلى محنوى من الكلوروفيل 172.07 ملغم 100 غم نبات $^{-1}$ وأعلى محصول إجمالي 27.94 ميكاغرام هكتار $^{-1}$

الكلمات المفتاحية: نبات اللهانة، الزيولايت الطبيعي، الاسمدة المعدنية.

INTRODUCTION

The Cabbage (*Brassica oleracea var. capitata* L.) is one of the main winter vegetable crops in Iraq. It is grown in most of its regions and belongs to the cruciferous family, as the part that is eaten from it is the wrapped leaves, which are fresh and may be used in making pickles and salad. Zeolite is a natural material that was discovered in 1756, it is one of sedimentary minerals, and it consists of aluminosilicates that are distinguished by their crystalline structure in form of three dimensions. Natural zeolite used as a natural fertilizer in traditional and protected agriculture, it improves soil properties and provides a good environment for plant growth and increased productivity, it has an importance in slow liberation for nutrients adsorbed and thus ensures continued supply of nutrients to plant during its growth stages, it also preserves soil moisture and increases microorganisms activity and decomposition of organic matter added to soil, and addition of zeolite helps plant to get rid of free radicals that form as a result of plant's exposure to stress (**Karami *et al.*, 2020**) .natural zeolite affect the growth and yield of plants, **Hasin *et al.*, (2021**) found a significant increase in yield of tomato (*lycopersicon esculentum* Mill), jasmine cultivar, when adding three levels of zeolite (0, 5, and 10 ton ha^{-1}), especially when adding at level 10 ton ha^{-1}. **Nooprom *et al.*, (2022**) conducted a study on broccoli plants (*Brassica oleracea* var. italica), Top Green variety grown in field, by treating plants with five levels of zeolite (0, 1,56, 3,12, 4,68, and 6,24 ton ha^{-1}) in which it was concluded that addition of levels 4.68 and 6.24 ton ha^{-1} led to an increase in growth and yield and a significant increase in stem diameter and a 50% reduction in flowering time, head diameter and total yield, compared to control treatment. Organic farming is one of most important modern practices in plant production, since organic fertilization is one of important ways to supply plants with needs of nutrients without any negative impact on environment and increase from it does not lead to plant damage that occurs when fertilizing with mineral fertilizers in large quantities. It also results from organic matter disintegration (Humic acid), which is important in plant nutrition by increasing soil mineral availability, and developing root system, which encourages its absorption and increases enzymatic activity and cell division. The organic matter also has a role in plant growth and yield, whether it is added to soil or foliar spray (**Muslat & Musleh, 2015; Nardi *et al.*, 2016**). Poultry manures are used widely and in large quantities compared to other animal wastes, because they are high in

nutrients, especially nitrogenous, compared to other animal wastes, and they are a source of macro and micronutrients, also, these remains do not contain slow-dissolving substances such as lignin and therefore, it facilitates the transformation of nitrogen into a ready-to-absorb form, which makes it a source that continues to provide the plant with this element throughout the growing season. Poultry manure content of high organic material and therefore will work when added to an increase of soil ability to retain water and nutrients and reduce their losses by washing (**Ali, 2012; Al-Hadethi, 2019**). Poultry manures affect the growth and yield of plants, Asomah et al (2021) found in an experiment that included adding poultry manure alone at a rate of 40-ton ha^{-1} or in combination with chemical fertilizers N, P, K to soil in cabbage growth, a significant superiority was obtained in vegetative plant growth characteristics and the studied yield characteristics. **Yeasmin *et al.*, (2021)** found in an experiment to find out effect of adding different organic fertilizers (poultry and cow waste and mustard husk residue and triple interaction between them) as well as control treatment on growth and yield of cauliflower plant, level of adding poultry waste was 15 ton ha^{-1}, The results showed that addition of poultry manure, either alone or by triple interaction, caused a significant superiority in all vegetative growth characteristics, and yield compared to control treatment.

The readiness of nutrients required for plants in sufficient quantities ensures a high amount of yield per unit area, as addition of chemical fertilizers may cause an increase of 50% or more in yield, provided that other growth factors are fully available. Because of this main effect of chemical fertilization, use of these fertilizers has increased, especially in irrigated agriculture, without thinking of any other considerations. This unscientific use of chemical fertilizers will be uneconomical and negatively affect plants. Due to side effects that chemical fertilizers may cause, they may be negative for humans, environment and living organisms. On which they live, alternative materials have been resorted to from natural compounds that can perform an effect similar to that of mineral fertilizers. The aim here is to reduce their use by relying on various mechanisms and strategies, including the addition of organic fertilizers (**Ali *et al.*, 2014**). Several studies have been conducted to determine role of chemical fertilizers in growth and yield of plants, **Ali &Al-Bahrani (2022**) mentioned that 100% of the fertilizer recommendation caused a significant effect in total yield of Cauliflower, Megha cultivar. **Al-Temimi & Al-Hilfy (2022)** studied the effect of five fertilizer treatments including 100 % and 50 % of the fertilizer recommendation on three varieties of maize (bohooth 5018, Baghdad 3 and Sumer) and found the treatment of 100% mineral fertilizer was superior in weight of 500 grains. The research aims to determine best level of zeolite for its significant effect on some soil properties (as a natural improver) and its reflection on growth and yield. And effectiveness of zeolite and organic fertilizers in reducing mineral fertilizers added to the soil.

MATERIALS AND METHODS

This experiment was conducted in one of fields belong to College of Agricultural Engineering Sciences / University of Baghdad –Station Research (F) in Jadriya. To find out effect of natural zeolite, organic fertilizer (poultry manure) and mineral fertilizers and their interactions on some soil characteristics, "Dounia" cabbage growth and yield, a field experiment was carried out in mixed clay soil classified at level of Typic Torrifluvent for fall season 2021. Treatments were replicated three times at factorial design in a RCBD. Factors of study experiment included addition of three levels of natural zeolite (without addition (Z0), 5

Mg.ha^{-1} (Z5), and 10 Mg.ha^{-1} (Z10)), while poultry manure was added with three levels; without addition (O_0) , 5 Mg.ha^{-1} (O5), and 10 Mg.ha^{-1} (O10), and added organic fertilizer and natural zeolite before planting, mixed with the soil, As for mineral fertilizer treatments, they were added in three levels (50%, 75%, and 100% of complete fertilizer recommendation), which were 100 kg ha^{-1} N, 150 kg ha^{-1} P, and 150 kg ha^{-1} K, which are denoted by symbols M50, M75, and M100, respectively. Nitrogen was added in urea form (46% N) in two batches, Ten days after planting, and second batch 20 days after first batch. Phosphate fertilizer was added in triple superphosphate (20% p) in one batch when planting and by feeding method. Potassium fertilizer was added in form of potassium sulfate (42% K) and two batches 10 days after planting and second batch 20 days after first batch. Drip system was used to irrigate the field. The following parameters were determined in experimental season:

1. Shoot and root dry weight (g): 5 plants were taken from each experimental unit and shoot was separated from root, after which shoot and root were washed well, then samples were cut and placed in paper bags to be dried in electric oven at 65 ° C until the weight was stable, then dry weight was calculated (**Al Sahaf, 1989**).
2. Leaf chlorophyll contents (mg.100g-1 fresh weight): content of fresh leaves of chlorophyll a and b was calculated, and then total chlorophyll in shoots before maturity was calculated. A weight of 5 gm was taken from the fresh leaves (fourth and fifth), fully ripe and free from any physiological injury, and cut into small pieces and mashed in a clean ceramic mortar by adding acetone at a concentration of 85% in the range of 2-10 ml, then the volume was added to 50 ml. filtrate was separated using a centrifuge for 10 minutes, process was repeated, extract was collected in tubes covered with opaque paper to block light from chlorophyll to prevent photo-oxidation of the dye. Then optical density of the filter was measured using a spectrophotometer at two wavelengths of 663 and 645 nm according to mackinny (1941).
3. Yield (µg ha^{-1}) Total yield of one experimental unit was calculated by calculating harvest yield cumulatively for each experimental unit and then attributed to hectares by following formula: Product of experimental unit (µg) x 10000 m^2 / experimental unit area (m^2).

The obtained results were subjected to analysis of variance according to (**Elsahookie & Wuhaib, 1990**) using L.S.D 0.05 for comparing differences between various treatment means.

RESULTS AND DISCUSSIONS

Effects of Natural Zeolite, Organic and Mineral Fertilizers and their interaction on shoot and root dry weight:

Data concerning effect of treatments on shoot and root dry weight are listed in (Tables 1 and 2). The data cleared that, natural zeolite at 10 µg. ha^{-1} (Z10) significantly increased in shoot dry weight of 113.74 gm plant^{-1} and root dry weight of 37.07 gm plant^{-1}, while lower values of these traits was in Z_0 treatment. Tables (1 and 2) also shows that poultry manure at 10 µg. ha^{-1} (O10) superiority of control treatment and gave highest shoot dry weight of 105.33 g. plant^{-1} and highest root dry weight of 31.38 g. plant^{-1}. Also, lower values of these traits were in control treatment (O_0). As for addition of mineral fertilizers, data cleared that, addition at 100%

of complete fertilizer recommendation (M_{100}) superiority of M_{50} and gave highest shoot dry weight of 109.24 g. plant^{-1}and highest root dry weight of 33.02 g. plant^{-1}. The interactions between poultry manure and natural zeolite significantly affected in shoot and root dry weight especially interaction treatment ($Z_{10}M_{10}$). The interactions between natural zeolite and mineral fertilizers significantly affected especially when interaction treatment ($Z_{10}M_{100}$) and gave 122.95 g. plant^{-1} as shoot dry weight and 42.62 g. plant^{-1} as root dry weight. As for adding poultry manure and their interaction with mineral fertilizers, data in tables (1 and 2) cleared that ($O_{10}M_{100}$) treatment gave highest shoot dry weight of 114.45 g. plant^{-1} and root dry weight of 35.81 g.plant^{-1}, while lower values of these traits was in O_0M_{50} treatment. Triple interactions between study factors had a significant effect in shoot and root dry weight specially $Z_{10}O_{10}M_{100}$ treatment.

Table (1): effect of natural zeolite, organic and mineral fertilizers on shoot dry weight (g. plant^{-1}) of cabbage plants.

Zeolite	Poultry manure (O)	Mineral fertilizer (M)			Z × O
		M_{50}	M_{75}	M_{100}	
Z_0	O_0	85.22	86.50	90.31	87.34
	O_5	85.72	90.80	91.70	89.40
	O_{10}	86.11	89.15	95.00	90.08
Z_5	O_0	86.58	88.90	105.02	93.50
	O_5	92.71	100.61	112.62	101.98
	O_{10}	94.43	105.63	119.70	106.58
Z_{10}	O_0	98.54	112.83	117.12	109.49
	O_5	95.33	118.81	123.07	112.40
	O_{10}	109.05	120.33	128.67	119.35
L.S.D 0.05		12.06			6.96
Z × M					Z
Z_0		85.68	88.81	92.33	88.94
Z_5		91.24	98.38	112.44	100.68
Z_{10}		100.97	117.32	122.95	113.74
L.S.D 0.05		6.96			4.02
O × M					O
O_0		90.11	96.07	104.15	96.77
O_5		91.25	103.40	109.13	101.26
O_{10}		96.53	105.03	114.45	105.33
L.S.D 0.05		6.96			4.02
M		92.63	101.50	109.24	

L.S.D 0.05	**4.02**	

This increase in dry weight may be due to added nitrogen content of soil as a result of zeolite retaining nitrogen and preventing its loss from soil, and then this led to an increase in its uptake by plant, which led to an increase in growth rate (**Sarkar & Naidu, 2015**). As nitrogen has a fundamental importance in building plant protein, thus increasing dry weight of vegetative and root system. The reason is also attributed to fact that enhancing nutrition with mineral fertilizers leads to an increase in root surface area, and then an increase in nutrients and water absorption, and this leads to an increase in total root dry mass. These results are consistent with the findings of **Al-Mharib *et al.*, (2020)** on kohlrabi and with **Al-Ubaidy *et al.*, (2019**) on red cabbage.

Table (2): effect of natural zeolite, organic and mineral fertilizers on root dry weight (g. plant^{-1}) of cabbage plants.

Zeolite	Poultry manure (O)	Mineral fertilizer (M)			Z × O
		M_{50}	M_{75}	M_{100}	
Z_0	O_0	18.48	19.96	22.81	20.41
	O_5	18.93	21.73	25.31	21.99
	O_{10}	20.52	24.18	27.19	24.14
Z_5	O_0	19.42	22.84	27.72	23.23
	O_5	23.67	24.52	31.39	26.52
	O_{10}	26.32	29.21	34.94	30.15
Z_{10}	O_0	25.34	36.12	38.76	33.43
	O_5	32.44	37.06	43.79	37.67
	O_{10}	35.35	39.43	45.32	40.03
L.S.D 0.05		4.11			2.37
Z × M					Z
Z_0		19.31	21.95	25.10	22.12
Z_5		23.13	25.52	31.35	26.66
Z_{10}		31.07	37.53	42.62	37.07
L.S.D 0.05		2.37			1.37
O × M					O
O_0		21.11	26.30	29.67	25.72
O_5		25.01	27.77	33.49	28.75
O_{10}		27.39	30.94	35.81	31.38
L.S.D 0.05		2.37			1.37
M		24.50	28.33	33.02	
L.S.D 0.05		1.37			

Effects of Natural Zeolite, Organic and Mineral Fertilizers and their interaction on leaf chlorophyll content and total yield: The data in Tables (3 and 4) cleared that, addition of zeolite did not significantly affect leaf chlorophyll content, while natural zeolite at 10 µg. ha^{-1} (Z10) significantly increased in total yield of 27.66 µg. ha^{-1}, while lower values of total yield was in Z_0 treatment. Tables (3 and 4) also shows that poultry manure at 10 µg. ha^{-1} (O10) superiority of control treatment and gave highest leaf chlorophyll content of 174.37 mg 100 g $plant^{-1}$ and highest total yield of 27.98 µg ha^{-1}. Also, lower values of these traits were in control treatment (O_0). As for addition of mineral fertilizers, data cleared that, addition at 100% of complete fertilizer recommendation (M_{100}) superiority of M_{50} and gave highest leaf chlorophyll content of 172.07 mg 100 g $plant^{-1}$ and highest total yield of 27.94 µg ha^{-1}. The interactions between poultry manure and natural zeolite significantly affected in leaf chlorophyll content and total yield especially interaction treatment ($Z_{10}M_{10}$). The interactions between natural zeolite and mineral fertilizers significantly affected especially when interaction treatment ($Z_{10}M_{100}$) and gave 176.39 mg.100 g. $plant^{-1}$ as leaf chlorophyll content and 32.50 µg ha^{-1} as total yield. As for adding poultry manure and their interaction with mineral fertilizers, data in tables (3 and 4) cleared that ($O_{10}M_{100}$) treatment gave highest leaf chlorophyll content of 178.25 mg 100 g $plant^{-1}$ (Abdel Rahim and Mohammed, 2020) and highest total yield of 31.01 µg ha^{-1}, while lower values of these traits were in O_0M_{50} treatment. Triple interactions between study factors had a significant effect in leaf chlorophyll content and total yield specially $Z_{10}O_{10}M_{100}$ treatment, and it's gave 186.89 mg 100 g $plant^{-1}$ and 34.90 µg ha^{-1}, respectively.

Table (3): effect of natural zeolite, organic and mineral fertilizers on Leaf chlorophyll contents (mg.$100g^{-1}$ fresh weight) of cabbage plants.

Zeolite	Poultry manure (O)	Mineral fertilizer (M)			Z × O
		M_{50}	M_{75}	M_{100}	
Z_0	O_0	152.29	161.89	163.05	159.07
	O_5	164.71	167.81	171.89	168.14
	O_{10}	163.41	170.64	175.21	169.75
Z_5	O_0	154.81	159.11	166.54	160.15
	O_5	165.11	162.49	170.10	165.90
	O_{10}	169.71	174.50	172.66	172.29
Z_{10}	O_0	154.65	156.68	170.96	160.76
	O_5	153.49	159.32	171.31	161.37
	O_{10}	176.32	180.01	186.89	181.07
L.S.D 0.05		9.54			5.51
Z × M					Z
Z_0		160.14	166.78	170.05	165.66
Z_5		163.21	165.37	169.77	166.12
Z_{10}		161.49	165.34	176.39	167.74
L.S.D 0.05		5.51			N.S
O × M					O
O_0		153.92	159.23	166.85	160.00
O_5		161.10	163.21	171.10	165.14
O_{10}		169.81	175.05	178.25	174.37

L.S.D 0.05		**5.51**		**3.18**
M	**161.61**	**165.83**	**172.07**	
L.S.D 0.05		**3.18**		

The increase in yield is due to zeolite role as an improver of some fertile and physical soil characteristics, and then an increase in yield, thanks to its unique properties, the ion exchange properties of zeolite can be used in agriculture due to its large porosity and high ability to exchange cations (**Kavvadias *et al.*, 2018**). This superiority is also due to organic fertilizers role in increasing readiness of nitrogen and phosphorus in soil and preserving them from fixation processes due to secretion of some enzymes and organic acids through activity of microorganisms, which was reflected in leaves chlorophyll content and thus increased the total yield (**Shilan & Hama, 2022**). This result is consistent with what was found by **Al-Amery *et al.*, (2020**) on potato plants. The reason may be explained by effect of mineral fertilizer on nutrients availability needed by plant and supplied directly from soil, as well as effect of zeolite on improving some of soil physical, chemical and fertility properties, which in turn leads to an increase in spread of root system and an increase in water and nutrients absorption. Organic matter has a role in improving nutrients availability for plant, The interaction between organic and mineral fertilizers lead to increase the plant productivity through increasing water holding capacity (**Al-Halfi & Al-Azzawi, 2022**), and these factors help in the formation of a good root system that reflects positively on absorption of nutrients and on processes that take place inside plant, and then plant total yield (**Sarkar & Naidu, 2015**).

Table (4): effect of natural zeolite, organic and mineral fertilizers on total yield (µg ha $^{-1}$) of cabbage plants.

Zeolite	Poultry manure (O)	Mineral fertilizer (M)			Z × O
		M_{50}	M_{75}	M_{100}	
Z_0	O_0	17.97	20.60	20.20	19.59
	O_5	20.13	19.53	23.70	21.12
	O_{10}	23.30	24.53	26.43	24.75
Z_5	O_0	19.67	22.30	22.87	21.61
	O_5	20.43	24.63	29.13	24.90
	O_{10}	20.77	30.40	31.70	27.62
Z_{10}	O_0	20.17	24.83	30.97	25.32
	O_5	21.17	25.40	31.63	26.06
	O_{10}	28.50	31.33	34.90	31.58
L.S.D 0.05		3.42			1.97
Z × M					Z
Z_0		20.47	21.55	23.44	21.82
Z_5		20.29	25.78	27.90	24.66
Z_{10}		23.28	27.19	32.50	27.66
L.S.D 0.05		1.97			1.14
O × M					O
O_0		19.27	22.58	24.68	22.17
O_5		20.58	23.19	28.15	23.97
O_{10}		24.19	28.75	31.01	27.98
L.S.D 0.05		1.97			1.14
M		21.35	24.84	27.94	

L.S.D 0.05	**1.14**	

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