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EFFECT OF USING TYPES OF FERTILIZERS IN CONTROLLING OF TWO SPOTTED SPIDER MITE *Tetranychus urticae* ON SOME CULTIVARS OF EGGPLANT

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ABSTRACT

This study was aimed to evaluate the role of Potassium silicate, humic acid, and salicylic acid in both normal and Nano sizes in eliminating *Tetranychus urticae* Koch infestations on the eggplant cultivars Jawaher, Barcelona, and Iraq wonder. Potassium silicate was used by 2.5 ml/L and 5 g/L, humic acid 10 ml/L and 20 g/L and salicylic acid 0.1 g/L and 0.2 ml/L for ambient and Nano size respectively, the treatment plants were observed weekly after application to determine the population density of TSSM .The use of prior fertilizers reduces the population density of TSSM as compared to the control treatment in all three cultivars. SEM pictures revealed that the potassium silicate Nano capsule (PSNC), humic acid Nano capsule, and salicylic acid Nano emulsion had diameters of 99, 92, and 26 nm, respectively. The zeta potential values for potassium silicate Nano capsule, humic acid Nano capsule, and salicylic acid Nano emulsion were -68.2, -43.5, and 63.1 mV, respectively.

Key words: Humic acid, Nano capsule, Nano emulsion, Potassium silicate, SEM, Zeta potential.

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INTRODUCTION

Eggplant is a vegetable crop that is grown all over the world and can provide substantial nutritional benefits because of its content of vitamins, phenols, and antioxidants, In addition, eggplant has potential therapeutic applications that are only recently being identified (Gürbüz et al., 2018) . Based on data from 2022, the global production of eggplant is around 59 million tons annually, with a net value of more than 12 billion US$ a year (FAO, 2022).Several pests significantly limit eggplant output; the most common are the leafhopper, whitefly, aphid, and two-spotted spider mite (Srinivasan, 2009). The two-spotted spider mite *Tetranychus urticae* Koch, 1836, is one of the most important agricultural pests (Salama et al., 2023), not only because of the harm it does, but also because of its extensive host range (Ribeiro et al., 2021), The TSSM's rapid developmental pace and strong reproductive capacity allow it to establish destructive population levels quickly when growth conditions are favorable, resulting in a rapid decline in host plant quality (Razmjou et al., 2009) . The use of synthetic acaricides is primarily relied upon to control *T. urticae* (Abd AL Jaleel et al., 2024) . On the other hand, *T. urticae*, has rapidly developed resistance to the majority of the acaricides available for control (Tsagkarakou et al., 2002) due to its very broad host plant range, extremely short lifecycle, high fecundity, arrhenotokous parthenogenesis, and overwintering strategy (Adesanya et al., 2021). In recent years, some studies have focused on

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plant defense against herbivores (Agut et al., 2018) , Plants have many defense mechanisms that can reduce herbivores abundance or increase plant tolerance to harm (Carmona et al., 2011). Cultural methods such as crop fertilization can affect the susceptibility of plants to herbivores by altering plant tissue nutrients (Altae & Al-Dahwi, 2023; Damghani et al., 2021). Ismail et al. (2022) found that the foliar application of two Silicon forms on strawberries caused a significant reduction in the number of TSSM adults, nymphs, and eggs compared to the control group. Modern nanotechnology has been considered one of the most significant inventions of the 21st century (Seleem & Abdel-Dayem, 2013). Many agricultural fields have been affected by nanotechnology (Zulfiqar et al., 2025). Pest control based on natural compounds needs to be enhanced by using this technology (Navia et al., 2024). In this study, we used three types of fertilizers in normal and nano size to evaluate their role in inducing resistance in eggplant cultivars against TSSM.

MATERIALS AND METHODS

We selected three cultivars of eggplant: Jawaher F1 from Enza Zaden, Netherlands; Barcelona F1 from Fito, Spain; and Iraq Wonder F1 obtained from Dr. Inad D. Abod, Iraq. The experiment was carried out in 2024 in a greenhouse at the College of Agricultural Engineering/ University of Baghdad/ Baghdad Province/ Jadriya.

Formulation of Nano capsule

75 g of polyethylene glycol 4000 (Loba chemie Pvt, India) was dissolved at 65º C, added 25 g of potassium silicate (Barricade from agri science Ltd, Turkey) with continuously heating and stirring by using a heating magnetic stirrer, then put the solution in the freezer until stiffened, then grind it by grinder to obtain a white powder (Gatarayiha et al., 2010) , the same method was followed to prepare humic acid Nano capsule.

Formulation of Nano emulsion

Nano emulsion were prepared by using the low energy method of emulsion phase inversion (EPI), which consists in the slow addition of an aqueous phase into an oil phase under constant stirring (Al Hilfy et al., 2022), the salicylic Nano emulsion was formulated by combing 10 g of salicylic acid ($C_7H_6O_3$) (Oxford lab chem, UK), 10 ml of sunflower oil, 10 ml tween 80 (Thomas Baker, India) as surfactant, 10 ml ethylene alcohol and 1 g of PEG 4000, under magnetic stirring for 30 min. Deionized water was added at 1.5 ml/min flow, under constant stirring (Ayllón-Gutiérrez et al., 2023). The whole volume of emulsion completed to 500 ml.

Characterizations of Nano capsule and Nano emulsion: Nano capsule and Nano emulsion shape and size were measured by Mira 3 field emission scanning electron microscopy (FE-SEM), Tescan, Korea (Hammed et al., 2023) . To determine the stability and activity of Nano capsule and Nano emulsion Zeta potential analysis was made by a HORIBA Zetasizer Nano-SZ-100V2 (HORIBA Scientific Instruments, Japan) (Al Hilfy et al., 2022).

Field experiment: Potassium silicate, humic acid and salicylic acid in both size normal and Nano were used to evaluate its roles in reducing infestation of TSSM on eggplant cultivars Jawaher, Barcelona and Iraq wonder. To assess the effect of previous fertilizers six plants of each cultivar were selected for each treatment in addition to the control treatment (Agut et al., 2018), depending on companies' recommendations fertilizers used, Potassium silicate was used by 2.5 ml/L and 5 g/L, humic acid 10 ml/L and 20 g/L and salicylic acid 0.1 g/L and 0.2 ml/L for ambient and Nano size respectively, it should be noted that concentrations of prepared Nano fertilizers were half of its concentrations in commercial products. The experimental units (plant) of each treatment were sprayed with a fertilizers solution and control treatments sprayed by water only, the treatment plants were observed weekly after application to determine the population density of TSSM (Mmbando et al., 2023).

Statistical analysis: The experiments were carried out according to factorial experiments using a completely randomized block design (CRBD), and the differences between the means of the treatments were tested according to the value of the least significant difference (L.S.D) at the probability level of 0.05. The

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results were analyzed by the statistical program Genstat (Genstat, 2009).

RESULTS AND DISCUSSION

Scanning Electron Microscopy (SEM) analysis: Analysis in (Figure 1) Shows analysis SEM, shows the diameter and shapes of potassium silicate Nano capsule, humic acid Nano capsule and salicylic acid Nano emulsion. The diameter average of potassium silicate Nano capsule (A) was 99 nm with oval shape. The diameter average of humic acid Nano capsule (B) was 92 nm with elongated shape. The diameter average of salicylic acid Nano emulsion (C) was 26 nm with irregular shape.

Zeta potential analysis

The zeta potential analysis (Figure 2) revealed that zeta potential mean of potassium silicate Nano capsule (A) was -68.2 mV, humic acid Nano capsule (B) was -43.5mV and salicylic acid Nano emulsion (C) was 63.1 mV.

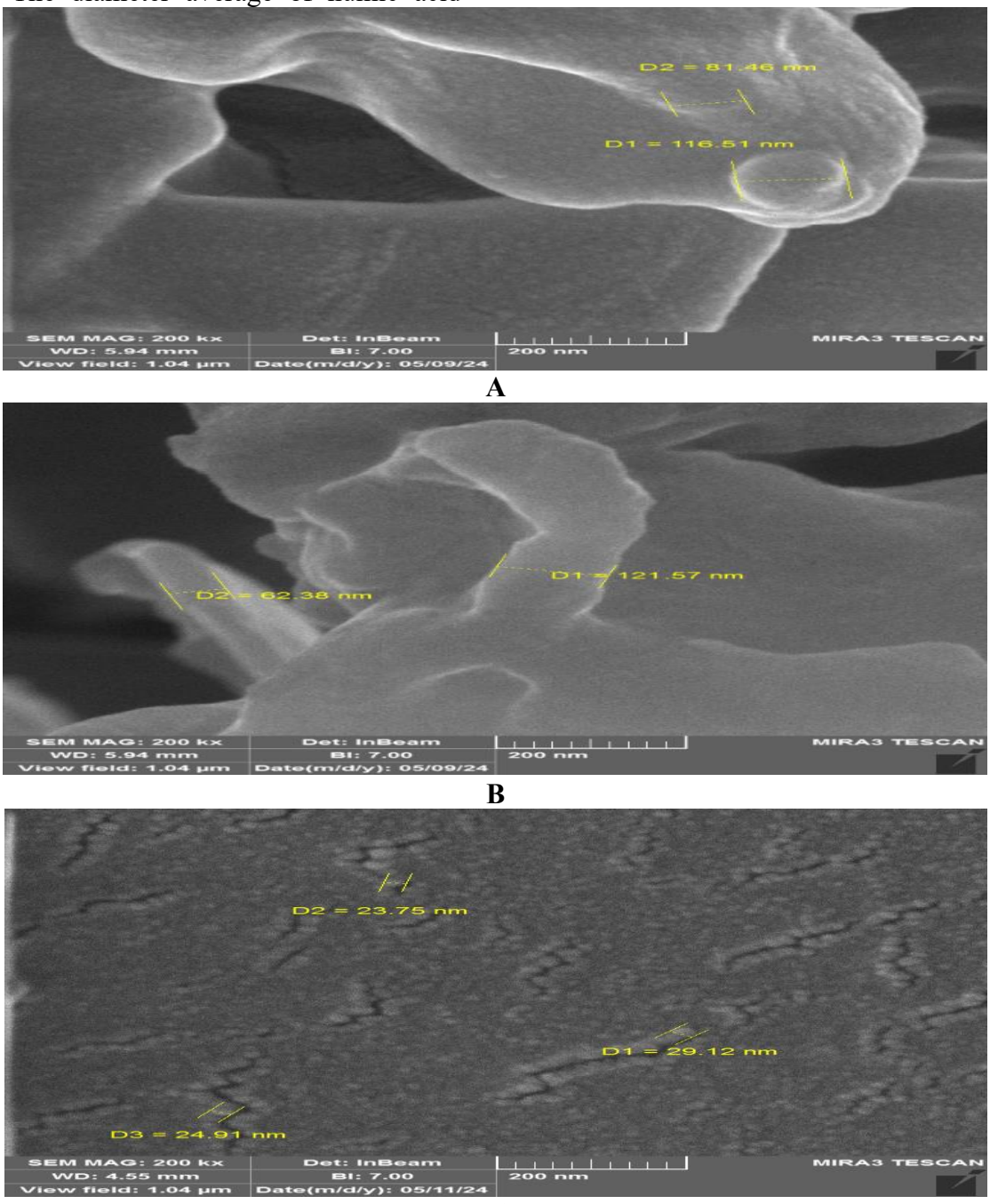

Figure 1. SEM images of formulations (A) potassium silicate Nano capsule, (B) humic acid Nano capsule and (C) salicylic acid Nano emulsion

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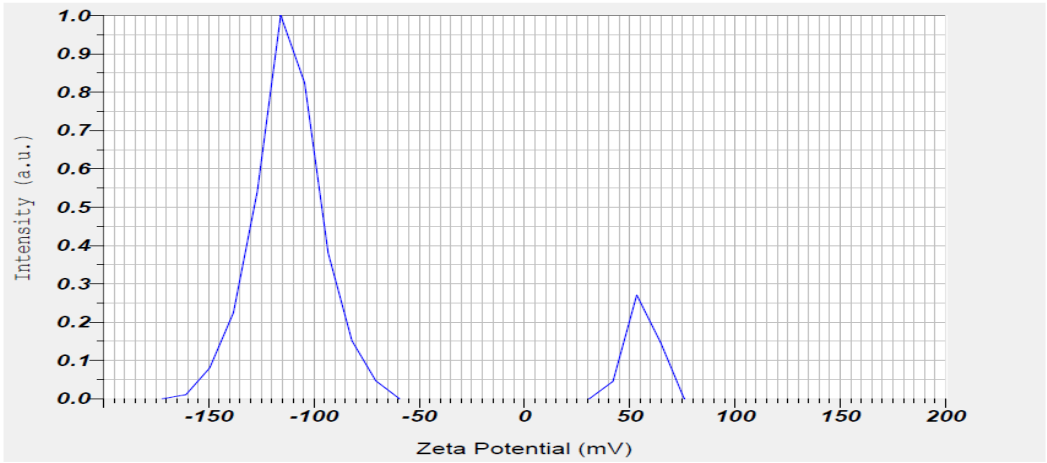
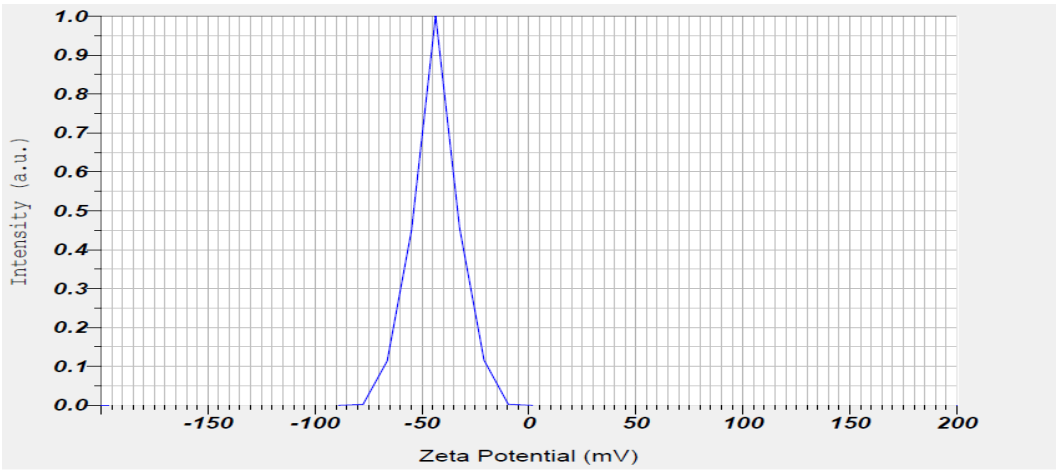
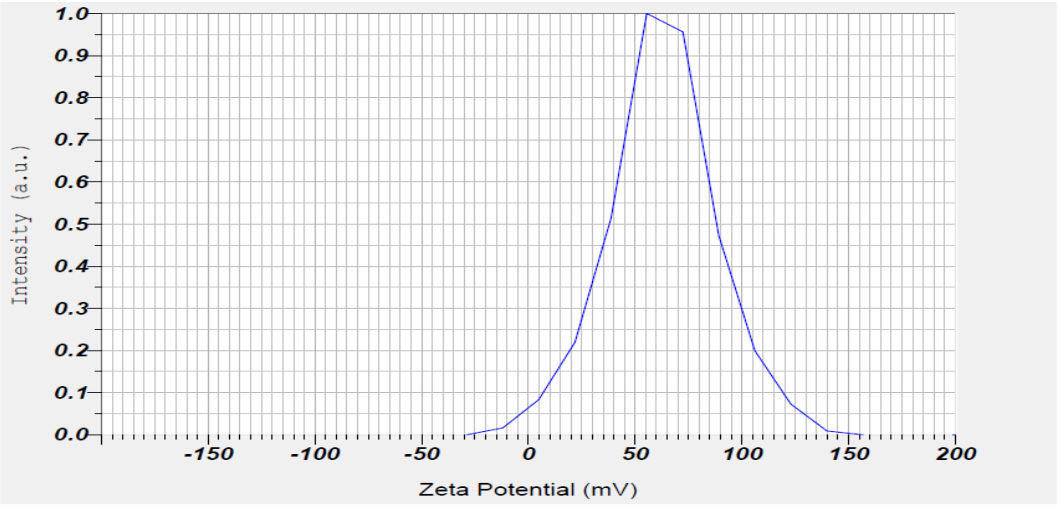


A



B



C

Figure 2. Zeta potential means (A) potassium silicate Nano capsule,(B) humic acid Nano capsule and (C) salicylic acid Nano emulsion

Effect of fertilizers on TSSM population density: Tables (1, 2, 3) show that potassium silicate, humic acid, and salicylic acid in both normal and nano sizes significantly outperformed control treatments in terms of reducing TSSM population density on eggplant cultivars Jawaher, Barcelona, and Iraq Wonder, additionally, potassium silicate fertilizer average was 1.86, 2.48, 3.14 mites/cm^2 (for both normal and nano sizes) significantly outperformed all other treatments in the three previous cultivars. The use of potassium silicate in normal and nano sizes results in a decrease in the population density

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of TSSM (Zulfiqar et al., 2025), the PSNC (potassium silicate nano capsule) may have stiffened and dried out the body of the mite (Hala & Elsamahy, 2016) apart from its function of promoting plant resistance. Normal-sized potassium silicate can encourage plant to produce fence materials such phenols, which lower the density of the TSSM population, so increasing plant resilience (Carmona et al., 2011; Gürbüz et al., 2018). Hussain et al. (2023) discovered that using potassium silicate significantly enhanced the thickness of the upper and lower epidermal cuticle layers, as well as the thickness of the leaf. The results of tables (1) and (2) demonstrate that PSNC averages 1.47, 2.04 mites/cm^2 significantly exceeds potassium silicate averages in normal size 2.26, 2.93 mites/cm^2 ; this is due to the nano size of PSNC (99 nm), and its stability derives from the zeta potential value of -68.2 mV (Clogston & Patri, 2011), As a result, PSNC is more efficient than a normal-sized PS. However, in table 3, there is non significant difference between PSNC and PS in normal size.

Table 1. Effect of types of fertilizers in normal and Nano size on the population density of TSSM on eggplant Jawaher cultivar

	Fertilizer type	Fertilizer size	No. of moving mites/cm^2/ leaf 9/5	16/5	23/5	30/5	Average
		normal	1.18	3.18	5.37	5.47	3.80
1	Humic acid	Nano	0.38	1.19	3.47	5.35	2.60
		average	0.78	2.19	4.42	5.41	3.20
		normal	0.83	1.67	2.17	4.36	2.26
2	Potassium silicate	Nano	0.00	1.10	2.03	2.75	1.47
		average	0.41	1.38	2.10	3.56	1.86
		normal	0.67	3.00	4.66	5.17	3.37
3	Salicylic acid	Nano	0.17	1.18	3.84	4.92	2.53
		average	0.42	2.09	4.25	5.05	2.95
4	Control		5.17	6.67	7.37	6.45	6.42
	Average of observation date		1.70	3.08	4.54	5.12	3.61

L.S.D (5% level)
Observation date: 0.51 Fertilizer type: 0.51 Fertilizer size: 0.36 Date* F.type: 1.01 F. type * F. size: 0.71 Interaction: 1.43

Table 2. Effect of types of fertilizers in normal and Nano size on the population density of TSSM on eggplant Barcelona cultivar

	Fertilizer type	Fertilizer size	No. of moving mites/cm^2/ leaf 9/5	16/5	23/5	30/5	Average
		normal	1.33	2.67	5.54	7.15	4.17
1	Humic acid	Nano	0.83	2.17	4.34	5.67	3.25
		average	1.08	2.42	4.94	6.41	3.71
		normal	0.73	1.50	4.17	5.33	2.93
2	Potassium silicate	Nano	0.50	1.32	2.33	4.00	2.04
		average	0.61	1.41	3.25	4.67	2.48
		normal	1.10	2.69	4.50	6.25	3.63
3	Salicylic acid	Nano	0.67	1.84	4.25	5.17	2.98
		average	0.88	2.26	4.37	5.71	3.30
4	Control		5.47	6.76	10.00	8.83	7.76
	Average of observation date		2.01	3.21	5.64	6.40	4.31

L.S.D (5% level)
Observation date: 0.52 Fertilizer type: 0.52 Fertilizer size: 0.36 Date* F.type: 1.03 F. type * F. size: 0.73 Interaction: 1.46

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Table 3. Effect of types of fertilizers in normal and Nano size on the population density of TSSM on eggplant Iraq Wonder cultivar

	Fertilizer type	Fertilizer size	No. of moving mites/cm^2/ leaf 9/5	16/5	23/5	30/5	Average
		normal	1.67	4.13	7.65	10.17	5.90
1	Humic acid	Nano	0.83	2.17	5.14	6.84	3.75
		average	1.25	3.15	6.39	8.50	4.82
		normal	0.89	1.84	4.15	6.94	3.45
2	Potassium silicate	Nano	0.67	1.51	3.17	6.00	2.83
		average	0.78	1.67	3.66	6.46	3.14
		normal	1.72	3.83	5.18	7.84	4.64
3	Salicylic acid	Nano	0.52	2.31	3.52	5.65	3.00
		average	1.12	3.07	4.35	6.74	3.82
4	Control		7.32	11.26	15.83	15.50	12.47
	Average of observation date		2.61	4.79	7.56	9.30	6.06

L.S.D (5% level)
Observation date: 0.63 Fertilizer type: 0.63 Fertilizer size: 0.45 Date* F.type: 1.26
F. type * F. size: 0.89 Interaction: 1.78

Tables (1) and (2) shows non-significant differences between humic acid and salicylic acid averages, while table (3) shows that the salicylic acid average 3.82 mites/cm^2 greatly exceeds the humic acid average 4.82 mites/cm^2. This could be due to how the cultivar reacts to the type of fertilizer applied (Salama et al., 2023) . According to tables (1, 2, 3) the humic acid nano capsule averages 2.6, 3.25, 3.75 mites/cm^2 outperformed normal-sized humic acid averages 3.8, 4.17, 5.9 mites/cm^2 in terms of reducing TSSM population density significantly. Because of the nano features, such as the nano size of 92 nm and the zeta potential value of -43.5 mV, humic acid in nano form improves and enhances its properties when compared to humic acid in normal form (Ismail et al., 2022). The results show that salicylic acid nano emulsion averages 2.53, 3 mites/cm^2 significantly exceeds salicylic acid in normal size averages 3.37, 4.64 mites/cm^2 in tables (1) and (3), while there is non-significant difference in table (2). Tables (1, 2, 3) demonstrate a considerable variance in observation date averages. The first observation date averages 1.7, 2.01, 2.61 mites/cm^2 greatly outperforms the other observation date, whereas the second observation date averages 3.08, 3.21, 4.79 mites/cm^2 outperforms the third and fourth observation date averages. Finally, the third observation date averages 4.54, 5.64, 7.56 mites/cm^2 outperforms the fourth observation date averages 5.12, 6.4, 9.3 mites/cm^2.

CONCLUSION

It could be concluded that the application of fertilizers can reduce the population density of TSSM; most of the fertilizers in nano form are more efficient than the normal form; the fertilizers' effect begins high and decreases with time.

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AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Author/s signature on Ethical Approval Statement.

Ethical Clearance and Animal welfare

Funds:

AUTHOR'S CONTRIBUTION STATEMENT

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تاثير استعمال انواع من الاسمدة في السيطرة على الحلم ذي البقعتين *Tetranychus urticae* في بعض اصناف الباذنجان

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المستخلص

هدف البحث الى دراسة تأثير سليكات البوتاسيوم، حامض الهيومك وحامض السالساليك بالشكل العادي والنانوي في خفض الكثافة السكانية للحلم على ثلاث أصناف من الباذنجان جواهر، برشلونة واعجوبة العراق. استعملت سليكات البوتاسيوم بمعدل 2.5 مل/لتر و 5 غرام/ لتر، حامض الهيومك استعمل بمعدل 10 مل/لتر و 20 غرام/لتر، حامض السالساليك استعمل بمعدل 0.1 غرام/لتر و 0.2 غرام/لتر للحالتين العادية والنانوية وعلى التوالي، فحصت النباتات بشكل اسبوعي بعد المعاملة لتقدير الكثافة السكانية للحلم ذي البقعتين. تبين ان استعمال الأسمدة سابقة الذكر أدى الى انخفاض الكثافة السكانية للحلم ذي البقعتين مقارنة بمعاملة المقارنة. أظهرت صور المجهر الماسح الضوئي بان معدل ابعاد كبسولات سليكات البوتاسيوم النانوية، كبسولات حامض الهيومك النانوية ومستحلب حامض السالساليك النانوي 99، 92 و 26 نانومتر على التتابع، بينما كانت قيم zeta potential لكبسولات سليكات البوتاسيوم النانوية، كبسولات حامض الهيومك النانوية ومستحلب حامض السالساليك النانوي –68.2، –43.5 و 63.1 mV على التتابع.

الكلمات المفتاحية: المجهرالماسح الضوئي، سليكات البوتاسيوم، حامض الهيومك، كبسولات نانوية، مستحلب نانوي، Zeta potential.