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Response of Life Table Criteria of Tetranychid Mite *Tetranychus urticae* (Acari: Tetranychidae) to Magnetic Water

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Abstract: Currently, there is an important need to find alternatives to chemical pesticides due to concerns about their harmful effects on the environment, non-target organisms and human health. So, research work was executed to compare the biological efficacy of pesticides versus magnetic water. *Tetranychus urticae* was bred on castor leaves treated with magnetized water after exposure to magnetic field for different periods by immersion method to find out its influence on the life cycle. Three treatments of magnetized water [MW20, MW30 and MW40], as well as Abamectin1.8%EC treatment and control treatment (distilled water), were used. Sublethal effects were studied on life-table parameters. The findings showed that the lowest net reproduction rate (R0) was achieved with Abamectin treatment (13.608), while the values with all magnetized water treatments [31.71, 30.24 and 35.91 for MW20, MW30 and MW40, respectively] were less than the control treatment that realized the highest value (51.03). Concerning the mean generation time (T), the lowest value was found with Abamectin treatment (13.06), while the values with all magnetized water treatments [15.07, 15.63 and 15.49 for MW20, MW30 and MW40, respectively] were less than the control treatment that realized the highest value (16.57). Abamectin showed a significant efficacy compared to other treatments, as it achieved the best effect on life cycle and life span as well as pre-oviposition, oviposition, post-oviposition, total number of eggs and daily rate of eggs for females. On the other hand, the vital effect of magnetized water treatments was weak or unclear compared to the control treatment. Generally, the obtained results proved that magnetic water isn't the most effective solution to protect crops from *Tetranychus urticae,* but perhaps with the continuation of research on this point, the potential of magnetized water can be maximized by combining it with other treatments that enhance its capacity.

Abbreviation: MW20: Distilled water exposed to a magnetic field of 180 m Tesla for 20 minutes, MW30: Distilled water exposed to a magnetic field of 180 m Tesla for 30 minutes, MW40: Distilled water exposed to a magnetic field of 180 m Tesla for 40 minutes

Key words: Abamectin · Magnetic water · Pesticides

INTRODUCTION

Tetranychus urticae Koch, commonly known as the two-spotted spider mite, is a species of spider mite that belongs to the family Tetranychidae. It is a tiny arachnid that feeds on the sap of plants and considered a significant pest of many crops, ornamental plants and greenhouse plants worldwide. The two-spotted spider mite is typically pale yellow to greenish in color and has two dark spots on its back, which give it its common name. It has four pairs of legs and is barely visible to the naked eye. The mites feed on the undersides of leaves, causing stippling or yellowing of the foliage, that lead to reduced growth and yield of the host plant. *Tetranychus urticae* is a prolific breeder and can reproduce rapidly, with a single female capable of laying up to 100 eggs in her lifetime. The mites are also known for their ability to develop resistance to a wide range of chemical pesticides, making them a challenging pest to control. Various methods can be used to manage *Tetranychus urticae*, including cultural practices such as removing infested leaves and pruning heavily infested plants, biological

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control through the use of natural enemies such as predatory mites and chemical control using acaricide. However, the selection and use of appropriate control methods depend on several factors, including the severity of the infestation, the crop being grown and the environmental conditions [1, 2].

Abamectin is a commonly used pesticide that belongs to the avermectin class of compounds. It has been shown to have significant effects on the life table criteria of the Tetranychid mite *Tetranychus urticae*, which is a common pest in agriculture and horticulture. Studies have shown that exposure to Abamectin can decrease the survival rate of *T. urticae* at different developmental stages, reduce their reproductive output and increase the duration of their developmental stages. Abamectin also affects the fertility of female mites, leading to a decrease in the number of eggs they produce and reducing the population growth rate of the mites. However, while Abamectin can be effective against *T. urticae*, it can also have harmful effects on the environment and human health. Abamectin can persist in the environment for extended periods, potentially contaminating soil, water and non-target organisms. It can also be toxic to beneficial insects such as pollinators, predators and parasites, disrupting the natural ecosystem balance. Abamectin can also pose a risk to human health, particularly to workers who handle or apply the pesticide. Exposure to Abamectin can cause skin irritation, respiratory problems and other health issues. It is essential to handle and use Abamectin carefully, following all safety instructions and use protective equipment to avoid harmful effects on human health and the environment [3-8].

The use of magnetic field and magnetism in pest control is an area of research that has shown promise in recent years. Magnetic field has been found to affect the behavior, physiology and reproduction of various pests, including insects and mites. Some studies have shown that exposure to magnetic field can interfere with the mating behavior and reproductive success of pests, leading to a reduction in pest populations. Other studies have focused on the use of magnetic field to alter the behavior of pests, such as directing them away from crops or attracting them to traps. However, it is important to note that although magnetic field and magnetism may offer potential benefits in pest control, there are still having many uncertainties and limitations that need to be addressed. For example, the effects of magnetic field on non-target organisms, such as beneficial insects or wildlife, are not well understood. Additionally, the effectiveness of magnetic field in pest control may depend on several factors, such as the strength and duration of exposure, the type of pest and the environmental conditions. Therefore, more research is needed to fully evaluate the potential benefits and limitations of magnetic field in pest control and to develop effective and sustainable methods for their use in agricultural settings [9].

So, the current research work was executed to compare the response of life table criteria of tetranychid mite *Tetranychus urticae* to Abamectin and magnetized water exposed to a magnetic field for different periods.

MATERIALS AND METHODS

Tested Mites: The original populations of tetranychid mites were obtained from infected castor bean plants, as identifying process was executed according to the detailed descriptions described by Zhang and Jacobson [10] and Zhang, [11] at the Acarology Lab., Plant Protection Research Institute, ARC.

Treatments

Distilled Water Was Used for the Control Treatment: Sublethal dose of the recommended pesticide Abamectin1.8%EC (LC_{25} = 0.044 ppm) according to a toxicity test calculated seven days post-treatment was used for pesticide treatment. A toxicity test for Abamectin was carried out in the laboratory using 5 concentrations (2, 1, 0.5, 0.25, 0.125 ppm).

A magnetic field system with an approximate 180 m Tesla field was built and measured in the faculty of engineering at Menoufia University was used. Distilled water was exposed to a 180 m Tesla magnetic field for different times 20 min (MW20), 30 min (MW30) and 40 min (MW40).

Experimental Setup: *Tetranychus urticae* was bred on castor leaves at room temperature (25 ± 2°C and RH 75 ± 5). Three treatments of magnetized water [MW20, MW30 and MW40], Abamectin1.8%EC and control treatments were used. After cleaning the castor bean leaf discs (1.0 x 1.0 cm), dipping technique was used for 30 sec. Leaf discs were left to dry naturally, then placed on moistened cotton wool pad in Petri dishes. Spider mite individuals were transferred to leaf discs with the aid of a fine camel's hairbrush. Breeding castor bean leaves were changed once a week. Also, the addition of water was implemented twice a week to prevent the escape of *T. urticae* individuals [12]. Fifty newly emerged unmated adult females, of nearly the same age, were transferred with fifty adult males to leaf discs with the aid of a camel's hairbrush and a stereomicroscope. After 24 hours of exposure, the surviving mites in each treatment were transferred to new clean leaf discs free of treatment residue for oviposition. Laid eggs were transferred individually on new clean leaf discs, each egg considered a replicate and 50 replicates were used for each treatment to evaluate the developmental times (egg to adult). Twice daily monitoring (12 hours intervals) of eggs was carried out until maturity.

Measurement Traits: For mite fecundity evaluation, a newly emerged female coupled with a newly emerged male obtained in the same experiment were placed on treated leaf discs with previous treatments mentioned before using a dipping technique for 30 seconds. After 24 hours of exposure, mites were removed as mentioned before. Each couple of male and female was considered as a replication unit and there were 20 replicates for each examined treatment. Mites were monitored daily and laid eggs were counted until all mites died naturally. Mites were transferred to new leaf discs weekly. Adult longevity and fecundity were recorded.

Life table criteria *i.e.,* mean generation time (T), net reproduction rate (R_0), intrinsic rate of increase (r_m) and finite rate of increase (λ) were calculated from survivors and fertility schedules [13].

The intrinsic rate of increase (rm) was measured using the the Euler–Lotka equation [14].

$$\sum_{x=0}^{\infty} x^{-r(x-1)} l_x m_x = 1$$

According Goodman, [15], with the age indexed from zero, the gross reproductive rate was calculated as follows:

$$GRP = \sum mx$$

The net reproductive rate was calculated as follows:

$$R_0 = \sum_{x=0}^{\infty} l_x m_x$$

Where it represents the mean number of offspring that an individual can produce during their lifetime.

Mean generation time defined as the period that a population needs to increase to R0-fold of its size was calculated as follows:

$$T = \frac{InR0}{r}$$

The finite rate of increase was measured as follows:

$$\lambda = e^r$$

Statistical Analysis: Data were statistically analyzed using one-way Analysis Of Variance (ANOVA) followed by Multiple Range Test at p-level ≤ 0.05 to compare means [16-17].

RESULTS AND DISCUSSION

The following tables show the developmental and life table criteria response of the tetranychid mite *Tetranychus urticae* to magnetic water and Abamectin *i.e.*, the incubation period, active larva, quiescent larva, active protonymph, quiescent protonymph, active deutonymph, quiescent deutonymph, immature, life cycle, longevity and life span for female (Table 1) and males (Table 3) as well as pre-oviposition, oviposition, post-oviposition, total No. of eggs and daily rate of eggs for female (Table 2). While Table 4 illustrates the effect of the studied treatments on net reproduction rate (R0), mean generation time (T), intrinsic rate of increase (rm), finite rate of increase (λ) and generation doubling time (day).

Abamectin showed a significant effect compared to other treatments, as it achieved the lowest incubation period (4.16 and 4 days), life cycle (8.63 and 9.56 days) and life span (27.03 and 24.9 days) for females and males, respectively. Pre-oviposition period (1.0 day), oviposition period (12.2 days), total No. of eggs (21.8) and daily rate of eggs (1.79) for females were significantly shorter on Abamectin. On the other hand, the vital effect of magnetized water treatments mentioned before was weak or unclear as female life span and daily rate of eggs recorded (30.54, 30.98, 27.81 days) and (3.1, 4.35, 4.6 egg/day) for the three treatments of magnetized water mentioned before, respectively, compared to control treatment (30.96 days) and (5.09 egg/day). Table 2 showed that the treatment of adult females with Abamectin pronouncedly reduced the total No. of eggs laid per female than magnetized water [MW20, MW30 and MW40] and control as it recorded as 21.8, 50.33, 54.16, 57.0 and 81.0 eggs, respectively.

On the other hand, the data of Table 4 showed that the lowest net reproduction rate (R_0) was achieved with Abamectin treatment (13.608), while the values with all magnetized water treatments [31.71, 30.24 and 35.91 for MW20, MW30 and MW40, respectively] were less than

Table 1: Impact of the magnetized water (MW20, MW30, MW40) and Abamectin on the duration of various stages of *Tetranychus urticae* (Female)

	Female							
	Treatment							
Stage	Control	Abamectin	MW20	MW30	MW40	LSD	F	*p*
Incubation period	5.25a±0.170	4.16b±0.307	4.5ab±0.223	5ab±0.258	5ab±0.258	0.721	3.144	0.0318*
Active larva	0.89a±0.152	0.791a±0.100	1.07a0.041	1.07a±0.018	1.04a±0.010	0.245	2.211	0.0968 ns
Quiescent larva	1.068a±0.055	0.791a±0.100	0.78a±0.138	0.85a±0.018	0.88a±0.020	0.236	1.993	0.1264 ns
Active protonymph	0.59bc±0.065	0.4c±0.05	0.76b±0.113	0.80b±0.125	1.06a±0.032	0.249	8.472	0.0002 ***
Quiescent protonymph	0.95a±0.077	0.66ab±0.105	0.75abc±0.083	0.83ab±0.040	0.58b±0.051	0.219	3.664	0.0176 *
Active deutonymph	0.86b±0.039	1.16a±0.083	1.15a±0.054	1.21a±0.105	0.89b±0.022	0.197	5.89	0.0018 **
Quiescent deutonymph	1.05a±0.025	0.65b±0.122	1.01a±0.11	1.04a±0.09	1.10a±0.040	0.253	4.432	0.0076 **
Immature	5.42a±0.178	4.46b±0.268	5.54a±0.159	5.82a±0.139	5.56a±0.127	0.529	8.247	0.0002 ***
Life cycle	10.67a±0.342	8.63b±0.389	10.04a±0.207	10.82a±0.20	10.56a±0.361	0.905	8.280	0.0002 ***
Longevity	20.29a±0.541	18.4a±1.019	20.5a±2.334	20.16a±2.914	17.25a±0.625	5.156	0.652	0.6302 ns
Life span	30.96a±0.812	27.03a±1.24	30.54a±2.278	30.98a±3.03	27.81a±0.844	5.417	1.037	0.4077 ns

Table 2: Impact of the magnetized water (MW20, MW30, MW40) and Abamectin on the fecundity of *Tetranychus urticae* (Female)

	Treatment							
Stage	Control	Abamectin	MW20	MW30	MW40	LSD	F	*p*
Pre-oviposition	2.0a±0.129	1.0b±0	1.5ab±0.223	2.0a±0.258	1.75a±0.15	0.518	5.526	0.0025**
Oviposition	15.79 a±0.708	12.2a±0.702	16.0a±2.113	13.83a±2.749	12.5a±0.763	4.804	1.167	0.3489 ns
Post-oviposition	2.5a±0.547	5.2a±0.476	3.0a±0.960	4.33a±1.520	3a±0.632	2.66	1.506	0.2305 ns
Total No. of eggs	81.0a±6.718	21.8c±1.851	50.33b±9.131	54.16b±8.439	57b±2.67	18.88	10.59	0.0000***
The daily rate of eggs	5.09a±0.236	1.79c±0.144	3.10b±0.308	4.35a±0.61	4.61a±0.259	1.026	14.323	0.0000***

Table 3: Impact of the magnetized water (MW20, MW30, MW40) and Abamectin on the duration of various stages of *Tetranychus urticae* (male)

	Male							
	Treatment							
Stage	Control	Abamectin	MW20	MW30	MW40	LSD	F	*p*
Incubation period	5a±0.365	4a±0.365	4.33a±0.210	5a±0.258	5a±0.258	0.868	2.5	0.0681ns
Active larva	1.37a±0.052	1.16b±0.105	1.07b±0.018	1.04b±0	0.99b±0.052	0.170	6.771	0.0008***
Quiescent larva	0.77ab±0.064	0.56±b0.042	0.94a±0.061	0.51b±0.082	0.62b±0.108	0.219	5.32	0.0031**
Active protonymph	0.54b±0.010	1.16a±0.105	0.51b±0.134	0.67b±0.111	0.66b±0.094	0.293	6.883	0.0007***
Quiescent protonymph	1.04a±0.014	0.66b±0.105	1.04a±0.052	0.73b±0.008	0.765b±0.079	0.186	7.945	0.0003***
Active deutonymph	0.735b±0.015	1.16a±0.105	0.54b±0.108	0.96a±0.015	0.63b±0.076	0.222	11.02	0.0000***
Quiescent deutonymph	0.96a±0.184	0.83a±0.21	1.16a±0.05	1.13a±0.03	0.946a±0.053	0.380	1.122	0.3685ns
Immature	5.42a±0.195	5.56a±0.456	5.28a±0.283	5.04a±0.064	4.62a±0.174	0.783	1.877	0.1459ns
Life cycle	10.42a±0.227	9.56a±0.78	9.61a±0.317	10.045a±0.319	9.625a±0.290	1.267	0.725	0.5830ns
Longevity	18.66ab±0.649	15.33bc±0.557	16bc±3.02	12c±0.774	22a±1.693	4.756	5.282	0.0032**
Life span	29.08ab±0.726	24.9bc±0.603	25.61bc±2.906	22.04c±0.948	31.62a±1.76	4.761	5.239	0.0033**

Table 4: Impact of the magnetized water (MW20, MW30, MW40), Abamectin on life table criteria of the tetranychid mite *Tetranychus urticae*

Parameters	Control	Abamectin	MW20	MW30	MW40
Net reproduction rate(R_0)	51.03	13.608	31.71	30.24	35.91
Mean generation time(T)	16.5765	13.06	15.0784	15.63	15.49
The intrinsic rate of increase (rm)	0.51504	0.55	0.53467	0.51285	0.53
Finite rate of increase (λ)	1.6737	1.74	1.70687	1.6700	1.70
Generation doubling time (day)*	1.3458	1.26	1.2964	1.3516	1.30

*Generation doubling time (day)= ln2/rm

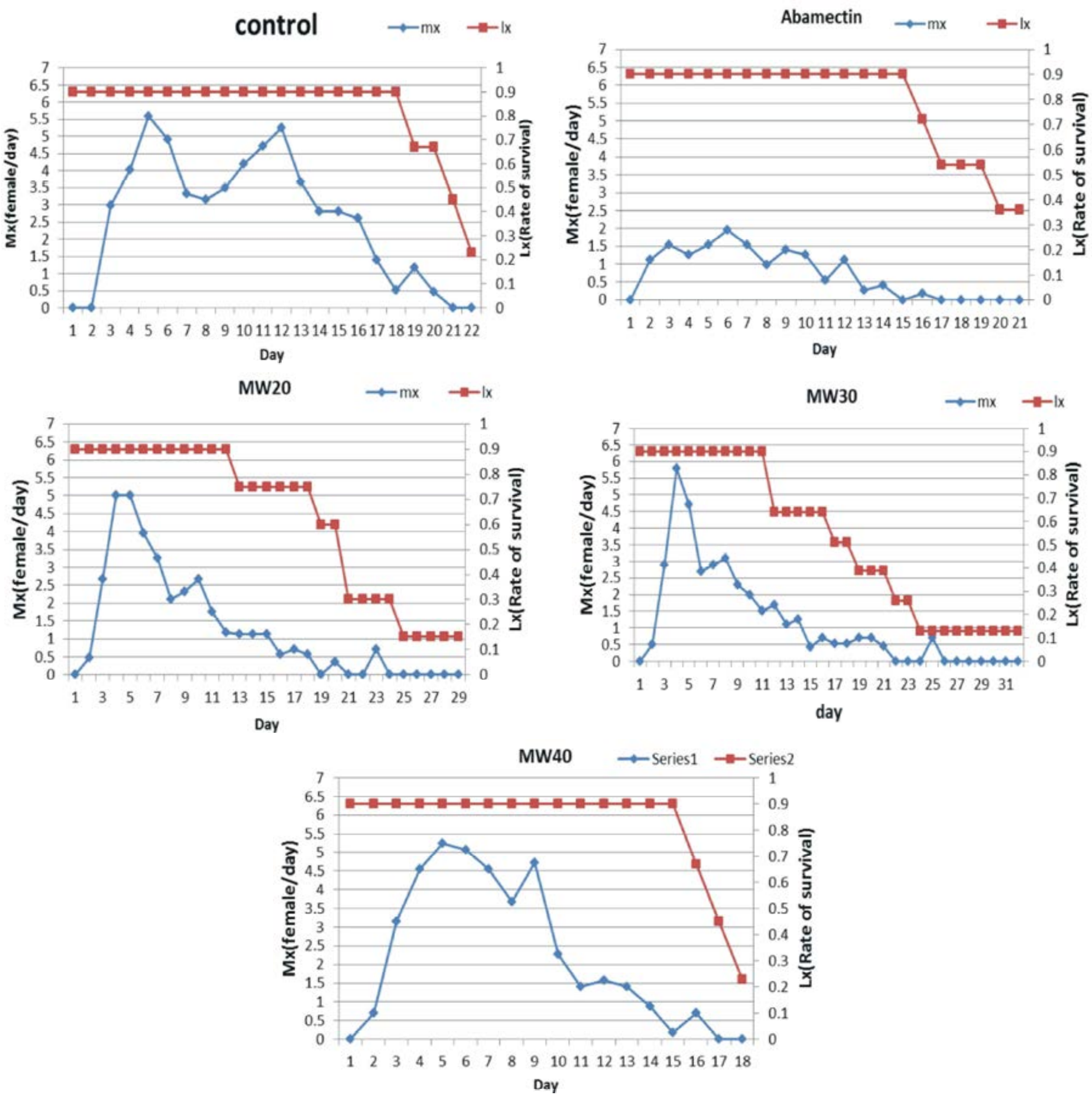

Fig. 1: Impact of the magnetized water (MW20, MW30, MW40) and Abamectin on mean age-specific fecundity (Mx) and survival rate (Lx) of the tetranychid mite *Tetranychus urticae* (female)

the control treatment that realized the highest value (51.03). Concerning the mean generation time (T), the lowest value was found with Abamectin treatment (13.06), while the values with all magnetized water treatments [15.07, 15.63 and 15.49 for MW20, MW30 and MW40, respectively] were less than the control treatment that realized the highest value (16.57). Regarding the intrinsic rate of increase (rm), the Abamectin realized the maximum value (0.55), while the values with all magnetized water treatments were 0.53, 0.51 and 0.53 for MW20, MW30 and MW40, respectively and 0.51 for the control treatment. As for the finite rate of increase (λ), the Abamectin realized the maximum value (1.74), while the values with all magnetized water treatments were 1.7, 1.67 and 1.7 for MW20, MW30 and MW40, respectively and 1.67 for the control treatment. Concerning the generation doubling time (day), the lowest value was found with Abamectin treatment (1.26), while the values with all magnetized water treatments were 1.29, 1.35 and 1.30 for MW20, MW30 and MW40, respectively and 1.34 for the control treatment.

Data illustrated in Fig. 1 for MX (female progeny/female/day) and LX (age-specific survival) curves were generated from previous life table data for each treatment. For mites exposed to magnetized water

(MW20, MW30, MW40) maximum oviposition rate/female/day (Mx) was 5.01 on the 4th and 5th day, 5.8 on the 4th day and 5.07 on the 6th day, respectively. When mites were treated with Abamectin these values decreased as it was 1.96 on the 6th day. While the normal value in control was 5.6 on the 5th day which was close to the magnetized water treatment.

Abamectin was the most effective material compared to all studied magnetic water treatments, as it has been shown to have significant effects on the life table criteria of the Tetranychid mite *Tetranychus urticae*. Thus, it can be said that exposure to Abamectin can decrease the survival rate of *T. urticae* at different developmental stages and reduce their reproductive output, but it decreases the duration of their developmental stages [3-5]. Abamectin also affects the fertility of female mites, leading to a decrease in the number of eggs they produce and reducing the population growth rate of the mites. Generally, it can be said that Abamectin can be effective against T. *urticae* [6-8].

The obtained results illustrated that exposure to magnetic water had a simple relative effect on the development and reproductive parameters of *T. urticae*. However, it is important to note that the results of this study are preliminary and more research is needed to confirm the effectiveness of magnetic water as a pest control method for *T. urticae*. Additionally, the mechanism by which magnetic water affects the life table criteria of *T. urticae* is not well understood and requires further investigation. Overall, while some studies suggest that magnetic water may have a positive effect on the life table criteria of *T. urticae*, more research is needed to understand the mechanism and effectiveness of this approach.

CONCLUSION

According to the obtained results, Abamectin was the most effective material compared to all studied magnetic water treatments.

It can be concluded that magnetic water isn't the most effective solution to protect crops from *Tetranychus urticae*, but perhaps with the continuation of research on this point, the potential of magnetized water can be maximized by combining it with other treatments that enhance its capacity. In other words, Magnetic water should not be relied upon as the sole method of pest control and should be used in combination with other integrated pest management strategies for effective control of *T. urticae*.

REFERENCES

1. Kumari, S., U. Chauhan, A. Kumari and G. Nadda, 2017. Comparative toxicities of novel and conventional acaricides against different stages of *Tetranychus urticae* Koch (Acarina: Tetranychidae). Journal of the Saudi Society of Agricultural Sciences, 16(2): 191-196.
2. Rincón, R.A., D. Rodríguez and E. Coy-Barrera, 2019. Botanicals against *Tetranychus urticae* Koch under laboratory conditions: A survey of alternatives for controlling pest mites. Plants, 8(8): 272.
3. Stumpf, N. and R. Nauen, 2002. Biochemical markers linked to abamectin resistance in *Tetranychus urticae* (Acari: Tetranychidae). Pesticide Biochemistry and Physiology, 72(2): 111-121.
4. Campbell, W.C., 2012. Ivermectin and abamectin. Springer Science and Business Media.
5. Bai, S.H. and S. Ogbourne, 2016. Eco-toxicological effects of the avermectin family with a focus on abamectin and ivermectin. Chemosphere, 154: 204-214.
6. Salem, R.E., 2020. Efficacy of certain insecticides for controlling the two spotted spider mite, *tetranychus urticae* (koch) and determination residues of abamectin on some quality parameters of cucumber fruits. egyptian academic journal of biological sciences, F. Toxicology and Pest Control, 12(1): 217-226.
7. Shalaby, A., M.A. Hendawy, A.A.A. Aioub and K.M. Saleh, 2020. Health risk assessment of abamectin and buprofezin residues in eggplant and pepper plants. Journal of Plant Protection and Pathology, 11(12): 693-699.
8. Pirasath, S., B. Nageswaran, R.P. Vasana Karunasena and M. Gevakaran, 2021. Acute abamectin toxicity: a case report. Toxicology Communications, 5(1): 66-68.
9. El-Bassouiny, H.M., W.A. El-Medany and M.A. Kandil, 2022. The impact of magnetic field on insecticide toxicity measured by biological and biochemical parameters of *Earias insulana* (Boisd). Bioelectromagnetics, 43(6): 368-380.
10. Zhang, Z.Q. and R.J. Jacobson, 2000. Using adult female morphological characters for differentiating *Tetrancyhus urticae* complex (Acari: Tetranychidae) from greenhouse tomato crops in UK. Systemic Applied Acarology, 5: 69-76.
11. Zhang, Z.Q., 2003. Mites of greenhouses: identification, biology and control. CABI Publishing, Wallingford, pp: 256.

12. Abd El-Wahab, R.A., 2003. Studies on some chemical compounds against some tetranychid mite species. M. Sc. Thesis., Pesticides Dept., Fac. of Agric., Mansoura Univ., Egypt, pp: 131.
13. Constantino, R.F., 1993. Applied demography for biologists with special emphasis on insects: James R. Carey, Oxford University Press, New York, 1993, $39.95 (cloth), pp: 206.
14. Grassly, N.C. and C. Fraser, 2008. Mathematical models of infectious disease transmission. Nature Reviews Microbiology, 6(6): 477-487.
15. Goodman, D., 1982. Optimal life histories, optimal notation and the value of reproductive value. American Nature, 119: 803-823.
16. Snedecor, G.W. and W.G. Cochran, 1980. Statistical methods. 7^{th}. Iowa State University USA, pp: 80-6.
17. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11(1): 1-42.