Advances in Entomology, 2016, 4, 260-267
http://www.scirp.org/journal/ae
ISSN Online: 2331-2017
ISSN Print: 2331-1991

The Influence of *Tetranychus urticae* Koch (Acari: Tetranychidae) Life Table and Reproductive Parameters by Applying Si on Bean at Library Condition

Elahe Sadeghi[1], Reza Vafaei Shoushtari[2], Hamid Madani[3]

[1]Entomology Student Department, Arak Branch, Islamic Azad University, Arak, Iran
[2]Faculty of Entomology, Arak Branch, Islamic Azad University, Arak, Iran
[3]Faculty of Agriculture, Arak Branch, Islamic Azad University, Arak, Iran
Email: elahe.sadeghi25302yahoo.com

How to cite this paper: Sadeghi, E., Shoushtari, R.V. and Madani, H. (2016) The Influence of *Tetranychus urticae* Koch (Acari: Tetranychidae) Life Table and Reproductive Parameters by Applying Si on Bean at Library Condition. *Advances in Entomology*, **4**, 260-267.
http://dx.doi.org/10.4236/ae.2016.45027

Received: August 17, 2016
Accepted: September 16, 2016
Published: September 19, 2016

Abstract

Two-spotted spider mite, *Tetranychus urticae* Koch, is one of the important pests of bean, which can cause severe damages on it. Silicon is one of the micronutrient elements, as its spray on the leaves can decrease the population of the pest. In this research, the impact of four different doses of Si (0, 1, 1/5, 2 ppm) was investigated on biological and population growth parameters of *T. urticae*. The experiments were carried out in Petri dishes in an incubator at 25˚C ± 2˚C, 65% ± 5% RH and 16 L: 8 D. The duration of developmental stage was significantly affected by Si dose. The longest immature period, the shortest longevity of females and the shortest oviposition period were obtained at 2 ppm. In addition, Si dose significantly affected population growth parameters of the mite. The intrinsic rate of natural increase (rm) of the mite ranged from 0.246 to 0.215 day which lowest and the highest values were at 2 ppm and control plants, respectively. The lowest net reproductive rate (R0) and finite rate of increase (λ) of the mite and the highest value of mean generation time (T) and doubling time (DT) were estimated at 2 ppm. The results of this peruse represented that 2 ppm had better potential for decreasing the population of the two-spotted spider mite, and it can be used in the mite integrated pest management programs.

Keywords

Two-Spotted Spider Mite, Si, Biological Parameters, Intrinsic Rate of Natural Increase

1. Introduction

Bean is one of the most critical crops in the world and makes up stable natural protein for human. Silicon is the second most abundant constituent in the earth's crust [1]. It constitutes 27.7% of the total weight in soil after the oxygen (47%). It ranges from 200 to300 g Si Kg^{-1} in clay soil and 450 g Si Kg^{-1} in sandy soils. Its content in soil varies from <1% to 45% by dry weight. The traditional practice of collecting the ashes from the back yard of houses supplies not only potash but also silicon. Silicon is an agronomically important fertilizer element that enhances plant tolerance to abiotic stresses. Silicon fertilizer has a double effect on the soil-plant system as under. 1) Improved plant-silicon nutrition reinforces plant-protective properties against diseases, insect attack, and unfavorable climatic conditions; 2) soil treatment with biogeochemical active silicon substances optimizes soil fertility through improved water, physical and chemical soil properties, and maintenance of nutrients in plant-available forms [2].

Silicon has generally not been considered essential for plant growth, although it is well recognized that many plants, particularly Poaceae, have substantial plant tissue concentrations of this element. For many years, silicon deficiency in crops went unrecognized, and this element was widely regarded as non-essential for plant growth, although often present in the highest concentration in inorganic constituents. However, there is now a greater consensus amongst scientists in the role of silicon as a "functional" plant nutrient. Silica content in the plant is reported to play an important role in strengthening the cell walls of plants [3]. In Florida, researchers found that after applying 20 t/ha of TVA slag to a muck soil, there was a significant decrease in leaf freckling in sugarcane. Furthermore, with improved silicon nutrition, there was an increase in sugarcane resistance to the stem borer *Diatraea saccharalis* F. [4]. In the greenhouse, sugarcane varieties were artificially inoculated with *E. saccharina* and treated with three doses (0, 5 and 10 t/ha) of calcium silicate. At 10 t/ha calcium silicate, there was a reduction of 30% in borer damage and 20% in borer mass. The most susceptible varieties showed the highest silicon uptake and the greatest response. Of the four carriers tested, stalkborer incidence declined as follows: South African calcium silicate > imported USA calcium silicate > local Slagment > flyash. In the field experiment, similar results were recorded [5].

Other experiments in Asia showed that, on rice, silicic acid at concentrations as low as 0.01 mg Si/ml was an active sucking inhibitor against the brown planthopper (*Nilaparvata lugens* (Stal) [6]. Furthermore, at high levels of silicon, fewer planthopper nymphs became adults and there was a decrease in adult longevity and female fecundity [4].

High silicon content contributed to maize (*Zea mays* L.) resistance to stalkborer (*Chilo zonellus* Swinhoe) damage. Similarly, in Benin, researchers evaluated the effects of silica application to maize on the borer, *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae). They applied sodium metasilicate ($Na_2SiO_{3.5}H_2O$) at a rate of 0, 0.56 and 0.84 g Si/plant. They recorded that an increasing silica supply reduced larval survival from 26.0% (control) to 4.0% at 0.56 g Si/plant [7]. Additionally, maize resistance to the second generation of *Ostrinia nubilalis* Hübner (Lepidoptera: Pyralidae) was significantly correlated with the silica content in the sheath and collar tissue [4].

Host plant resistance can be a fundamental factor of a successful integrated pest management (IPM) system. Integration of resistant plants with other pest control methods results in conservation of beneficial natural enemies and decreased usage of pesticides [8].

Tetranychus urticae is an important pest of a variety of agricultural crops [9]. Adults and immatures feed primarily on leaves producing tiny gray or silvery spots known as stippling damage. Damage to the leaves inhibits photosynthesis, and severe infestations can result in premature leaf fall, shoot dieback, and decreased plant vigor [10]-[12]. Although chemical control is a common method, it cannot decrease number of mites. Therefore, the main target of the present study is to determine the effects of Si on the demographic parameters of *T. urticae*.

2. Material and Methods

This experiment was carried out at the laboratory of Arak Azad University. Red bean cultivar Akhtar was used as host plant. Cultivar was selected by advisement of plant protection experts in khomein research center. Seeds were drenched 24 h. before planting and they were planted in pots (10 liters in size) that were filled with cocopeat and perlite (1:1) in a hydroponic system. The pots were kept in a greenhouse at 28˚C ± 2˚C, with a light intensity of 13,000 Lux and were fed by the nutrient solution (Rash) three times daily [13]. The mites collected from greenhouse of Markazi province, Iran. The mites were maintained in potted young akhtar plants in a laboratory at 26˚C ± 1˚C, 75% - 80% relative humidity (RH), and 14 h light/10h dark cycle with no acaricide exposure for a long time [14].

They were separately reared on bean leaves which were sprayed with different value of Si. According to the amount Si that bean plants need for growing and previous studies, the effect of various doses of Si (0, 1, 1.5, 2 ppm) on life parameters and reproductive parameters of the spider mite were evaluated on 3 cm diameter leaf discs placed on soppy cotton in a 3 cm diameter Petri-dish with 1.5 cm diameter hole was drilled and covered with ruching for ventilation. Water was daily added to cotton for keeping the leaves fresh [15].

The experiment was conducted as split-plot in a complete randomized design with 100 replications. Five adult female mites were abandoned on the leaf disc per module. After 72 h., the damage score of the leaf discs, the number of eggs and the percentage of dead mites were registered. The damage was determined pursuant to a damage score method [16]-[19].

Female and male spider-mite cohorts were situated a pair on a leaf disc. The mites were abolished after 3 h. and only one egg was retained on each leaf disc. Units were surveyed every 12 h (at 7 am and 7 pm). After adult emanate, females were copulated with males taken from the colony of the mite on the same cultivar. Then the duration of egg, larva, protonymph and deutonymph, adult longevity, fecundity and mortality of the mite were registered for each sample the death of the last mite [18].

All population growth parameters were estimated, according to Carry's formula [20]. The All statistical analyses were carried out using software of Microsoft Excel 2003 [21] and SPSS 17.0 [22].

3. Results

3.1. Developmental Times of Immature Stages

The developmental times of immature stages (days) of *Tetranychus urticae* on bean plants amended with different Si ppm are reported in **Table 1**. Analysis of variance indicated significant differences in duration of immature stages of *Tetranychus urticae* in different levels of Si. (F = 4.76, P = 0.004). The results showed that the maximum duration of incubation were happen in 2 and 1.5 ppm samples of Si and the minimum were happen in 0 ppm. *T. urticae* eggs hatched to six legged larvae in the shortest duration of 1.32 ± 0.09 Days and the longest duration of 1.80 ± 0.10 days (**Table 1**). No significant variations were observed between samples for nymphal periods (F = 2.74, P = 0.05). The shortest immature stages of host were registered for 0 ppm trial.

3.2. The Biological and Reproduction Parameter

The biological and reproduction parameter of mature stages (days) of *Tetranychus urticae* on bean plants amended with different Si ppm are calculated and presented in **Table 2**. In this study female and male longevity were affected by different doses of Si (F = 4.92, P = 0.004 ♂) and (F = 4.92, P = 0.004 ♀). The highest female longevity was recorded for 0 and 1 ppm samples, while the shortest was recorded for 2 ppm samples (**Table 2**). In 0 ppm test male longevity was the maximum and the minimum was in 1.5 and 2 ppm . Analysis of variance indicated significant differences in duration of oviposition stages of *Tetranychus urticae* in different levels of Si. (F = 4.67, P = 0.005). According to the **Table 2**, the longest oviposition term was expressed about 0 and 1 ppm samples, as the shortest oviposition term was reported for 2 ppm test. There was no considerable variation about total fecundity.

3.3. Population Growth Parameters

The population growth parameters of *Tetranychus urticae* on bean plants amended with different Si ppm is presented in **Table 3**. Analysis of variance indicated significant

Table 1. Mean (±SE) developmental times of immature tages days of *Tetranychus urticae* on Bean plants amended with different Si.

Si (ppm)	Incubation	Larval period	Nymph period	Total immature stage
0	3.17 ± 0.08	1.32 ± 0.09	3.62 ± 0.08	8.22 ± 0.10
1	3.40 ± 0.09	1.46 ± 0.08	3.67 ± 0.07	8.52 ± 0.13
1.5	3.55 ± 0.09	1.73 ± 0.09	3.62 ± 0.13	8.90 ± 0.17
2	3.57 ± 0.08*	1.80 ± 0.10*	3.97 ± 0.10*	9.37 ± 0.14*

*In columns, means followed by different letters are significantly different (p < 0.05; Tukey test).

Table 2. Mean (±SE) biological and reproduction parameter of mature stages (days) of *Tetranychus urticae* on bean plants with amended with different Si ppm.

Si (ppm)	Female longevity	Pre-oviposition (day)	Oviposition (day)	Post-oviposition (day)	Total fecundity
0	16.00 ± 1*	8.50 ± 0.01	13.83 ± 0.1	1.10 ± 0.17	75.10 ± 5.17
1	15.57 ± 1.10	7.28 ± 1	13.10 ± 1.07	1.20 ± 0.14	75.01 ± 5.85
1.5	13.15 ± 0.99	6.38 ± 0.5	11.90 ± 0.92	1.15 ± 0.17	67.55 ± 7.60
2	11.95 ± 0.41	5.62 ± 0.34*	9.50 ± 0.58*	1.13 ± 0.11	65.04 ± 3.72*

*In columns, means followed by different letters are significantly different ($p < 0.05$; Tukey test).

Table 3. Mean (±SE) population growth parameters of *Tetranychus urticae* on bean plants amended with different Si.

Si (ppm)	Intrinsic rate of natural increase	Net reproductive rate	Finite rate of increase	Doubling time	Mean generation time
0	0.252 ± 0.004	35.7 ± 0.01	1.30 ± 0.005	2.7 ± 0.04	14.6 ± 0.23
1	0.230 ± 0.004	36.2 ± 1	1.29 ± 0.007	2.8 ± 0.05	15 ± 0.16
1.5	0.232 ± 0.006	31.3 ± 0.5	1.28 ± 0.009	2.9 ± 0.08	15 ± 0.19
2	0.220 ± 0.003	27.6 ± 0.34	1.25 ± 0.004	3.1 ± 0.05	15.9 ± 0.26

*In columns, means followed by different letters are significantly different ($p < 0.05$; Tukey test).

differences about intrinsic rate of natural increase (rm) of *Tetranychus urticae* in different levels of Si. ($F = 7/25$, $p < 0/001$). The least intrinsic rate of natural increase was observed in 2 ppm treatment, whenever the most was recorded in 0 ppm. The greatest net reproductive rate (R0) was registered for 0 ppm test, as the lowest was registered for 2 ppm trial. The observation about doubling time (DT) showed significant diversity (**Table 3**). The highest value of mean generation time (T) was observed about 2 ppm assay, and the lowest was recorded for 0 ppm assay.

4. Discussion

This study investigates that the different levels of Si have effect on life table and reproductive parameters of *Tetranychus urticae* on bean cultivar akhtar at library condition. The pests have different survival, development and reproductive rates on the host species and cultivars because plants vary greatly in suitability as hosts. Shorter development time and high reproduction of pests on host plans demonstrate greater suitability of those plants indicate greater suitability of those plants for colonization of pests [23]. The outcome of this etude confirmed the previous studies regarding effect of quality of host plant on the pest biology.

According to the previous studies, developmental time of immature stages include 2.37 (day) larval period, 6 (day) nymph period, and 15.375 (day) total immature stage [24]. Developmental time of immature stages in 2 ppm assay showed the most and 0 ppm test showed the least. Due to significant increase of immature stages growth, the adult longevity and egg number decrease [25].

The population parameters (r, R_0, λ, and T) are the obtained parameters, computed based on the presumption, which the environmental elements are constant and the structure population structure reaches a stable age-stage distribution as time approach infinity [26]. The intrinsic rate is a perfect parameter to reveal and compare the potential of insect populations under different treatments. It is practical application in pest management, however, is limited [8]. The maximum of this parameter makes clear that host plant is suitable for development of pest and the minimum of it means the host is not fit [27]. Pursuant to prior perusal, there is a positive correlate between leaf N and oviposition rate of *Tetranychus urticae* [28] and *Tetranychus pacificus* [29]. Variation of applying elements can be the main reason of increase or decrease of oviposition rate. In the present study, population growth parameters were significantly effect from Si treatments and the lowest amount of intrinsic rate of natural increase was recorded in 0 ppm test.

Therefore, the use of nutrition elements such as Si can help to success an integrated pest management program. Various rates of resistance to *tetranychus urticae* were observed in red bean akhtar cultivar by using different dose of Si. The best dose of Si for bridling *T. urticae* is 2 ppm value.

Validation of silicon application for pest control, identification of satisfaction silicon sources, and their optimal dosages for effective pest control in different crops, and integration of silicon applications with biological control for ecologically sustainable pest and disease management can be future researchers' topics.

Acknowledgements

This research has been supported by Department of Entomology, Arak Azad University of Iran, which is greatly appreciated.

References

[1] Ehrlich, H.L. (1981) Geomicrobiology. Marcel Dekker Inc., New York, 393.

[2] Meena, V.D., Dotaniya, M.L., Coumar, V., Rajendiran, S., Ajay, Kundu, S. and Subba Rao, A. (2014) A Case for Silicon Fertilization to Improve Crop Yieldsin Tropical Soils. *Proceedings of the National Academy of Sciences*, *India*, *Section B*: *Biological Sciences*, **84**, 505-518. http://dx.doi.org/10.1007/s40011-013-0270-y

[3] Painter, R.H. (1951) Insect Resistance in Crop Plants. Macmillan, New York. http://dx.doi.org/10.1097/00010694-195112000-00015

[4] Laing, M.D., Gatarayiha, M.C. and Adandonon, A. (2016) Silicon Use for Pest Control in Agriculture: A Review. https://www.researchgate.net/publication/228760373

[5] Keeping, M.G. and Meyer, J.H. (2003) Effect of Four Sources of Silicon on Resistance of Sugarcane Varieties to *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *South African Sugar Technologists' Association*, **77**, 99-103.

[6] Yoshihara, T.K., Sogawa, M.D., Pathak, B.O. and Sakamura, S. (1979) Soluble Silicic Acid as a Sucking Inhibitory Substance in Rice against the Rice Brown Planthopper (Delphacidae: Homoptera). *Entomologia Experimentalis et Applicata*, **26**, 314-322. http://dx.doi.org/10.1111/j.1570-7458.1979.tb02932.x

[7] Sétamou, M.F., Schulthess, F., Bosque-Perez, N.A. and Thomas-Odjo, A. (1993) Effect of Plant N and Sion the Bionomics of *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae). *Bulletin of Entomological Research*, **83**, 405-411. http://dx.doi.org/10.1017/S000748530002931X

[8] Lorenzen, J., Balbyshev, N., Lafta, A., Casper, H., Tina, X. and Sagredo, B. (2001) Resistant Potato Selections Contain Leptine and Inhibit Development of the Colorado Potato Beetle (Coleoptera: Chrysomelidae). *Journal of Economic Entomology*, **94**, 1260-1267. http://dx.doi.org/10.1603/0022-0493-94.5.1260

[9] Jeppson, L.R., Baker, E.W. and Keifer, H.H. (1975) Mites Injurious to Economic Plants. University of California Press, Berkely, 614 pp.

[10] Zhang, Z.Q. (2003) Mites of Greenhouses: Identification, Biology and Control. CABI Publishing, Cambridge, UK, 244 pp.

[11] Meck, E.D., Kennedy, G.G. and Walgenbach, J.F. (2013) Effect of *Tetranychus urticae* (Acari: Tetranychidae) on Yield, Quality, and Economics of Tomato Production. *Crop Protection*, **52**, 84-90. http://dx.doi.org/10.1016/j.cropro.2013.05.011

[12] Kamelmanesh, M., Hesami, asah., Namayandeh, A., Ahmadi, B. and Dorri, H.R. (2010) Evaluation of Resistance Mechanism of Some Navy Bean Genotypes to Two-Apotted Spider Mite (*Tetranychus urticae*). *Plant Protection Journal*, **2**, 111-125.

[13] Mohammadi, S., Seraj, A.A. and Rajabpour, A. (2015) Evaluation of Six Cucumber Greenhouse Cultivar for Resistance to *Tetranychus turkestani* (Acari: Tetranychidae). *Crop Protection*, **4**, 545-556.

[14] Zhang, Q., Ding,L., Li, M., Cui, W., Ding, W., Luo, J. and Zhang, Y. (2013) Action Modes of *Aloe vera* L. Extracts against *Tetranychus cinnabarinus* Boisduval (Acarina: Tetranychidae). *Advances in Bioscience and Biotechnology*, **4**, 117-122.

[15] Leyla, M., Jabraeil, R., Mehdi, H., Mojgan, M.T. and Pejman, T. (2015) Biological and Population Growth Parameters of Two-Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) on Cucumber: Effect of Different Vermicompost: Soil Ratios. *Plant Pest Research*, **6**, 13-44.

[16] Nihoul, P.T., Hance, B.M. and Van-Impe, G. (1992) Physiological Aspect of Damage Caused by Spider Mite on Tomato Leaflets. *Journal of Applied Entomology*, **113**, 487-492. http://dx.doi.org/10.1111/j.1439-0418.1992.tb00693.x

[17] Gimenes-Ferrer, R.M., Scheerens, J.C. and Erb, W.A. (1993) *In Vitro* Screening of 76 Strawberry Cultivars for Two-Spotted Spider Mite Resistance. *Horticultural Science*, **28**, 841-844.

[18] Smith, M.C. (2005) Plant Resistance to Arthropods: Molecular and Conventional Approaches. Springer, Berlin, 421 p. http://dx.doi.org/10.1007/1-4020-3702-3

[19] Saeidi, Z. (2006) Nature of Resistance to Two-Spotted Spider Mite *Tetranychus urticae* Koch. (Acari: Tetranychidae) in Lycopersicon Species. PhD Dissertation, University of Agricultural Sciences Bangalore, Bangalore.

[20] Carey, J.R. (1993) Applied Demography for Biologists with Special Emphasis on Insects. Oxford University Press Inc., New York.

[21] Microsoft Execel Institute (2003) A Guide to Statistical and Data Analysis.

[22] SPSS (2004) SPSS Base 13.0 Users Guide. SPSS Inc., Chicago.

[23] Van Lenteren, J.C. and Noldus, L.P.J.J. (1990) Whitefly-Plant Relationships: Behavioral and Ecological Aspects. In: Gerling, D., Ed., *Whitefly: Their Bionomics, Pest Status and Management*, Intercept, Andover, 47-89.

[24] Mehrdad, A., Fathipour, Y., Kamali, K. and Moharami, S. (2004) Biology of *Tetranychus*

urticae on Different Cultivars of Bean. *The* 16*th Iranian Plant Protection Congress*, Tabriz, 28 August-1 September 2004, 266.

[25] Razmjou, J., Mohammadi, M. and Hassanpour, M. (2011) Effect of Vermicompost and Cucumber Cultivar on Population Growth Attributes of the Melon Aphid (Hemiptera: Aphididae). *Journal of Economic Entomology*, **104**, 1379-1383.

[26] Huang, Y.B. and Chi, H. (2012) Life Tables of *Bactrocera cucurbita* (Diptera: Tephritidae) with an Invalidation of the Jackknife Technique. *Journal of Applied Entomology*, **137**, 327-339. http://dx.doi.org/10.1111/jen.12002

[27] Mottaghinia, L., Razmjou, J., Nouri-Ganbalani, G. and Rafiee-Dastjerdi, H. (2011) Antibiosis and Antixenosis of Six Commonly Produced Potato Cultivars to the Green Peach Aphid, *Myzus persicae* Sulzer. (Hemiptera, Aphididae). *Neotropical Entomology*, **40**, 380-386.

[28] Wermelinger, B., Oertli, J.J. and Baumgärtner, J. (1991) Environmental Factors Affecting the Life-Tables of *Tetranychus urticae* (Acari: Tetranychidae) III. Host-Plant Nutrition. *Experimental and Applied Acarology*, **12**, 259. http://dx.doi.org/10.1007/BF01193472

[29] Modarres Najafabadi, S.S., Vafaei Shoushtari, R., Zamani, A.A., Masoud, A. and Farazmand, H. (2011) Effect of Nitrogen Fertilization on *Tetranychus urticae* Koch. (Acari: Tetranychidae) Populations on Common Bean Cultivar. *Middle-East Journal of Scientific Research*, **8**, 990-998.