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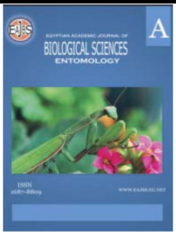

Heat Unit Accumulation for The Two-Spotted Spider Mite, *Tetranychus urticae* (Acari: Tetranychidae) On Potato And Tomato Crops Under Climatic Changes

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ABSTRACT

Climate change could profoundly affect the status of agricultural insect pests. This study is a predict of the two-spotted spider mite in potato and tomato cops annual generation peaks under current and expected future climate by using the relationship between the accumulated thermal heat units expressed as degree-days unit (DDU) and the population fluctuations. The results indicate the population of the predicate annual generation number and duration of *T. urticae* of tomato and potato crop under current and expected future climatic changes and their relationship with accumulated thermal units (degree-days units), at Beheira, Bani sweif and Sohag governorates. Under current climate mean generation numbers of *T. urticae* (10-12 and 12) and mean numbers days per generate (21-19 and 19) and mean degree-days units for *T. urticae* (170.7- 170.9 and 167.4) at Beheira, Bani sweif and Sohag governorates, respectively were highly recorded compared with expected future climate in 2050s and 2100s. Meanwhile, future predicate in 2050s and 2100s, mean generation numbers (15-17 generation) were highly recorded, but mean degree-days units (165.2-172.3 unit) were highly recorded and days numbers per generate (14-17 days per generate) were less recorded compared with data of current climate, respectively.

INTRODUCTION

A well known fact is that members of the Actinedid family Tetranychidae contains more than 1,200 polyphagous mite pest species and *Tetranychus urticae* Koch (TSSM) might be considered the most important one (Alzoubi and Cobanoglu, 2008). It attacks over 300 host plants including vegetables (e.g., beans, eggplant, peppers, tomatoes, and potatoes), fruits (e.g., strawberries, raspberries, currants, and pear) and ornamental plants (Le Goff *et al.*, 2009). Defoliation, leaf burning, and even plant death can occur due to direct feeding damage. Indirect effects of feeding may include decreases in photosynthesis, transpiration and can lead to yellow to white discoloration of the leaf often referred to as bronzing, causing loss of quality and yield or the death of the host plants (Park and Lee, 2002). Temperature has been recognized to be a key abiotic factor driving population dynamics of arthropods, which has resulted in a plethora of studies on the relationship between arthropod developmental biology and temperature. To predict developmental rates of poikilothermic arthropods, both linear and nonlinear models have been developed. With warmer temperatures occurring earlier in the spring, pest population can become established and thrive during earlier and more vulnerable crop growth stages. Additional insect generation and greater populations encouraged by higher temperatures and longer growing seasons will require greater efforts of pest management (Stinner *et al*., 1989). Estimates of future global climate change are necessarily somewhat imprecise, with different models showing substantial remember, however that at least for the next 40 years or so a large amount of this change is already built into the system and cannot be reversed. Climate change beyond this period will be influenced by future emission rates and change models utilize a rage of carbon dioxide and aerosol emission scenarios. Here, we use climate change scenarios effects of climate change in the UK and in sub-Saharan Africa (Chancellor and Kubiriba, 2006).

In the present work, it was planned to study the influence of degree-days units on generation number and days number per generate of *Tetranychus urticae* Koch (TSSM) infesting the Tomato and potato crops, under Egyptian environmental conditions.

MATERIALS AND METHODS

Determination of degree-days units (DDU)

Daily maximum and minimum temperatures which recorded and obtained from CLAC were transformed to heat units using the lower threshold temperature of (TSSM) *Tetranychus urticae* (where, t0 was 10.0°c with 100 unit for generate according to Herbert (1982). Degree-days units were calculated by applying Richmond *et al*. (1983) formula as follows:

H =Σ H J (Where: H = number of degree-days units)

H J = {(max + min)/2} – C (If max. > C and min. > C)

H J = {(max. – C) 2 /2 (max.-min.)} (If max. > C and min. < C)

H J = 0 (If max. < C and min. < C)

C = t0

Effect of current climatic changes on TSSM:

These experiments were carried out on spider mite *T. urticae* infesting Potato and Tomato crops, at Beheira, Sohag and Beni Suef governorates, during September-April for ten successive seasons 2003-2015. These mites were (TSSM) two spotted spider mite: *Tetranychus urticae*. Average temperatures (daily maximum and minimum) were calculated according to the data which recorded and obtained from central Laboratory for Agriculture Climate (CLAC).

Effect of Expected Future Climatic Changes on TSSM:

This study was carried out to predicate numbers and durations of generations and degree-days units (accumulated thermal heat units) in expected future climate change 2050s and 2100s. Climate change scenarios for locations were assessed according to future conditions derived from MAGICC/ SCENGEN software of the University of East Angle (UK). In this study one scenario of climate data was used A1(Table1). The principal of MAGICC/ SCENGEN data were used to explore the consequences of a medium is allowing the user to explore the consequences of a medium range of future emission scenarios. The user selects two such scenarios from library of possibilities. The reason for two scenarios is to able to compare a no action scenario with an action or policy scenario. Thus, in MAGICC/ SCENGEN the tow emissions scenarios were referred to as a reference scenario and policy scenario (Wigley *et al*., 2000). The data which generated from MAGICC/ SCENGEN are represented in one scenario A1. These scenarios are described by IPCC (2001) as "The A1 scenario describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies" (Meehl *et al*., 2007).

Table 1: Simple model results of the climate change versus the current level of climate. Global mean temperature change for the illustrative SRES scenarios (A1).

Month	2025	2050	2075	2100
A1				
Jan.	1.1	1.9	2.5	2.8
Feb.	1.1	1.9	2.5	2.9
Mar.	1.0	1.8	2.4	2.7
Apr.	1.0	1.7	2.2	2.6
May.	1.0	1.8	2.3	2.7
Jun.	1.3	2.3	3	3.5
Jul.	1.5	2.6	3.4	3.9
Aug.	1.2	2.1	2.7	3.1
Sep.	1.5	2.6	3.3	3.8
Oct.	1.3	2.3	3	3.4
Nov.	1.0	1.8	2.3	2.7
Dec.	1.0	1.8	2.4	2.7

RESULTS AND DISSCUTION

Effect of climatic changes on spider mite, *Tetranychus urticae* Koch (TSSM) :

The aim of the present experiments is to study the influence of climatic changes on degree-days units, days number per generate and generations number of *Tetranychus urticae* Koch (TSSM) during current climate for growing seasons of 2011 to 2015 predict in 2050s and 2100s, at Beheira, Beni Suef and Sohag governorates, under environmental Egyptian conditions (Tables 2-4).

Table 2: Influence of heat units on generation numbers and generation periods of *Tetranychus urticae* Koch (TSSM), at Beheira governorate during current climate (2011-2015) and climate change (2050s-2100s) under environmental emption condition.

No. Generation	Date	Current		Date	s2050		Date	s2100	
		Days	DDU		Days	DDU		Days	DDU
G1	Sep	11	175.3	Sep	14	161.75	Sep	8	158.6
G2	Sep	11	169.35	Sep	9	163.7	Sep	9	176.2
G3	Oct	12	175.25	Sep	10	172.6	Oct	9	174.95
G4	Oct	13	165.15	Oct	11	165.25	Oct	10	169.75
G5	Oct	14	166.05	Oct	11	162.05	Oct	11	177.35
G6	Nov	17	170.95	Nov	13	162.75	Oct	11	173.65
G7	Dec	23	168.85	Nov	14	163.5	Nov	13	168.1
G8	Jan	45	171.3	Dec	19	165.65	Nov	14	164.9
G9	Mar	42	169.4	Jan	28	166.45	Dec	18	172
G10	Apr	26	175.6	Feb	29	164.1	Jan	24	167.1
G11				Mar	29	162.25	Feb	27	168.55
G12				Mar	21	172.35	Feb	26	166.95
G13				Apr	19	165.5	Mar	20	168.55
G14							Apr	17	168.1
Average		21	170.7		17	165.2		15.5	169.6

Table 3: Influence of heat units on generation numbers and generation periods of *Tetranychus urticae* Koch (TSSM), at Bani Sweif governorate during current climate (2011-2015) and climate change (2050s-2100s) under environmental emption condition.

No. Generation	**Date**	**Current**		**Date**	**s2050**		**Date**	**s2100**	
		Days	**DDU**		**Days**	**DDU**		**Days**	**DDU**
G1	Sep	9	166.45	Sep	13	165.45	Sep	13	175.05
G2	Sep	10	184.1	Sep	9	178.45	Sep	8	168.6
G3	Sep	9	170.1	Oct	9	175.4	Oct	8	170.4
G4	Oct	11	172.95	Oct	10	165.3	Oct	10	177.6
G5	Oct	20	169.45	Oct	11	167.85	Oct	10	172.25
G6	Nov	16	171.4	Nov	11	162.25	Nov	11	175.2
G7	Dec	23	172.95	Nov	14	175.85	Nov	13	183.8
G8	Jan	47	166.25	Dec	17	164.9	Nov	15	171.65
G9	Feb	31	166.8	Dec	19	170	Dec	14	163.25
G10	Mar	17	173.45	Jan	33	166.65	Jan	23	169.2
G11	Mar	16	172	Feb	24	171.55	Jan	24	170.65
G12	Apr	17	164.3	Mar	20	170.4	Mar	22	170.25
G13				Mar	16	168.7	Mar	18	173.6
G14				Apr	12	167.65	Mar	15	169.95
G15							Apr	11	173.35
G16							Apr	14	166.75
Average		19	170.9		16	169.3		14	172.3

Table 4: Influence of heat units on generation numbers and generation periods of *Tetranychus urticae* Koch (TSSM), at Sohag governorate during current climate (2011-2015) and climate change (2050s-2100s) under environmental emption condition.

No. Generation	**Date**	**Current**		**s2050**				**s2100**			
		Days	**DDU**	**No. Generation**	**Date**	**Days**	**DDU**	**No. Generation**	**Date**	**Days**	**DDU**
G1	Sep	9	168.45	G1	Sep	8	170.6	G1	Sep	13	175.05
G2	Sep	9	162.8	G2	Sep	8	165.85	G2	Sep	8	168.6
G3	Sep	9	156.55	G3	Sep	9	179.45	G3	Oct	13	170
G4	Oct	12	169.85	G4	Oct	10	174.4	G4	Oct	14	173.15
G5	Oct	13	167.8	G5	Oct	10	165.55	G5	Nov	14	172.1
G6	Nov	15	172.05	G6	Oct	11	168.75	G6	Nov	12	170.1
G7	Nov	19	166.7	G7	Nov	13	175	G7	Nov	15	166.95
G8	Dec	25	167.5	G8	Nov	13	155.65	G8	Dec	15	171.85
G9	Feb	47	165.95	G9	Dec	17	168.45	G9	Dec	13	108.45
G10	Mar	32	163.6	G10	Jan	27	169.2	G10	Jan	28	162
G11	Mar	19	174.1	G11	Feb	28	172.1	G11	Feb	17	173.5
G12	Apr	20	173.25	G12	Feb	26	177.3	G12	Mar	22	165.25
G13				G13	Mar	17	172	G13	Mar	15	172.2
G14				G14	Mar	13	164.4	G14	Mar	12	173.05
G15				G15	Apr	15	172.95	G15	Apr	13	168.6
Average		19	167.4			15.0	170.1			15	166.1

Generation numbers of TSSM were more under climatic changes comparison with current climate, at different governorates, where generation numbers ranged from 11 to 16. With increasing degree-days units led to increase generation number, where degree-days units increased from 165.2 to 172.3 unit. Also, increasing degree-days units led to decreased days number per generate, where days number per generate decreased from 14.0 to 16.0 days when degree-days units were increased from 165.2 to 172.3 units.

Using degree-days allows for predicting pest occurrence, also can be an aid tool for scheduling sprays and beneficial insect releases at the optimum time to insure the best results and helpful in monitoring pest activity (Farag *et al*., 2009). The standard degree-days methods to predict by several insects, where degree-days can be defined as the units combining between time and temperature used to measure the development of an organism from one point to another in its life cycle (Wilson and Barnett, 1983 and Zalom *et al*., 1983). Accumulated thermal units have been used to predict the seasonal development and emergence of various insect (Eckenrode *et al*., 1975; Sevacherian *et al*., 1977 and Farag *et al*., 2009).

A -Current climate:

Under current climate for growing seasons 2011-2015 recorded with TSSM at Beheira, Beni Suef and Sohag governorates generations number and degree-days units were less recorded during current climate, but days number per generate were highly recorded during current climate as compared with data of 2050s and 2100s, where in case of current climate degree-days units 170.7, 170.9 and 167.4 unit were recorded and 21.0, 19.0 and 19.0 days at Beheira, Beni Suef and Sohag governorates, respectively (Tables 2-4).

Temperature is usually the environmental factor with the greatest effect on developmental rate of immature mites and other poikilotherms. To quantify the effect of temperature on mite development, life stages of a spider mites *T. urticae* may be held at constant temperature and the resultant development times can be used to estimate developmental rate curves (Southwood, 1978). From these developmental rate curves, models can be formulated to predict development time as a function of temperature. These models are useful in making pest management decisions, or to be used as components of more comprehensive models for the investigation of population dynamics (Riahi *et al*., 2013).

B - Future predicting in 2050s and 2100s:

Climate changes scenarios for Beheira, Beni Suef and Sohag governorates were assessed according to future conditions derived from MAGICC/SCENGEN Software of the University of East Angle (UK) and these relation with TSSM. Generation number increased from 13 to 15 in 2050s and from 14 to 16 in 2100s, respectively. Days number per generate decreased to 17.0, 16.0 and 15.0 days in 2050s, but it decreased to 15.5, 15.0 and 14.0 days in 2100s, respectively. Also, degree-days units increased to 165.2,169.3 and 170.1 units in 2050s, but increased to 169.6,166.1 and 172.3 units for TSSM (Tables 1-3).

The Intergovernmental Panel on Climatic Changes (IPCC) found that predicted an increment in mean temperature from 1.1 to 5.4°c toward the year 2100 (Meehl *et al*., 2007). Kriticos *et al*. (2007) mentioned that climate change scenarios for the 2080s indicate that in the central pacific, the change in potential distribution is relatively minor for oriental fruit fly. Estay *et al*. (2009) predict a change in the equilibrium density of the confused flour beetle from 10 to 14% under the moderate B2 scenario and 12 to 22% under the extreme A2 scenario to the period 2017-2100.

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ARABIC SUMMERY

حساب الوحدات الحرارية المتجمعه وعدد الأجيال فى الاكاروس على محصولى البطاطس والطماطم تحت ظروف تغير المناخ

شاكر ابو المعاطى1 - آمنه مقلد[2] - نجلاء رياض[2]

1- المعمل المركزي للمناخ الزراعى

2- معهد بحوث وقاية النباتات – مركز البحوث الزراعية

يعتبر تغير المناخ من العوامل التى تؤثر على حالة الافات الحشرية بصفه عامه ، وفى هذه الدراسة تم حساب الوحدات الحراريه المتجمعة للأكاروس على محصولى البطاطس والطماطم تحت الظروف الحالية وظروف تغير المناخ .حيث تم استخدم احد مخرجات نماذج حسابات تغير المناخ للمحافظات التي تحت الدراسة (البحيرة ،بنى سويف ،سوهاج)،حيث اشارت النتائج الى ان عدد الأجيال تحت الظروف الحالية يتراوح من 10 إلى 12 جيل بينما يزداد الى 15-17 جيل تحت ظروف تغير المناخ . وتعتبر هذه الدراسة من الدراسات الاولية فى مصر لمعرفة تاثير تغير المناخ على الآ فات