

Biological Characteristics and Life Table Parameters of *Chrysoperla carnea* (Steph.) Reared on *Tetranychus urticae* Koch at Constant Temperatures

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Abstract: Laboratory experiments were carried out in the plant Protection Research Institute at Mansoura, to investigate the biological aspects, duration in days, food consumption and life table parameters of the green lacewing, *Chrysoperla carnea* (Steph.), reared on *Tetranychus urticae* at three constant temperatures 20°C, 25°C and 30°C. The findings revealed that temperature degree had a significant influence on the growth and predation rate of *C. carnea*. Larval instars at 30°C had the shortest duration days, while at 20°C showed the longest duration days than at 25°C respectively. During *C. carnea* 1st, 2nd and 3rd larval instars high consumption rate of *T. urticae* females was recorded at 30°C than at 25°C and 20°C temperatures, respectively. Obtained results cleared a significant range among pre-oviposition, oviposition, post-oviposition and total longevity while the predator adult male longevity was high significantly shorter at 30 than 25 and 20°C temperatures. The life table parameters of *C. carnea* were significantly higher at 30°C than at 20°C and 25°C when reared on the females of *T. urticae*. Mean generation time (T) and the doubling time (DT) were higher at 20°C than at 25°C and 30°C when reared on the *T. urticae* females individuals. The net reproduction rate (R_0), the intrinsic rate of increase (r_m) and the finite rate of increase (λ) were higher at 30°C than at 25°C and 20°C respectively.

Key words: *Chrysoperla carnea* (Steph.) • *Tetranychus urticae* Koch • Biology • Feeding capacity • Life table

INTRODUCTION

Tetranychus urticae Koch spider mite (Acari: Tetranychidae), is one of the most destructive pests to several greenhouses, ornamental crops, vegetables, fruit trees and several crops. Direct effects run from minute spots on the upper surface of the leaf due to the chlorophyll reduction, webbing and defoliation up to necrosis in young leaves and stem, or even the death of the plant [1]. *Chrysoperla carnea* (Steph.) (Chrysopidae) Neuroptera species are considered successful predators in mass-rearing programs, especially in hot spot areas. Their activity in searching is higher than that of any other predator [2]. To use these predators in biological control programs, there is an important need to understand their life table parameters before releasing them on the farm because it is a generalized predator that preys on a wide range of insects and *T. urticae* mite. Common green

lacewing is a polyphagous predator commonly found in a wide range of agriculture systems. Hassan [3] described *C. Carnea* as an insect in the chrysopoid family (Neuroptera: chrysopoidae), it is a polyphagous natural enemy widely distributed in the world [4-7]. Although the adults feed on nectar, pollen and aphid honeydew, the larvae were an active predator for *T. urticae* and other small insects reported in almost all farmland. It has been used in the biological control of pests on crops. Abdelsalam [8] reported that *C. carnea* is considered one of the successful predators in mass-rearing programs, especially in hot spot areas. Sharanabasava [9] reported their effectiveness in controlling the two-spotted spider mite *T. urticae* populations on different vegetable crops.

It is very important to have attention to longevity, fecundity and life table parameters to be able to use these predators for biological control program requirements, such as mass rearing and releasing [10].

The current study aimed to determine all biological aspects and life table parameters of the predatory insect *Chrysoperla carnea* to be used in the future in controlling spider mites.

MATERIALS AND METHODS

These experiments were carried out at the laboratory at Mansoura district at the plant protection research institute under three constant temperatures 20, 25 and 30°C±1°C and 65±5R. Hrelative humidity. The predator *C. carnea* (Steph.) larval instars were fed on the female of *Tetranychus urticae*.

Rearing of *T. urticae*: The (*Phaseolus vulgaris* L.) plants were planted before the start of the laboratory studies. When it matures and leaves appear, they are cleaned and washed to prevent any pests and mites in the leaves. In the laboratory, we created an artificial infestation using mature *T. urticae* for 2-3 weeks to accumulate prey that served as a daily amass source of food for the three larval predators.

Rearing of *C. carnea*: *Chrysoperla carnea* adults were collected from different fields of crops at Mansoura distract they were placed in a glass jar the adult was provided by artificial diet food consists of 1g honey +1ml water + 1g pollen on a food card 3×4 cm. The food cards were given out every 24 hours. Daily egg counts were performed and newly hatched larvae were removed. Freshly hatched larvae were taken to start the laboratory experiments. Twenty replicates of *C. carnea* first-instar were isolated in Petri –dishes. (9cm in diameter) to avoid cannibalism that had been grown using a female *T. urticae* as prey was placed individually in a petri dish (10cm diameter) with filter paper on its bottom. Every day the number of *T. urticae* adult female individuals consumed per three *C. carnea* larvae was counted and recorded until the pupation period occurred. After *C. carnea* adults' emergence, they were placed in jars to allow for mating.

Adult females and males were inserted inside a glass chimney (20cm height with 9cm top and 10cm bottom diameter). A rubber band was used to firmly fasten a black muslin cloth covering the top open and glass chimney. Small paper strips each strip being drilled were prepared with 6ml of water + 3ml of the honey bee and 1g dry yeast was present as adult food to make pits for the holding of diet. The diets were with the 24hours over muslin cloth to maintain

moisture. The eggs laid per female provided on the walls of the chimney and muslin cloth were counted daily.

Data Analysis: Data of immature stages developmental time, larvae and adult consumption rates and total longevity of females (pre-oviposition, oviposition and post-oviposition periods), female's fecundity, fecundity rate and males' longevity of *C. carnea* reared on *T. urticae* at three constant temperatures were subjected to one-way analysis of variance (ANOVA). Using Duncan's Multiple Range Test (CoHort Software [11]) and the means were separated.

The incubation duration of the eggs and larval stage was calculated according to Omkar and James [12]. Life table parameters are important to determine all aspects of predators' biology and their prey and provide, valuable knowledge for the fecundity and growth potential of *C. carnea* under helping environmental conditions. The population growth rate is an ecological characteristic. Often, it is stated as the intrinsic rate of natural increase (r_m) which is regarded as the most accurate single estimate of species growth under given conditions [13]. For predator selection, more so than ever, r_m is a useful tool for assessing the mass-rearing efficiency of biological control agents. It can be determined by looking at its rate of developmental time and reproduction. It has been employed as an index population rate response to chosen prey and to compare a species under various environmental conditions [14-17]. The longevity, fecundity and life table parameters for mass-rearing have received a scare amount of attention when the predator feeds on *T. Urticae* at three constant temperatures (20°C, 25°C and 30°C).

RESULTS AND DISCUSSION

The effect of three constant temperature degrees (20°C, 25°C and 30°C) on the biological aspects of *C. carnea*, when reared on *T. urticae* was studied in the laboratory.

Development of *Chrysoperla carnea* (Steph.)

Incubation Period: Data in Table (1) showed that the mean incubation period of *C. carnea* decreased as temperature increased. It averaged 6.6 ± 0.22 , 4.7 ± 0.21 and 2.02 ± 0.20 days at three tested temperatures 20, 25 and 30° C, respectively. Shaukat [2] recorded that the incubation period of *C. carnea* eggs significantly differs according to the prey.

Table 1: Developmental period in days Mean \pm SE of *Chrysoperla carnea* larval instars and pupal stages when fed on *Tetranychus urticae* at three constant temperatures

Temperature (°C)	Egg	Larval instars			Total larval stage	Pupal stage
		1 st	2 nd	3 rd		
20	6.6a \pm 0.22	6.8a \pm 0.249	5.1 a \pm 0.276	3.6 a \pm 0.266	15.5a \pm 0.521	5.9a \pm 0.37
25	4.7b \pm 0.21	5.6b \pm 0.40	3.3 b \pm 0.3	2.4 b \pm 0.221	11.3b \pm 0.667	3 b \pm 0.258
30	2.02c \pm 0.20	2.5c \pm 0.268	2.6b \pm 0.221	1.9b \pm 0.233	7.0c \pm 0.365	2.4 b \pm 0.22
LSD	0.614	0.909	0.777	0.699	1.545	0.852
F -value	108.669	50.16	23.149	13.127	63.669	40.596
P	0.0000***	0.0000***	0.0000***	0.0001***	0.000***	0.0000***

Means followed by the same letter in a column are insignificantly different at the 5% level probability (Duncan's Multiple Range Test)

Table 2: Average number of *Tetranychus urticae* mature stages consumed by *Chrysoperla carnea* larval instars reared at constant temperatures

Temperature (°C)	Larval instars		
	1 st	2 nd	3 rd
20	37.3b \pm 2.34	80.6b \pm 2.214	151.7c \pm 3.768
25	43.7b \pm 1.633	84b \pm 1.021	176.7b \pm 2.828
30	55.4a \pm 5.08	92.7a \pm 1.054	191.1a \pm 3.354
LSD	9.766	4.327	9.690
F -value	7.436	17.509	35.638

Means followed by the same letter in a column are insignificantly different at the 5% level probability (Duncan's Multiple Range Test)

Larval and Pupal Stages: As shown in Table (1), larval development was temperature-dependent, with significant differences in the duration of the first instar and total evolution time between tested temperatures. The first instar larvae of *C. carnea* had a different impact when reared on *T. urticae* (6.8 \pm 0.249, 5.6 \pm 0.40 and 2.5 \pm 0.268 days) at the three temperatures tested respectively.

The third larval instars grew significantly faster at 30°C (1.9 \pm 0.233 days) compared to those at 25°C and 20°C (2.4 \pm 0.221 and 3.6 \pm 0.266 days). The second larval instar grew in (5.1 \pm 0.276, 3.3 \pm 0.3 and 2.6 \pm 0.221 days) at the same temperatures, respectively. The total larval stage developmental periods among the tested temperatures were significantly decreased when the tested temperature was increased, it recorded 15.5 \pm 0.521, 11.3 \pm 0.667 and 7.0 \pm 0.365 days, respectively.

Chrysoperla carnea had total pupa periods of 5.9 \pm 0.37, 3 \pm 0.258 and 2.4 \pm 0.22 days when reared on *T. urticae* at 20°C, 25°C and 30°C, respectively, (Table 1). These results were similar to the results of Ahmad-Ur-Rahman [18], who recorded a significant difference in the developmental times of three larval instars of *C. carnea* and the four tested temperatures and reported that the developmental time for *C. carnea* larval instar was significantly decreased when the temperature increased.

Saleh [19] recorded that the total developmental time from hatching egg to adult emergence was 21.2, 20.6 and 23.8 days for *C. carnea* when fed on *Sitotroga cerealella* (Oliver), *Ephestia kuehniella* (Zeller) and *Aphis gossypii* (Glover), respectively.

Feeding Capacity of Larvae: The mature individuals of *T. urticae* devoured by the first instar of *C. carnea* were recorded (37.3 \pm 2.34, 43.7 \pm 1.633 and 55.4 \pm 5.08 individuals) at 20°C, 25°C and 30°C, respectively. The 2nd instar larvae consumed 80.6 \pm 2.214, 84 \pm 1.021 and 92.7 \pm 1.054 individuals at the same temperatures mentioned before. The number of individuals devoured by the 3rd instar larvae was 151.7 \pm 3.768, 176.7 \pm 2.828 and 191.1 \pm 3.354 individuals of *T. urticae* female. The individuals of *T. urticae* consumed by the three larval instars of *C. carnea* were significantly higher at 30°C than those consumed by the other temperatures 20°C, 25°C (Table 2).

Sengonca [20] indicated that the first and second-instar larvae had mean daily feeding durations of 0.5 hours each but third-instar larvae had 0.4 hours. With *T. urticae* protonymphs, the mean feeding time of *C. carnea* larvae was significantly longer. A protonymph was consumed by the first larvae for a mean of 22.6 seconds, the second larval instar for 13.2 seconds and the third larval instar for 6.8 seconds. Hence the mean daily feeding durations of *T. urticae* protonymphs for *C. carnea* larvae were 0.8, 0.9 and 1.0 hours per day for the first and second-instar larvae, respectively.

Longevity of Adults: Females of *C. carnea* had the shortest pre-ovipositional period (1.8 \pm 0.2 days) at 30°C, followed by (4.5 \pm 0.268 days) at 25°C. The longest period was recorded when *C. carnea* fed on *T. urticae* (6.5 \pm 0.268 days) at 20°C. *C. carnea*, ovipositional period,

Table 3: Developmental period in days Mean \pm SE of *Chrysoperla carnea* mature stage fed on *Tetranychus urticae* at three constant temperatures

Temperature ($^{\circ}$ C)	Pre- Oviposition	Oviposition	Post- Oviposition	Longevity $_{\text{f}}$	Longevity $_{\text{m}}$
20	6.5a \pm 0.268	24.4a \pm 0.498	4.6a \pm 0.426	35.5a \pm 0.582	27.5a \pm 1.4
25	4.5b \pm 0.268	21.6b \pm 0.452	3.5b \pm 0.268	29.6b \pm 0.561	23b \pm 0.918
30	1.8c \pm 0.2	16.2c \pm 0.553	1.8c \pm 0.2	19.8c \pm 0.785	19.4c \pm 0.979
LSD	0.719	1.46	0.909	1.889	3.26
F -value	90.487	68.578	20.275	148.299	13.044

Means followed by the same letter a column for each *Chrysoperla carnea* adult are insignificantly different at the 5% level probability (Duncan's Multiple Range Test)

Table 4: Life table parameters of *C carnea* adult female at three constant temperatures

Temperature ($^{\circ}$ C)	DT	R_0	T	rm	(λ)
20	2.708	145.8	29.128	0.256	1.28
25	1.994	229.5	22.25	0.3477	1.41
30	1.174	392.4	14.02	0.5903	1.84

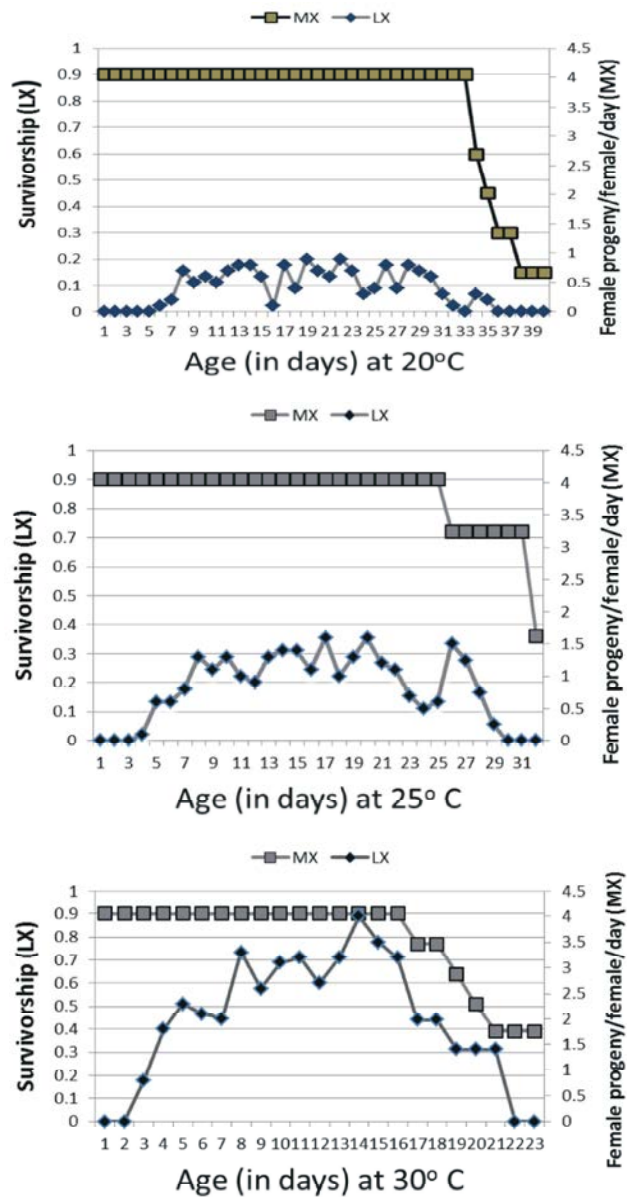


Fig. 1: Age-specific fecundity (Mx) and survivorship (Lx) of *Chrysoperla carnea* when reared on *Tetranychus urticae* at constant temperatures

was significantly shorter (16.2 ± 0.553 days) at 30°C compared to (21.6 ± 0.452 days) at 25°C and (24.4 ± 0.498 days) at 20°C . When *C. carnea* was fed on *T. urticae*, the post-ovipositional period was significantly longer (4.6 ± 0.426 days) at 20°C . On the other hand, when females were reared at 25°C the post-oviposition period was (3.5 ± 0.268 days) it was significantly shorter (1.8 ± 0.2 days) at 30°C , (Table 3).

Adult longevity was significantly higher in females reared at 20°C (35.5 ± 0.582 days) than (29.6 ± 0.561 days) at 25°C but it was significantly lower in females fed on *T. urticae* (19.8 ± 0.785 days) at 30°C temperature. Females lived more than males at the last three temperatures mentioned before. Males lived significantly longer when fed on *T. urticae* (27.5 ± 1.4 days) at 20°C , (23 ± 0.918 days) at 25°C and significantly shorter at 30°C (19.4 ± 0.979 days) (Table 3).

Life Table Parameters of *C. carnea* Adult Female When Provided with *T. urticae* under Laboratory Conditions at Three Constant Temperatures: The values of life table parameters of *C. carnea* fed on *T. urticae* are shown in Table (4). The most important parameters, (rm), (R_0) and (T) differed when *C. carnea* reared at the three temperatures studies. At 20°C (rm) = 0.256, (R_0) = 145.8 and (T) = 29.128. The highest value of *C. carnea* (rm) was at 30°C (0.5903), followed by 25°C (0.3477). Similarly, (R_0) value increases with increasing temperature. The significantly highest (R_0) value of *C. carnea* fed on *T. urticae* was determined at 30°C (392.4), followed by 25°C (229.5). Whereas, the highest doubling time (DT) was 2.708 days recorded at 20°C , while the lowest was 1.174 days at 30°C .

At three constant temperatures, the survivorships (Lx) for females aged for *C. carnea* and the maximum oviposition rate per day (Mx) were recorded as shown in (Figure 1). It recorded that the survivorship (Lx) were 0.9 for female fed on *T. urticae* at 30, 25 and 20°C tested temperatures which mean that the most of eggs had developed to maturity and *C. carnea* females' death occurred during oviposition period gradually. Maximum oviposition rate per female per day (Mx) was 0.9 on the 19th and 22nd day at 20°C , 1.6 on the 17th and 20th day at 25°C and 4.0 on the 14th day at 30°C .

Hassanpour [21] mentioned that the first and second larval instars of *C. carnea* were calculated to have attack rates (a) and handling times (Th) of 1.758 /h, 0.995 /h and 0.163 /h, 0.038 /h, respectively. Attack coefficient (b) and handling time for the predator's third instar larvae were 0.014 and 0.032/h, respectively. The predator's last instar larvae were found to be subject to the highest theoretical

maximum predation, which was assessed to be 187.5, followed by second and first larval instars (157.89 and 36.81, respectively). Also, they recorded that *C. carnea* larvae, particularly those in their last instar, have a good predation potential in preying on adult female two-spotted spider mites. Our results were in agreement with Ahmad [18] who studied life table parameters and the rate of reproductive and developmental stages of the predator *C. carnea* on Cabbage aphid *Brevicoryne brassicae* at four constant temperatures, the best temperature in this study was 28°C than 20, 24 and 30°C respectively.

REFERENCES

1. Van der Geest, L.P., 1985. Pathogens of spider mites. Spider mites. their biology, Natural Enemies and Control, 1: 247-58.
2. Shaukat, M.A., 2018. Feeding behaviour and life durations of *Chrysoperla carnea* (Stephensens) (Neuroptera: Chrysopidae) feeding on a variety of hosts. Journal of Entomology and Zoology Studies, 6(1): 691-7.
3. Hassan, K., 2014. Feeding capacity and host preference of *Chrysoperla carnea* (Stephensens) (Neuroptera: chrysopidae) on three different insect prey under laboratory conditions. Journal of Plant Protection and Pathology, 1; 5(12): 1045-51.
4. McMurtry, J., C. Huffaker and M. Van de Vrie, 1970. Ecology of tetranychid mites and their natural enemies: A review: I. Tetranychid enemies: Their biological characters and the impact of spray practices. Hilgardia, 1;40(11): 331-90.
5. Jeppson, L.R., H.H. Keifer and E.W. Baker 1975. Mites injurious to economic plants. Univ of California Press, California, pp: 615.
6. Stark, S.B. and F. Whitford, 1987. Functional response of *Chrysopa carnea* [Neur: Chrysopidae] larvae feeding on *Heliothis virescens* [Lep.: Noctuidae] eggs on cotton in field cages. Entomophaga, 32: 521-7.
7. Jokar, M.N. and M. Zarabi, 2012. Investigation effect three diets on life table parameters *Chrysoperla carnea* (Stephens.) (Neuroptera: Chrysopidae) under Laboratory Conditions. Egyptian Academic Journal of Biological Sciences. A, Entomology, 1;5(1): 107-14.
8. Abdel-Salam, A.H., H.A. El-Serafi, M.H. Bayoumy and A.A. Abdel-Hady, 2018. Effect of Eggplant Varieties and Temperatures on Development and Fertility Life Tables of *Chrysoperla carnea* (Stephens.) (Neuroptera: Chrysopidae). Journal of Plant Protection and Pathology, 1;9(6): 369-74.

9. Sharanabasava, H., M. Manjunatha, S.G. Hanchinal and S.V. Kulkarni, 1999. Interaction of *Chrysoperla carnea* with botanicals and recommended pesticides used against spider mite *Tetranychus neocaledonicus*. *J. Acarol*, 14: 16-21.
10. Abdel-Salam, A.H., A.A. Ghanim, H.A. El-Serafi, M.E. El-Naggar and F.M. Saleh, 2010. Biological and life table parameters of *Stethorus gilvifrons* (Muls.) (Coleoptera: Coccinellidae) reared on *Tetranychus urticae* Koch. *Journal of Plant Protection and Pathology*, 1;1(6): 393-402.
11. Cohort Software CoStat, 2004. A statistical program (Internet). Monterey (CA). Available from. www.cohort.com.
12. Omkar, B.E. James, 2004. Influence of prey species on immature survival, development, predation and reproduction of *Coccinella transversalis* Fabricius (Col., Coccinellidae). *Journal of Applied Entomology*, 128(2): 150-7.
13. Shih, C.I., P.J. Lin and T.W. Chang, 1991. Biology, predation, life table and intrinsic rate of increase of *Stethorus loi* Sasaji. *Plant Protection Bulletin (Taipei)*, 33: 290-300.
14. Birch, L., 1948. The intrinsic rate of natural increase of an insect population. *The Journal of Animal Ecology*, 1: 15-26.
15. Hulting, F.L., D.B. Orr and J.J. Obrycki, 1990. A computer program for calculation and statistical comparison of intrinsic rates of increase and associated life table parameters. *Florida Entomologist*, 1: 601-12.
16. Roy, M., J. Brodeur and C. Cloutier, 2003. Effect of temperature on intrinsic rates of natural increase (rm) of a coccinellid and its spider mite prey. *BioControl.*, 48: 57-72.
17. Lanzoni, A., G. Accinelli, G.G. Bazzocchi and G. Burgio, 2004. Biological traits and life table of the exotic *Harmonia axyridis* compared with *Hippodamia variegata* and *Adalia bipunctata* (Col., Coccinellidae). *Journal of Applied Entomology*, 128(4): 298-306.
18. Ahmad-Ur-Rahman Saljoqi, N.A., J. Khan, S. Ehsan-ul-Haq, Z.H. Rehman, H.G. Saeed, M. Nadeem, M. Salim, B. Ahmad and H. Zada, 2015. The impact of temperature on biological and life table parameters of *Chrysoperla carnea* Stephensens (Neuroptera: Chrysopidae) fed on cabbage aphid, *Brevicoryne brassicae* (Linneaus) J. *Entomology and Zoology Studies*, 3(2): 238-242.
19. Saleh, A.A., H.M. El-Sharkawy, F.S. El-Santel and R.A. Abd El-Salam, 2017. Studies on the predator *Chrysoperla carnea* (Stephensens) in Egypt. *International Journal of Environment*, 6(2): 70-7.
20. Sengonca, C. and S. Coepicus, 1985. Feeding activity of *Chrysoperla carnea* (Stephensens) compared to *Tetranychus urticae* Koch. *Zeitschrift fuer Angewandte Zoologie (Germany, FR)*.
21. Hassanpour M., G. Nouri-Ganbalani, J. Mohaghegh and A. Enkegaard, 2009. Functional response of different larval instars of the green lacewing, *Chrysoperla carnea* (Neuroptera: Chrysopidae), to the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *Journal of Food, Agriculture and Environment*, 1;7(2): 424-8.