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RESEARCH ARTICLE

REPRODUCTIVE PERFORMANCE OF COTTON LEAF WORM *SPODOPTERA LITTORALIS* EXPOSED TO NECOTINOIDS

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ABSTRACT

Neonicotinoid insecticides, is the nicotinic acetylcholine receptors agonist, have been widely used against several insect pests. Insect individuals exposed to an insecticide, exhibit differences in susceptibility and responses to insecticide stress like *Spodoptera littoralis* (Boisd) (Lepidoptera: noctuidae) one of a distinct attacking crop pests in Egypt. Lifetable assessment after exposure become urgent need to evaluate newer insecticide efficacy. Laboratory rearing ad field batch from *S. littoralis* were exposed to sublethal dose for acetamiprid, thiamethoxam and imidacloprid for monitoring life table under this stress. Results reveals values of LC_{50} refers to imidacloprid was the most effective and acetamiprid was the less effective for both susceptible and field population. Survival rate of the developmental stages larvae pupae and adult was lower in susceptible than in field for the three insecticide, and control were more than 97%. The number of individual expected to live the same age but different stage is the Life expectancy (e_x) of 4th instar larvae were ranged between (11.45, 5.2, 7.3 and 6.0) and (6.4, 3.5, 3.6, 3.0) for thiamethoxam, imidacloprid, acetamiprid and control, of susceptible and field population, respectively. The mean of reproductive rate (R_0) of the susceptible ranged from (1.35 to 1.88) and (4.79) for control but field population R_0 ranged from 1.19 to 1.52 and 3.77 for control. The mean generation time (T) for susceptible was 24.98, 24.12, 30.05 and 24.19 days for control, acetamiprid, thiamethoxam and imidacloprid respectively and field was 24.88, 23.31, 59.9 and 23.9 days for field respectively. The average intrinsic rate of increase (rm) allows the intrinsic birth, death rate, and the stable age distribution determination, and describe the population dynamics, and for susceptible was 0.063, 0.012, 0.016, and 0.026 and for field was 0.053, 0.007, 0.016, and 0.018 female per female per day. The finite rate of increase (λ) is the number of individuals in each age-stage group will increase λ-fold after one age was 1.056, 1.013, 1.017 and 1.026 for susceptible and 1.55, 1.07, 1.012, and 1.018 for field of acetamiprid, thiamethoxam and imidacloprid respectively. Results showed elongation in developmental period of treatments compared with control and the changes of oviposition period can affect population life table parameters and high significant in imidacloprid lower fecundity were found after insecticide treatment. Conclusion of this study suggested that nicotinoid at this concentration of treatment was enough to kill survivor individuals at less than this concentration or this population of *S.littoralis* were susceptible to those insecticides.

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INTRODUCTION

Neonicotinoid insecticides, is the nicotinic acetylcholine receptors agonist (nAChRs), including imidacloprid, acetamiprid and thiamethoxam have been widely used against several insect pests (Lepidoptera, coleopteran, and sucking sap pests leafminers, aphids), causing nerve stimulation, paralysis, and death. Neonicotinoids by stomach and contact treatment have insecticidal activity can affects longevity, fecundity, fertility and life table demographic parameters of many pests cited in literatures. Insecticide selection pressure and intensity of schedule spraying definitely causing a series problem in field cultivation with any crops lead to continuous death of pest susceptible individuals that represents a big portion of the pest population and the small portion is that the resistant individuals remains in stability numbers. In addition, lead to range of pest infestations, moreover, the conventional compounds as pyrethroids and organophosphates stopping from used to control series pests because a continuous rises in resistance alleles and expression of resistance severity in a population. Insect individuals exposed to an insecticide, exhibit differences in susceptibility and responses to insecticide stress like *Spodoptera littoralis* (Boisd) (Lepidoptera: noctuidae) one of a distinct attacking crop pests in Egypt. Insecticides can affect pest survival, and its life history and behavior that called sub lethal effects on life table parameters.

Pest life table trailer is the pest population regulations and dynamics changes over time are important tools to evaluate pesticide efficacy trials. Determination and analyzing the mortality fluctuation of insect population, and identify the factors responsible for the highest population mortality occurred, then the life table parameters must be measured. It is Sometimes determined by two types; Age Specific and Stage Specific Life Table Kakde etal., 2014, also called vertical and horizontal life tables. Lotka (1039 and I945), construct the Lotka–Volterra approach of demographic method of calculations or models; can translate toxicant effects on individuals into consequences for populations. Such studies were conducted with long life cycle-lived invertebrates to follow the distribution. Briefly: models can solve many platforms like abundance of insect growth, birth rate, death rate, dispersal, and including single-species models as density dependent or independent, age-structured vs. stage-structured model and age-specific survival and age-specific fecundity. as well as two-sex life table, and the multispecies predation competition, continuous and discrete predator–prey models, and many other model event faces insect stresses as (temperature dependency, disease effects, spatiotemporal effects models and insecticide exposure as stress), that related to ecosystem dynamics.

The use of structured population models has increased in recent years, by means of a life table analysis into many scientific researches papers edited by many researchers like (Ascough II, *et al*. 2008), (Chen *et al*.2017), and many others. Moreover, various mathematical formulas recently constructed for fecundity life tables, stable age-stage distribution and life expectancy evaluation by cohort or static methods. Any stress as pesticide have effects that can changed pest gene or genome structure in susceptible and resistant groups, physiological parameters evaluation could be larval developmental time, adult longevity, fecundity, fertility, reproductive potential and behaviour parameters like mating competitiveness and ability to avoid predators. The information of modifications in physiological and reproductive features could realize by comparing life-trait parameters between susceptible and resistant populations.

All of these condition measurements can held in long length of time in laboratory rearing systems, depending on a time and species biology background. Steps began from following the subsequent survival and reproduction rates of a population leading to significant calculation of some population status and information like finite population growth rate, and generation time, net reproductive rate, and finite (λ) rates of increase. There are five parameters related to pest fertility life table and population growth potential as follows: the net reproductive rate (*Ro*), the intrinsic rate of increase (*rm*), the mean generation time (T), doubling time (DT), and the finite rate of increase.Those parameters measurements could fill in population matrix model. In addition to Life expectancy in specific instar at the maximum pest mortality attained and for managing pests control preparation in a time, Maia, etal., 2000 and Fujiwara and Diaz-Lopez, 2017. In this study the intrinsic rate of increase evaluation of the cotton leafworm *S.littoralis* susceptible and field populations, exposed to sublethal doses of three of neonicotinoid insecticide scan affect survival and reproduction were defined and several calculation methods of Demography and Age-Structured Populations were intended.

MATERIALS AND METHODS

Insect sources and rearing: Susceptible strain of cotton leaf worm *S. littoralis* (Boisd.) used in this study were mass reared in standard lab rearing room conditioned on Castor bean plant leaves *Risinus comunus* for feeding and oviposition materials was Tafla plant, *Nerium oleander* (L.) plant. Rearing were continuously about many years in agriculture research center at 25 ± 2ºC and 16:8 h light: dark apart from insecticide exposure according to (Shaaban *et al*., 1985) and many others. Another batch were *S.littoralis* eggs and larvae collected from field of kalubia governorate, used immediately in the initial bioassay and the sublethal treatment alongside with the susceptible laboratory reared strain. In addition, the effect on survivor ship assessments and the effect on life table parameters assessments were assessed against both populations tested of this pest.

Insecticides: About three insecticide formulations were used in the baseline bioassay and the survivor ship assessments as well as population parameters measurements. All insecticides originated from central agricultural pesticide laboratory delivered from china manufacturer companies, were as follows: Acetamiprid (Starmax WDG 25%), imidacloprid (Condorfast SC 35%), and thiamethoxam (Clipper WG25%).

Concentration-mortality bioassays: Bioassays were performed on susceptible and field population using a leaf dip method according to Paramasivam and Selvi (2017). Uninfected fresh castor bean leaves were individually and efficiently dipped in subsequent diluted serial solutions of five concentrations, and left to dry, controls were dipped in water only. Afterward, treated leaves were placed individually in 9-diameter petri dish filled with 10 4^{th} instars larvae and three replicate were done for each concentration. The dishes were preserved in controlled conditions at 25 ± 2ºC and 16:8 h light: dark in laboratory chamber. Mortality was recorded 24 h after treatment.

Sublethal concentration toxicity procedure: A great-defined number of third instar larvae of *S. littoralis* were spend 24 h feeding on castor bean leaves dipped in the aqueous solutions containing sub lethal insecticide concentration (LC_{30}) was 192.1 ppm for acetamiprid, 119.6 for thiamethoxam and 42.67 ppm for imidacloprid that previously determined for each insecticide from the baseline bioassay (Table 1). Three replicate for each treatment, control dipped in water only and maintained in laboratory conditions as previously described in big glass containers filled with 100 larvae of 4^{th} instar. Survived individuals were reared for each pesticide alone from larvae to adult emergence and oviposition, and the mortality, Fertility, fecundity, through all stages duration, was recorded consistently. Fresh castor bean leaves were provided daily.

Life Stages development assessments: After treatment with sublethal dose, the egg masses produced from *S. littoralis* lived females were reared on glass containers from egg hatch to moth dying, feeding on castor bean leaves and monitored for larval duration and pupation rate, adult emergence and individual deformities determination from the susceptible and field strains of every day constant counting.

Population life table assessments: Another batch of the survivor females reared on glass container until moth emergence feed on 10% sucrose solution.

The adult egg laying observed every day until all female adults were dead. The total number of eggs laid by each female was recorded. The *S.littoralis* age-specific fecundity life table were followed according to Birch methodology (1948) and Carey (1993, 1995), for the population changes parameters monitoring of the treated *S.littoralis* population by sublethal concentration were calculated.

Life table calculation methods: according to the formulas the foundations were: $R_0=\sum x1_x m_x$where R_0 is the Net reproduction rate represent the average fecundity (Total progeny) of each adult. Then the Intrinsic rate of increase $(rm) = e^{-r\ mx}\ l_x m_x = 1$or $rm = R_0/T$ where rm is the reproductive potential of the insecticide treated populations and T is the growth time from eggs to adult. While $l_x m_x$ is the No, of female produced of age x multiplied by no. of females surviving at age x. and e_x = life expectancy for individual of age $x=T_x/l_x$., Where $T_x = (\sum L_x)$ from x to the end of the experiment, Stable age distribution=$C_x= \lambda\text{-}xl_x/\sum\lambda\text{-}xl_x$ and reproductive value $(v_{xj}) =\sum (l_t/l_x)\ m_t$, were calculated. The population parameters (r, the intrinsic rate of increase or population growth),λ, the finite rate of increase or No. of individuals added by a female per (day), $\lambda = erm$. Also $R0$, is the net reproductive rate; and T is the mean generation time=$log\ R_0/r_m$) or is the doubling time in days required by a population to double= e_m/r_m were calculated, (Lu Peng etal. 2015). The abbreviations in formula constructions was as follows: x, is the insect age intervals in days for the developmental stages, mn_x is the number of produced female at age x and l_x is number of female survivors at the last time intervals (age specific survival rate).Where m_x means number of female of the next generation produced from females at x time (offspring No.) or age specific fecundity, in addition to T_x is the total number of insect ages in the experiments. The survival rate of population changes (S_x) within stages, the age-stage specific fecundity (f_{xj}), the mean fecundity (F), j is the life stage number after egg hatch were assessed.

Statistical analysis: The initial mortality bioassay data results were carried out to estimate the LC_{30}, LC_{50} and LC_{90} values using Ldp line by Ehab-Soft a Computer Software Program Calculation according to Finney Probit analysis (1971), correction for control mortality were included and Resistance Ratios (RR) were calculated by comparison LC_{50} values of the field strains by that of the susceptible strain. Sublethal treatment Data were submitted to Excel 2010 sheets to edit and calculate all life table parameters using the previous formulas defined by some scientists in literatures at this field of pest population investigations. In addition, Curves were drawn by Excel 2010. The means, standard errors, and variances of the population parameters were estimated. All significant differences results were completed by SPSS 2019 program software for one way ANOVA through Levene's test was used to estimate homogeneity of variances, and Kruskal-Wallis non-parametric analysis of variance followed by multiple comparisons between ranks Duncns were performed.

RESULTS AND DISCUSSIONS

Insecticide dose-response bioassay: The results of the *S. littoralis* susceptible lab reared population baseline toxicity data of ($LC_{30,\ 50,\ 90}$) nicotinoid insecticide calculated according to Finney probit analysis used to detect differences in response between insecticides are found in table (1). Values of LC_{50} in ppm showed slight variations between insecticides that belong to the same classes. Imidacloprid was the higher toxicity detected and acetamiprid was the lower. No. of death in control were detected, which treated of water only. The slope of the toxicity lines calculated were between (1.29, 1.49 and 1.77) for imidacloprid, thiamethoxam and acetamiprid, respectively. Parameters of the toxicity lines fit showed low χ^2 values (ranged from1.16, 1.39 and 1.78) and high p-values (ranged from 0.0172, 0.409 and 0.7), respectively. Relative toxicity revealed that imidacloprid was 4.5 times more toxic than acetamiprid. No significant differences detected between insecticides or between populations. Results of baseline toxicity data of *S.littoralis* field population treated with sublethal dose of nicotinoid insecticides were in table (2). Values of LC_{50} refers to imidacloprid was the most effective 329.9 ppm and acetamiprid 1032.4 ppm was the less effective. Values of resistance ratio (RR) was 7, 2 and 2 for imidacloprid, acetamiprid and thiamethoxam respectively. Statistical analysis revealed no significant differences between insecticides in field population.

Insecticide sublethal effect on population developmental parameters: The age-stage life expectancy (*exj*) is used to estimate the time of individual at age x and stage j is expected to live and it reveal differences in individuals of the same age but different stage. The results of survival rate (*sx*) and life expectancy (e_x) which is the average lifespan remaining for an individual of age x. of the *S. littoralis* susceptible and field population treated with sublethal dose of three nicotinoid insecticide is LC_{30} are found in (Table 3, 4). Results showed throughout all-developmental stages (Larvae, Pupae and adults) from day of treatment to moth die, two sex survival rate was lower on thiamethoxam 57% ,35% and 12 % for larvae pupae and adult stage of the susceptible respectively and higher on acetamiprid for larvae and pupae of the susceptible was 61% and 43% and for adult was 6% only.

The survival rates of larvae, pupae and adult were all about to 99%, 98, and 97% for susceptible control. In field treatment, survival rate was almost similar for acetamiprid field treated population, 59,35 and 2 %, respectively, 60, 39 and 11 respectively for imidacloprid and 52, 35 and 6% respectively for thiamethoxam. The statistical analysis of significant differences were (F= 0.173, df= 4, and p= 0.86) between insecticides for larvae of the susceptible, (F=0.133, df=4,p=0.88) for pupae of the susceptible and (F=0.25, df=4,p=0.81 for adult susceptible). However the significant differences was (F=0.11, df =4, p=0.90), (F=0.22, df=4, p=0.83) and (F=0.25, df=4, p=0.81) for larvae, pupae and adult of field population respectively. This result suggested that nicotinoid concentration treatment at this time of the pest generation was enough to kill individuals the survivors at less than this concentration or this population were susceptible to those insecticides and enough concentration for controlling this pest. Also slight statistical significant differences detected between both population or between insecticides and control of (s_x) or within time as follows: (F=6.2,df=9,p=0.0) for control, (F=7.2, df=9, p=0.0) for acetamiprid, (F=6.67, df=9, p=0.0) for imidacloprid and (F=21.8, df=9, p=0.0) for thiamethoxam (Table 4). Results of Life expectancy (e_x) of 4th instar larvae were ranged between (11.45, 5.2, 7.3 and 6.0) and (6.4, 3.5, 3.6, 3.0) for thiamethoxam, imidacloprid, acetamiprid and control, of susceptible and field population, respectively.

Table 1. Probit analyses for nicotinoid insecticide bioassay of *S. littoralis* susceptible

Insecticide	Slope ±SE	LC_{30} (95% CI)	LC_{50} (95% CI)	LC_{90} (95% CI)	χ2	p	RT
Thiamethooxam	1.49±0.14	119.6(82-158.1)	269.1(211.0-329.6)	1952(1464.4-2869.2)	1.39	0.70	2.8
Imidacloprid	1.29±0.167	42.7(32.9-51.1)	108.1(92.4-132.7)	1051.0(608.8-2596.4)	1.78	0.409	1
Acetamiprid	1.77±0.158	192.1(72.4-266)	380.3(203.1-624.3)	2018.1 (1584.6-8010.6)	1.16	0.017	4.5

CI=Confidence intervals at 95% RT= Relative toxicity= LC_{50} for the less toxic/LC_{50} of the other insecticides

Table 2. Probit analyses for nicotinoid insecticide bioassay of *S. littoralis* field population

Insecticide	Slope± SE	LC_{30} (95% CI)	LC_{50} (95% CI)	LC_{90} (95% CI)	χ2	p	RR
Thiamethooxam	1.87±0.11	289(175.6-477.2)	550.7(333.5-909.1)	2661(1611.9-4393.5)	0.96	0.13	2
Imidacloprid	2.5±0.347	177.6(125.2-226.7)	329.9(262.4-411.9)	1069.9(783.8-1748.6)	1.22	0.74	7.0
Acetamiprid	1.67±0.119	501.4(293.2-857.7)	1032.4(603.6-1765.7)	6028.7(3824-9559)	0.64	0.05	2

RR= resistance ratio= divided LC 50 of the field by the LC 50 of the susceptible.

Table 3. Population survival rate (s_x) for *S. littoralis* treated with nicotinoid insecticide

	Susceptible (s_x) (Mean±SE)			Field (s_x) (Mean±SE)		
Inecticide	Larvae	Pupae	Adult	Larvae	Pupae	Adult
Thiamethooxam	57.0±0.11	35.0±0.45	12.0±0.75	52±0.22	35±0.29	6.0±0.29
Imidacloprid	60.0±0.32	44.0±0.27	19.0±0.45	60.0±0.11	39.0±0.27	11.0±0.277
Acetamiprid	61.0±0.33	43.0±0.33	6.0±0.277	59.0±0.45	35.0±0.45	2.0±0.277
Control	99.0±0.23	98.0±0.45	97.0.0±0.48	97.0±0.54	94.0±0.48	89.0±0.48

Table 4. Life expectancy (e_x) of*S. littoralis* treated with nicotinoid insecticide

	Susceptible (e_x) (Mean±SE)			Field (e_x)(Mean±SE)		
Inecticide	Larvae	Pupae	Adult	Larvae	Pupae	Adult
Thiamethooxam	7.3±.66	5.3±0.44	1.1±0.089	6.18±0.36	4.89±0.28	1.0±0.06
Imidacloprid	5.2±0.43	3.8±0.32	0.1±0.0	6.1±0.35	4.0±0.23	0.5±0.03
Acetamiprid	6.0±0.5	4.2±0.35	1.33±0.11	5.17±0.30	3.1±0.18	1.5±0.18
Control	11.5±0.95	8.4±0.70	1.5±0.124	10.9±0.64	8.1±0.47	1.5±0.18

Table 5. Life table parameters of *S. littoralis* susceptible population development after nicotinoid insecticide treatments

Life table parameters (Mean±SE)	Control	Acetamiprid	Thiamethoxam	Imidacloprid
Net reproductive rate, R_0	4.79±0.98	1.35±0.1	1.49±0.23	1.88±0.5
Mean Generation Time	24.98±0.7d	24.12±2.0	30.05±4.9	24.19±0.19
Intrinsic Rate of Increase (*rm*)	0.063±0.05	0.012±0.01	0.016±0.013	0.026±0.021
Doubling days *DT*	11.054±1.2	55.71±6.3	29.69±4.7	26.56±2.1
Approximate generation time *Tc*	25.21±0.9	24.15±2.1	24.34±2.2	24.27±1.2
Capacity of increase *rc*	0.062±0.05	0.012±0.01	0.016±0.013	0.026±0.021
Finit rate of increase *λ*	1.065±0.18n/d	1.013±0.14	1.017±0.04	1.026±0.05
Stable age distribution C_x	1.0±0.13	1.0±0.03	1.0±0.03	1.0±0.03
Reproductive age distribution V_x	4.1±0.4	2.453±.10	3.14±0.6	3.37±0.8
Gross reproductive rate (*GRR*)	6.1±0.23	3.8±0.14	6.4±0.33	4.79±0.36

If R_0 =1 population is stable, If R_0<1 population is decreasing and take long time, and If R_0>1 population is increasing through short time.

Table 6. Life table parameters of *S. littoralis* field population development after nicotinoid insecticide treatments

Life table parameters (Mean±SE)	Control	Acetamiprid	Thiamethoxam	Imidacloprid
Net reproductive rate, R_0	3.77±3.0	1.19±0.91	1.31±0.10	1.52±0.118
Mean Generation Time*T*	24.88±0.26d	23.31±0.19	59.9±4.9	23.9±1.98
Intrinsic Rate of Increase (*rm*)	0.053±0.039	0.007±0.077	0.016±0.07	0.018±0.068
Doubling days *DT*	12.99±0.17	92.89±0.77	59.84±4.9	39.6±3.28
Approximate generation time *Tc*	25.09±0.28	23.33±0.19	23.35±1.9	23.97±1.98
Capacity of increase *rc*	0.053±0.039	0.007±0.077	0.012±0.075	0.017±0.069
Finit rate of increase *λ*	1.055±0.19n/d	1.007±0.17	1.012±0.176	1.018±0.176
Stable age distribution *Cx*	1.0±0.174	1.0±0.17	1.0±0.175	1.0±0.174
Reproductive age distribution *Vx*	4.1±0.13	2.453±0.19	3.14±0.253	3.37±0.272
Gross reproductive rate (*GRR*)	4.08±0.28	4.69±0.17	4.46±0.27	4.47±0.11

If R_0 =1 population is stable, If R_0<1 population is decreasing and take long time, and If R_0>1 population is increasing through short time.

Table 7. Insecticide treatment effect on *S.littoralis* susceptible population life history developmental stages

Life history traits (Mean±SE)	Control	Acetamiprid	Thiamethoxam	Imidacloprid
Female ratio (%)	37.6±3.1	31.0±2.58	43.0±3.57	34.5±2.87
Eggs/female/day	264±21.9	61.6±5.1	104±8.6	88.4±7.35
Fecundity: Eggs/female (%)	8.6±0.71	8.5±0.7	8.0±0.66	7.88±0.65
Fertility (%)	44±3.6	15.4±0.12	26.5±2.2	22.2±1.84
Pupal weight (g)	0.55±0.045	0.49±0.140	0.51±0.042	0.50±0.041
No.Adult emergence	98±8.2	56±4.6	48±3.9	52±4.32
Adult longevity (days)	9.00±0.74	6.00±0.49	5.00±0.41	5.00±0.41
Oviposition (days)	8.00±0.66	5.00±0.46	4.00±0.33	4.00±0.33

Fecundity= no. of egg deposited from each female. Fertility= no. of egg hatched from each survived female.

Table 8: Insecticide treatment effect on *S.littoralis* field population life history developmental stages

Life history traits (Mean±SE)	Control	Acetamiprid	Thiamethoxam	Imidacloprid
Female ratio (%)	53.44±4.4	34.79±2.88	43.66±3.6	45.47±3.77
Eggs/female/day	64±5.3	36±2.98	57.6±4.78	30.6±2.53
Fecundity: Eggs/female (%)	8.27±0.67	6.43±0.52	8.53±0.17	6.7±0.54
Fertility (%)	16±1.3	12±0.99	14.4±1.19	10.2±0.84
Pupal weight (g)	0.52±0.034	0.499±0.033	0.50±0.133	0.489±0.032
No.Adult emergence	89±7.39	53±4.4	44±3.65	48±3.98
Adult longevity (days)	8.3±0.68	5.4±0.44	6.2±0.5	4.5±0.36
Oviposition (days)	7.0±0.57	4.0±0.32	3.0±0.24	3.8±0.3

Fecundity= no.of egg deposited from each female. Fertility= no. of egg hatched from each survived female

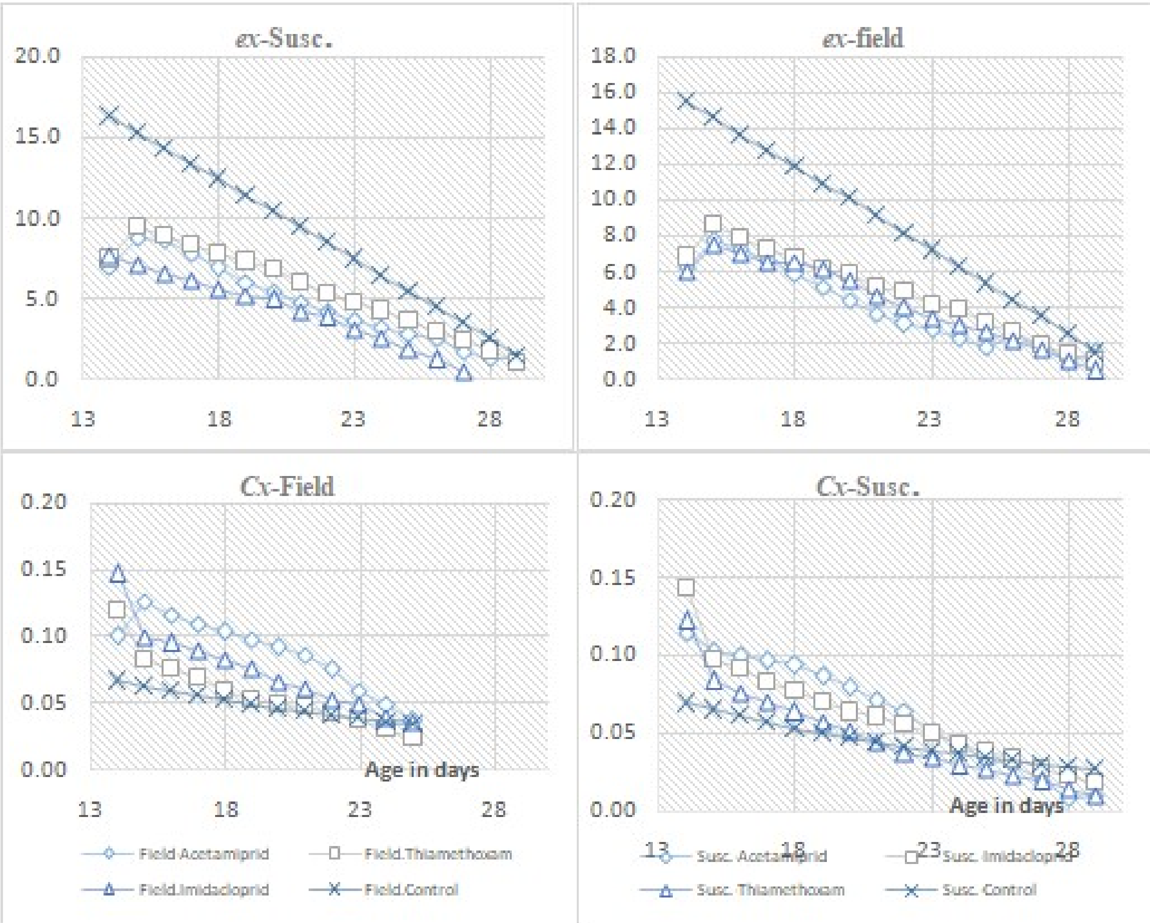

Figure 1: Life expectancy and stable age distribution calculated from fecundity life table of *S. littoralis* stages after sublethal dose treatment of nicotinoid insecticides tested.

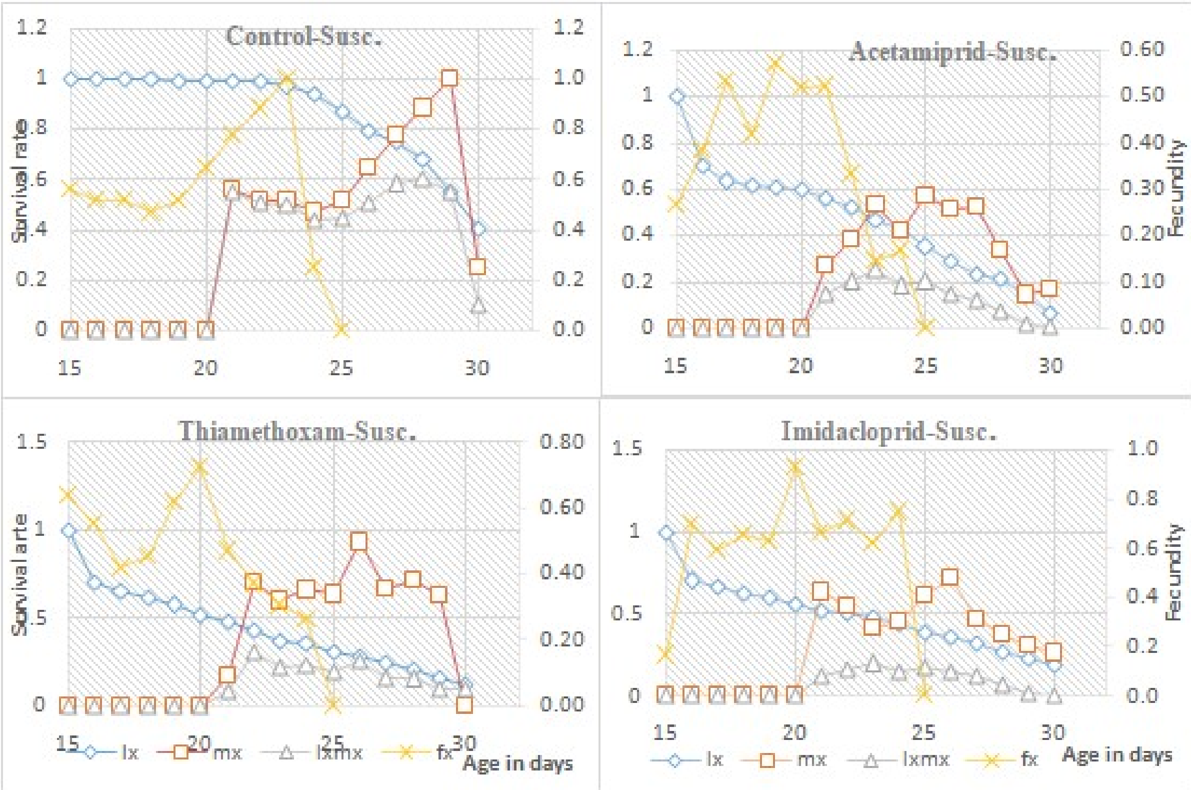

Figure 2. **Age-specific-survival rate (l_x), fecundity (m_x), and net maternity (l_xm_x) and age-specific fecundity (f_x) of the Age-stage life table of susceptible population structures show productivity and development time through the life stages of *S.littoralis* and number of female offspring per parental female and development time of females, after insecticide sublethal dose treatments**

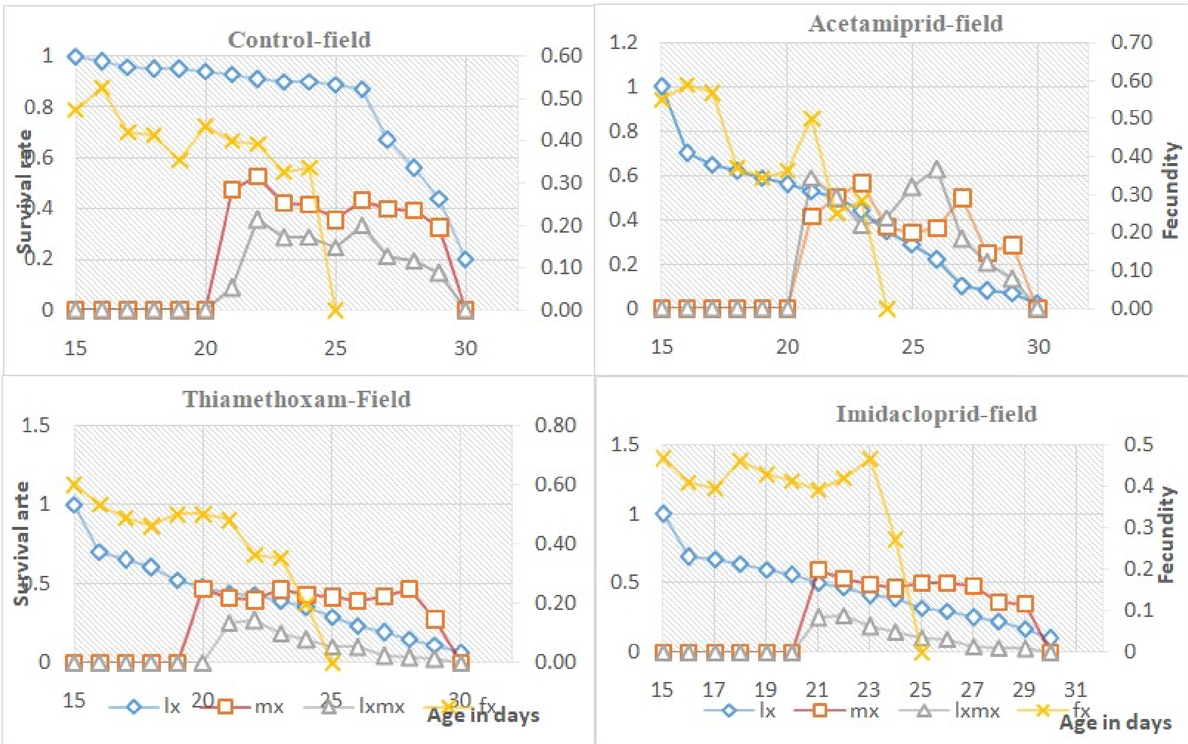

Figure 3:Age-specific-survival rate (l_x), fecundity (m_x), and net maternity (l_xm_x) and age-specific fecundity (f_x) of the Age-stage life table of field population structures show productivity and development time through the life stages of *S.littoralis* and number of female offspring per parental female and development time of females, after insecticide sublethal dose treatments.

Significance differences between populations calculated for the life expectancy were (F=10.1, df=15, p=0.0) for control, (F=18.4, df=15, p=0.0) for acetamiprid, (F=14.3, df=15, p=0.0) for imidacloprid, and (F=9.94, df=15, p=0.0) for thiamethoxam. Results of the gross reproductive rate ($\sum m_x$) is the total reproductive time in the absence of mortality for both populations revealed no significant differences between insecticide and the control about productivity of the pest although the higher death according to treatment (Table 5 and 6).The age-structured estimation could be converted into a stage-structured model for further analyses according to Euler-Lotka equation. Because achievement of the estimating generation time was not accurate, when using the small bias (Fujiwara and Diaz-Lopez, 2017). Similar case were 5th instar *S. littoralis* females larvae exposed to Novaluron at 0.100 to 0.0001ppm has low effect on adult survival in contrast with the higher concentrations. But last instar larvae resulted in morphogenesis and no adult deformities, ovarian maturation acceleration, shortened adult longevity, and the oviposition period (Hamadah etal., 2015).

Insecticide sublethal effect on life table parameters: Results of life table assessment were tabulated as net reproductive rate (R_0), mean generation time (*T*), doubling days (*DT*), the intrinsic rate of increase (*rm*), and approximate generation time (*Tc*), capacity of increase (*rc*), finite rate of increase (*λ*) in table (5,6). In addition, stable age distribution (C_x) (the proportion of individuals in each age class is constant through time), and reproductive values (V_x)of *S. littoralis* were all calculated and listed in table (5, 6) as susceptible and field data. Data inspect the mean of net reproductive rate (R_0) of the susceptible was significantly different from field data and the values was acetamiprid treatment (1.35), followed by thiamethoxam was (1.49) and imidacloprid (1.88) but control was (4.79) females per female with significant difference was (F= 9689, df=3, and p= 0.000). Nevertheless, field population R_0 was 3.77, 1.19, 1.31, and 1.52 for control, acetamiprid, thiamethoxam and imidacloprid respectively. The mean generation time(is the period that a population requires to increase to R-fold of its size)for susceptible was significantly lower 24.98, 24.12, 30.05 and 24.19 day for control, acetamiprid, thiamethoxam and imidacloprid respectively and field was 24.88, 23.31, 59.9 and 23.9 days respectively. Statistical difference for mean generation time between insecticides was (F=175, df =3, and p= 0.000). The average intrinsic rate of increase (*rm*) allows the intrinsic birth, death rate, and the stable age distribution determination, which describe the population dynamics. The *rm* for susceptible was 0.063, 0.012, 0.016, and 0.026 and for field was 0.053, 0.007, 0.016, and 0.018 females per female per day for control, acetamiprid, thiamethoxam and imidacloprid respectively. Its statistical difference was (F=15.5, df= 3 and p= 0.001). The finite rate of increase (λ) is the number of individuals in each age-stage group will increase λ-fold after one age, was 1.056, 1.013, 1.017 and 1.026 for susceptible and 1.55, 1.07, 1.012, 1.018 for field respectively, statistical difference was significantly higher (F=152.3, df =3, p= 0.000). where capacity of increase (*Rc*) was (F= 8.6, df=3, p =0.007), and approximate generation time (*Tc*) was (F =10.1,df=3,p =0.004) and doubling days (*DT*) was (F=19146.3,df =3,p =0.000). The age-stage reproductive value (v_{xj}) reveals the possible differences among female individuals of the same age but different stage, and it similar to the finite rate and shows the effect of an individual from age x to stage j(Table 5, 6).

The curves for reproductive value significantly increase when reproduction begins at the day 21 until the end. Results of reproductive values between populations significant differences were (F=4.33,df=15,p=0.0) for control, (F=2.94, df=15,p=0.006) for acetamiprid, (F=3.35,df=15,p=0.003) for imidacloprid and (F=4.68,df=15,p=0.0) for thiamethoxam. The results of stable age distribution (C_x) exhibit significant differences between populations was as follows: (F=0.105, df =15, p=1.0) for control, (F=0.37, df=15, p=0.979) for acetamiprid, (F=0.188, df=15, p=0.999) for imidacloprid and (F=0.162, df=15, p=1.0) for thiamethoxam. Some literature cited similar data for example: the age-stage life tables and fitness for diamondback moth, *Plutella xylostella* (L.) showed Egg hatching rate, survival and fecundity of the inbred line declined and lower (*r*), (R_0), (*λ*), and increasing generation time (*T*) compared to the outbred line Peng etal., (2015). The net reproductive rate of the stinkbug *Supputius cincticeps* (Stål) (Heteroptera: Pentatomidae), the predator of Coleoptera and Lepidoptera larvae was (18.31), infinitesimal (*rm*) (0.050) and finite (*λ*) (1.051) rates of increase were higher, while generation time (57.93 days) was shorter than in the control. This indicates a higher rate of population increase of this predator when exposed to thispermethrin dose (Zanuncio *et al*., 2005). Also the net fecundity rate of cabbage aphid, *Brevicoryne brassicae* L. (Homoptera: Aphididae) were decreased, (*rm*), (*b*), (*T*) and (*DT*) and the average longevity were also lower than in controls, and no significant differences between imidacloprid and pymetrozine -treated populations (Lashkari, *et al*., 2007). However, *Bemisia tabaci* (Gen.) two biotype (Hem. Aleyrodidae) (*rm*) was 0.1010 females per female per day, (R_0) was18.4075 females per female. (*T*) was 30.079 day (d) on cotton; 0.1286, 30.6760 and 26.77 d on rapeseed; for *B. tabaci* A biotype, but for B those was 0.1033, 27.8426 and 32.74 d on cotton and 0.1750, 40.75 and 21.27 d on rapeseed. The total survival from the egg to adult on cotton was 22.08 and 22.25, of A and B biotype respectively, (Samih, *et al*, 2014**)**. In addition, the intrinsic rate of increase to two aphid species (*rm*) was lowest (0.167) on first plant variety and highest (0.350) on the second plant variety (Davis *et al* 2007). The curves of life expectations and stable age distribution of both populations exposed to sublethal dose of nicotinoid insecticides in this study were in fig (1).

Insecticide treatment effect on S.littoralis life history developmental stages: Results of rearing *S.littoralis* developmental stages for evaluating the effect of nicotinoid insecticide tested on (female ratio, egg/female/day, fecundity, fertility, pupal weight, no. of adult emergence, longevity and oviposition durations for the susceptible and field population were found in table (7, 8). Results showed elongation in total developmental period compared with control and no significant different between insecticides or between populations. Also changes found in adult oviposition period and high fecundity although insecticide treatment, this data were similar to Rasheed *et al*., 2020, investigate the effect of chlorpyrifos on the Asian ladybeetle *Harmonia axyridi.* Results founds of Treatment with LC_{10} (4.62 mg a.i.) shortened the developmental period of third instar larvae, whereas it prolonged those of fourth instar larvae and pupa. Treatment with LC_{30} (9.59 mg a.i.) significantly increased the larval and pupal developmental period compared with that of the control, female fecundity, and adult longevity significantly decreased. This differences in developmental time my due to the detoxification process according to genetic changes and transcriptal level after treatment. The curves for both populations of l_x, survival rate (s_x), age specific fecundity (m_x) and the average number of offspring produced by an individual in its lifetime ($l_x m_x$) and age-stage-specific fecundity (f_x) for both populations after exposure to sublethal dose of nicotinoid insecticides were in fig 2. The figure showed that reproduction began at age 21day of the pest life cycle with no differences, and the fecundity of imidacloprid was significantly lower than other tested in both populations (Fig. 2). About factor, affecting changes in fecundity for example there was insecticide resistance mutations in *Myzus persicae* could rise reproductive fitness of aphids on favorable and unfavorable hosts. Genotypes with multiple mutations exhibited higher r_m, without altering the transcriptional levels of the studied genes (Silva, *et al*. 2012). The variation in the offspring sex ratio of the female age were alters the sex ratio of the population over time and affect the population growth rate.

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