Fitness cost of resistance to chlorpyrifos in *Lipaphis erysimi* (Homoptera: aphididae)

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Abstract

Genetic and physiological changes conferring resistance to insecticide may induce a fitness cost in the previous adapted population. The present study demonstrates the differences in the fitness of chlorpyrifos resistant and susceptible strains of *Lipaphis erysimi*. The resistant strain had been selected for three generations in laboratory, and the resistance ratio was > 433- fold compared with the susceptible strain. The F_3 of both strains was used in this study. We found that nymphal survival in susceptible strain was significantly higher than resistant strain (50.99±2.79 and 75.02±7.56, respectively). The slower nymphal development associated with the resistant strain in *Lipaphis erysimi* was also observed. In addition, resistant apterae produced 59.45% fewer nymph than susceptible strain. The resistant strain also exhibit a shorter reproductive period (4.94±0.58 versus 6.95±1.56) and less numbers of nymphs laid per day. These results were discussed together with ecological consideration which shows that the over all fitness of individuals was decreased as the dose tolerance capability of individuals increased after continuous exposure to the chlorpyrifos.

Key words: Fitness cost, Chlorpyrifos, *Lipaphis erysimi*, Insecticidal selection, Inheritance

Introduction

The mustard aphid, *Lipaphis erysimi* (Kaltenbach), is found through out India and primarily associated with Brassica crops (Prasad, 1988). The biology of apterous *L. erysimi* on several brassica crops were well documented (Ahlawat & Chenulu, 1982; Amjad & Peters, 1992; Begum, 1995; Chander & Phadker, 1994; Liu et al., 1997; Singh & Sachan, 1995). The nymph and adults principally feed on the sap from the leaves, young shoots, inflorescence and young pods, resulting in chlorophyll reduction or even plant death (Liu & Yue, 2001). Additionally, alate individuals of *L. erysimi* can transmit some important plant virus diseases, such as sugarcane mosaic potyvirus (Ahlawat & Chenulu, 1982).

Although the use of chemical insecticides has been found very effective and a number of insecticides such as endosulfan, dimethoate, methyl-o-demeton and malathion have been recommended for its control (Singh, 1998). The sustained usage of these insecticides usually results in the emergence of insecticide resistance in insect pest. Georghiou & Taylor (1977) emphasized that responses of different populations of insects to various insecticides must be detected as early as possible to prevent the uninvited side effects and for use in IPM, judiciously. Several laboratory studies (Groeters et al., 1994; Tabashnik, 1994) demonstrate that individuals have variation in their fitness cost depending on the insect species and population selected.

The present paper analyzes continued selection experiments and correlation between fitness components and insect susceptibility.

Materials and Method

(i) Lipaphis erysimi samples

Lipaphis erysimi colonies were collected from *Brassica juncia* (variety: Varuna) from crop research centre, GBPUA&T, pantnagar, and transferred to the laboratory where budding nymphs were removed daily. The newly emerged nymphs were reared on tender leaves of mustard variety varuna in separate rearing cages at 22±1^{o}C temperature, 70% relative humidity and a photo period of 12L: 12D.

(ii) Identification of Susceptible Strain

Two hundred apterous colonies in their 4th instar stage were analyzed for calculating their LC_{50} values against chlorpyrifos (Dursban 20EC). The colony which showed least LC_{50} value was selected as susceptible population and reared in a different incubator at the same temperature and humidity. The nymph laid were removed and kept in separate rearing jars in the same incubator.

(iii) Insecticidal Selection for Development of Resistant Strain

The resistant population was developed from susceptible population (selected above) through continuous selection against chlorpyrifos. Selection experiments took place under controlled temperature (22±1^{o}C) and at 70% relative humidity in Economic Entomology Laboratory, GBPUA&T, Pantnagar. The selection procedure developed by Goel (2002) was used with modification in exposure time of the individuals on the treated surface. After exposure, treated individuals were transferred to untreated surface in separate rearing cages. The mortality was assayed after 48 hour of exposure. The F_3 generation was used as resistant strain for comparison of various life stages.

(iv) Pre-reproductive, Reproductive, Post-reproductive and Fecundity Experiment

To determine whether the variation between reproductive capabilities of resistant and susceptible apterae was significantly larger than the measurement error we reared 20 apterae individually from both, resistant and susceptible strain, on detached tender leaf of mustard, variety varuna, after 4^{th} molting at 22±1°C temperature and 60% r. h. and 12L:12D photoperiod according to procedure developed by Sumati (1985). Survival, development, and number of newborn nymphs were recorded and removed daily until the adult died. Leaf disks were replaced at the first sign of deterioration, normally 2-3 day intervals

(v) Nymph Viability Test

The F_3 generation was used to study viability difference in juvenile stage between resistant and susceptible strains. The experiments were started by randomly selecting 35 nymphs of same age from each population of both, resistant and susceptible strains, separately. It is assumed that newly laid nymphs are in their 1^{st} instar stage. This experiment had 5 replications for each population. A total of 4 populations were studied from each strain.

(iv) Data Analysis

LC_{50} data were analyzed assuming probit analysis. Data were corrected for control mortality using Abbott's formula (Abbott, 1925) before they were analyzed. The resistance ratio was calculated by dividing LC_{50}s of resistant strain with susceptible strain within each generation. The ecological fitness data (presented in table 2) was resultant of complete randomized block design analysis from biological parameters considered from various populations. The significance level between two means was calculated by using Fisher's t-test.

Results and Discussion

(a) Resistance Progression: Data present in table 1 reveals that *Lipaphis erysimi* population is capable to acquire resistance to chlorpyrifos (>433 times), readily within a short period of time when their vulnerability were compared by putting susceptible population as standard. In comparison with previous report with other insects (Trisyono & Whalon, 1997), we observed higher rate of increase in resistance ratio in the present study. This increase in resistance ratios indicate the cumulative inheritance of resistance gene to the successive generations because of the mode of parthenogenetic reproduction exhibited by *Lipaphis erysimi* where resistance have least chance of dilution due to the lack of mating.

Table1: Resistance progression in *Lipaphis erysimi* to chlorpyrifos under continuous selection at each generation

Generation	number	Slope±SEM	LC_{50}(mg a.i./litre)	RR(Resistance Ratio)
2	210	0.61±0.22	0.23	2.84
4	210	0.34±0.41	9.83	121.51
6	210	0.78±0.16	35.1	433.87
Susceptible	210	0.33±0.35	0.081	

(b) Effect of resistance on Reproductive potential: We have noticed significantly decrease in reproductive period (4.94 ± 0.58) and fecundity (26.09 ± 4.15) in case of resistant strain as compared to susceptible strain (6.95 ± 1.56 and 26.09 ± 4.15, respectively). The resistant apterae was produced less number of nymph per day in comparison of susceptible strain (4.61 ± 0.30 versus 5.48 ± 0.52) but this difference was found insignificant in our experiment (table 2). The pre-reproductive period and post-reproductive period were insignificantly larger in resistant strain.

Table2: The length of each developmental stage for chlorpyrifos resistant and susceptible strains of *Lipaphis erysimi*.

Life-stage Parameters	Resistant Strains(mean±SD)	Susceptible Strains(mean±SD)
Pre-reproductive period, d	0.91 ± 0.02a	0.83 ± 0.06a
Reproductive period, d	4.94 ± 0.58a	6.95 ± 1.56b
Post-reproductive period, d	1.50 ± 0.12a	1.28 ± 0.08a
Number of nymphlaid per day	4.61 ± 0.30a	5.48 ± 0.52a
Fecundity	26.09 ± 4.15a	38.25 ± 7.95b
Nymphal period, d	5.29 ± 0.25a	4.78 ± 0.30a
Nymphal survival	50.99 ± 2.79a	75.02 ± 7.56b
Adult longevity, d	7.35 ± 0.52a	9.05 ± 0.85b
Total life-span, d	12.63 ± 0.71a	13.84 ± 0.59b

d= number of days

(c) Nymphal Development, Survivorship and Longevity: An insignificant retardation in nymphal development was noticed in resistant strain as increase in the nymphal period noticed here. But decrease in nymphal survival in resistant strain was found significant (50.99 ± 2.79 in resistant strain versus 75.02 ± 7.56). Adult longevity and total life-span were noticed significantly lower in resistant strain (7.35 ± 0.52 and 12.63 ± 0.71, respectively) than in susceptible strain (9.05 ± 0.85 and 13.84 ± 0.59, respectively).

Insect tolerating the functional doses of insecticides may compensate by reduced physiological and reproductive features (Van Rie et al., 1990; Bower, 1992; Trisyono & Whalon, 1997). This may be because most of energy budget was exhausted as pay cost of chemical defenses. Our results show that resistant development in a population takes its toll by reduced reproductive period, decreasing number of nymph laid per day, lower fecundity, prolonged nymphal period, reduced survival of nymphs and decreased adult longevity.

Conclusion

It was concluded that the over all fitness of individuals was decreased as the dose tolerance capability of individuals increased after continuous exposure to the chlorpyrifos

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