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Interactions of Transgenic-Bt Potato Resistance to Colorado Potato Beetle with the Fitness and Behavior of the Potato Aphid *Macrosiphum euphorbiae*

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ABSTRACT

The performance and flight behavior of the potato aphid *Macrosiphum euphorbiae* was studied on the 'Superior-BT' line transgenic for the CryIIIA toxin of *Bacillus thuringiensis* (BT), resistant to the Colorado potato beetle; and non transformed 'Superior' line which served as control. Mortality of the treated aphids was negligible and potato lines did not affect the development time of *M. euphorbiae*, but aphids were largest on 'Superior' and smallest on BT potatoes. This difference was reflected in aphid fecundity, which was lowest on 'Superior-BT', and highest on Superior. Incidence of flight in newly emerged alate *M. euphorbiae* that developed on BT was high compared to control. The results illustrate that the performance of a secondary pest of potato can be unpredictably affected by the resistance factor involved in developing specific resistance to a primary pest.

Keywords: *Bacillus thuringiensis*, Colorado potato beetle, *Macrosiphum euphorbiae*, Plant-insect interaction, Potato transgenic-BT.

INTRODUCTION

The development of plant resistance as an alternative to chemical control is mostly concerned with primary pests. In contrast, the effects of plant resistance on secondary pests are rarely considered, although altering plant genomes to reduce primary pest damage may strongly influence the fitness and behavior of secondary pests (Teetes, 1985; Wiseman, 1994; Hanzlik *et al.*, 1997). Several studies suggest that the fitness and behavior of secondary pests may change unpredictably when they feed on host plants with improved resistance against primary pest targets (e.g. Shieh *et al.*, 1994; Hanzlik *et al.*, 1997; Girard *et al.*, 1998; Ashouri *et al.*, 2001; Davidson *et al*., 2006).

The Colorado potato beetle (CPB) *Leptinotarsa decemlineata* (Say) is the most important cultivated potato pest in the world (Radcliffe, 1982; Hare, 1990; Holliday, 1996). Chemical insecticide applications can successfully control the CPB but there is growing concern about the mid-term outlook of this approach. It is undesirable from an environmental pollution view point and its long term efficacy is regularly threatened by the evolution of new resistance to previously effective chemicals on beetle populations (Martel, 1987; Hare, 1990; Boiteau *et al*., 1996).

A variety of secondary insect pests can cause damage to potato crops, including aphids which both cause direct damage by feeding on plant sap, and indirectly damage plants by acting as plant virus vectors (Radcliffe, 1982; McLeod and Tolman, 1987). An important aphid pest of potato occurring worldwide is the potato aphid *Macrosiphum euphorbiae* (Thomas). *Macrosiphum euphorbiae* is a polyphagous aphid, attacking many different crop and non crop plant spe-

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cies (Blackman and Eastop, 1984). It is also a vector of several persistent and nonpersistent viral diseases, and thus can be a serious problem in seed as well as table potato production (Shands *et al.,* 1972; Lange and Broson, 1981; Walker *et al.,* 1984; Boiteau, 1994). *Macrosiphum euphorbiae* and other aphid pests of potato are of only minor concern in the CPB's presence, because they may be indirectly controlled by effective chemicals (Boiteau *et al*., 1996).

Transgenic potatoes containing a *Bacillus thuringiensis* ssp. *tenebrionis* (CryIIIA) resistant to CPB are currently being subjected to field trial (Gill *et al.,* 1992; Perlak *et al.,* 1993) and are expected to be generally available to the public soon. Very little is known about the possible effects of this factor of resistance on secondary potato pests (e.g. Boulter *et al.,* 1990; Shieh *et al.,* 1994; Canedo *et al.,* 1998; Ashouri *et al.,* 2001). This resistance mechanism is unlikely to interact with secondary aphid pests as they do with primary defoliators such as the CPB. The objective of this study was to examine the effects of the CPB transgenic-BT resistant line on the potato aphid, *M. euphorbiae*. We were mostly interested in finding out how this line might affect potato aphid performance, as expressed in its life history characteristics and behavior.

MATERIALS AND METHODS

Host Plants

Two potato lines were used for the treatments: (1) the CPB resistant 'Superior-BT' line (Newleaf™), which is transgenic for the CryIIIA toxin of *B. thuringiensis tenebrionis* (Gill *et al.,* 1992; Perlak *et al.,* 1993) and (2) the 'Superior' variety which served as the control. For the experiments, we used plantlets at the 4-6 leaves stage.

Insects

Aphids used in the bioassays were obtained from a colony initiated from the potato aphid, *Macrosiphum euphorbiae* (Thomas), collected from a potato field. We reared aphids on cv. 'Norland' potato seedlings in growth chambers at 20±1°C and 65±10% RH under 16L:8D h photoperiod. Plants of each line were caged and maintained under the same conditions as above. Newly emerged 0-12 hour-old adults were used as the test insects.

Nymphal Mortality and Development Time

The development time and mortality rate from birth to adulthood of 60 aphids per plant treatment were measured. Two adult apterous aphids were caged together on a leaf and, after 12 hours, the adults, and all but one 0-12 hour-old nymph were removed. Infested plants were maintained under a controlled temperature regime fluctuating according to a sine wave pattern between 12 and 22°C (average=17°C), 65±10% RH under 16L:8D h photoperiod. Daily observations were performed in the morning (10 AM) until all the nymphs were either dead or had reached maturity.

Adult Mortality and Fecundity

We determined adult *M. euphorbiae* and fecundity on the leaves of each potato line, for apterae which had previously developed on the same line. We placed one newly (0-12 hour-old) molted adult aptera on a caged leaf. Twenty plants were used per line. Plants were maintained at 20±1°C and 65±10% RH under 16L:8D h photoperiod. Mortality was checked daily and the nymphs produced were counted and removed. Total fecundity was calculated as the number of nymphs produced by a female over 10 days following adult emergence.

Body Size

Newly emerged 0-12 hour-old adult apte-

rae reared from each line (developed on whole plants under the above conditions) were killed by freezing. Frozen aphids were dried in an oven (Precision Scientific Inc, Chicago, IL, USA) at 60°C for 48 hours. The dry mass of each adult aphid was measured using a microbalance (sensitivity 0.001 mg).

Flight Tendency

Twenty-five plants per line were used to compare flight tendency of the young *M. euphorbiae* alatae on the two potato lines under laboratory conditions. Newly emerged 0-24 hour-old adult alatae (developed on leaves of the same line) were released at the upper (abaxial) leaf surface, on the 2 second or third leaf of each plant. We observed the tendency to fly for each individual on a daily basis until they were 10 days old. Each morning following adult emergence, the aphids were individually exposed to a light source until they left the plant or until 60 seconds had elapsed. Counts of aphids taking flight within 60 seconds were used to obtain the age-specific flight incidence for each line.

Statistical Analysis

All experiments were arranged as a completely randomized design with two host plants as treatments (Superior-BT and Superior). We used a Pearson's Chi-square test to detect any effect of host plants on aphid mortality and flight tendency. We used 2-factor analysis of variance (ANOVA) with morph (two levels: alate/apterous), plant treatment (two levels) and their interaction to analyze data on aphid development time. For statistical analyses of adult fecundity and dry weight an independent t-student test was performed.

RESULTS

Mortality

Nymphal mortality to adult emergence was not significantly (X^2_1 =1.7; P=0.186) affected by plant line. Cumulative mortality up to the 8th day of adult life was also not significantly affected by plant line (X^2_1 = 2.105; P=0.147; Table 1).

Development Time

Two-factor ANOVA indicated no significant interaction between the host plant and aphid morph for aphid development time ($F_{1, 106}$ =0.095; P=0.759). For this reason, we examined the effect of host plant line separately for each aphid morph. Apterous aphids developed significantly more rapidly than alate aphids on two lines (Table 1).

Table 1. Mortality (%) and development time (day; Mean ± SEM) from birth to adult molt of *Macrosiphum euphorbiae* confined to leaves of two potato lines.

Potato line	Mortality		Development time (d)		
	n [a]	%	Morph	n [a]	Mean ± SEM
Superior-BT	60	11.67 a	alate	16	10.47 ± 0.18 b
			apterous	37	9.63 ± 0.03 a
Superior	60	5.00 a	alate	16	10.48 ± 0.09 b
			apterous	41	9.69 ± 0.05 a

[a] number of replicates.
Mean values with the same letter do not differ significantly at the 5% error rate based on Fisher's PLSD test.

Body Size

Dry weight of *M. euphorbiae* apterous adults was significantly affected by the plant line used during nymphal development ($F_{1, 112}$ =178.912; P<0.0001). Aphids on the Superior-BT line, were smaller than on the non transformed Superior line (113 ± 3.7 µg and 205 ± 6.1 µg respectively; Table 2).

Fecundity

Fecundity in apterous *M. euphorbiae* varied significantly among host plant lines ($F_{1, 38}$ =7.77; P<0.0082). This was lowest aphids on Superior-BT and highest on Superior (on average 41.40 ± 1.65 and 47.40 ± 1.38 nymphs per 10 days, respectively; Table 2).

ingiensis tenebrionis CryIIIA toxin negatively affected adult fitness of *M. euphorbiae* and increased their flight tendency. This and related endotoxins of *B. thuringiensis* are not known to affect aphid feeding or nutrition directly. Our results cannot tell us if the toxin was ingested or if indirect effects of transgene products on aphids are possible. Overexpression of the *B. thuringiensis* toxin in foliage might lower the availability of important aphid nutrients, such as free amino acids in phloem sap (Chu and Henneberry, 1995; Rahbé *et al.*, 1995; Sauvion, *et al.*, 1996; Fischer *et al.*, 1998; Dutta *et al*., 2005).

Antibiotic plant resistance generally reduces herbivore size (Panda, 1979; Stapl *et al.*, 1997; Souissi and Le Ru, 1998). Smaller adult aphid size could affect population

Table 2. Dry weight (µg; Mean ± SEM) of newly emerged adult and fecundity (Mean ± SEM; per female/10 d) of apterous *Macrosiphum euphorbiae* reared on the leaves of two potato lines.

Potato line	Dry weight (µg)		Fecundity / female/ 10 d	
	n[a]	Mean ± SEM	n[a]	Mean ± SEM
Superior-BT	61	113.23 ± 28.58 ***	20	41.40 ± 1.65 **
Superior	53	205.68 ± 44.45	20	47.40 ± 1.38

[a] number of replicate.
** and *** Significant differences using independent t-student test at P<0.001 and P<0.0001, respectively.

Flight Tendency

Aphid flight tendency varied according to age and potato line (Figure 1). In early adulthood, cumulative flight tendency increased rapidly up to day 3, but remained more or less stable after that. On day 10, more than 76% of aphids on the Superior-BT had exhibited the tendency to fly compared to <28% on Superior, hence the cumulative incidence of flight being significantly different between potato lines (X^2_1=11.54; P<0.0007; Figure 1).

DISCUSSION

Our results indicated that, unexpectedly, Newleaf™ potatoes expressing the *B. thur-*

growth in the field through lower or delayed reproduction. Smaller aphids are a potential side-effect of transgenic-BT potatoes which could lead to reduced survival, slower growth, development and their population increase (Ashouri, 2004). Although we found no relation between aphid size variation and potato line, and development time in this study. The reduced availability of nutrients and/or endotoxins of *B. thuringiensis* would negatively affect aphid fitness, and could also enhance flight propensity.

In aphid populations, the proportion of individuals dispersing by flight in search of new host plants usually increases with aphid density, and decreases with host plant quality (Jepson, 1983; Dill *et al.*, 1990). A key life history trait of aphids for surviving systematic variability of host plant quality is the

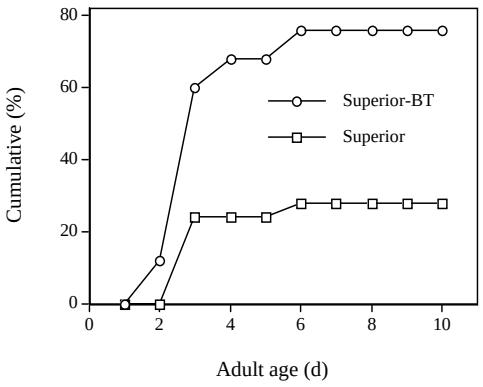

Figure 1. Age-specific incidence of take off by *Macrosiphum euphorbiae* alatae reared on two potato lines. *n* = 25 replicates per line.

facultative dispersal by newly-emerged alate individuals (Dixon, 1998). Young alatae will usually take flight if the host plant is maturing or deteriorating, but will remain and reproduce locally if the host plant is young and in good conditions (Kennedy and Fosbrooke, 1973; Dixon, 1998).

Despite evidence that the *B. thuringiensis* transgenic potato is not an ideal host for the potato aphid, the aphids matured to become functional alate dispersers that apparently were fully able to express their ability to leave in search of more suitable hosts.

Aphid dispersal and probing behavior are two distinct factors in nonpersistent virus transmission (Boiteau and Singh, 1991; Bailey *et al.,* 1995; Dixon, 1998). Shieh *et al.* (1994) reported that transgenic potatoes with the *B. thuringiensis* gene did not affect probing behavior of the green peach aphid, *M. persicae*. However, increased flight tendency, as we observed for *M. euphorbiae* alatae on Superior-BT, suggests that more frequent movement by alate aphids may occur in transgenic *B. thuringiensis* potato crops which, in turn, would enhance the risk of spreading viral diseases. The confirmation and characterization of such risk would require additional research.

Our results may also be relevant to understanding and predicting the possible effects of 'pyramidal' resistance to potato insect pests. Multi-mechanistic plant resistance development ('pyramiding') is seriously considered as an option for herbivorous pest control (Boulter *et al.,* 1990; MacIntosh *et al.,* 1990; Gatehouse and Gatehouse, 1998; Westedt *et al.,* 1998). In theory, such pyramidal resistance could be effective against a significant range of primary and secondary potato pests, including the CPB, other major defoliators such as lepidopterous larvae, and herbivores of the sucking guild including aphids. However, since even the simple monogenic resistance factor can have quite unanticipated effects on non-target pests, making predictions about the outcome of pyramidal plant resistance is very risky at this stage. Much more research is necessary to verify empirically the anticipated effects, and to discover the unanticipated ones, before broad-spectrum plant resistance based on multiple resistance factors in crops such as potatoes can become a reality.

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REFERENCES

1. Ashouri, A. 2004. Transgenic-Bt Potato Plant Resistance to the Colorao Potato Beetle Affect the Aphid Parasitoid *Aphidius nigripes*. *Comm. App. Biol. Sci.,* **69(3)**: 185-200.
2. Ashouri, A., Michaud, D. and Cloutier, C. 2001. Unexpected Effects of Different Potato Resistance Factors to the Colorado Potato Beetle (Coleoptera: Chrysomelidae) on the Potato Aphid (Homoptera: Aphididae). *Environ. Entomol.*, **30**: 524-532.
3. Bailey, S. M., Irwin, M. E., Kampmeier, G. E., Eastman, C. E. and Hewing, A. D. 1995.

Physical and Biological Perturbations: Their Effect on the Movement of Apterous *Rhopalosiphum padi* (Homoptera: Aphididae) and Localized Spread of Barley Yellow Dwarf Virus. *Environ. Entomol.*, **24**: 24-33.

4. Blackman, R. L. and Eastop, V. F., 1984. *Aphids on the World's Crops*: *An Identification and Information Guide*. Wiley, New York.
5. Boiteau, G. 1994. Pomme de terre. In : *Maladies et ravageurs des cultures léguminières au Canada*. Richard, C. and Boivin, G. La Société Canadienne de phytopathologie et la Société d'entomologie du Canada, Ottawa, pp. 247-290.
6. Boiteau, G. and Singh, R. P. 1991. Difference in the Transmission of PVY to Potato and Tobacco by the Potato Aphid, *Macrosiphum euphorbiae* (Thomas): Effects of Probing Duration and Frequency. *Can. Entomol.*, **123**: 869-874.
7. Boiteau, G., Duchesne, R. M. and Ferro, D. N. 1996. Use and Significance of Traditional and Alternative Insect Control Technologies for Potato Protection in a Sustainable Approach. In: *Lutte aux insectes nuisibles de la pomme de terre - Potato insect pest control.* Duchesne, R. M. and Boiteau G. Proceedings, Symposium, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, QC, Canada, pp. 169-178.
8. Boulter, D., Edwards, G. A., Gatehouse, A. M. R., Gatehouse, J. A. and Hilder, V. A. 1990. Additive Protective Effects of Different Plant-derived Insect Resistance Genes in Transgenic Tobacco Plants. *Crop Prot.*, **9**: 351-354.
9. Canedo, V., Benavides, J., Golmirzaie, F., Cisneros, F., Ghislain, M. and Lagnaoui, A. 1998. Assessing Bt-transformed Potatoes for Potato Tuber Moth, *Phthorimaea operculella* (Zeller), Management. *CIP Program Report 1997-98*, pp. 161-169.
10. Chu, C. C. and Henneberry, T. J. 1995. *Bemisia argentifolii* (Homoptera: Aleyrodidae): Host Preference and Factors Affecting Ovipositing and Feeding Site Preference. *Environ. Entomol.*, **24**: 354-360.
11. Davidson, M. M., Butler, R. C., Wratten, S. D. and Conner A. J. 2006. Field Evaluation of Potato Plants Transgenic for a Cry1Ac Gene Conferring Resistance to Potato Tuber Moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae). *Crop Protec.*, **25**: 216–224.
12. Dill, L. M., Fraser, A. H. G. and Roitberg, B. D. 1990. The Economics of Escape Behavior in the Pea Aphid, *Acyrthosiphon pisum*. *Oecologia*, **83**: 473-478.
13. Dixon, A. F. G., 1998. *Aphid Ecology*. 2nd Edition. Chapman & Hall, London.
14. Dutta, I., Majumder, P., Saha, P., Ray, K. and Das, S. 2005. Constitutive and Phloem Specific Expression of *Allium sativum* Leaf Agglutinin (ASAL) to Engineer Aphid (Lipaphis erysimi) Resistance in Transgenic Indian Mustard (Brassica juncea). *Plant Sci.*, **169**: 996–1007.
15. Fischer, W., Andre, B., Rentsch, D., Krolkiewicz, S., Tegeder, M., Breitkreuz, K. and Frommer, W., 1998. Amino Acid Transport in Plants. *Trends Plant Sci.*, **3**: 188-195.
16. Gatehouse, A. and Gatehouse, J., 1998. Identifying Proteins with Insecticidal Activity: Use of Encoding Genes to Produce Insect-resistant Transgenic Crops. *Pestic. Sci.*, **52**: 165-175.
17. Gill, S. S., Cowles, E. A. and Pietrantonio, P. V. 1992. The Mode of Action of *Bacillus thuringiensis* endotoxins. *Ann. Rev. Entomol.*, **37**: 615-636.
18. Girard, C., LeMetayer, M., Zaccomer, B., Bartlet, E., Williams, I., Bonadé Bottino, M., Pham Delegue, M. and Jouanin, L. 1998. Growth Stimulation of Beetle Larvae Reared on a Transgenic Oilseed Rape Expressing a Cysteine Proteinase Inhibitor. *J. Insect Physiol.*, **44**: 263-270.
19. Hanzlik, M. W., Kennedy, G. G., Sanders, D. C. and Monks, D. W. 1997. Response of European Corn Borer (*Ostrinia nubilalis*, Hubner) to Two Potato Hybrids Selected for Resistance to Colorado Potato Beetle. *Crop Prot.*, **16**: 487-490.
20. Hare, J. D. 1990. Ecology and Management of Colorado Potato Beetle. *Ann. Rev. Entomol.*, **35**: 81-100.
21. Holliday, N. J. 1996. Economic Thresholds and Monitoring. In: *Lutte aux insectes nuisibles de la pomme de terre - Potato insect pest control.* Duchesne, R. M. and Boiteau, G. Proceedings, Symposium, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, QC, Canada, pp.113-142.

22. Jepson, P. C. 1983. A Controlled Environment Study of the Effect of Leaf Physiological Age on the Movement of Apterous *Myzus persicae* on Sugar Beet Plant. *Ann. Appl. Biol.*, **103**: 173-183.
23. Kennedy, J. S. and Fosbrooke, I. H. M. 1973. The Plant in the Life of an Aphid. *Symp. R. Entomol. Soc. London*, **6**: 129-140.
24. Lange W. H. and Bronson L. 1981. Insect Pests of Tomatoes. *Ann. Rev. Entomol.*, **26**: 345-371.
25. MacIntosh, S. C., Kishore, G. M., Perlak F. J., Marrone, P. G., Stone T. B., Sims, S. R. and Fuchs, R. L. 1990. Potentiation of *Bacillus thuringiensis* Insecticidal Activity by Serine Protease Inhibitors. *J. Agric. Food Chem.*, **38**: 1145-1152.
26. Martel, P., 1987. Chemical Control and Resistance Development in Potato Pests. In: *Lutte aux insectes nuisibles de la pomme de terre - Potato insect pest control.* Duchesne, R. M. and Boiteau, G. Proceedings, Symposium, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, QC, Canada, pp. 173-183.
27. McLeod, D. G. R. and Tolman, J. H. 1987. Evaluation of Losses in Potatoes. In: *Potato Pest Management in Canada-Lutte contre les parasites de la pomme de terre au Canada*. Boiteau G., Singh R. and Parry R. Agriculture and Agri-Food Canada. Fredericton, NB, Canada, pp. 363-373.
28. Panda, N. 1979. *Principles of Host-plant Resistance to Insect Pests*. Allanheld/Universe, New York.
29. Perlak, F. J., Stone, T. B., Muskopf, Y. M., Petersen, L. J., Parker, G. B., McPherson, S. A., Wyman, J., Love, S., Reed, G., Biever, D. and Fischhoff, D. A. 1993. Genetically Improved Potatoes: Protection from Damage by Colorado Potato Beetles. *Plant Mol. Biol.*, **22**: 313-321.
30. Radcliffe. E. B. 1982. Insect Pests of Potato. *Ann. Rev. Entomol.*, **27**: 173-204.
31. Rahbé, Y., Sauvion, N., Febvay, G., Peumans, W. J. and Gatehouse, A. M. R., 1995. Toxicity of Lectins and Processing of Ingested Proteins in the Pea Aphid *Acyrthosiphon pisum*. *Entomol. Exp. Appl.,* **76**: 143-155.
32. Sauvion, N., Rahbé Y., Peumans, W. J., Van Damme, E. J. M., Gatehouse, J. A. and Gatehouse, A. M. R., 1996. Effects of GNA and Other Mannose Binding Lectins on Development and Fecundity of the Peach-potato Aphid *Myzus persicae*. *Entomol. Exp. Appl.*, **79**: 285-293.
33. Shands, W. A., Simpson, G. W. and Wave, H. E., 1972. Seasonal Population Trends and Productiveness of the Potato Aphid on Swamp Rose in Northeastern Maine. Maine Agricultural Experiment Station, *Technical Bulletin*, **52**: 1-35.
34. Shieh, J. N., Berry, R. E., Reed, G. L. and Rossignol, P. A. 1994. Feeding Activity of Green Peach Aphid (Homoptera: Aphididae) on Transgenic Potato Expressing a *Bacillus thuriengiensis* ssp. *tenebrionis* delta-endotoxin gene. *J. Econ. Entomol.*, **87**: 618-622.
35. Souissi, R., and Le Ru, B. 1998. Influence of Plant of the Cassava Mealybug *Phenacoccus manihoti* (Hemiptera: Pseudococcidae) on biological Characteristics of its Parasitoid *Apoanagyrus lopezi* (Hymenoptera: Encyrtidae). *Bulletin Entomol. Research*, **88**: 75-82.
36. Stapl, J. O., Waters, D. J., Ruberson, J. R., and Lewis, W. J., 1997. Development and Behavior of *Spodoptera exigua* (Lipidoptera: Noctuidae) Larvae in Choice Tests with Food Substrates Containing Toxins of *Bacillus thuringiensis*. *Biol. Control*, **11**: 29-37.
37. Teetes, G. L., 1985. Insect Resistant Sorghums in Pest Management. *Insect Sci. Appl.*, **6**: 443-451.
38. Walker, G. P., Nault, L. R. and Simonet, D. E. 1984. Natural Mortality Factors Acting on Potato Aphid *Macrosiphum euphorbiae* Populations in Processing-Tomato Fields in Ohio. *Environ. Entomol.*, **13**: 724-732.
39. Westedt, A., Douches, D., Pett, W. and Grafius, E., 1998. Evaluation of Natural and Engineered Resistance Mechanisms in *Solanum tuberosum* for Resistance to *Phthorimaea operculella* (Lepidoptera: Gelechiidae). *J. Econ. Entomol.*, **91**: 552-556.
40. Wiseman, B. R., 1994. Plant Resistance to Insects in Integrated Pest Management. *Plant. Dis.*, **79**: 927-932.

برهمکنش گیاه سیب‌زمینی تراریخته- Bt مقاوم به سوسک کلرادو با شته *Macrosiphum euphorbiae*

ا. عاشوری

چکیده

شایسنگی و رفتار پروازی شته سیب‌زمینی *Macrosiphum euphorbiae* روی رقم Superior-Bt، گیاه سیب‌زمینی ترانس‌ژنیک با ژن CryIIIA باکتری *Bacillus thuringiensis*, مقاوم به سوسک کلرادو در مقایسه با همان رقم (Superior) ولی غیر ترانسفورمه (شاهد) در شرایط آزمایشگاهی مورد مطالعه قرار گرفت. مرگ و میر شته‌ها روی هر دو گیاه ناچیز بوده و طول دوره نشو و نما تحت تاثیر گیاهان نبوده است. ولی شته‌های رشد یافته روی گیاهان ترانس‌ژنیک کوچک‌تر از شاهد بوده‌اند. این اختلاف روی میزان زادآوری شته‌ها تاثیر گذاشته، بشکلی که زادآوری شته‌های پرورش یافته روی گیاهان ترانس‌ژنیک به مراتب کمتر از شاهد بوده است. میزان پرواز شته‌های بالدار جوان پرورش یافته روی گیاهان ترانس‌ژنیک در مقایسه با شاهدین بیشتر بوده است. نتایج نشان می‌دهد عوامل ایجاد مقاومت در برابر آفات درجه اول می‌توانند بطور غیر قابل پیش‌بینی، یک آفت درجه دوم و غیر هدف را تحت تاثیر قرار دهند.