Jour. Agric. Res. China (中華農業研究) 33(3) : 331~336 (1984)

The Occurrence of Insecticide Resistance in Three Lepidopterous Pests on Vegetables[1]

by

Tao-mei Chou, Ching-hua Kao and Edward Y. Cheng[2]

Abstract : The imported cabbageworm, *Pieris rapae* Boisduval ; the tobacco cutworm, *Spodoptera litura* Fabricius ; and the cabbage looper, *Trichoplusia ni* Hübner, were sampled from several major vegetable growing areas for the insecticide susceptibility study. For each species, susceptibilities differ among sampled populations resulted from resistance. The finding of this investigation indicated that the imported cabbageworms were free from the resistance problem and chemical control is a very effective measure for controlling this pest. The cabbage loopers are sensitive to neither mevinphos nor carbofuran and are very sensitive to the insecticidal action of synthetic pyrethroids. The test results clearly showed that resistance had developed in tobacco cutworms and the degree of resistance varied from region to region. The highest resistant ratios observed in tobacco cutworm were 63.0 for mevinphos, 79.0 for carbofuran, 13.0 for permethrin and 4.1 for fenvalerate.

In general, the synthetic pyrethroids are still the most effective agents for controlling the three tested pest species, but the organophosphorus and carbamates have encountered resistance problem in both cabbage loopers and tobacco cutworms.

Introduction

Three important vegetable lepidopterous pests, the imported cabbageworm, *Pieris rapae* Boisduval ; the tobacco cutworm, *Spodoptera litura* Fabricius ; and the cabbage looper, *Trichoplusia ni* Hübner, were usually controlled chemically in Taiwan. An insecticide resistance survey carried out in 1980-81 by this laboratory had clarified the effectiveness of several officially recommended insecticides for the control of the diamondback moth, *Plutella xylostella* (L.) [5], another important vegetable pest. The

1. Contribution No. 1174 from Taiwan Agricultural Research Institute and the study is supported by CAPD grant 1982-4. 1-117(05).

2. Project assistant, research assistant and senior entomologist, respectively, Department of Applied Zoology, TARI, Wufeng, Taichung, Taiwan, ROC.

serious situation encountered in the diamondback moth implied that the resistance problem should not be overlooked in other pests. Since the resistance information is urgently needed in field to select the best or the most reasonable insecticide, Taiwan Agricultural Research Institute has decided to find out to what extent the resistance problems have developed in three above mentioned pests. Currently, more than thirty insecticides are registered for cruciferous vegetable pests control [12] and their effectiveness have not been carefully re-examined ever since the registration. This study, performed similarly to that for the diamondback moth, was intended to identify : (1) whether the resistance has already occurred or not, and (2) whether the resistance has caused the threats in current control practices.

Materials and methods

Insects were sampled from several major vegetable growing areas for the insecticide susceptibility studies. Each species was collected according to the stages which were suitable for rearing enough number of insects for the necessary test. Enough imported cabbageworms can be easily collected from field and no rearing from generation to generation is necessary. The egg mass of tobacco cutworms usually is the most convenient stage for collecting and enough larvae can be obtained from just a few egg masses. If not enough egg masses were collected, one or two generations of rearing is needed to provide enough larvae for the tests. The cabbage loopers were collected and reared in the laboratory because the occurrences of looper's larvae and eggs were rather few and sporadical.

Of all three species, only the third instar larvae were used in testing the insecticide susceptibility and the treatments were carried out in the same way as that of the diamondback moth study [6]. All insecticides used were commercially formulated products and the dilutions were made in distilled water. A preliminary test to determine the effective range of insecticide for each sample population was needed before selecting seven evenly spaced testing dosages. The post-treatment holding temperature and relative humidity were 25°C and 80-90%, respectively. The mortality of treated insects was examined 24 hours after the treatment and the results were analyzed in probit.

Results

The susceptibilities of four imported cabbageworm populations to insecticides were compared in Table 1. The susceptibilities were very close in both permethrin and mevinphos studies and only minimum differences were detected in regard to fenvalerate and carbofuran. Although four populations were collected far apart from each other, the extreme resemblance in their insecticide susceptibilities indicated that the imported cabbageworms have not developed appreciable resistance yet. The results also showed that populations were well mixed in Taiwan that an almost homogeneous response can be concluded from every insecticide tested. Obviously, no sign of resistance in this species has created problems in the control practice.

No appreciable difference in the insecticide susceptibility can be found among

Table 1. The susceptibilities of four field strains of imported cabbageworm to four commonly used insecticides

Location	LC_{50}-(Slope)-R. R.			
	Fenvalerate	Permethrin	Mevinphos	Carbofuran
PT	3.1-(0.89)-1.0	1.3-(0.80)-1.0	31.1-(1.03)-1.2	190-(0.94)-6.2
HH	8.4-(0.62)-2.7	1.6-(1.16)-1.3	34.0-(0.78)-1.4	84-(0.37)-2.7
TC	10.1-(0.93)-3.3	1.3-(1.65)-1.0	25.1-(1.26)-1.0	31-(1.07)-1.0
TY	25.1-(1.08)-8.1	3.4-(2.54)-2.7	34.8-(1.12)-1.4	118-(1.29)-3.9

PT : Ping-tung, HH : Hsi-hu, TC : Taichung, TY : Ta-yuan.

Table 2. The susceptibilities of three field strains of cabbage looper to four commonly used insecticides

Location	LC_{50}-(Slope)-R. R.			
	Fenvalerate	Permethrin	Mevinphos	Carbofuran
PT	6.9-(1.25)-2.0	12.2-(2.79)-2.4	4198-(0.85)-3.5	15257-(0.90)-1.9
PZ	8.6-(1.27)-2.5	5.1-(1.25)-1.0	1205-(0.83)-1.0	16990-(0.47)-2.1
HH	3.4-(1.20)-1.0	5.3-(1.66)-1.0	3159-(1.13)-2.6	8170-(0.91)-1.0

PT : Ping-tung, PZ : Pu-tzu, HH : Hsi-hu

different field populations of cabbage loopers (Table 2). The loopers were almost immuned from the insecticidal actions of both mevinphos and carbofuran and whether this insensitivity was induced by insecticides or occurred naturally is still unclear. Judging from the results in Table 2, the synthetic pyrethroids are still good agents for looper's control.

The tobacco cutworm is the most studied species in this investigation, a total of eight field populations from different regions were compared in their insecticide susceptibilities (Table 3). Although the synthetic pyrethroids were the most effective group, three out of eight populations had developed resistance to permethrin but not fenvalerate. The resistance to both mevinphos and carbofuran was clearly demonstrated in Table 3, the highest resistant ratios observed were 63.0 for mevinphos and 79.0 for carbofuran. The sample collected from Hsi-hu, the most intensively cultivated vegetable growing area, has the highest resistance problem. The most susceptible tobacco cutworms were found in a mountainous vegetable field. We suspect that due to the polyphagous nature of this species, the population is not limited within the cabbage field, hence has minimum contact with insecticides.

Table 3. The susceptibilities of eight field strains of tobacco cutworm to four commonly used insecticides

Location	LC_{50}-(Slope)-R. R.			
	Fenvalerate	Permethrin	Mevinphos	Carbofuran
PT	14.3-(1.00)-2.8	6.0-(0.56)- 1.4	210-(0.51)- 3.3	596-(0.55)- 1.2
LC	7.0-(0.94)-1.3	5.8-(1.40)- 1.4	586-(0.71)- 9.1	1218-(0.34)- 2.4
PZ	12.1-(1.10)-2.3	24.9-(1.27)- 5.9	652-(1.18)-10.0	2035-(0.69)- 3.9
HH	17.7-(0.69)-3.4	25.0-(1.14)- 6.0	4014-(1.33)-63.0	41048-(2.31)-79.0
TC	12.9-(1.04)-2.5	8.0-(0.77)- 1.9	73-(0.54)- 1.1	3443-(0.52)- 6.7
CP	20.9-(0.90)-4.0	55.0-(0.83)-13.0	73-(0.80)- 1.1	1575-(0.71)- 3.0
TY	5.2-(1.00)-1.0	4.2-(0.71)- 1.0	407-(1.11)- 6.4	2113-(0.64)- 4.1
YM	21.3-(1.20)-4.1	4.7-(0.79)- 1.1	64-(0.41)- 1.0	517-(0.30)- 1.0

PT : Ping-tung, LC : Lu-chu, PZ : Pu-tzu, HH : Hsi-hu, TC : Taichung, CP : Chu-pei, TY : Ta-yuan, YM : Yang-ming shan.

Discussion

In Taiwan, the easiest and the most convenient way to control the vegetable pests is by applying insecticides, and the development of resistance in the pest population certainly becomes a risk which usually resulted from the insecticide usage. The insecticide resistance has been detected in the diamondback moth and the same problem may also occur in other vegetable pests. This investigation will help us to re-evaluate the effectiveness of many officially recommended insecticides.

The test result has revealed that the imported cabbageworms have not developed resistance to insecticides and their susceptibilities to different insecticides are still high[1,3,8]. Obviously, the chemical control is still desirable in controlling this pest. We have no information concerning why the imported cabbageworms did not develop resistance, but it seems that the great migration ability of this species could mix population from different regions. Whether this genetic dilution has relieved the insecticide pressure is an interesting subject for the future study.

The cabbage loopers usually stay and feed on the foliage just as the importd cabbageworms, and should have similar opportunity in receiving the insecticide sprays, but the cabbage loopers are insensitive to both mevinphos and carbofuran. Mevinphos was not reported as a good insecticide for the cabbage looper[4,7,8,11], and the ineffectiveness of carbofuran in the looper control was also demonstrated by other investigators [7,9,10,11]. These facts matched the results obtained in this study. In the synthetic pyrethroid tests, both cabbage looper and imported cabbageworm have similar sensitivities to fenvalerate except higher dosage of permethrin is needed for the looper control than that for the imported cabbageworm.

The test results indicated that tobacco cutworm was capable of developing resistance to fenvalerate, permethrin and mevinphos. The permethrin resistance occurred in three out of eight sampled regions and the mevinphos resistance was already prevailing in most of the sampled areas. Although the resistance to fenvalerate is still mild, it is much more wide-spread than that for permethrin. Judging from the susceptibilities of the most susceptible sample, fenvalerate, permethrin and mevinphos should be very effective if the tobacco cutworm had not developed resistance. The carbofuran resistance is more serious than other tested insecticides, because none of our sampled populations were really sensitive to carbofuran and the resistant ratios were also extravagant.

Hsi-hu is a region where vegetables constantly grows with heavy insecticide application, and the tobacco cutworm sampled from this area is highly resistant to all four tested insecticides. Practically, mevinphos and carbofuran were completely ineffective to control the cutworm in this area and permethrin has gradually lost its effectiveness. An interesting fact is that the most susceptible tobacco cutworm population was collected from an intensively cultivated vegetable field in Yangming mountain region. The low resistance may result from the polyphagous nature of this pest, which are not necessarily living within the vegetable growing area. The vast population in the mountain vegetation can constantly intermingle with the survivors from insecticide sprays and hence relieve the selection pressure.

Conclusions drawn from this investigation are that the synthetic pyrethroids are still effective in controlling the three studied pest species. The efficiencies of organophosphorus and carbamates are still good for the imported cabbageworm control but need to be re-evaluated in the cabbage looper and the tobacco cutworm. Third, the tobacco cutworm is definitely developing resistance to insecticides in many intensively cultivated regions.

References

1. 蘇智勇 羅士 1977 合成除蟲菊劑防治十字花科蔬菜害蟲之田間試驗。植物保護會刊19：13—20
2. AVRDC Progress Report. 1975. pp. 37-40.
3. AVRDC Progress Report. 1976. pp. 51-59.
4. Boling, J. C. 1972. Insecticidal control of cabbage looper in small field plots. J. Econ. Entomol. 65 : 1737-1738.
5. Cheng, E. Y. 1981. Insecticide resistance study in *Plutella xylostella* (L.) II. A general survey (1980-81). J. Agric. Res. China 30 : 285-293.
6. Chou, T. M. and E. Y. Cheng. 1983. Insecticide resistance study in *Plutella xylostella* (L.) III. The insecticide susceptibilities and resistance response of a native susceptible strain. J. Agric. Res. China 32 : 146-154.
7. Greene, G. L., W. G. Genung, R. B. Workman and E. G. Kelsheimer. 1969. Cabbage looper control in Florida-A cooperative program. J. Econ. Entomol. 62 : 798-800.
8. Greene, G. L. and R. B. Workman. 1971. Cabbage looper control on collards in Florida. J. Econ. Entomol. 64 : 1331-1332.
9. Hale, R. L. and H. H. Shorey. 1972. Cabbage looper control on cole crops in southern California : granular systemic insecticides in soil indicate lack of promise. J. Econ. Entomol. 65 :

1658-1661.

10. Harris, C. R. and H. J. Svec. 1969. Laboratory studies of the contact toxicity of some insecticides to cabbage loopers. J. Econ. Entomol. 62 : 1013-1016.

11. Judge, F. D. and F. L. McEwen. 1970. Field testing candidate insecticides on cole crops for control of cabbage looper and imported cabbageworm in New York state. J. Econ. Entomol. 63 : 862-866.

12. Plant Protection Manual. 1982 ed. pp. 86 Department of Agricultural and Forestry, Prov. Gorn. of Taiwan, Rep. of China.

十字花科蔬菜三種鱗翅目害蟲抗藥性之探討[1]

周桃美 高靜華 鄭 允[2]

摘 要

本省歷年來蔬菜之蟲害保護工作多仰賴殺蟲劑，以致近年來害蟲相較趨於單純，但使用藥劑時，常有效果減退之現象發生。查其原因，可能係害蟲已對常用殺蟲劑產生不同程度之抗藥能力，小菜蛾，*Plutella xylostella* (L.)，即是一已經證實且抗藥問題極嚴重之十字花科蔬菜害蟲。此外，在十字花科蔬菜上經常發生的鱗翅目害蟲尚有紋白蝶，*Pieris rapae* Boisduval、斜紋夜盜 *Spodoptera litura* Fabricius及擬尺蠖 *Trichoplusia ni* Hübner。爲瞭解後三種害蟲是否亦對殺蟲劑產生某種程度之抗藥力，乃進行本研究。

研究結果發現，本省各地採得之紋白蝶對四種常用殺蟲劑，美文松 (Mevinphos)、加保扶 (Carbofuran)、百滅寧 (Permethrin) 及芬化利 (Fenvalerate)，均極爲敏感，無抗藥性產生之跡象，因此利用化學藥劑防治紋白蝶，仍爲經濟可行而無抗藥性顧慮之防治方法。而擬尺蠖則對美文松、加保扶均不甚敏感，根據美、加地區之試驗結果報導，上述兩種藥劑對擬尺蠖之防治效果亦不甚良好；所測得之芬化利及百滅寧對擬尺蠖則無優良殺除效果。就斜紋夜盜而言，在所採得樣品中已明顯地發現，某些蔬菜密集生產地區之斜紋夜盜已經對常用殺蟲劑產生極高之抗藥性，溪湖地區即爲明顯之例證，該樣品較敏感品系對加保扶、美文松之抗藥力分別高出79倍及63倍，對合成除蟲菊精類殺蟲劑亦有輕微之抗藥性。斜紋夜盜對不同殺蟲劑產生之抗藥程度，依地區有甚大之差異，但一般而言除蟲菊精類仍有相當好的防治效果；約有半數取樣地區之斜紋夜盜已對美文松產生中等程度以上之抗藥性；而加保扶之防治效果已明顯地消退。本研究之結論爲：暫時使用合成除蟲菊精類殺蟲劑，仍爲防治此三種鱗翅目害蟲之通用辦法；若採用有機磷劑或氨基甲酸鹽劑作爲防治藥劑時，必須密切注意該地區此等害蟲抗藥性之發展。

1.臺灣省農業試驗所 研究報告第1174號。本計畫承行政院農業發展委員會補助，編號爲 71—4.1—117(05)，謹致謝忱。

2.本所應用動物系計畫助理、助理及研究員。臺灣省 臺中縣 霧峰鄉。