Discussion

E. D. MAGALLONA: I find your results with mevinphos interesting because it agrees with our own work in the Philippines. Based on your results would you suggest that mevinphos be used as a reference material in DBM resistance studies.
E. Y. CHENG: Yes, but one must standardize the test condition because different insecticides show different initial and residual effect. Mevinphos will be a good standard for short spray interval tests.

N. S. TALEKAR: Is the existence of susceptible strain in I- lan due to less pesticide use there?
E. Y. CHENG: Yes, the I-lan area has high annual precipitation which reduces the persistence of pesticide residues on the treated plants. This in turn reduces the insecticide selection pressure.

H. CHI: In general, the relationship between cv and sample size is dependent on population density and distribution pattern. However, you concluded that a sample size of 5 gives about 10% cv disregarding population density. Any comment?
E. Y. CHENG: We did not disregard the population density factor. We established insecticide resistance information for 16 locations in one area as the sample population and found that by sampling five of them we could get a cv of about 10%. It is a practical way to reduce the sample size to save time and labor, and still get information accurate enough to reflect field condition.

H. CHI: Based on findings of your experiments in the laboratory, have you conducted any experiments at specific locations where DBM has developed resistance to insecticides? If so what are your results?
E. Y. CHENG: Most of our field study was carried out in TARI's farm which is located in Taichung. The DBM population in this area is resistant to most insecticides. Generally, our laboratory finding fit very well with the test of DBM resistance on our farm.

A. SAGENMUELLER: In your conclusions you are recommending alternative spraying of products with different modes of action. The sequence may be quite complicated in practice. Does it mean that mixtures of these compounds are less suitable to avoid or reduce the probability of resistance build-up?
C. N. SUN: Our recommendations are not that complicated once the principles are grasped. I even think they are quite suitable for 'package deal'. We have no data regarding the use of mixtures and resistance development.

B. MORALLO-REJESUS: What is the explanation for the effectiveness of MGK-264 against fenvalerate/piperonyl butoxide (PB) resistant DBM?
C. N. SUN: As a microsomal oxidase inhibitor, MGK 264 has different chemical structure from that of PB, a methylenedioxyphenyl compound. We assume that DBM selected with fenvalerate/PB develops a resistance to PB (and possibly other methylenedioxyphenyl compounds). Fortunately, DBM seems to retain its response to the synergistic action of MGK-264, and hopefully of other types of microsomal oxidase inhibitors.

B. ROWELL: You seem to have made a strong recommendation that we should use organophosphorus insecticides until they lose effectiveness. Is this not recommending the same old course that has been followed during the past 10 to 15 years? Would you still recommend these chemicals where parasitoids are important and in the light of safety hazards to the applicators?
C. N. SUN: Our recommendations are based solely on considerations of resistance development. It is definitely important than an integrated approach be made.

H. GLASS: You said that DBM has 'little or no resistance to IGRs'. What does little resistance mean?
C. N. SUN: Our limited data show that some IGRs, such as IKI- 7899, are effective against both susceptible and field resistant strains of DBM. But it is still more effective against the susceptible strain. CME 134 is also very effective according to what I saw in the AVRDC farm during yesterday's field trip.

N. S. TALEKAR: Is there any health hazard associated with the use of PB in the field?
C. N. SUN: PB was reported to be cocarcinogenic in mice (Epstein et al. 1967. Nature 214:526-528). But I am not aware of any serious concerns regarding any possible health hazards.

G. S. LIM: The suggested rotation and change of insecticides for overcoming some of the insecticide resistance problems certainly looks very reasonable. However, in your presentation you do not put any indicative value on the degree of the resistance that may be used as a guide for making the relevant decision of change. Do you have any suggestions for such values?
C. N. SUN: It is quite easy to detect the onset of resistance in the laboratory. However, it is not so easy to make observations in the field. Our data show that one to two generations of selection with pyrethroid fenvalerate are sufficient to lower the effectiveness significantly. So, one may have to shift right away to organophosphorus compounds before actually observing the failure of the third spray. It takes six to eight generations of selection with pyrethroid/PB before an apparent decrease of effectiveness of this combination appears in the laboratory. Subsequently, this combination may be applied for a longer period of time in the field. I have to remind you again that the validity of our recommendations has not been tested in the field. And we would like to know the outcome of such a test in case anyone would like to try.

G. S. LIM: Different authors use different susceptible strains such as French strain, I-lan strain, Penghu strain, Japan strain of DBM for base comparison. Is it necessary to standardize the susceptible strain? What are the advantages of such exercise? How should we go about doing it?
C. N. SUN: It is helpful in the study of resistance mechanisms to have a standard susceptible strain of DBM, like the NAIDM strain for housefly work. On the other hand, it is not a bad thing to retain a few (not too many) susceptible strains from locations quite apart from one another. They may have unique genetic make-up with regard to their responses to insecticides.
T. MIYATA: If we have a standard susceptible strain, it is very easy for us to compare the data obtained at different locations. But the problem is how we can get a standard susceptible strain. If you compare the susceptibility of susceptible strains used by different institutions, you can find some differences. Another problem which would be solved is the plant quarantine one. Even if we do not have a standard susceptible strain, if the strain is susceptible to certain insecticides, we can use it as a susceptible one.

E. Y. CHENG: I agree with you that it would be most desirable to have standard susceptible strain for all studies. The advantage will be an easy comparison of research results from different labs. I really do not know how to have everybody to cooperate on this, but cooperation is essential in selecting a standard strain.

N. WILDING: Dr. Cheng stated that there was crossresistance between organophosphorus and synthetic pyrethroids; Dr. Sun that there was not. Of course, different labs obtain different results but this seems to be a very fundamental point. Has anyone else any relevant information?
C. N. SUN: I think this inconsistency of results is inevitable when the study of DBM resistance is so scanty. Think of studies of housefly resistance that started only a couple years after the second World War. This insect deserves more attention from the research than it has received.
T. MIYATA: In Japan, Miyata et al (1982), Noppun et al (1983) and Hama (1984) reported that there was no crossresistance between organophosphorus insecticides and synthetic pyrethroids. Crossresistance is recognized in two different ways. In a narrow sense, the same gene(s) controls resistance for different chemicals. In a wide sense, crossresistance is a phenomenon obtained only from mortality data. In some cases the crossresistance may not be controlled by the same gene(s). When only one major gene is responsible for crossresistance, we may get the same results from different strains. However, when different genes are responsible for crossresistance, it is easy to understand that we get different results from different strains. Resistance is thought to be an evolutionary phenomenon; different strains with a different history of insecticide treatment may show different phenomena of crossresistance. Unfortunately we have no information about the genes responsible for resistance.
E. Y. CHENG: We stated that crossresistance exists between synthetic pyrethroids and some organophosphorus, but it is not a general phenomenon. We do believe that more research effort is needed in this aspect. We have also doubts about the crossresistance between synthetic pyrethroids and carbamates, although both were detoxified mainly by mixed function oxidase. There is certain specificity in MFO to detoxify different carbamates; for example, I-lan strain DBM is highly susceptible to synthetic pyrethroids and carbofuran but is rather insensitive to carbaryl.
M. SAKAI: Few cases of resistance development have been found for cartap in spite of its wide use in Japan. On the other hand, quite rapid resistance development has been reported in tropical countries. Probably the difference in the speed of resistance development between different regions depends on the type of insecticides and duration of their use before the introduction of newer chemicals. Further studies on genetics and on the biochemistry of DBM insecticide resistance should be conducted to clarify the aspects of the resistance.

S. A. RAHMAN: In toxicity and resistance studies different workers use different methods. I would like to know which method is most suitable and whether it is possible to agree upon a standard bioassay method.
E. Y. CHENG: I do not think it is necessary. The bioassay method to be used should depend on what the final objective of the study is. In a practical field study, commercial grade pesticides diluted in water as test spray will provide you much more direct information than the insecticide/acetone solution in the topical application method. In the resistance mechanism study, the situation is different.
C. N. SUN: I think FAO proposed topical application as the standard bioassay method for DBM. We have been routinely using spraying, and lately have also tried the residual film (on glass surface) method. Results from the two methods on pyrethroids are well correlated. Topical application requires CO_2 anesthetization or lowering of

temperature. We have found the residual film method suitable to observe the knockdown effect of pyrethroids against DBM. But with compounds of different properties, they may not apply. For instance, to test IGRs will require a different bioassay method.
Y. I CHU (COMMENT): I-lan county of Taiwan is a special area from the point of view of insect distribution. We observed this in the case of brown planthopper. It is possible that there is a separate DBM strain.
C. N. SUN: Here the definition of strain is rather dubious. But I am in no position to discuss that. It has generally been believed that less insecticides have been used in the I- lan area, for the control of DBM, brown planthopper and possibly other insect pests. But there is no actual data (record of insecticide usage) to support this statement.
E. Y. CHENG: We used the I-lan strain as the native susceptible strain for all the resistance simultion study. We have obtained satisfactory results in terms of selection of strain resistant to organophosphorus insecticides. But we are not yet successful in the case of synthetic pyrethroids. The reason for this is not clear so far.

R. S. REJESUS: What is your prediction or speculation regarding DBM developing resistance to *Bt*?
C. N. SUN: Devriendt and Martouret (1976. Entomophaga 21:189- 199) reported that selection for 10 generations of the 4th instars of DBM did not result in significant resistance to *Bt*. However, I tend to think that if *Bt* were used on a scale comparable to that of the synthetic insecticides, DBM might become just as resistant.

H. T. FENG: For the practical purposes of DBM control in the field, comparing the susceptibility of a strain with a specific dose is more appropriate than the use of RF values to clarify the impact of resistance on the effectiveness of an insecticide. Any comment?
C. N. SUN: A laboratory test including the construction of a concentration-mortality curve is meant to give a more accurate estimation of the susceptibility of a certain population. Using only one dose to compare the susceptibility inherently is subject to much greater error. One, of course, should be constantly aware of the limitations of applying laboratory data to the field.
T. MIYATA: As a initial step to monitor the existence of resistance, to use a specific dose will be helpful. But to get more information about the resistance, more detailed toxicity tests are required.
E. Y. CHENG: It has always been our point of view. For susceptibility test we usually use formulated insecticides, diluted in water at different concentrations. This provides not only the information on resistance, but also on the effective dosages for field practice.

N. S. TALEKAR: Despite the widespread use of cartap, DBM doesnot seem to have developed strong resistance to it. What are the reasons?
C. N. SUN: Since the chemical structure of cartap is quite unique and its mode of action is different from that of conventional insecticides, the insect may have to muster up additional weapons from its arsenal to cope with it. Our work indicates about 200-fold difference in cartap susceptibility between the FS strain and the resistant BC strain. Besides, the usage of cartap in the field is hardly comparable to that of OP, and pyrethroids. Consequently, the selection pressure of cartap has been much less.
M. SAKAI: Yes, in Japan, despite widespread use of cartap the level of resistance in DBM to cartap is insignificant. We have data on cartap selection studies with *Chilo suppressalis*, which showed a resistance factor of only 1.2 to 1.3. My hypothesis to explain this is as follows: insects poisoned by cartap can revive if they are in favorable conditions for survival. In the field poisoned insects are exposed to unfavorable circumstances and die. Even susceptible strains probably have an enzymatic detoxication mechanism, but

have little room to develop resistance after cartap poisoning in the field because of their rapid death.

S. A. RAHMAN: Since DBM has developed resistance to commonly used insecticides, I would like to know from chemical industry as to what will be their approach. Will it be IGRs or new pyrethroids or just follow Dr. Sun's recommendations of rotating the compounds?
P. WEBER: What kind of strategy should the chemical industry adopt with respect to DBM control? It is not easy to give a general answer. It depends on the range of products a company has to offer. At present IGR compounds are gaining popularity with vegetable farmers. However, continuous use of these compounds may not be the right strategy. It would be desirable if we could include them in a spray rotation with conventional chemicals some of which are still effective, but use of them alone will lead to the inevitable development of resistance. Rotation will delay development of resistance to IGR as well as conventional chemicals.

A. SIVAPRAGASAM: What do you mean by percent control?
R. YEH: The percent control shown in my slides is adjusted from the number of live insects before and after application of the target chemical and is computed by the Henderson and Tilton Formula.
J. L. LIM (COMMENT): Mr. Sivagaprasam brought up the subject of percent control. Results expressed as percent control are relative, they are only ratios. For example: one larva on a treated plot and 10 on a check plot is 90% control; 10 larvae on a treated plot and 100 on a check plot is also 90% control; 0.1 larvae on a treated plot and one on a check plot also 90% control. Thus unless the data expressed in this form is supported by damage rating and yield, it would appears to be rather meaningless in field trials.

M. SAKAI: How effective is deltamethrin + *Bt* combination against insecticide resistant DBM?
R. YEH: After continuous applications of deltamethrin + *Bt*, the DBM populaton is still there but it is less than on untreated plants and most of them, I would say more than 90%, are restricted to the lower part and unproductive leaves.

S. SUDARWOHADI: Your conclusion does not indicate the type of synergistic effect of deltamethrin and *Bt*. You used much higher rates of deltamethrin (12.5 g AI/ha) and *Bt* (1 kg product/ha). Any comment?
R. YEH: The effects of deltamethrin and *Bt* are quite independent of each other; there is additive effect between them, not synergistic. To have satisfactory control of DBM, deltamethrin applied at 12.5 g AI/ha and *Bt* applied at 1 kg, product/ha is quite reasonable. Besides, to obtain the additional repellent effect to restrict DBM larvae to the lower and unproductive part of the plant, the dose at 12.5 g AI/ha is certainly necessary.

V. HARRIES: You mentioned the antifeeding effect of deltamethrin which forces DBM larvae to the lower parts of the plant. Do not you consider these larvae as potential re - infestation source?
R. YEH: Yes, I agree that DBM larvae restricted to the lower plant parts might be the source of re-infestation. That is why it is necessary to apply the mixture at weekly interval during the whole crop growing period.

V. HARRIES: What method did you use to assess the number of adults landing on a cabbage plant?

R. YEH: In the open field, patting the randomly selected cabbage head in an unit area, such as an experimental plot, and counting the number of adults flying out from it was used in our observations. It is important to avoid to sample two adjacent plants as well as taking more than one observation in a single day in the same plot.

P. A. C. OOI: You mentioned an increase in fecundity of about two times due to stimulation by methomyl application. Do you think this is sufficient to account for the resurgence of the DBM population in the field? How important is this factor as compared to the differential mortality between predators and prey?
H. NEMOTO: The application was made only once. I think it is not sufficient to account for the resurgence in my case. Predator mortality is more important.

H. CHI: Why did you express the finite rate using the time unit 'month'?
H. NEMOTO: This is because DBM lifespan in Japan, especially in spring and autumn, is one month.

Y. I. CHU: Do you have any data regarding the mortality of predators by insecticides, such as accumulation of insecticide in the predator's body, or inactivation of predatory behavior?
H. NEMOTO: I have not examined it yet.

S. SUDARWOHADI: Did you also apply methomyl to the cabbage plants and does it have any effect against the resurgence of DBM?
H. NEMOTO: I have not examined it yet. Because it is difficult to divide the stimulating influence of the pesticide on the pest directly from that achieved via the plant.

N. WILDING: It is very interesting that in the laboratory methomyl treatment increased the fecundity of the insect and the fertility of the eggs. Did you study the survival of the larvae?
H. NEMOTO: No, not yet.

O. MOCHIDA: H. Nemoto presented a paper on resurgence of DBM due to methomyl. Do you have any information on resurgence of DBM to insecticides other than methomyl?
C. N. SUN: No.
T. MIYATA: No, I have not.
E. Y. CHENG: We did not study in this area, but we are looking forward to this kind of study and cooperating with the specialists in Taiwan.