CONTROLLING INSECT PESTS OF STORED TOBACCO BY REDUCING THEIR REPRODUCTIVE POTENTIAL

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INTRODUCTION: Tobacco, a high priced agricultural commodity, is subjected during storage to devastating infestations of Lastoderma serricoarne (F.), commonly known as the cigarette beetle or tow bug, and Ephesia elutella (Hübner), the tobacco or warehouse moth. The length of the tobacco storage period, which may vary from one and one-half to three years, and the types of storage structures employed, provide these insects with many opportunities to invade the commodity and establish large colonies unless checked by the use of chemical pesticides.

During preparation for storage, the tobacco is exposed to steam-vacuum and re-drying treatments, which, if properly conducted, result in the death of all stages of all infesting insect species. However, after the tobacco has been placed in storage, it is subject to attack by either L. serricoarne or E. elutella, the degree of infestation depending on tobacco type, container makeup, and warehouse construction. In some instances, the infestation potential is reduced by segregating new tobacco stocks from old, or leaf from stems, and with the use of liners or wrappers that either prevent or limit entry by these two insects into the stored tobacco. Generally, however, the container and their contents permit infestation to take place throughout the entire warehouse complex.

In recent years, chemical control methods for insect infestation in stored tobacco have included the application of pyrethrins, DDVP (Dichlorovos, Vapona) and phosphine (Phostoxin, Delia). Pyrethrum, a botanical contact insecticide of limited capability has not been used as often as DDVP. This latter chemical kills by vapor and contact action, and has been used advantageously in warehouses which are not airtight. However, it has definite limitations, for it can reach and kill only those insects found in the warehouse airspace, and cannot penetrate hogsheads, bales, liners, and cases to kill the insect forms living within the tobacco. Phosphine fumigant is employed to give total kill of infesting insects in and out of the commodity, but airtight warehouses are mandatory for its proper use. The minimum phosphine fumigation period at the exterminating concentration of 200 ppm is forty-eight hours. Following fumigation re-infestation by either the beetle or moth may take place immediately if the temperature of the commodity and surrounding air is above 18°C.

BIOLOGICAL POTENTIAL: Both the beetle and moth have two and one-half to three generations a year in the tobacco storage and
processing areas of the United States. The rate of increase of *L. serricorne* breeding in various food materials has been studied by a number of researchers. Howe (1) has given an excellent review of the literature on this subject, including population figures based on actual warehouse data and on theoretical calculations. Some of the factors that influence the rate of population growth are the temperature and relative humidity (R. H.) ranges within the commodity and warehouse, and the types of tobacco, storage containers, their liners, and warehouse structures employed. The sum total of these factors has an impact on the number of generations per annum of *L. serricorne* that can be produced, and on the rate of increase per generation.

As already noted, both counting and formulae methods have been employed to determine beetle population increases. On a theoretical basis, Howe (1) estimated that at about 25°C-27°C and at a R. H. of 70%, a stable population of *L. serricorne* was capable of increasing by about 60% every week. Warehouse data on rate of increase gave values ranging from 20 to 50% per week. In one instance, Jepson (2) found that one pair of beetles gave 2000 descendants in four months when protected from natural controlling factors. This number represents a 50% weekly increase.

The number of generations per year for *L. serricorne*, as given in the literature (1, 3) varies from one to seven. In the U.S., it ranges from a low of two and one-half in the tobacco processing areas to a high of five or six in some of the southern growing areas. The temperature and relative humidity ranges within each geographical area dictates the number of generations developed per year. The average number of eggs deposited by the female beetle in the U.S. has been reported as varying from 45 to 116.

The biotic potential of the cigarette beetle can be determined from these data. If we assume that the median number of eggs laid per female is 80, that the mean egg mortality to be about 20% (from laboratory studies), that the environmental stress (ES) (e.g., diseases, predators, parasites, unfavorable microclimate, etc.) produces a 50% mortality in the surviving larvae and that the surviving adults have a 1:1 sex ratio, we obtain the following biotic potential formulae for each generation (Fn):

\[ F_1 = \frac{(\text{Median Egg No.}) - (20\% \text{ Nonhatch}) - (50\% \text{ Larval Loss to ES})}{2} = \frac{80}{16} = 32 \]

\[ F_2 = \frac{\text{No. } F_1 \text{ Adults}}{2} \times (\text{Median Egg No.}) - (20\% \text{ Nonhatch}) - (50\% \text{ Larval Loss to ES}) \]

\[ F_3 = \frac{\text{No. } F_2 \text{ Adults}}{2} \times (\text{Median Egg No.}) \text{ etc.} \]

By the end of one season, or three generations, the larval figure can read 16,384 or 8,192 surviving adults.
As can be seen, by the end of the second year of storage or sixth beetle generation (F₆), the descendant adults could number in the millions.

In the case of the tobacco moth, its biotic potential in the field is more difficult to project. The median number of eggs deposited by the female moth is well over 100, and the number of generations per year is three in the tobacco storage and processing areas of the U.S. However, the moth larvae that hatch face a more formidable road to adulthood than do the beetle larvae. The latter remain within the containers to pupate, but the former leave the commodity in which they have been hidden and seek out free spaces to form their pupal cases. They are, therefore, more exposed to external environmental stress factors than the beetle larvae. Nevertheless, the moth has on numerous occasions demonstrated its potential for developing large numbers of very destructive larval infestations, especially in baled tobacco.

RATIONALE AND METHODS: The cigarette beetle control programs in the tobacco storage areas of the U.S. are generally conducted from the middle of April to the middle of October, and an individual warehouse may receive from 120 to 170 separate applications of DDVP during this period, depending on whether they are made with manually operated equipment, or by automatically operated dispensers, respectively. The dosage rate for manual delivery ranges from 0.5 gram to 0.75 gram per 28.32 cubic meters (1000 cubic feet) five days a week, or 0.5 gram per 28.32 cubic meters per day for automatic application.

A medium sized warehouse of approximately 17,668 cubic meter capacity (500,000 cubic feet) exposed to either manual or automatic treatment receives well over 50 kilograms of actual DDVP per season. In addition, if the warehouse is of the sealed type, it may also receive one fumigation per year with phosphine at a treatment level of 22 grams of phosphine per 28.32 cubic meters, or 13.7 kilograms per 17,668 cubic meters.

Without question, the continuous use of these two insecticides contributes greatly to suppressing the cigarette beetle population, but by no means does it prevent initial infestations, or re-infestation of the stored tobacco after aeration has been completed.

The ideal pesticide for the control of insects attacking stored tobacco obviously would be one that when applied to the commodity at the time it is packed for storage would destroy any eggs deposited by visiting female adults, or kill the first instar larvae that emerge from the eggs. The pesticide should be harmless to man, not affect the smoking quality of the tobacco, and be effective for the duration of the storage period. There are proprietary residual insecticides available, such as the chlorinated hydrocarbons and carbamates, that do function as ovicides or larvicides. However, their use is not permitted for
many reasons, including their toxicity to man and their deleter-
ious effect on the smoking quality of the tobacco.

A review of the literature on the use of insect growth
regulators (IGRs), a class of chemicals added to the family of
pesticides within the past decade, indicated that methoprene
(also known as ALTOSID\textsuperscript{(R)}) , a commercially available product,
would warrant study as a control for stored tobacco pests (4).
Investigations conducted over a period of three years at labora-
tory, pilot plant, and commercial levels have shown that this
chemical holds promise as a population control agent for
\textit{L. serricorne} and \textit{E. elutella} (5, 6). Large scale hoghead tests
have been conducted with the former species under an experimental
permit granted to the manufacturers of methoprene by the U.S.
Environmental Protection Agency.

Methoprene does not behave as an ovicide or even as a
total larvicide, but it does prevent the last instar larval form
of both insect species from developing into normal pupae or
adults. It therefore limits the initial infesting cycle of a
gravid female to less than one generation. A single application
of this IGR at 10 ppm to tobacco prior to packing in hogsheads
has prevented the development of \textit{L. serricorne} larvae into first
generation adults for a period exceeding two years. Laboratory
trials with \textit{E. elutella} have shown it to be more susceptible to
methoprene than \textit{L. serricorne}.

CONCLUSIONS: Although methoprene does not meet all of the
criteria for the ideal stored tobacco control agent, it does
possess the following positive characteristics:

1) All toxicity studies indicate that it offers no
hazard to man or the environment (4).

2) It has no deleterious effect on treated tobacco
when employed at the experimental level of 10 ppm.
Cigarettes made from treated tobacco were undetect-
able from control cigarettes in smoking panel
tests.

3) At the 10 ppm application level, residues on
tobacco have been effective for over a two-year
storage period.

Therefore, the possibility exists that a new agent may
be added to our integrated control program for pests of stored
tobacco, one that will severely reduce the reproductive potential
of both \textit{L. serricorne} and \textit{E. elutella}.

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