

# INSECTICIDAL VALUE OF PHOSPHINE IN THE CONTROL OF STORED TOBACCO INSECT PESTS

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**INTRODUCTION:** Control of the tobacco moth and the cigarette beetle (*Ephestia elutella* Hübner and *Lasioderma serricornis* F.) is a very serious problem in the modern tobacco industry, especially when tobacco is stored for years in warehouses. Modern warehouses for stocking of dry tobacco, particularly the chambers for maturation with fixed temperature, provide especially favorable for insect development.

For many years the study of the efficiency of various fumigants for the control of stored tobacco insect pests in our country and the world. However recently there has been an increase in the research effort on the problems of stored tobacco insect pests. Among all methods used (mechanical, biological, and chemical) for control of pest insects in warehouses, the chemical method is most widely used in practice [1,2,3,4,5,6]. Over the years many different fumigants were used such as carbon disulphide, sulphur-carbon, acrylonitrile (carbon tetrachloride mixture), methyl bromide, hydrocyanic acid, ethylene oxide, DDVP. However recently hydrogen phosphide (phosphine), in a form of "Phostoxin" tablets or pellets is often used.

Our investigations during 1959 [7] with ethylene oxide (T-gas) in rate of 100 g/m<sup>3</sup> and chamber temperature of 17° C with relative humidity of 60% have given excellent results with 100% mortality of *Ephestia elutella* larvae exposed in the interior of bales for a period of 24 hours. A rate of 51 g/m<sup>3</sup> of this fumigant have shown to be unsatisfactory. The standard toxic fumigants (hydrocyanic acid, methyl bromide, acrylonitrile, and others) have presented serious obstacles in fumigating warehouses of the tobacco industry; due to the openness of the warehouses, danger to applicators, and difficulties in penetration of the fumigant into the interior of the "tonga" bales. The use of phosphine, formulated in tablet or pellet form, could solve many problems due to simplified application.

The use of phosphine in the control of warehouse pests on tobacco in our country was begun in 1959. Based on our study of phosphine efficiency [7] this pesticide has found large applications in the control of stored tobacco pests, *Ephestia elutella* and *Lasioderma serricornis*.

**MATERIAL AND METHOD OF WORK:** Based on the literature available, there are not many references to Phostoxin (phosphine) studies and its application on the warehouse tobacco pest control. In the summary of Bruel and Bollaerts [1] it has been pointed out that Phostoxin could be used not only in the control of warehouse granary

pests, but also in the control of meat, cheese, and tobacco pests during the period of their storage. According to Childs et al. [8], tobacco removed from cigarette beetle-infested hogsheads after phosphine fumigation contained no living larvae, pupae, or adults. Takaoka and Naito [9], in their investigations, established that 3 to 5 days' exposure to phosphine evolved from a dosage of 30 tablets per 1,000 ft<sup>3</sup> controlled all stages of the cigarette beetle and tobacco moth in warehouses. Kuhn et al. [10] has stated that an extremely high dosage of 5 tablets per m<sup>3</sup> of Phostoxin produced a marked alteration of the smoking character of all types of treated tobacco.

In the course of our investigations, we conducted tests for the control of *Ephestia elutella* Hb. and *Lasioderma serricorne* F. under normal warehouse storage conditions on tobacco bales in 3 localities and on 3 Oriental tobacco types as: "Yaka," "Otlja," and "Dzebel." These tests were made in 1968, 1971, and 1973.

The stores had been humidified by air conditioning the tobacco 1-2 days prior to fumigation. The air conditioning system was stopped before treatment as Phostoxin tablets must be distributed on a completely dry surface.

Phostoxin tablets in a wooden case or on paper were placed on the floor or in the frames particularly distributed on the lowest stage frame where "tonga" or producer bales were stored. At the time of treatment, temperature of the tobacco was 18-23°C and relative humidity was 70-75%.

**RESULTS AND DISCUSSION:** Test 1 - Phostoxin in this test was applied at 1.06 tablets (1 g PH<sub>3</sub>) per m<sup>3</sup>. Volume of the chamber treated was 3,600 m<sup>3</sup>. The air temperature was 22° C and the relative humidity 75%. The chamber was charged with "tonga" and "yarma" bales placed on wooden frames of four shelves. On every shelf in the chamber there had been placed diagonally 25 larvae of *Ephestia elutella*. Glass flasks covered by wire net contained larvae and a small quantity of tobacco were also placed in the midst of the "tonga" and "yarma" bales to test the efficiency of the phosphine. The insects were exposed to phosphine for 68 hours. Forty-eight to 72 hours after fumigating, the efficiency of the pesticide was determined by the mortality of the larvae. The efficiency of the pesticide was also determined by inspection for live insects on "tonga" and "yarma" bales taken diagonally from each frame.

On the basis of the results referred to in Table 1, Phostoxin gave 100% mortality of *Ephestia elutella* exposed on "tonga" and "yarma" bales at various heights on the frames and killed all insects noted in the inspected tobacco bales.

Test 2 - In chambers with 17.087 capacity, in Kumanovo district, tests were conducted with Phostoxin at a rate of 1.07 and 0.97 tablets per m<sup>3</sup>. Ambient temperature was 21-22°C and the relative humidity was 70-75%. Sizes of "tonga" and "yarma" bales stored in the warehouses of this district ("Otlja" tobacco type) are by far larger than those evaluated in the previous test. Density of tobacco in bales has been an important factor in all the

TABLE I. Results of the efficiency of phostoxin in the control of *Ephestia elutella* Hb.:

Bales exposition with bio-tests in chamber	Larvae number	Mortality of larvae in bales in %		Temp. in cham.	% R.H. in chamber
		"Tonga"	"Yarma"		
On the floor	25	100	100	22°C	72
I shelf	25	100	100		
II shelf	25	100	100		
III shelf	25	100	100		
IV shelf	25	100	100		

Variants - 5  
 Treated m<sup>3</sup> - 3.600  
 Dose - 1.06 Phostoxin tablet/m<sup>3</sup>  
 Treated exposition - 68 hours  
 Locality - Resen, year 1968

investigations of efficiency of a number of pesticides used for the control of tobacco warehouse pests.

Test results referred to in Table 2 lead to the conclusion that the mortality of *Ephestia elutella* larvae was the same as in test 1. Inspected bales showed a 100% mortality with the three replications and the two dosage rates used.

TABLE II. Results of the efficiency of phostoxin in the control of *Ephestia elutella* Hb.:

Bales	Treated m <sup>3</sup>	Dose of tablets per m <sup>3</sup>	Mortality of larvae Repetitions			Temp. in cham.	% of R.H. in cham.
			I	II	III		
"Tonga"	11.175	1.07	100%	100%	100%	21°C	70
"Yarma"	11.175	1.07	100%	100%	100%	21°C	70
"Tonga"	5.912	0.97	100%	100%	100%	21°C	75

Treated exposition - 68 hours  
 Number of the *Ephestia elutella* Hb., larvae in bio-test 35

Test 3 - Test conditions were quite different from those applied in the two previous tests: Namely, our intention was to study the phosphine efficiency for the control of *Lasioderma serricorne* adult and larval stages. Flasks containing larvae and adults were placed in the interior of every second bale, with 8 bales stacked one over the other. This experiment was conducted to study the efficiency of phosphine and its penetration into the interior of bales of stored tobacco. The phosphine dosage for this test was a little higher than for the two previous tests, amounting to 1.5 tablets/m<sup>3</sup>. After 72 hours of exposure, mortality of larvae and adults of cigarette beetles was 100% in all samples

(Table 3).

TABLE III. Results of the efficiency of phostoxin in the control of *Lasioderma serricornis* F.

Exposition of bales one over the other in chamber	Number of glass flasks	<i>Lasioderma serricornis</i> number in bio-test		Mortality in %	
		Larvae	Imagos	Larvae	Imagos
		I	0	0	0
II	1	10	30	100	100
III	0	0	0	0	0
IV	2	10	30	100	100
V	0	0	0	0	0
VI	3	10	30	100	100
VII	0	0	0	0	0
VIII	4	10	30	100	100

"Tonga" Bales

Treated exposition - 72 hours

Dose - 1.5 tablets/m<sup>3</sup>

Locality - Skopje, Year 1970

Test 4 - This test was conducted to study the efficiency of the new phosphine formulation called "pellets." It was carried out in small chambers at the Tobacco Institute in Prilep. Exposure of insects to phosphine was for 120 hours. Flasks containing *Ephesia elutella* larvae were placed at various heights. This was done for the purpose of studying the distribution of the phosphine gas.

On the basis of these tests we could make the following statements: With a dosage of 1 pellet, 0.2 g. of phosphine per m<sup>3</sup>, and exposure of 120 hours, we found very low, nearly insignificant mortality of tobacco moth larvae. However, increased dosages of two, three, and five pellets (0.4, 0.6, and 1 g of PH<sub>3</sub> per m<sup>3</sup>) gave 100% mortality.

Besides investigating the efficiency of Phostoxin with its "pellet" formulations, we have studied its gas development intensity in treated chambers. Measurement of phosphine concentrations was with "Auer-Gas-Tester 5140," giving phosphine detection from 0.1-100 ppm, and with a tube detector 50/a(PH<sub>3</sub>) measuring from 100-1,000 ppm. Based on our measurements, we have come to the conclusion that the concentration of phosphine in an area treated with one tablet per m<sup>3</sup> was highest after 48 hours (400 ppm) at the temperature of 18°C. Phostoxin pellet registered the highest after 3-4 hours at temperatures of 20-12°C and relative humidities of 60-65% (Fig. 1). After exposure of 72 hours, the concentration had decreased to 20 ppm with the two formulations.

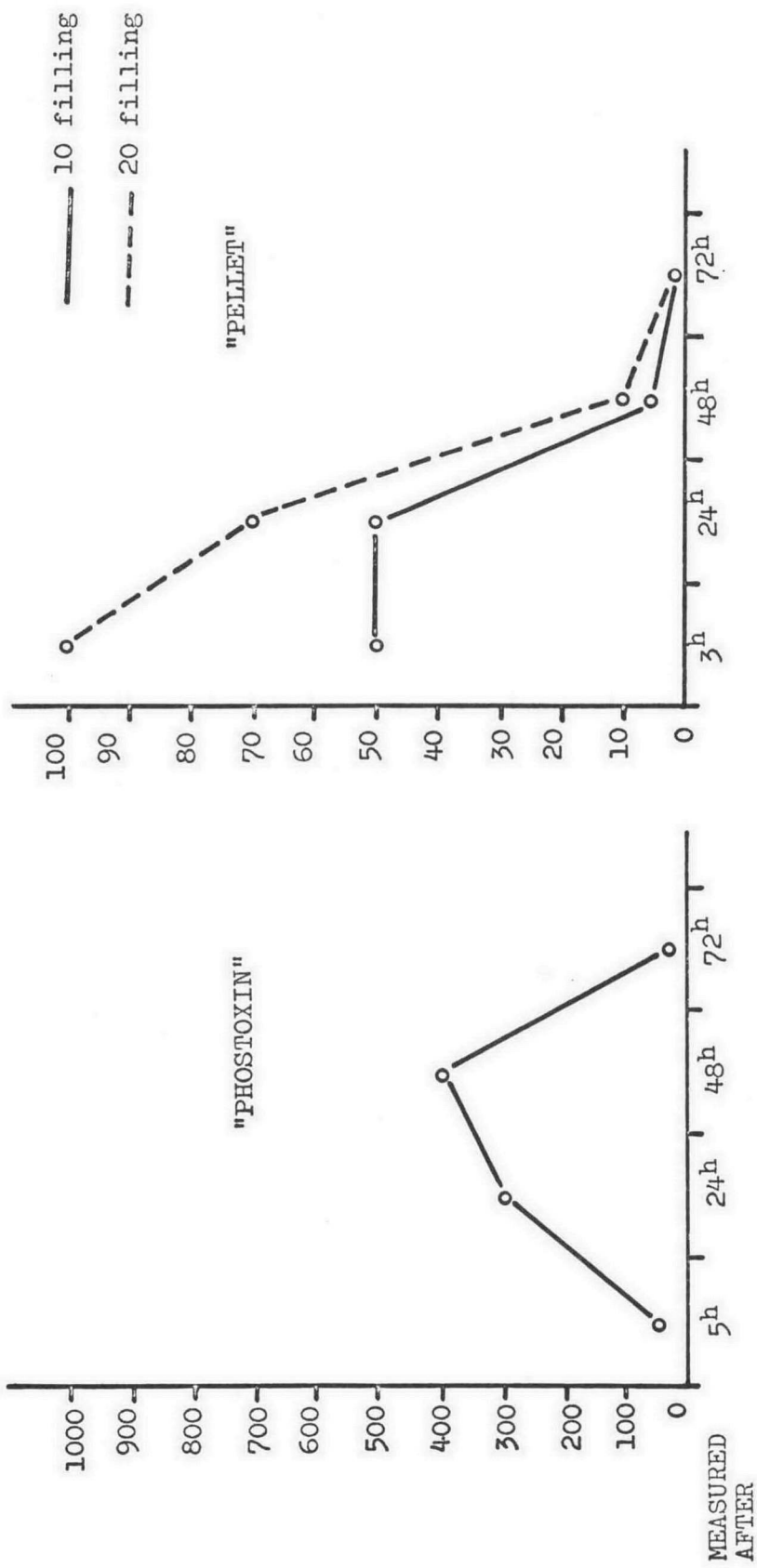


FIGURE 1. Contamination of phosphine in treated chamber measured by "Auer-Gas-Tested 5140"

**ANALYSIS OF RESIDUES:** Besides the investigations of hydrogen phosphide efficiency in control of stored tobacco pests, *Ephestia elutella* and *Lasioderma serricornis*, we have also carried out analysis of residues in treated tobacco--a very important problem in the current tobacco industry.

Determination of residues were made in the Degesch Laboratory in Germany as follows:

Design of tests:

- |          |   |   |
|----------|---|---|
| Control  | = | Untreated tobacco, type Oriental  |
| Test I   | = | Cigarettes ground exposure 72 hours treated with 3 pellets per m <sup>3</sup>                         |
| Test II  | = | Bales exterior, exposure 72 hours treated with 3 pellets/m <sup>3</sup>                               |
| Test III | = | Bales interior, 72 hours exposure, treated with 3 pellets/m <sup>3</sup>                              |
| Test IV  | = | Non-fermented tobacco, exposure 72 hours treated with Phostoxin tablets at rate of 1.4/m <sup>3</sup> |

The analysis was carried out according to the modified method of White and Buschey. On the basis of the results of this analysis in 1970, it was impossible to state if traces of hydrogen phosphide were present in treated tobacco.

**CONCLUSIONS:** Based on our investigations we conclude the following:

Hydrogen phosphide in formulations as Phostoxin in either pellets or tablets showed very high toxicity and could be successfully used for control of *Ephestia elutella* and *Lasioderma serricornis*, tobacco warehouse insect pests.

Tablets and pellets gave very strong phosphine penetration in all sorts of packing materials for tobacco (various) tests, thus proving high mortality.

A dose of one pellet, 0.2 g of PH<sub>3</sub> per m<sup>3</sup>, and exposure of 120 hours were nearly insignificant insecticidity to tobacco moth larvae. A dose of two, three, and five pellets, 0.4, 0.6, and one g of PH<sub>3</sub> per m<sup>3</sup>, gave 100% mortality in all variations investigated.

On the basis of the results of residue analysis, it was impossible to detect hydrogen phosphide in treated tobacco.

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