POST-HARVEST FUMIGATION OF TUBERS FOR THE CONTROL OF SWEET POTATO WEEVIL

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ABSTRACT

The use of ethylene dibromide (EDB) and phostoxin in controlling sweet potato weevil was evaluated. Larvae and pupae were effectively controlled when EDB was used at the rate of 32 ml/cu m. However, phostoxin at 10.5 tablets/cu m was more effective than EDB in controlling the different developmental stages of the weevil. This showed the greater potential of phostoxin in controlling the pest aside from its superior characteristics as compared to that of EDB. Phostoxin is less toxic (LD_{50} = 50 ppm) than EDB (LD_{50} = 20 ppm), and is easier to apply, hence, an inexpensive fumigation chamber could readily be rigged up in rural areas utilizing this fumigant.

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KEY WORDS: Sweet potato. Weevil. *Cylas formicarius elegantulus.* Fumigation. Ethylene dibromide. Phostoxin. Chemical control.

INTRODUCTION

Exploitation of the search for other crops besides the staple commodities as a source of high energy food has hastened the development of root crop production technology. Root crops possess promising attributes due to their high starch content and varied industrial uses. Aside from their economic importance, root crops, particularly sweet potato, have long storage life, hence are considered as the most important crops in the Philippines (Gonzales, 1955).

Sweet potato tubers can be stored from 4 to 6 months under favorable storage conditions. However, the tubers cannot be stored for long periods of time because of the damage caused by the sweet potato weevil *(Cylas formicarius elegantulus* Fabr.). This insect pest is considered the most serious pest of sweet potato both in the field and in storage. If weevil-infested tubers are stored with uninfested ones, it is likely that most of the tubers will soon be infested, if no preventive control measures are taken.

Control of sweet potato weevil is limited only to the use of insecticides and natural enemies in the field coupled with planting at appropriate seasons (Gonzales, 1955). Chemical control alone cannot provide satisfactory control of the weevil. Furthermore, the natural enemies and the seasonal conditions are not very effective in controlling this pest.

In storage areas, no attempt has been undertaken yet in controlling this insect pest by fumigation, although it is used extensively to control pests of stored fruits and cereals. Fumigation with 0.5, 1.0 or 1.5 g/cu m of ethylene dibromide (EDB) was effective against the eggs and larvae of fruit flies (Eaks and Sinclair, 1955; Claypool and Vines, 1956). On mango fruits, it was observed that fumigation using EDB at 0.25 g/cu m for 2 hr while at 0.5 g/cu m, and at temperatures ranging from 27°C to 33°C (Bergonia and Deloy, 1974), killed the larvae and pupae of the pest. Moreover, on orange and lemon fruits, EDB fumigation killed the eggs and caused the larvae of both the Oriental fruit fly *(Dacus dorsalis* Hendel and the Mexican fruit fly *(Anastrepha ludens* Coq.) sterile (Eaks and Ludi, 1958). On other crops, methyl bromide was used as a quarantine treatment against the potato tuber moth (Claypool and Vines, 1956) while ammonia gas fumigation was found to be effective in controlling rhizomes rot in peaches (Eaks *eat al.,* 1958).

Phostoxin is a fumigant that is toxic but with excellent penetrative power in controlling insect pests of stored commodities (BPI, 1978). It has an LD 50 of 50 ppm and is sold in pellets or tablets for more convenient use. It was recently found to be effective against the tuber moth for seed potatoes at a dosage of 15.75 tablets/cu m (personal communication at the Phil-German Seed Potato Program, Baguio City).

Due to the desirable characteristics and apparent effectiveness of EDB and phostoxin in controlling stored product pests, their effectiveness in controlling the sweet potato weevil attacking stored sweet potato tubers was tested. This study was conducted at the ASEAN - Postharvest Horticulture Training and Research Center laboratory, UP at Los Baños, Laguna, from January to February 1981 to determine the effectiveness of EDB and phostoxin as fumigants for controlling the sweet potato weevil.

MATERIALS AND METHODS

Construction of Fumigation Cham-

ber. — An improvised fumigating box (45 cm x 45 cm x 30 cm) was constructed using a wooden frame covered with 4-mil polyethylene film. During fumigation, the box was sealed with masking tape.

Treatments. — Sweet potato (BNAS-51) tubers infested with the weevil were selected, cleaned and used as sample materials for the fumigation test. Twenty-five tubers were used per treatment. Both ends of each tuber was cut for 0.5 cm using a sharp knife to determine the presence of larvae, pupae or adult of the sweet potato weevil.

The treatments used were as follows:

F_0 = control (no fumigant applied)
F_1 = EDB at 10.7 ml/cu m
F_2 = EDB at 21.3 ml/cu m
F_3 = EDB at 32 ml/cu m
F_4 = Phostoxin at 10.5 tablet/cu m
F_5 = Phostoxin at 21.0 tablet/cu m
F_6 = Phostoxin at 31.5 tablet/cu m

All the treatments were replicated 3 times and arranged in a completely randomized design.

Fumigation with EDB. — Before fumigation, the tubers were placed inside the box frame and covered with a polyethylene film shaped to fit the frame. A 15-cm high improvised wire stand was placed inside the box to support the cup-shaped

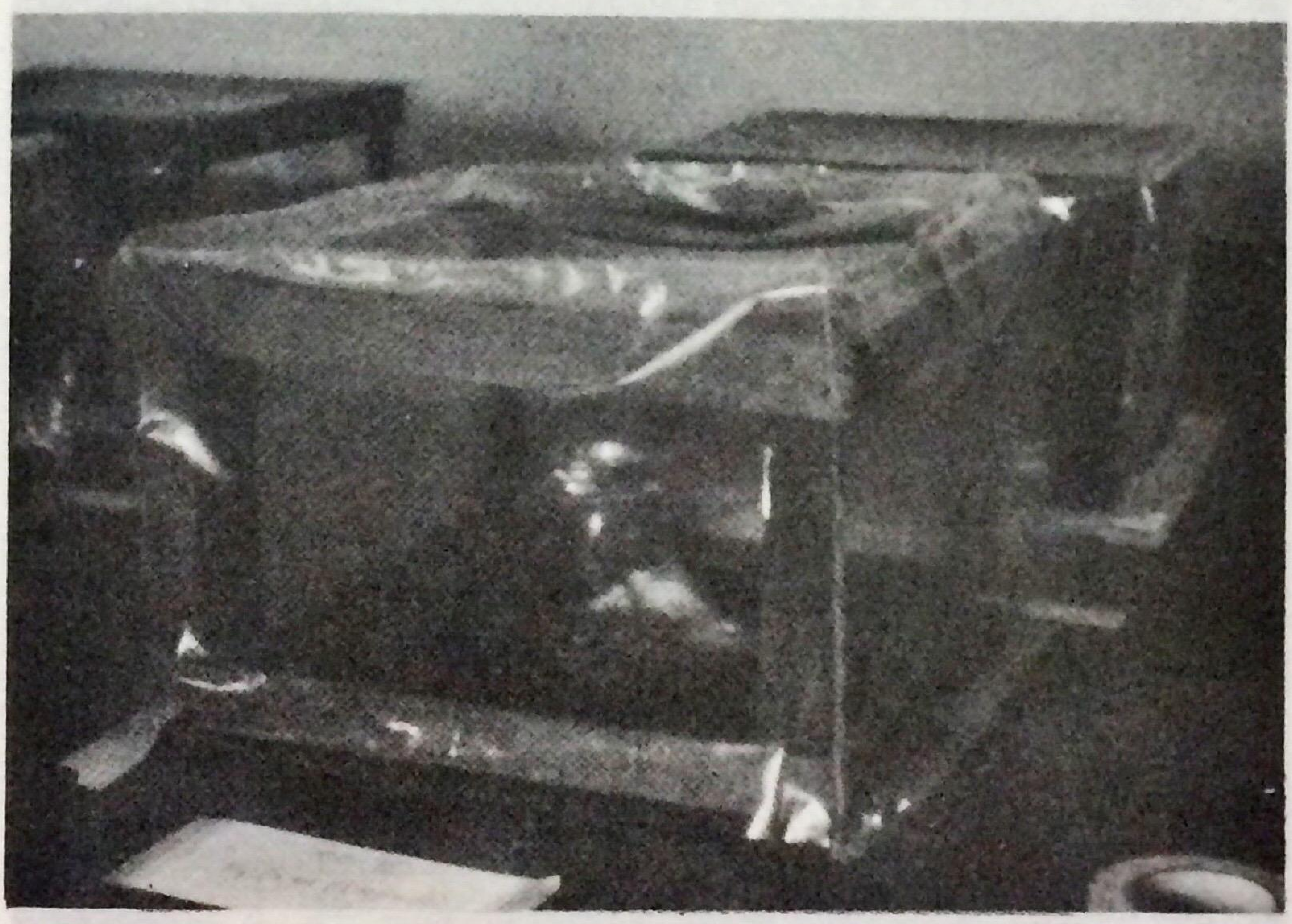

Fig. 1. An improvised fumigation chamber containing ethylene dibromide (EDB). The EDB (liquid) was placed in a cup-shaped aluminum food container which was gradually heated with alcohol lamp to release the bromine gas.

aluminum foil on which the EDB liquid was placed. An alcohol lamp with a small flame was placed under the cup-shaped aluminum foil to gradually vaporize the EDB (Fig. 1). After placing the alcohol lamp, the three sides of the improvised chamber were sealed to prevent loss of vapor. After the EDB was totally vaporized, the fourth side of the box was sealed cutting off the oxygen supply and extinguishing the flame. After fumigating for 5 hr, the tubers were removed from the box and stored at ambient temperature after aerating them for 8 hr. The ethylene concentration inside the fumigation box was taken as a measure of the vaporization of the liquid using a Varian Gas Chromatograph.

Fumigation with Phostoxin.— The phostoxin tablets were placed in the fumigation box containing the tubers, immediately covered with polyethylene film and then sealed with masking tape. Since the release of phostoxin gas is more rapid at a high relative humidity, a basin of water was placed in the fumigation box before putting the phostoxin tablets to increase the moisture content inside (Fig. 2). The tubers were fumigated for 3 1/2 days. The exposure time took longer because phosphine gas was usually released more slowly than bromine gas as in the case of EDB. The tubers were stored at ambient temperature after aerating them for 8 hr.

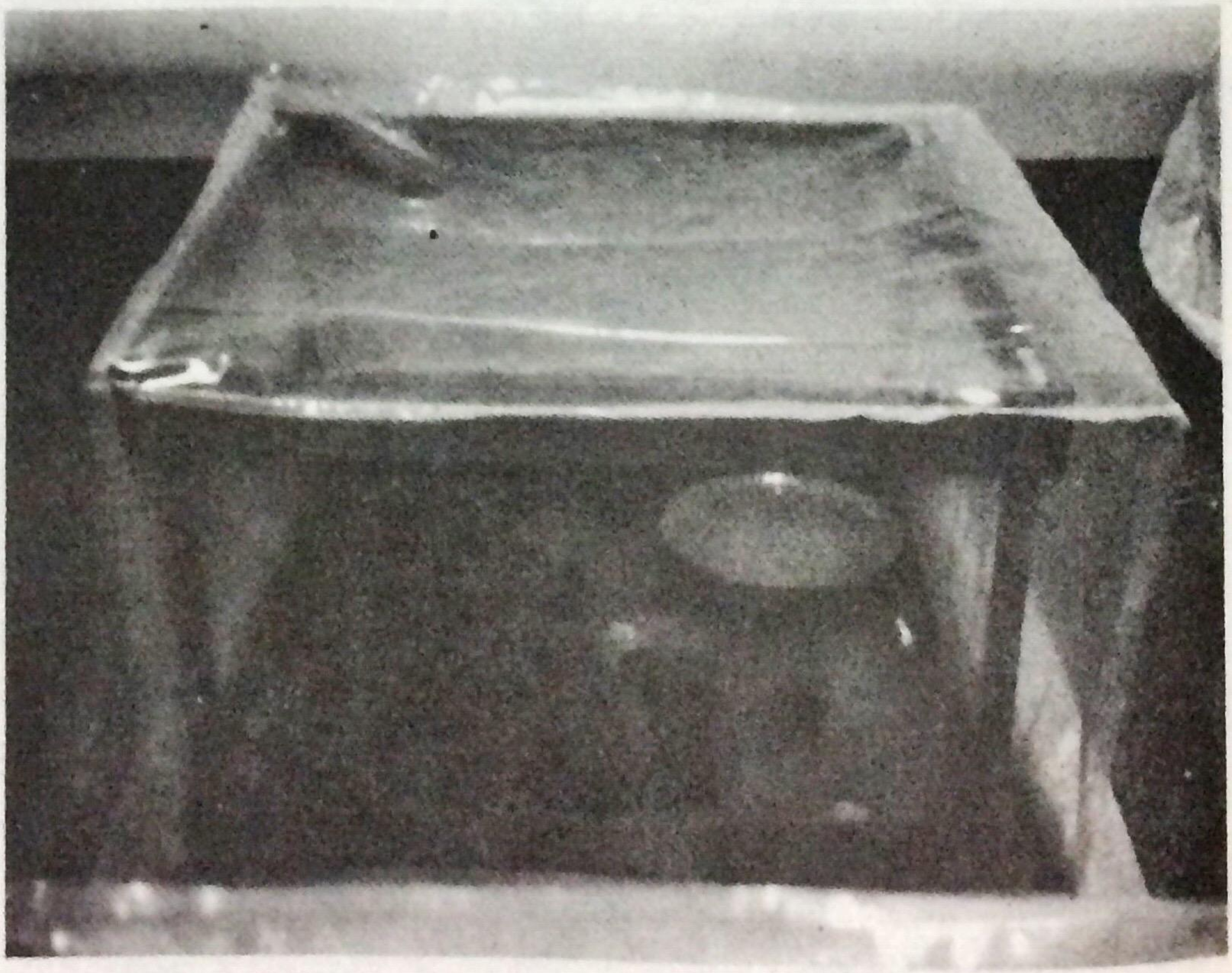

Fig. 2. Fumigation chamber provided with a basin of water to increase the relative humidity to enhance the release of phosphine gas from phostoxin tablets.

Gathering of Data. – Sampling of tubers was done 5 times at 5-day interval from fumigation examining 5 sample tubers per sampling time. In sampling the tubers, a sharp knife was used in examining the tubers and counts of larvae, pupae and adults, either dead or alive, were taken and the percentage mortality calculated.

The relative humidity inside the fumigation box with phostoxin was taken using a psychrometer with the wet and dry bulb thermometer inserted through 2 rubber tubings attached to the fumigation box.

RESULTS AND DISCUSSION

Phostoxin and EDB have different requirements for enhanced evolution of the gas. The evolution of phosphine gas from phostoxin which was in tablet form could be enhanced by high relative humidity. By providing a small basin of water inside the fumigation box, it was found that the relative humidity was increased by about 16.47%, from a relative humidity of 72.31% without a basin of water. An indication that phosphine has completely evolved is the disintegration of the tablets to dust form after 2 1/2 days.

Ethylene dibromide is a liquid which needs to be vaporized to release the bromine gas. Heating the liquid hastened this process. A measure of the ethylene released 1 hr after placing the EDB in the fumigation box showed that the ethylene proportionately increased as the concentration is increased from 10.7 ml to 32 ml/cu m. After 5 hr during which the sweet potato tubers were allowed to remain inside the box, the ethylene had decreased a little (Table 1). This amount could have been taken up by the roots or lost through leakage.

Control of Larvae.

Both EDB and phostoxin gave good control of the weevil larvae in all concentrations used (Table 2). Generally, phostoxin was more effective in controlling the larvae

Table 1. Amount of ethylene gas (ppm) inside the fumigating boxes with the different EDB concentrations at initial and final readings.

Time of Sampling	Levels of EDB (ml/cu m)	Samples 1	2	3	4	5	Average
Initial reading	10.7	40.39	46.48	44.87	41.35	44.87	43.59
(during the	21.3	64.11	51.28	73.72	76.93	68.59	66.93
first hour of	32.0	92.95	99.36	98.72	98.72	104.49	98.85
fumigation)							
Final reading	10.7	29.49	33.34	24.36	38.46	37.18	32.57
(after 5 hr	21.3	44.87	71.80	76.93	67.95	46.90	61.69
of fumigation)	32.0	83.34	89.75	89.75	88.47	60.65	90.39

Table 2. Percent mortality of larvae of the potato weevil found in tubers fumigated with ethylene dibromide and phostoxin.

Treatment	Weeks After Fumigation					Mean[1]
	1	2	3	4	5	
Control	0	0	0	0	0	
Ethylene dibromide (ml/cu m)						
10.7	37.67	57.67	24.33	66.67	73.00	51.87b
21.3	52.00	56.00	46.00	80.00	91.67	65.13bc
32.0	66.33	58.00	66.33	89.00	94.33	74.80cd
Phostoxin (tablet/cu m)						
10.5	85.00	87.67	97.00	100.00	100.00	93.93de
21.0	92.33	95.33	96.33	100.00	100.00	96.80e
31.5	95.33	97.33	98.00	100.00	100.00	98.13e

[1] Means followed by the same letters are not significantly different at 5% level, DMRT.

than EDB. Application of 10.5-21.0 phostoxin tablets/cu m was as good as that of 31.5 tablets/cu m. However, the highest concentration of EDB and the lowest concentration of phostoxin did not significantly differ in their effectiveness in killing the larvae. EDB at 10.7-21.3 ml/cu m killed 52-65% of the larvae. These were not significantly different from each other.

Control of Pupae.

Both EDB and Phostoxin had similar trend in effectiveness in controlling the pupae as that of the larvae of the weevil. Phostoxin at 31.5 tablets/cu m gave the highest level of control of pupae, but its effectiveness was not significantly different from the effectiveness of 10.5-21.0 tablets phostoxin/cu m and 21.3-32 ml EDB/cu m. The lowest concentration of EDB controlled only 35% of the pupae which was not significantly different from that of the control

Control of Adults.

The number of adults per tuber ranged from 0 to 8. Again, phostoxin controlled adult weevils better than EDB. There were no significant differences between concentrations of each fumigant, although higher mortality of adults occurred with an increase in concentration. Phostoxin at 31.5 tablets/cu m provided 100% control of the adults. Fumigation with the lowest concentration of phostoxin tablet/cu m seemed to be as effective as any of the concentrations of EDB used. EDB killed only 24-43% of the adults, which was not significantly different from the control.

Table 3. Percent mortality of pupae of the sweet potato weevil found in tubers fumigated with ethylene dibromide and phostoxin.

Treatments	Weeks After Fumigation					Mean[1]
	1	2	3	4	5	
Control	**0**	**0**	**0**	**0**	**0**	**0**
Ethylene dibromide (ml/cu m)						
10.7	**29.33**	**32.67**	**35.67**	**41.67**	**38.33**	**35.53ab**
21.3	**25.00**	**43.00**	**37.67**	**54.33**	**58.00**	**43.60abc**
32.0	**44.67**	**55.67**	**53.33**	**45.67**	**58.00**	**51.47bc**
Phostoxin (tablet/cu m)						
10.5	**16.67**	**73.67**	**89.00**	**91.67**	**84.67**	**67.80bc**
21.0	**61.00**	**66.67**	**100.00**	**100.00**	**100.00**	**85.53bc**
31.5	**66.67**	**66.67**	**100.00**	**100.00**	**100.00**	**86.67c**

[1] Means followed by the same letters are not significantly different at 5% level, DMRT.

Table 4. Percent mortality of adult sweet potato weevil found in tubers fumigated with ethylene dibromide and phostoxin.

Treatments	Weeks After Fumigation					Mean[1]
	1	2	3	4	5	
Control	**0**	**0**	**0**	**0**	**0**	**0**
Ethylene dibromide (ml/cu m)						
10.7	**25.00**	**0**	**22.00**	**53.33**	**20.33**	**24.13ab**
21.3	**28.67**	**16.67**	**13.33**	**50.00**	**44.33**	**30.60ab**
32.0	**34.33**	**50.00**	**33.33**	**41.67**	**56.67**	**43.20abc**
Phostoxin (tablet/cu m)						
10.5	**75.67**	**43.67**	**66.67**	**100.00**	**83.33**	**73.87bcd**
21.0	**66.67**	**85.00**	**100.00**	**91.67**	**100.00**	**88.67cd**
31.5	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00d**

[1] Means followed by the same letters are not significantly different at 5% level, DMRT.

In general, phostoxin gave better control of the weevil at all stages of its development. This fumigant, since it is in tablet form, can easily be applied in an inexpensive fumigation chamber which can be constructed in the rural areas. Furthermore, the sweet potato tuber can be

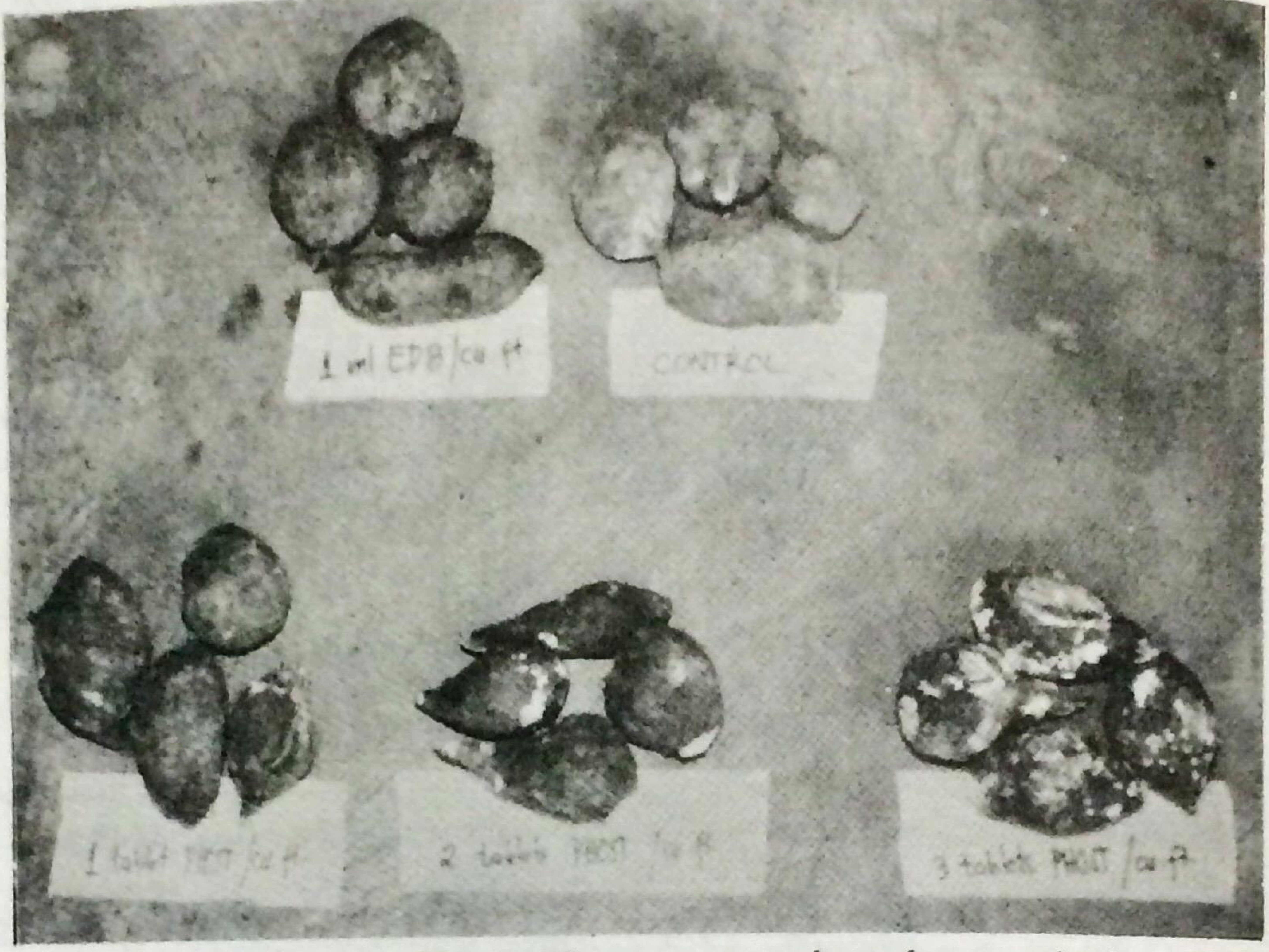

Fig. 3. External appearance of fumigated sweet potato tubers after 1 week of storage at ambient temperature.

fumigated in drums as long as these can be covered with plastic or canvas during fumigation.

Ethylene dibromide, being in liquid form is more difficult to apply than phostoxin. Higher amounts were needed to affect good circulation of the gas in the fumigation chamber and heat is needed to vaporize it. However, it also gave good control of all stages of the sweet potato weevil at higher concentrations. It is possible that its effectiveness can be increased by lengthening the exposure of the tubers to the fumigant. It should be pointed out that the tubers in this experiment were exposed only to EDB for 5 hr, following the recommendation for other crops, while tubers were exposed to phostoxin for 3 days which was actually the time it took for the tablet to disintegrate to dust form.

Length of Effectiveness of the Fumigant.

The effectiveness of the fumigants lasted up to the end of the experiment, as evidenced by the more or less similar percentage control incurred on any of the life stages of the sweet potato weevil from the first to fifth sampling time (at 5-day interval). To determine the actual effectiveness of the fumigants, the duration of the study should be extended.

The effect of longer exposure of

the tubers on the different stages of the weevil is not yet known. Finding the minimum time for exposure that is also effective against the weevil is needed to avoid build-up of the heat of respiration inside the fumigation chamber. Very high temperature hastens deterioration of the tubers. However, if refrigeration is available, deterioration of tubers is not a problem.

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