Integrated Control of Potato Moth in Rustic Potato Stores

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ABSTRACT

Experiments related to integrated control of Potato Tuber Moth *Phthorimaea operculella* (Zeller) in rustic diffuse light stores at San Ramon, Peru investigated the effect of various traditional practices, the effect of biological control using biological insecticide Dipel a formulation of *Bacillus thuringiensis*, the effect of synthetic pyrethroid Fenvalerate, and the use of water and synthetic sex pheromones consisting of a mixture of trans-4, cis-7-tridicadien-1-ol acetate (PTM 1) and trans-4, cis-7, cis-10-tridecatrien-1-ol acetate (PTM 2). Tuber and sprout damage in potatoes stored for 4 months was significantly reduced in all treatments when tested alone. Promising control components for inclusion in an integrated pest-management program included use of the weed *Lantana* sp., *Bacillus thuringiensis*, water on walls of store and synthetic sex pheromones used in combination with a funnel trap.

Introduction

The potato tuber moth *Phthorimaea operculella* (Zeller), is a widely distributed pest of solanaceous crops and thrives best in areas with hot dry summers (Foot, 1975). Under field conditions, pest populations become apparent when the average daily temperature reaches 16°C. Population increase is fastest when average temperature is between 20° and 25°C, when the life cycle takes between 3 and 4 weeks to complete (Haines, 1977). Although eggs are reported not to hatch at 10°C and below (Haines, 1977), there are indications that this and related species are becoming increasingly tolerant to cooler conditions.

During growth of host plants, tuber moth larvae live as miners in the foliage and stems. Prior to harvest, tubers may become infested by direct larval attack or by adults laying eggs on exposed tubers. During storage, larvae already present in infested tubers may spread to healthy tubers and reinfestation by adults entering the store occurs.

Damage caused to both growing crops and stored tubers can be extensive. Potatoes planted in the hot dry summer on the coast of Peru suffer heavy attacks when adequate control measures are not followed. Infestation of tubers in the field has been shown to be as high as 50% (Anonymous, 1980). Storage losses are reported to vary from 30% to 70% in country stores in India (Nirula, 1960) and as high as 86% in Tunisia, Algeria and Turkey, despite the use of insecticides such as malathion dust (Anonymous, 1980). In San Ramon, over 90% tuber infestation has been recorded following 2 months storage (Anonymous, 1981).

Reports of successful pre- and post-harvest pest control using a range of insecticides can be found in the literature. Also reported are high levels of pest resistance to several insecticides in several countries (Haines, 1977). The development of insecticidal resistance by this pest together with frequently inadequate means of monitoring tuber moth populations commonly result in excessive use of insecticides (Kennedy, 1975). The undesirability and potential dangers of applying large and uncontrolled quantities of insecticides to potato tubers which later may be consumed must be recognized.

Although host plant resistance has been reported (Raman and Palacios, 1982) --physical and biological control methods are also to be found in the literature (Haines, 1977)--little use of these data has been made to develop integrated control measures which could reduce the present reliance on toxic insecticides. The sex pheromone of this insect, consisting of a mixture of trans-4, cis-7-tridicadien-1-ol acetate (PTM-1), and trans-4, cis-7, cis-10-tridecatrien-1-ol acetate (PTM-2), has been shown to be highly effective in capturing male tuber moth (Raman, 1982a) and a simple funnel trap for mass trapping in the field has been developed (Raman, 1982b). Insect populations and crop damage in the field are reduced in rainy seasons and where overhead sprinkler irrigation is used (Langford and Cory, 1982; Foot, 1976). Similarly, directly wetting stored tubers has been reported to reduce infestation levels on stored tubers (Haines, 1977; Parker, 1981). Inert mineral dusts have been shown to be an effective means of controlling damage to tubers, but not to growing sprouts, in stores (Helson, 1942).

Present tuber moth research at the International Potato Center (CIP) is aimed at identifying and testing potential components of an integrated potato tuber moth control program, and later to put these together in appropriate combinations that will minimize or even exclude the use of toxic insecticides. This paper reports evaluation of several control components for use in low-cost natural diffused light seed stores.

Materials and Methods

These studies were at the CIP experiment station in the tropical humid hills at San Ramon, Peru. San Ramon is situated at a latitude of 11°08 S at an altitude of 800 masl. The mean temperature is 24°C, mean minimum temperature 18°C, mean maximum temperature 30°C and the annual rainfall is 2,000 mm. All trials were in simple natural diffused light stores (Anonymus, 1979, 1980, 1981), maintained at ambient temperatures.

In all experiments 50 tubers (variety Revolucion) were stored in small (36x28x18 cm) wooden seed crates. Each crate was considered a replicate and four replicates were used per treatment which were laid out in the form of a randomized block. All treatments were equally exposed to natural tuber moth infestation.

During these studies the following treatments were compared:

1. Traditional practices:
   (a) Dried weeds. Dried foliage of the following common weed plants were chopped and spread on top of the tubers to a depth of 2 cm: *Lantana* sp., a common weed of many tropical countries; Muña

(Minthostachys sp.), a weed of the high Andes, and Cymbopogan citratus a weed occuring in San Ramon and other similar tropical locations.

(b) Lime dust applied at 10-12 g per crate.
(c) Wood ash.
(d) Rice straw.

To avoid possible interference from the repellent effect of weed treatments, these were placed in an isolated corner of the store, well away from other treatments.

2. Use of Dipel. The biological insecticide Dipel, containing active spores of Bacillus thuringiensis, was applied as a single spray containing 0.2% and 0.5% a.i. prior to storage.

3. Use of Fenvalerate. The synthetic pyrethroid, Fenvalerate, at 0.2% a.i. was sprayed on the stored tubers every 15 or 30 days throughout the storage period.

4. Use of sex pheromones and water. Three pheromone traps were placed in one store at the same height as the stacked crates, a second store had no pheromone traps. In a third store, water piped from an irrigation canal was made to fall in a curtain-like manner down the screen walls of the store.

Observations were made following 120 days in store of all tubers stored for (a) number of tubers infested, (b) number of sprouts damaged, and (c) number of tubers rotting due to larval penetration followed by decay by soft rotting organisms.

Results

During these trials it became apparent that for the particular situation of the storage of seed tubers, the number of sprouts damaged and the percentage of tubers rotting were the most important observations recorded. Total number of tubers infested did not indicate the viability of the tubers as seed and was thus not a useful indicator of effectiveness of treatments for storage of tubers.

Traditional practices. All treatments tested significantly reduced the percentage of sprouts damaged and the three weed species and the lime treatment also significantly reduced tuber rotting (Figure 1). When compared with the inert materials, rice straw, wood ash and lime, only the weed lantana significantly reduced both sprout damage and tuber rotting (Figure 1).

Use of Dipel. The single pre-storage spray of both concentrations of the biological insecticide significantly reduced both sprout damage and tuber rotting (Figure 2). The highest concentration tested resulted in the least damage.

Use of Fenvalerate. Both spray regimes significantly reduced sprout damage and tuber rotting. Spraying every 15 days resulted in significantly less sprout damage than spraying at 30-day intervals (Figure 3). Spraying with 0.2% Fenvalerate every 15 days, which thus required a total of 8 sprays during the 120 day storage period, gave similar levels of tuber moth control as the single pre-storage spray with 0.5% Dipel (Figures 2 and 3).

Use of sex pheromones. A total of 13,800 male moths were caught in the pheromone traps during the storage trial. Sprout damage was reduced to a level similar to that obtained with Dipel and Fenvalerate sprays (Figure 4).

Use of water. Although water on the store screen walls did not reduce the amount of sprout damage to the same degree as following the use of Dipel and Fenvalerate sprays, it did reduce the number of damaged sprouts by more than 50% as compared with the control treatment (Figure 4).

Discussion

Although none of the treatments gave complete control of the tuber moth, it is nevertheless possible to select several methods which may be combined and tested in an integrated control program depending on specific local conditions.

The results indicate that the weed species tested, and particularly the *Lantana* sp., have tuber moth repellent properties and so reduce sprout damage over and above that obtained from the physical barrier effect resulting from covering stored tubers with inert materials. If these specific plants are not available locally other plants could usefully be screened for tuber moth repellent qualities. The application of such materials as a powder may combine their repellent qualities with the recorded physical barrier effect of inert dusts. Also, and depending on the plant species involved, it might be worth considering planting a small area around the store with such plants if they can also be shown to be repellent in this form.

Results obtained following the use of the biological insecticide, Dipel, are promising and merit further testing of the material both as a curative and protective insecticide for potential incorporation in an integrated control program. Where chemical insecticides have to be used in stores the synthetic pyrethroids, like Fenvalerate, show promise. However, to prolong potential usefulness of such insecticides with low mammalian toxicity their use should be limited and because of the potential development of insect resistance their extensive and indiscriminate use in both fields and stores should be discouraged.

Where water availability and store design permit, the use of water in conjunction with storage structures should be examined as a potential means of reducing tuber moth infestation pressure. In hot dry regions and/or periods, the presence of water through natural evaporative cooling will help reduce the store temperature. Although little or no reduction of store temperature will occur in hot humid areas or periods, the present results together with those of Parker (1981) indicate that the presence of free water on the store walls or on the tubers themselves reduces tuber damage caused by tuber moth. However, the presence of a free water film on tuber surfaces for prolonged periods will greatly enhance the risk of bacterial soft rotting, particularly at elevated storage temperatures.

The use of sex pheromone traps within simple seed stores appears to be a promising and simple means of reducing infestation pressure. The use of simple traps is easily incorporated into an integrated control program.

Thus, it may be concluded that the potential is high for developing an integrated potato tuber moth control program for use in simple diffused light seed stores. Depending on specific local conditions and availability of materials, several components have been identified in the study which merit continued evaluation. However, the control of potato tuber moth in seed tuber stores must not

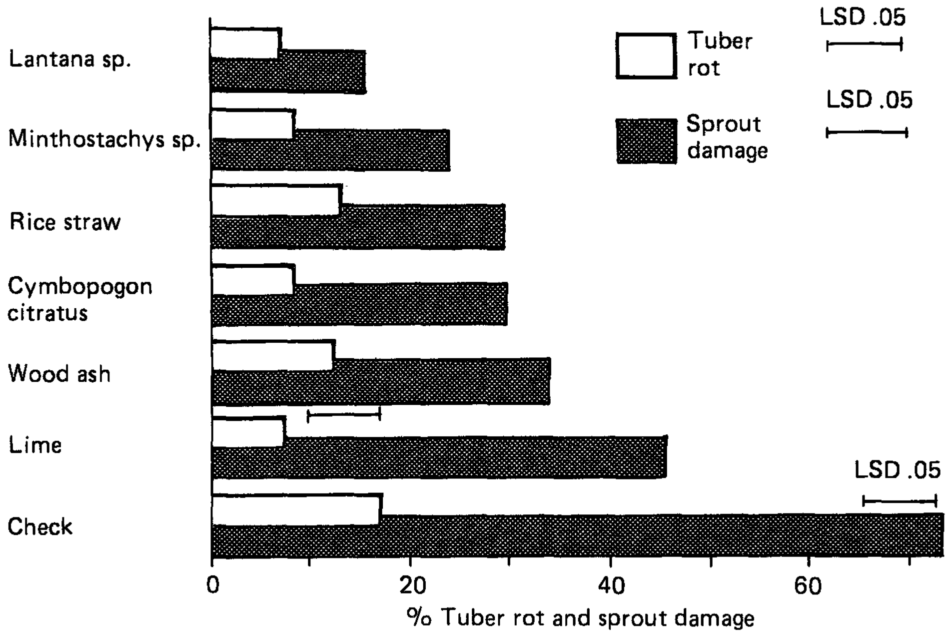

Figure 1. Comparison of some traditional practices for control of P. operculella, San Ramon (1982).

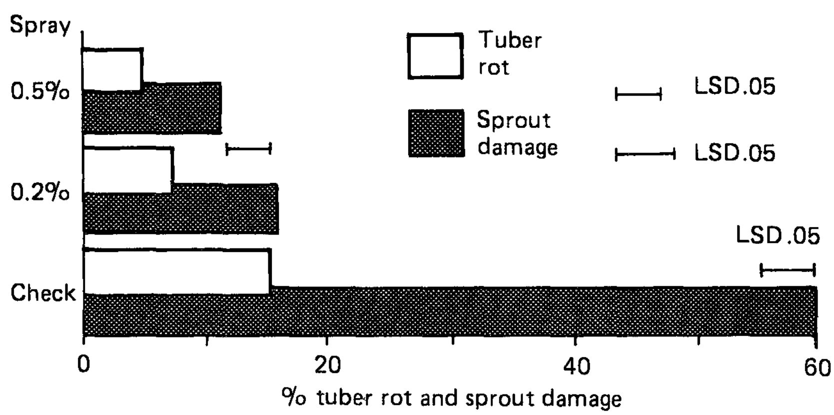

Figure 2. Effect of Bacillus thuringiensis (Dipel) in controlling P. operculella.

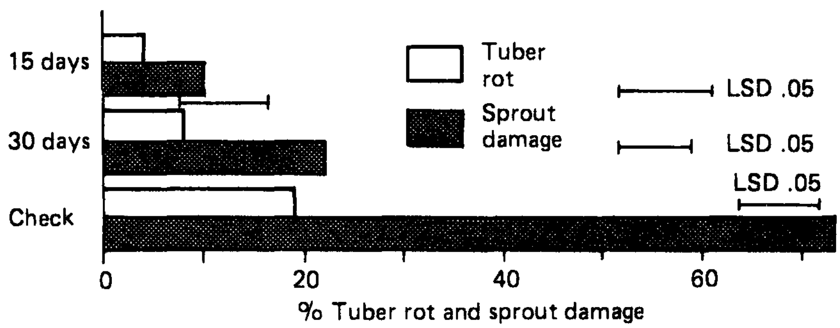

Figure 3. Effect of synthetic pyrethroid (Fenvalerate) at different spray intervals on P. *operculella*. San Ramon (1982).

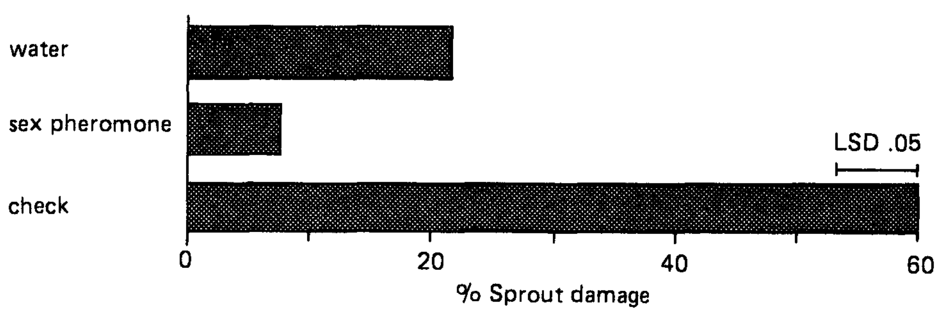

Figure 4. Use of synthetic sex pheromone and water (humidification) for control of P. *operculella*, San Ramon (1982).

be considered in isolation. The effectiveness of any control system applied during storage is likely to be much greater if the number of already infested tubers coming from the field is reduced through proper selection and the general population of potato tuber moth available to reinfect stores is also reduced. Thus any program aimed at reducing potato tuber moth damage in stores should be closely linked to overall efforts to reduce infestation by this devastating pest.

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