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DESIGN OF A MECHANICAL RELEASE SYSTEM OF *PERILLUS BIOCULATUS* TO CONTROL THE COLORADO POTATO BEETLE, *LEPTINOTARSA DECEMLINEATA* (SAY)

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ABSTRACT The Colorado potato beetle (CPB), *Leptinotarsa decemlineata (Say)*, is definitely a major insect pest of potato crops in North America, Europe, and Asia. Large amounts of chemical insecticides are used to control this pest. However, heavy reliance on these chemicals can often result on serious health and environmental problems. Also, the CPB has developed over the years a resistance to most of the registered chemical insecticides, including those that were very effective at one time. Consequently, most of the registered chemicals are not capable of effectively managing this insect pest on a long term basis. One of the most promising alternatives to chemical insecticides consists of taking advantage of the natural enemies of this insect pest. The use of the stink bug predator *Perillus bioculatus* to control the CPB has been successful on a pilot scale. However, this natural enemy is not abundant in nature and its hand release on large areas is not feasible. To remedy this problem, predators must be massively released in potato fields using a mechanical distributor. This represents a huge challenge because the predators are both very small and fragile. A mechanical distributor of predators has been designed and built at the Department of Soil Science and Agri-Food Engineering of Université Laval. In this distributor, masses of predators are placed in small containers and mixed with a carrier material. In the field, the containers are mechanically opened at different locations, based on a source-point mass release option. These locations are determined in advance following a field monitoring of the populations of CPBs. The success of this release system with *Perillus bioculatus* in potato crops could be generalized to other predator insects. In this case, other crops such as strawberry and lettuce could be similarly protected against pest insects.

Keywords: Potato, Colorado potato beetle, chemical insecticides, biological control, natural enemies, source-point mass release, mechanical distributor.

INTRODUCTION AND LITERATURE REVIEW The Colorado potato beetle (CPB), *Leptinotarsa decemlineata* (Say), is the major insect pest of potatoes crops in North America, Europe and Asia (Hare, 1980; Boiteau et al., 1992; Howard et al., 1994, Jolivet, 1991, and Radcliffe et al., 1993). Currently, the most common mean used to control this insect consists on regularly applying chemical insecticides. However, chemical methods are often controversial because their excessive and uncontrolled use is hazardous for both the environment and the human health (Hill et al., 1990). Also, there is a growing demand from modern society for agricultural products free of chemical residues. For these reasons, other reliable means to control the CPB are needed. For this purpose, many alternatives to chemical pesticides have been investigated.

There are three approaches to crop protection: chemical control (herbicides, insecticides, fungicides and acaricides (miticides)), physical control (mechanical and non-mechanical) and biological control (bio-pesticides, pests, natural enemies and resistant plants). As alternatives to chemical control against CPB, several interesting solutions which have no impact on the environment and human health have been developed.

Physical control involves mechanical and non-mechanical methods. Non-mechanical methods include (1) delay of planting time, i.e. planting later in the season or after the period of hatching (Hill et al. 1990), (2) crop rotation: the basic technique of sustainable agriculture, that consists on changing the location of a crop from one year to another and thereby delaying the emergence of insect pest, (3) manual repression which is both labor inconceivable at large scale, and (4) physical barriers, which consist on hampering the passage of parasites to protect the plants by digging trenches and installing vertical lines and other slippery surfaces.

Mechanical methods include pneumatic, electromagnetic, and thermal control. The pneumatic method involves two processes: air suction and blowing. In both cases, the main idea consists first of all on dislodging the insects by the drag force of air or by any other vibrating system, and then, transporting them through the airflow into a passive collecting system or a continuous disposal system (Lacasse, 1996). The electromagnetic method uses radiation: microwaves, radio-frequency X-rays or UV rays. The principle is to burn the inner cells of the insect pest by waves. The thermal method uses thermal shocks to rapidly raise or lower the temperature inside the insect to hopefully cause its death. This method also includes exposing the insects directly to the flames of propane burners. The major problem with these methods is that they require the use of large amounts of energy, which increases the production costs. Also, they are generally complex and bulky, making them expensive.

The biological control method uses the action of pathogen (usually bacteria and parasites) or predators to keep the density of insect pest populations at a lower level (Lachance, 1996). Hence, this method mainly involves the use of biopesticides and predator insects. Biological control also involves the use of resistant transgenic plants. However, this technique is less common because of the controversy surrounding the use of transgenic products.

Compared to chemical insecticides, biological control is completely environmentally safe and harmless to human health. Indeed, biological control uses the resources that nature itself uses to self-regulate. Furthermore, the development of possible resistance of the

CPB to a natural predator is less obvious (de Ladurantaye, 2008). Finally, biological control is often compatible with other physical control methods (crop rotation, physical barriers, and others).

Biopesticides mainly rely on the use of bacteria, viruses, microorganisms or disease. The most common is B.t. (*Bacillus thuringiensis*), which uses microorganisms. Once ingested by the insect pest, the B.t. undermines the regulation system of the insect body which results on its slow dying. Given that the CPB is a very resistant insect, it has also managed to develop over the time some resistance to biopesticides. The use of B.t. in combination with insect predators could however improve the effectiveness of the biological control, already convincingly against the CPB.

The use of natural predators is the most promising mean to control the CPB. Indeed, this method has been investigated for several years and the results have demonstrated and proven its effectiveness against the CPB (Hagen et al., 1999). Against this insect pest, two predators have been studied: *Perillus bioculatus* (F.), commonly known as two-spotted stink bug (Figure 1, left) and *Podisus maculiventris* (Say), also known as spined soldier bugs (Figure 1, right). Both predators are resistant to the harsh North American climate. They are native to Canada and attack all CPB development stages without damaging the plants. *Podisus maculiventris* is however a generalist predator, i.e. it feeds not only from CPB, but also from other species. On the other hand, *Perillus bioculatus* is a specialist predator, i.e. it feeds exclusively from CPB. For this reason, *Perillus bioculatus* is mostly documented in controlling CPBs. Ferro (1994) showed that three *Perillus bioculatus*/plant can reduce 60% of the population of CPB in a potato field.

Figure 1**:** Adult *Perillus bioculatus* (left) and adult *Podisus maculiventris* praying at a CPB larva (right) (source: http://naturenm.org/NMPhotos/Perillus_bioculatusSleepy.jpg (left) and photo by S. de Ladurantaye (right)).

At a small scale, manual release tests of *Perillus bioculatus* proved that this predator is able to effectively control the CPB populations. In their study, Cloutier et al. (2002) manually released predators in the L2-L3 larval stage on potato plants at specific locations in the field using a brush. Such a manual release of predators is not conceivable at large scale. According to Cloutier et al. (2002), a rate of two to four predators per plant is in general sufficient to control the CPB. This represents a huge number of predators to release in potato fields. It is known that *Perillus bioculatus* is already naturally present in the fields, but not abundant enough to manage the population of CPBs. Release of additional masses of this predator, known as inundative release, is therefore required.

Once released, the predator, *Perillus bioculatus,* scatters across potato field and feeds primarily on CPB eggs, and also on larvae (Figure 1, right) and adults. This predator can be massively reared in growth chambers for eventual release.

As mentioned earlier, manual release of this predator at large scale is unrealistic because it is both time consuming and laborious. Nevertheless, the main purpose of using predator insects to control the CPB is to find an alternative to chemical insecticides widely used in commercial potato fields, which covers large areas. Since labor force in agriculture is rather rare and expensive and the manual distribution of predators is laborious, it is necessary to mechanize the release operation in the field, which represents a major challenge. The main objective of this research study was therefore to design and build a mechanical distributor of predator insects.

MECHANIZED BIOLOGICAL CONTROL Very few attempts have been made to develop mechanical systems to distribute insect predators in agricultural fields and none is currently available on the market. It is then obvious that no commercial system mainly designed for the mechanical distribution of the bug *Perillus bioculatus* in potato fields is available. A research team has been working on this project for five years at the Department of Soil Science and Agri-Food Engineering of Université Laval, Quebec, Canada. After exploring the storage and transport conditions of the predators before releasing them in the field, the team successfully designed, built, and tested a release system in the laboratory. Thereafter, the team met the challenge by developing a first prototype of a mechanical distributor that has been successfully tested in laboratory. This prototype could achieve massive release of predator insects while preserving their physical integrity. In a third step, a second prototype (Figure 2) has been developed and will be tested this coming summer in potato fields under real conditions.

Figure 2: Overall view of the prototype of the mechanical distributor of predator insects hitched to a tractor. The container is mechanically opened using the yellow component and its content is already on the ground.

This mechanical predator distributor is designed to be coupled to any tractor and controlled by its hydraulic system in the field. This distributor mainly consists on containers of predator insects, a frame, and an opening system. Before releasing the predators, the field is monitored and several specific locations infested by the CPB are market out. Knowing that the predators could scatter once released to cover a certain area in the field; it was decided to use a source point release method. In the field, the tractor drives the hydraulic motor of the distributor. The chains on which hang the containers are activated by the hydraulic motor. When the containers cross the opening system of the distributor (one at a time), they open and drop their content (a mixture of predators and a carrier material). The predators which reach the ground along with the carrier material walk and climb on potato plants to settle and look for food, in this case the CPB. The carrier material is popcorn because it is lightweight (it does not hurt the insect), inexpensive to produce, biodegradable, contains several caves where predators can hide, and falls easily without clinging to the walls of the container.

Field trials with this distributor will be based on the assumption that the method of mechanically releasing predator insects at large scale will be as effective as the manual release at small scale. This will eventually keep the population of CPB under the economic threshold of defoliation of the plants and consequently the use of chemical insecticides will be unnecessary.

Although this mechanical distributor has been specifically designed to release *Perillus bioculatus* in potato fields, it could also be used to control insect pests in many other crops such as eggplants, strawberries and more. In this case, the distributor could be widely used to release other kinds of insect predators. This particular predator releasing concept is unique in the world.

CONCLUSIONS Chemical control of CPB is still widely used by potato growers, but alternative means are currently in growing demand because the CPB is increasingly resistant to chemical insecticides. Also, chemicals are the source of major human health and environmental problems. Biological control means are on the other hand very promising, in particular the use of natural predators. Thus, mechanized biological control using predator insects is one of the most interesting alternatives to control the CPB. Compared to chemical insecticides, its impact on the environment and human health is very low or non-existent. The designed mechanical distributor is environmentally friendly and safe for human health. This distributor is revolutionary and dedicated to a promising future!

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