A New Version of Prototype for Mechanical Distribution of Natural Enemies

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Abstract

The aim of this research is to assess the performances of a new version of the device patented by University of Catania and already used in natural enemy distribution trials on greenhouse vegetable crops. The prototype has been designed and constructed by Mechanics Section of DIA in order both to increase the work capacity and to promote a low impact pest control, which respects the environment and consumers' and farmers' health.

This version has the same working principle of the former prototype, but materials and dimension of the hopper, the distributor and the rotating disc have been changed. Moreover it has a handle directly carried by the worker.

From the laboratory trials, the dosage and distribution mechanism of the prototype seem well suited to biological pest control strategies. Negligible or absent impact on natural enemies proves prototype efficacy and enables its usage both with technical and economic advantages on manual distribution.

With this model the device performance is improved in manoeuvrability. Consequently, greater work capacity and higher work quality will be achieved in greenhouses and in field.

Keywords: plant protection machines, sustainable pest management, natural enemies.

Introduction

In the last years the orientation of consumers, who prefer more and more products obtained by biological crop, is encouraging the adoption of the biological control of agricultural pests also between the Italian farmers. This technique involves seasonal inoculative or inundative releases of natural enemies, as the predatory mite *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) and the bug *Orius laevigatus* (Fieber) (Hemiptera: Anthocoridae) in the horticultural crops. In fact, it is demonstrated in several experiments (Morse and Trumble, 1991; Trumble and Morse, 1993), that these two arthropods are valid instruments to keep the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) and the western flower thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) and they are reared and distributed by commercial insectaries (Tropea Garzia et al., 2006).

At present, in Italy the predators are realised manually in the protected crops. On one hand this method of distribution allows to reduce the number of treatments effected with chemical products, and so the risks for environmental pollution and for workers' safety; on the other hand it requires long time and high costs and does not guarantee an uniform distribution. In order to solve these difficulties it is necessary to mechanise the distribution of predators; with this aim a prototype was designed and built by the Mechanics Section of the Agricultural Engineering Department of the University of Catania (Blandini *et al.*, 2006; Blandini *et al.*, 2007). This prototype uses operating principles which are different from those of other equipment on the market (Giles *et al.*, 1995; Morisawa e Giles, 1995; Gardner e

Giles, 1997; Wunderlich e Giles, 1999; Pezzi *et al.*, 2001; Pezzi *et al.*, 2002; Van Driesche *et al.*, 2002; Opit *et al.*, 2005; Baraldi *et al.*, 2006).

The results obtained with the prototype were excellent, nevertheless a new version of the prototype was built to improve its performances in terms both manoeuvrability and range of action reducing the distribution time. Therefore, this study refers about the laboratory tests effected to assess the performance of the last version of the prototype.

Materials and Methods

The distribution of the arthropods with the prototype came by means of centrifugal force developed by the rotation of a finned distributor disc (fig. 1). The arthropods, together with the substrate they are sold, are poured into a hopper placed above the distributor disc and are released down through a calibrated hole. On the axis of the hopper there is a rotating measuring device with flexible fins to guarantee continuous flow. Both the distributor disc and the measuring device are moved by means two direct-drive electric motor each one connected to the corresponding device. The two devices are fixed to the same frame which can be attached to a portable structure, tractor driven or in greenhouses carried on mechanically driven frames over the crop rows. However, it is possible regulate the position of the hopper with respect to the distributor disk in order to change the throw direction.

The modifies carried out on the prototype do not have changed its working principle. They have been involved the frame, the distributor disk, the hopper and the measuring device (fig. 2).

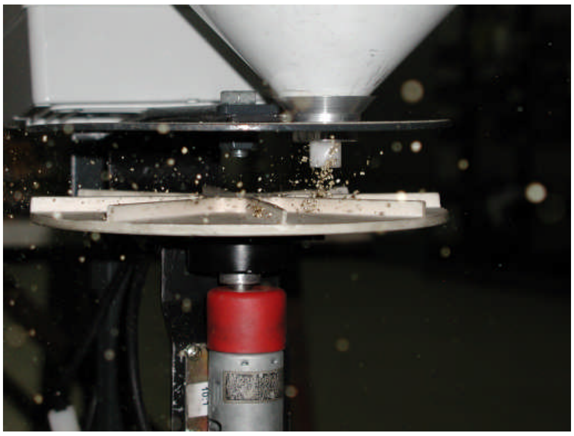


Figure 1. The finned distributor disk

Figure 2. The last version of prototype

In particular:

- a cylindrical articulation has been attached to the frame so it is possible regulate its inclination with respect to the portable structure and keep it parallel to the ground;
- the distributor disk has been built with aluminium and greater than the first version (300 mm diameter vs. 200 mm) so to improve the centrifugal force at the same rotation velocity and the range of the action;
- the hopper has been built with aluminium too, but its volume has been reduced with respect the first version (1.5 dm^3 vs. 2 dm^3) in order to lighten it; the exit hole has been increased in order to insert bush with different internal diameter (16, 17, 19, 21, 23, 25 mm) to regulate the amount of product released in the time, taking into account of the

granulometry of the substrate; however, the new capacity of the hopper still allows the treatment of 1000 m^2 without refill;

- the measuring device now has a simplified shape to reduce the production costs; it is a cylinder 190 mm high with 15 mm diameter without the helicoidal profile of the first version; the end of the device, which is inserted into the bush, has been symmetrically milled to have 10 mm thick; in order to remove the product from the inner side of the hopper and to help regulate product flow, two flexible plastic fins are applied along vertical axis of the measuring device.

Despite the modifies carried out to the prototype, do not found great difference in dimension (38 cm long, 30 cm large and 42 cm height) and in weight (4.3 kg) with respect the first one version.

In order to improve the manoeuvrability of the prototype along the inter-rows of the horticultural crops in greenhouses, it is applied to a rod carried by a worker (fig. 3). In fact, the first structure, which keeps constant the height of the prototype from the ground, showed some difficulty during the manoeuvres to turn back along an inter-row. To help the worker to support the prototype a shoulder-strap is applied to the rod. Furthermore, at the same rod it is applied an accumulator battery (6 V – 7.2 Ah) and a button to operate the electric motors which move the distributor disk and the measuring device.

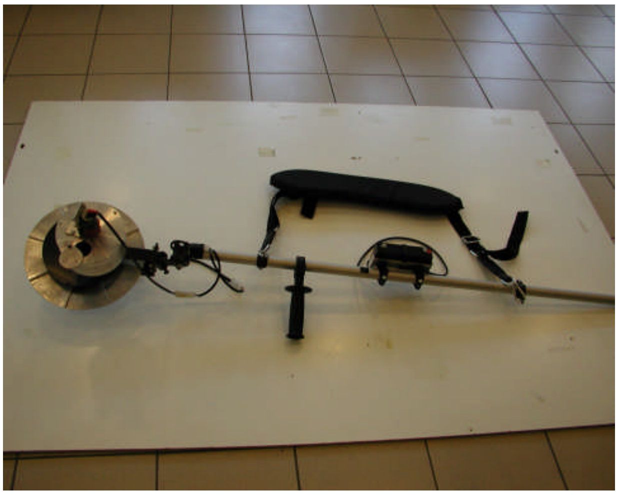



Figure 3. The old and new portable versions

In order to assess the performance of the new version of the prototype several laboratory tests have been carried out to evaluate some machine parameters: the throw direction, the quantity distributed, the uniformity of throw in time (fig. 4), the vertical distribution of product at different distributor heights (90 and 130 cm from the ground) as well as at different distances (40 and 70 cm) from the test bench: 150 cm high, 100 cm wide and made up of 10 vessels to recover product at 15 cm separation (fig. 5). The tests were run with inert material commonly used for marketing bottles of predators: humid vermiculite and buckwheat husks mixed with humid vermiculite.

Moreover, experienced entomologists have evaluated throw effects on natural enemies vitality, with samples both from the hopper and from the rotating disc throw.

Figure 4. Laboratory tests: uniformity of throw in time

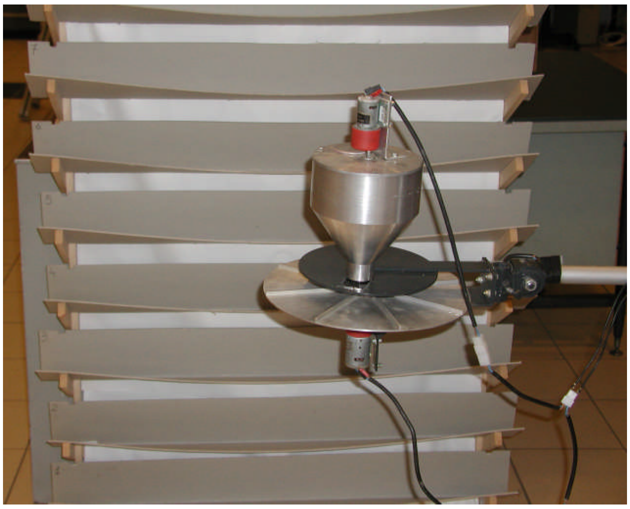


Figure 5. Laboratory tests: the vertical test bench

Results

Several laboratory tests were carried out in order to determine the working parameters of the prototype according to the distributing product and to optimise some components for later greenhouse tests.

The overall results of numerous tests, with only the hopper and measuring device, varying the measuring device diameter and its shape, the hopper's hole (16-17-19 mm) and using the same power supplied (6 V) already defined in previous tests (Blandini *et al*., 2007), helped define the product quantity for distribution in greenhouse. Particular attention was paid on length and orientation of the flexible fins situated in the measuring device, in order to guarantee continuous flow.

In particular, 6 V was chosen to power both the measuring device and disc distributor which rotated at about 30 and 600 rpm, and to use the same measuring device with a hopper hole of 16 mm for *Phytoseiulus persimilis* (with humid vermiculite) and 19 mm for *Orius laevigatus* (with buckwheat husks mixed with humid vermiculite). In these configurations a 1000 m^2 greenhouse needs 4-5 bottles (35 g each one) of *P. persimilis* (about 9 g/min) and 2 bottles (60 g each one) of *O. laevigatus* (about 6 g/min).

The tests carried out on the uniformity distribution in time with buckwheat husks mixed with humid vermiculite show (fig. 6) the quantities of samples varied between about 7 – 2 g without extreme values and between 11 – 1 g including extreme values. In the first case the data processing show a 33% CV, in the other a 43% CV. The distributed product is subject to a sharp decrease to the 11^{th} sample, while the next samples are quite constant. Further tests are necessary to verify if the prototype is able to keep the regulation constant in time and even for several treatments.

The results of vertical distribution (Figures 7 and 8) show significant differences between the test types (90 cm height and 40-70 cm from the test bench; 130 cm height and 40-70 cm from the test bench) both as regards product quantity monitored at different heights of the test bench as well as product type (HV = humid vermiculite; DV= dry vermiculite; BV= buckwheat husks mixed with humid vermiculite). The tests show the humid vermiculite is able to hit the target in greater quantity while the dry vermiculite in lower quantities. But in any tests the product dispersion is greater than previous tests carried out with old version of prototype (Blandini et al., 2007).

In general, comparing the two tests at 40 cm from the test bench and then the two tests at 70 cm, more material is recovered (less dispersion) in both cases fixing the prototype at 90 cm from the ground irrespective of the product used.

It should be highlighted that, the results show good agreement between prototype and target height with most concentration of distributed product.

Conclusions

From the laboratory trials, the dosage and distribution mechanism of the prototype seem well suited to biological pest control strategies. Negligible or absent impact on natural enemies proves prototype efficacy and enables its usage both with technical and economic advantages on manual distribution. Further tests to verify the capability of maintaining over time the same product quantities should be carried out.

The tests carried out to assess the vertical distribution of product at different distributor heights as well as at different distances from the test bench, have shown a good agreement between prototype and target height with most concentration of distributed product.

With this new version, set on a handle directly carried by the operator, the device performance is improved in manoeuvrability. Consequently, greater work capacity and higher work quality will be achieved in greenhouses and in field.

Even the possible use of small battery-run electrical motors thanks to the limited power usage, can reduce costs and environmental impact.

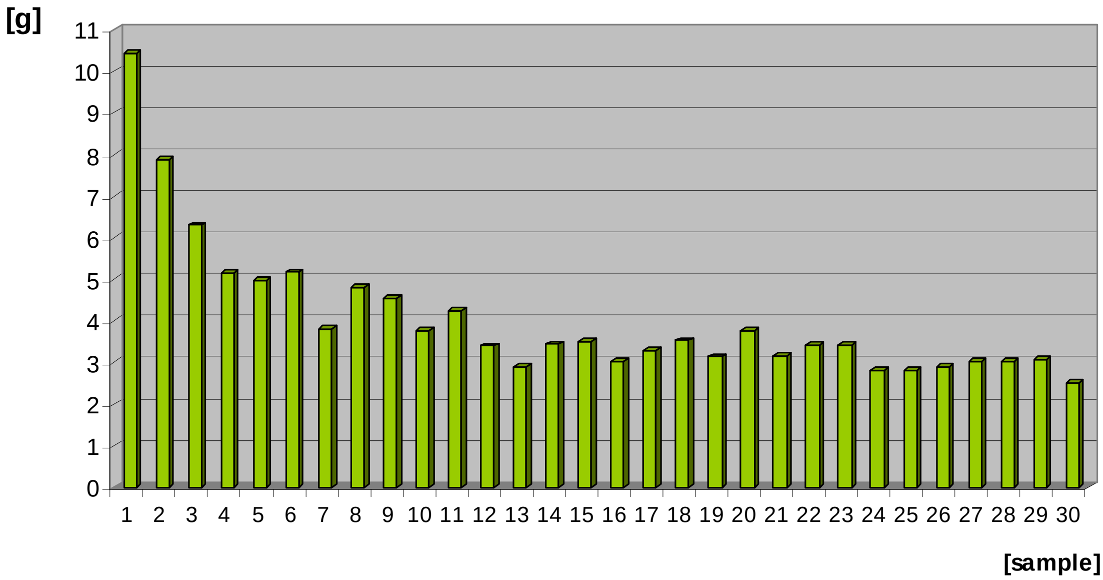
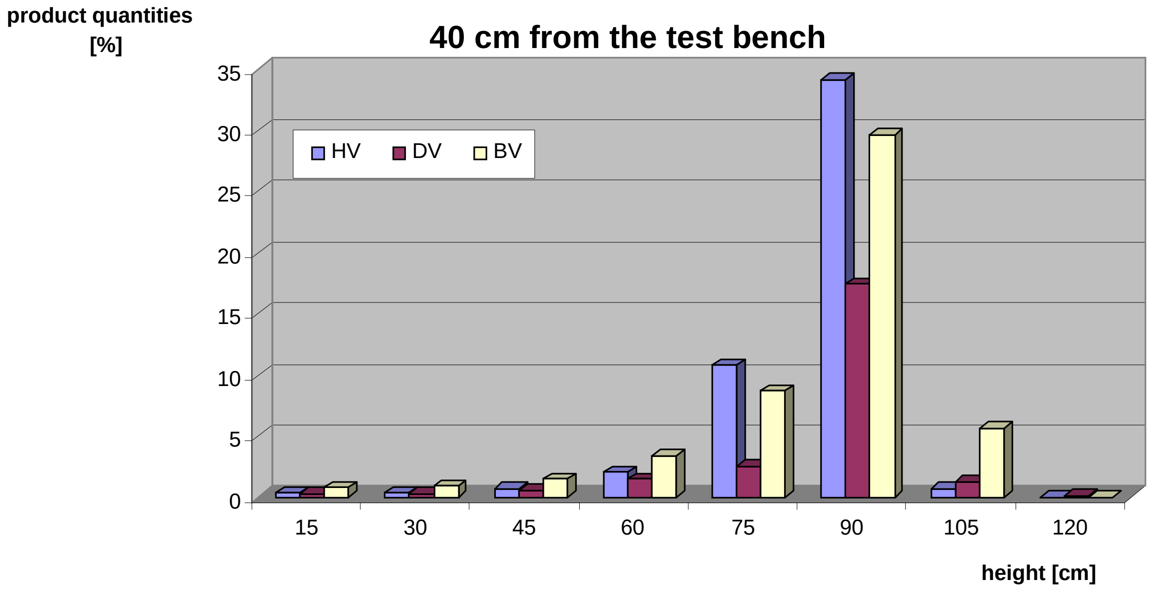


Figure 6. Mean values of buckwheat husks mixed with humid vermiculite and *O. laevigatus* delivered [g] every 30 s



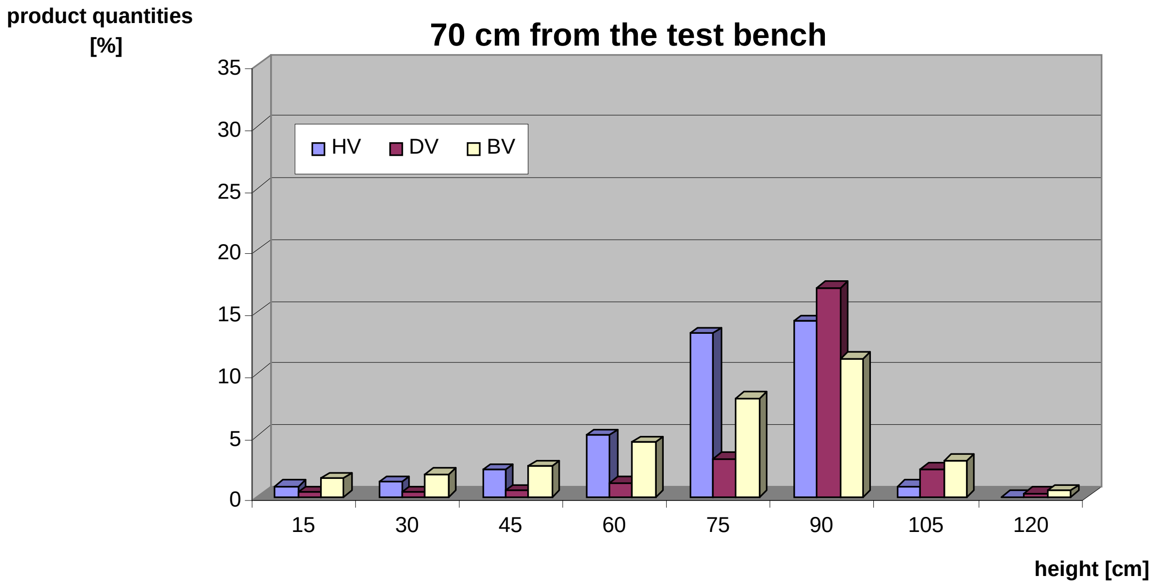
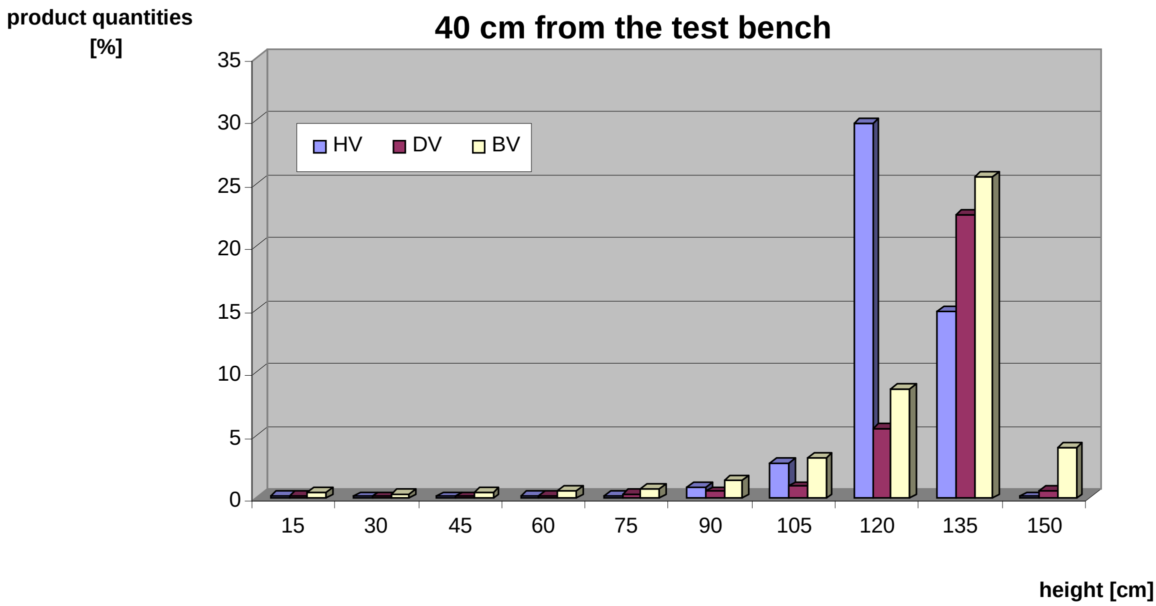


Figure 7. Product quantities collected [%] in the tests with the prototype <u>90 cm</u> from the ground



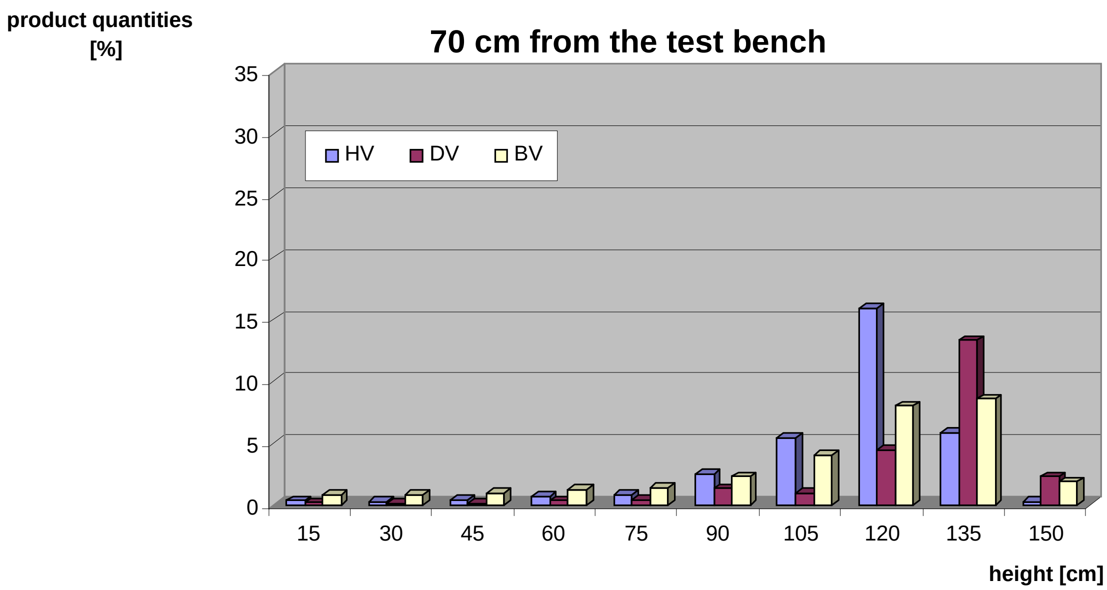


Figure 8. Product quantities collected [%] in the tests with the prototype 130 cm from the ground

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