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A New Version of the Prototype for Mechanical Distribution of Beneficials

Rita Papa, Giacomo Blandini, Giuseppe Emma, Sabina Failla and Giuseppe Manetto

University of Catania, DIA, Mechanics Section - Via S. Sofia, 100 - 95123 Catania (CT), ITALY, sfailla@unict.it, gmanetto@unict.it

Abstract

A new version of the device patented by University of Catania and already used in natural enemy distribution trials on greenhouse vegetable crops has been designed and built in order both to increase the work capacity and to promote a low impact pest control.

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. With this model, set on a handle directly carried by the operator, the device performance will be essentially improved in manoeuvrability within a greenhouse.

Negligible or absent impact on natural enemies proves prototype efficacy and enables its usage both with technical and economic advantages on manual distribution.

Introduction

In the last years in the European Union, organic farming has grown in terms of both farms' number and invested areas, thanks to consumers' new demands. In this context, Italy is the most involved country and Sicily is the most organic crop - oriented Italian region.

Organic farming involves the use of natural enemies to control pests and in vegetable crops the predatory mite *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) and the bug *Orius laevigatus* (Fieber) (Hemiptera: Anthocoridae) are usually released; these arthropods respectively control 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, these predators are released manually in protected crops. This method, however, requires long time and high costs and does not guarantee a uniform distribution. In order to solve these difficulties it is necessary to mechanise the above-mentioned operation. 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 and Giles, 1995; Gardner and Giles, 1997; Wunderlich and 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 former prototype were excellent, nevertheless a new version of the prototype was built to improve its performances in terms of both manoeuvrability and range of action reducing the distribution time. Therefore, this study refers about the laboratory trials effected to assess the performance of the last version of the prototype.

Materials and Methods

The prototype releases arthropods by means of centrifugal force developed by the rotation of a finned distributor disc. Natural enemies, together with the substrate they are sold with, are poured into a hopper placed above the distributor disc and are released 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 driven by means of two direct-drive electric motors and they are fixed to the same frame.

Some adjustments have been carried out on the first version of the prototype (fig. 1):

- it has been installed on a handle carried by a worker in order to improve its manoeuvrability along the inter-rows;
- a shoulder-strap has been applied to the handle to help the worker to support the prototype;
- a cylindrical articulation has been attached to the frame in order to regulate the inclination with respect to the portable structure and keep it parallel to the ground;
- the distributor disc and the hopper have been built with aluminium; moreover, the first device is now greater than before (300 mm diameter vs. 200 mm) in order to improve both the centrifugal force at the same rotation speed and the range of action; the hopper's volume, instead, has been reduced (1.5 dm^3 vs. 2 dm^3) in order to lighten the prototype, but it still allows a 1,000 m^2 greenhouse treatment without refill; the exit hole has been enlarged to insert bushes with different internal diameter (16÷25 mm) to regulate the amount of product released in the time;
- the measuring device has now a simplified shape to reduce production costs and two flexible plastic fins have been applied along its vertical axis in order both to remove the product from the inner side of the hopper and to help regulate product flow;
- an accumulator battery (6 V – 7.2 Ah) has been applied to the handle and a button can operate the electric motors.

In order to assess the performance of the new version of the prototype, several laboratory trials have been carried out to evaluate some machine parameters: the throw direction, the quantity distributed, the uniformity of throw in time, 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). The trials 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.

Fig. 1. On the left: the old version of the prototype; on the right: the new portable version.

Results

Several laboratory trials were carried out in order to determine the working parameters of the prototype according to the product distributed and to obtain optimum components' conditions for later greenhouse trials.

The overall results of numerous trials, with only the hopper and the measuring device, varying the measuring device diameter and its shape, the hopper's way out hole (16-17-19 mm) and using a 6 V power (with measuring device rotating at 30 rpm and distributor disc at 600 rpm) as already defined in previous trials (Blandini *et al*., 2007), helped to establish 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.

It was decided to use the same measuring device with a 16 mm hopper's way out hole for *Phytoseiulus persimilis* (with humid vermiculite) and a 19 mm one for *Orius laevigatus* (with buckwheat husks mixed with humid vermiculite). In these configurations a 1,000 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 trials carried out on the distribution uniformity in time with *O. laevigatus* and its substrate show (fig. 2) the quantities delivered every 30 s varied between 7.9 – 3.1 g without extreme values and between 10.4 – 2.5 g including extreme values. In the first case the data processing shows a 33% CV (Coefficient of Variation), in the other a 43% CV. The product distributed is subject to a sharp decrease until the 11^{th} sample, while the next samples are quite constant. The same trials run with *P. persimilis* and its substrate show (fig. 3) the quantities distributed varied between 6.5 – 0.9 g without extreme values and between 6.7 – 0.5 g including extreme values. In the first case there is a 40% CV, in the other a 45% CV. The amount of product distributed is quite constant until the 13^{th} sample, then it has a progressive decline till the last sample.

Further trials are necessary to verify if the prototype is able to keep the regulation constant in time and even for several treatments.

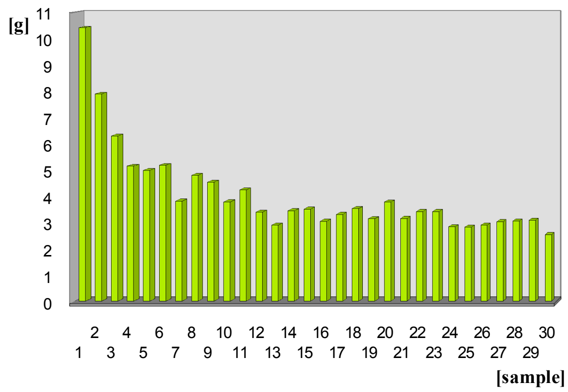

Fig. 2. Mean values of buckwheat husks mixed with humid vermiculite and *O. laevigatus* delivered [g] every 30 s

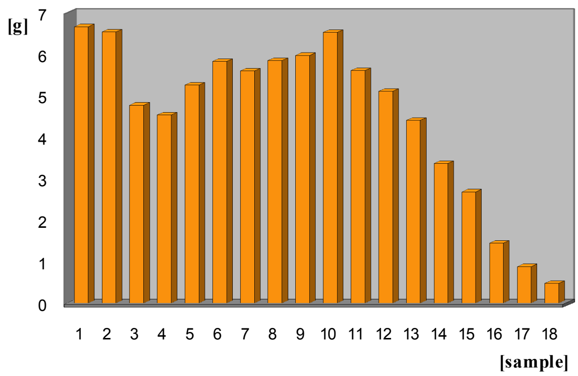

Fig. 3. Mean values of humid vermiculite and *P. persimilis* delivered [g] every 30 s

The results of vertical distribution (figg. 4 and 5) show significant differences between the trial types (90 cm height and 40-70 cm from the test bench; 130 cm height and 40-70 cm from the test bench) as regards both product quantity monitored at different heights of the test bench and product type (HV = humid vermiculite; DV= dry vermiculite; BV= buckwheat husks mixed with humid vermiculite). The trials show the humid vermiculite is able to hit the target in greater quantity while the dry vermiculite in lower quantities. But in any trial the product dispersion is greater than in previous trials carried out with the old version of the prototype (Blandini *et al*., 2007).

In general, comparing the two trials at 40 cm from the test bench and then the two trials 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.

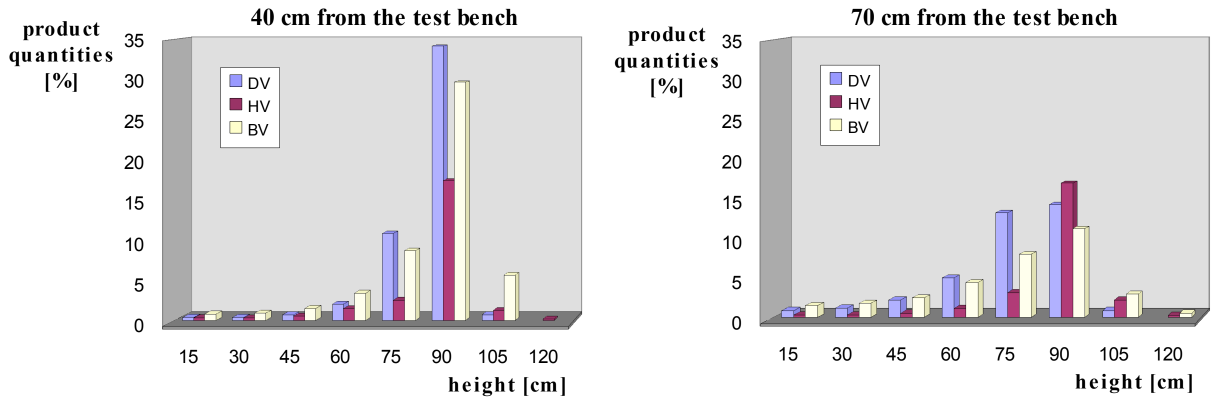

Fig. 4. Product quantities collected [%] in the trials with the prototype 90 cm from the ground

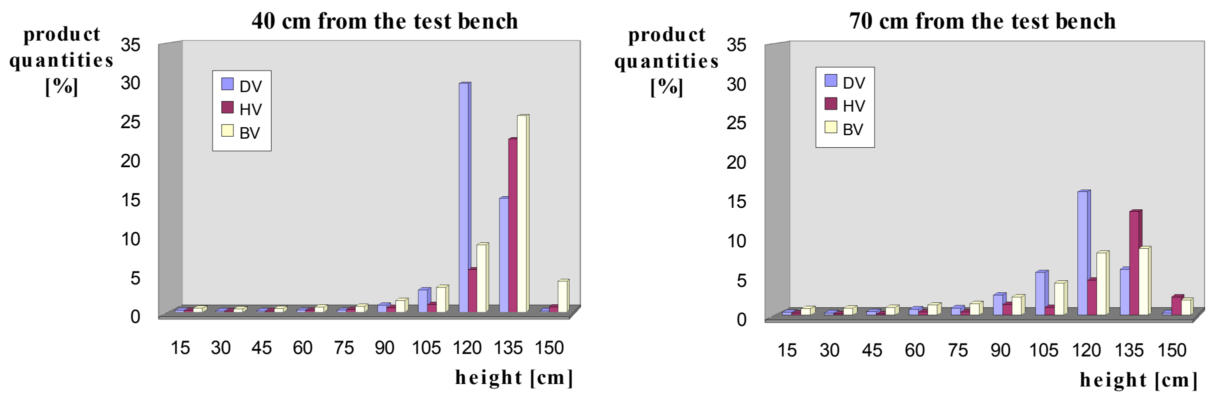

Fig. 5. Product quantities collected [%] in the trials with the prototype 130 cm from the ground

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

Conclusions and Outlook

From the laboratory trials, 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 trials should be carried out in order to verify the capability of delivering over time the same product quantities.

The trials 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.

The preliminary trials are really encouraging and let us think about a possible wide diffusion of this device for natural enemies' distribution in organic crops. The prototype could be even tractor driven or carried on mechanically driven frames over the crop rows in greenhouses.

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