Applicability evaluation of draft test protocol for functional inspection of solid fumigant applicators.

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Summary

The applicability of draft test protocol for functional inspection of solid fumigant applicators has been checked.

Two widespread machine models, normally used in horticultural farm of Liguria Region (north-west Italy) for broadcast soil fumigation were tested.

Pre-inspection phase does not show specific problems; also the functional inspection phase, both for visual check operation -presence or not of some devices on the machines- and for test of they function if present, does not show specific hurdles.

In particular the test of distribution uniformity, performed using rubber granules as blank test, give some indications on how to modify the current test protocol draft. The modification consist in change the admissible threshold; the maximum deviation of each distribution pipe, relative to the mean value, have to be varied from 10% (current draft) to 15%. Furthermore, it is suggested an alternate method to assess the distribution uniformity of rubber granules; this method considers the use of horizontal patternator fitted by grooves similar to that used to check the distribution uniformity of boom sprayers. The proposed method will facilitate the coefficient of variation (CV) calculation.

Keywords: inspection, fumigant, pesticide application, SPISE, uniformity distribution

Introduction

Soil disinfection with solid fumigant applicators is pretty diffuse in several countries like Italy in horticultural area, both in open field and in protected crops, including glass-greenhouses, but walk-in-tunnels, and multispan plastic greenhouses too. Soil fumigation is periodically performed, also depending from the restrictions reported by the registered label [in accordance with Regulation (EC) No 1107/2009] with the aim to disinfested a soil layer of 30-35 cm depth against fungi, insects, nematodes and weeds.

A solid fumigant applicator is a device to apply fumigants (generally Dazomet) in a solid form, as dry granules or micro granules. It typically consists of a hopper, an agitation system, a metering system to deliver a measured quantity of granules and a delivery system. Delivery system refers to the part of the machine from the metering outlets to the point where the product is delivered

Applicator can be configured in many different ways depending on the distribution system, on the size and quantity of hoppers, the number of outlets, the drive type and the presence of a soil rototiller and of a compaction system. Hopper capacity is generally between 30 and 150 l and working width can go up to 3 m. Advanced applicators are equipped with a controller box to adjust the setting of the machine.

<u>Applicators combined with a soil rototiller</u> are used without any overlapped application. In principle, the applicator includes following parts:

fumigant hopper provided with a top cap firmly closing the hopper avoiding any accidental granules/dust leak,

mechanical or agitation mixer: the mechanical mixer delivers the solid fumigant to the soil trough distribution pipes or other driving device. The mechanical mixer can be mechanically or electronically driven during the solid fumigant delivery,

distribution pipes: distribution pipes drive the solid fumigant from the hopper throughout the mechanical mixer to the soil eventually throughout a soil injector. The number of distribution pipes might depend on mechanical mixer characteristics and on the injection/distribution system. When available the soil injector allows the distribution of the solid fumigant deep into the soil. Injection depth can be adjusted. The number of injector depends from working width,

soil mixer: the soil mixer is basically a rotary tiller made as common soil tiller,

soil compaction roll: such roll, mechanically driven or not, ensure a surface coil compaction aimed at limiting fumigants losses,

soil mulching system: this system, when present, ensure the complete soil mulching of the fumigated soil strip.

In applicator not combined with a soil rototiller**,** contrary to applicator combined with a soil rototiller, the solid fumigant is always delivered by injection into the soil. Application rate can be mechanically or electronically tuned.

In the framework of the Spise TWG 10 a specific Spise Advice draft concerning the functional inspection of soil disinfection machine for liquid (part 1) and solid (part 2) formulation distribution has been developed. The applicability of draft test protocol for solid fumigant applicator (part 2) has been checked on two machine models used on basil farms of Liguria Region (north-west Italy).

Materials and methods

The solid fumigant applicator OLIVER FPA 300 (Figure 1) is equipped with a 350 Kg single hopper. Eight metering units are placed on the hopper bottom; from each metering unit two pipes distributor deliver the fumigant product to the soil. The machine is equipped with front rototiller and rear soil compactor roller that are activated by PTO unit. The cage roller, due to the contact with soil, transmit the movement to the pinion that control the rotary movement of metering units; the fumigant application is allowed by machine forward progression. The metering units provide a fix volumetric dosage and the applied dose is determined varying the pinion dimension. Once distributed on the soil surface, the fumigant product is buried and mixed with soil by the rototiller action.

Figure 1. – Solid fumigant applicator model OLIVER FPA 300.

The solid fumigant applicator FORIGO Mix Tiller Dry 35 – 230 (Figure 2) is equipped with double hopper of 100 Kg each one. Each hopper is provided of six hopper draining pipes used to conduct the solid pesticide to the metering units placed near the soil surface. The machine hoppers are equipped with centrifugal fans that provide an air flow inside the hopper draining pipes, in order to supply a constant flow of solid fumigant granules to the metering units. The rotary movement of metering units determines the dosage that is proportional to the forward speed; it is detected by the trailing land-

wheel. An electronic device, placed inside the tractor cabin, allow to enable or disable the solid fumigant application. Also in this case the fumigant, once distributed on the soil surface, is buried and mixed with soil by the rototiller action. The tilled soil is finally compacted throughout a mechanically driven compaction roll.

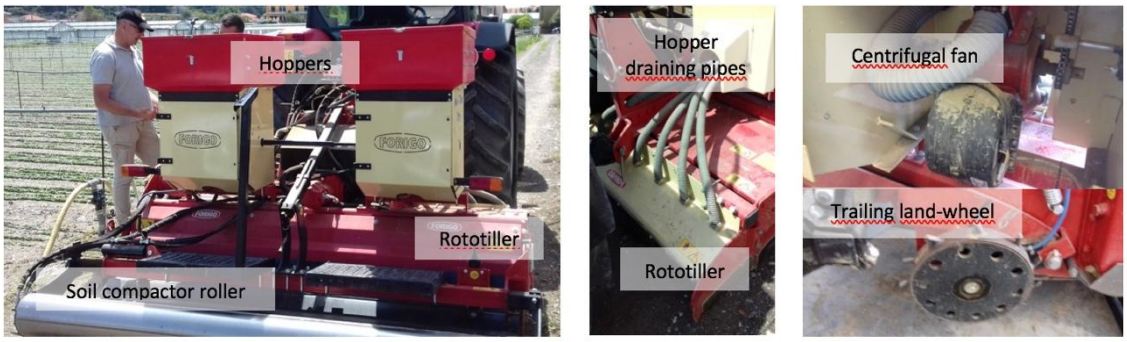

Figure 2. Solid fumigant applicator model FORIGO Mix Tiller Dry 35 – 230

Following the draft test protocol, contained in the current Spise advise, the pre-inspection and functional inspection were performed for both solid fumigant machines tested.

To simplify the data collections, "ad hoc" datasheet was created (Figure 3).

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Inspection of solid formulation fumigant application equipment

Test station (workshop) _____

Name of the inspector _____

Owner's identity _____

Owner's address _____

Owner's signature _____

Inspector's signature _____

Date of inspection _____

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2 MACHINE DESCRIPTION

Manufacturer: _____

Model: _____

Serial number or other identification: _____

Year of construction: _____

Drive: a) mounted [ ] b) trailed [ ] c) self-propelled [ ] d) hand operated

Working width (m): _____

Hoppers: Number _____ Volume (m³ – kg) _____

Metering unit: a) Rotating cylinder [ ] b) Positive displacement rotor [ ]

If b)

Speed of rotation governed by: trailing land-wheel [ ] electrical motor [ ]

Soil rototiller: a) yes [ ] b) no [ ]

Distribution set-up used _____

Number of distributors (delivery system) _____

Controller box: a) yes [ ] b) no [ ]

Speed sensor: a) yes [ ] b) no [ ]

GPS: a) yes [ ] b) no [ ]

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4 INSPECTION[3]

4.1 Leakage

Static - With the machine not working and parked on a level surface, there is no leakage from any part of the machine in all position of lift a) yes [ ] b) no [ ]

Dynamic - Working under normal working condition, there is no leakage of product from any part of the machine a) yes [ ] b) no [ ]

4.2 Metering unit

4.2.1 Drive

Drive of the metering unit(s) functions correctly: a) yes [ ] b) no [ ]

Electronic signal, GPS sensors and radar sensors (if present) function correctly: a) yes [ ] b) no [ ]

Drive ids-engagement) functions correctly (if fitted): a) yes [ ] b) no [ ]

4.2.2 Metering shaft alignment

Drive shaft is in correct alignment and rotated easily without binding: a) yes [ ] b) no [ ]

4.2.3 Meter rotor condition

The rotor is not damaged or dirty: a) yes [ ] b) no [ ]

All rotors and cassettes are fitted according to manufacturer's guidelines: a) yes [ ] b) no [ ]

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Figure 3. Extract of datasheet used during functional inspection.

The test protocol application procedure requires numerous qualitative evaluations (presence or absence of specific machine devices, function of that devices, etc.); the unique measurement required is the test on uniformity of distribution: "the measured output per output shall be within ±10% of the average output".

So the trials of distribution uniformity were performed using rubber granules to simulate the solid fumigant product; this specific materials was chosen based on previously results obtained at Crop Protection Technology (DiSAFA, University of Torino) facilities testing the functional inspection of micro-granulator (Manzone et *al.*, in press). During all the trials the amount of rubber granules was enough to ensure the full coverage of granules supplier mechanical elements (Figure 4).

Figure 4. Rubber granules in the hoppers.

The distribution uniformity trials performed using OLIVER machine do not show any specific problem. A plastic bag was fixed at each hopper draining pipes output (12 in total) with the purpose to collect the rubber granules supplied (Figure 5). The machine supply system was manually activated through the revolution of cage roller (Figure 6). The distribution uniformity deriving from two different dosages were assessed: tested doses were determined by the activation of two pinion sizes (15 and 18 teeth pinion) and each trial duration was based on 10 completed revolutions of cage roller. Once finished the trials, the granules collected in each plastic bag were weighted to determine the precise amount supplied by each hopper draining pipes (Figure 5).

Figure 5. Rubber granules collection using plastic bags.

Figure 6. Manual rotation of the cage roller.

Different way was followed to measure distribution uniformity of FORIGO machine; the presence of air flow inside the hopper draining pipes did not allow to fix the plastic bag at they output. So, a horizontal patternator fitted by grooves, similar to that used to check the distribution uniformity of boom sprayers, was employed. The patternator was placed on the soil surface, directly under the machines that was lifted up 5 cm on the edge wall grooves level (Figure 7). The supplied dose was provided through the manually revolution of trailing land-wheel (Figure 6); also in this case the trail duration corresponds to 10 completed revolutions.

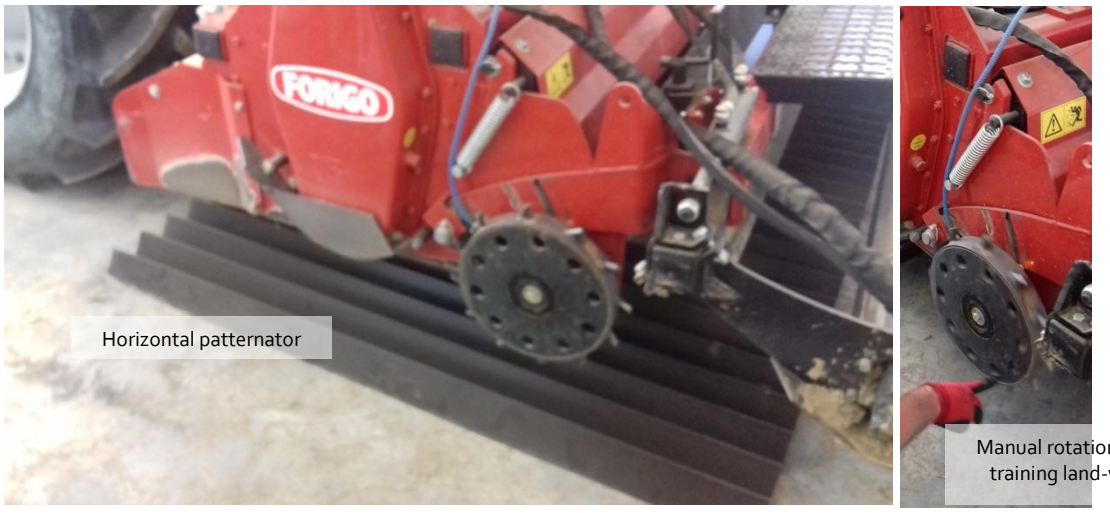

Figure 7. Rubber granules collection using horizontal patternator.

Results

For both pre-inspection and functional inspection phases where a visual control was required No problems were encountered during application of test protocol for both machines tested. In particular the application of pre-inspection, that requires only visual assessment of presence or absence of specific devices mounted on the machine, was easy and fast. Also the function qualitative evaluation, of above mentioned specific devices (metering unit characteristics, hopper/s, measuring system, pipes an hoses, delivery system, presence of leakage), did not show specifically trial difficulties.

Instead, some difficulties were encountered performing distribution uniformity trials.

The OLIVER machine show CV% results (for both tested dosages) little bit higher than 10% threshold fixed by test protocol. Given that the solid fumigant product supplied by the machine is left on the soil surface and buried/mixed with soil in a second step by machine rototiller, the uniformity of distribution acquires less importance because it has to be ensured the uniformity in the tilled/mixed soil. So, in this particular case, could be more suitable increase the CV% threshold from 10% to 15% because machines characterized by CV equal to 15% could guarantee the uniformity of distribution in the tilled/mixed soil.

The FORIGO machine showed the bad results in terms of distribution uniformity. Just the visual check of rubber granules collected by patternator grooves was enough to realize that the CV% not follow the threshold stated in the draft test protocol. In fact, some grooves contain two or three fold more than the lower amount collected (Figure 8): the distribution was not homogenous.

The deep differences of rubber granules amount collected by the grooves could be attributable to the uneven airflow rate, distributed by the centrifugal fan, inside hopper draining pipes; this results in different amount provided by the different hopper draining pipes. However, to provide an indication about distribution quality, the rubber granules amount supplied by each hopper was recorded; the two hoppers differed 5%.

The uniformity distribution problems encountered during trials were reported to the FORIGO manufacturer. The manufacturer was already aware about the uniformity distribution problems of the machine model inspected. Furthermore, the manufacturer confirmed that the problem is linked to the uniformity of distribution of fan airflow rate among the six hopper draining pipes. The fumigant product, once arrived in a unique collector, is divided between the six draining pipes, but only by the fan air flow. This means that a minimal physical variation (e.g. humidity, etc.) of fumigant product at the time of distribution is translated in deep differences between product amount supplied by each draining pipe resulting in uneven distribution uniformity. As reported by the manufacturer, high improvements were recently included in the last model of this solid fumigant applicator, modifying the collector with six elements that separate equally the fumigant products between the draining pipes; the fan is only intended to aid the transportation of product inside the draining pipes. It will be useful perform further trials using this last version of FORIGO fumigant applicator to check the improved distribution system.

Figure 8. Example of bad distribution obtained

Conclusions

The functional inspections were conducted on two representative models of solid fumigant applicators widespread in horticultural Italian farms; the main aspects emerged are:

- the draft protocol test provided by Spise advise is applicable and easy to follow;
- the rubber granules used to perform the uniformity distribution trials are suitable for these tests; furthermore, they are easy to recycle and no residuals inside the machine were detected at the end of trials;
- increase the CV threshold, of amount measured in each supplier and the mean of amounts supplied by the different suppliers, from 10 to 15%;
- the use of horizontal patternator with grooves, similar to that used for boom sprayers, is proposed as effective alternate test method to evaluate the distribution uniformity when rubber granules cannot be easily collected from delivering systems.

Acknowledgments

Authors wish to thank following farms:

- "Azienda Agraria Anfossi Società Agricola s.s" - via Paccini, 39 Fraz. Bastia, Albenga (SV) anfossi@aziendaagrariaanfossi.it
- "Azienda Agricola Bracco Paolo" - Strada Piangrande 20/A Andora (SV) www.facebook.com/aziendabraccopaolo

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