Research of an appropriate inert compound to use as an alternative to the granules of the plant protection products in the inspections of microgranulators

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Summary

The goal of this experimentation was to find an appropriate inert and hydrophobic compound with physical-dimensional properties as close as possible to those of the granules of the plant protection products (particle size: 0,3-1,2 mm and density: 0,6-1,4 g/cm3) in order to allow the micro granulator periodical inspection following the incoming SPISE Advice related to this aspect. In addition, the inert should be also commercially available guarantee for a long time and not abrasive. During the test, four inert materials were analysed: corn flour, rubber granules, glass microspheres, and plastic granules.

Tests were performed in the laboratory using a specific device in order to drive the micro granulators. For each regulation, it was measured the amount of outlet every two rotations of the metering unit drive shaft, up to a maximum of 10 rotations (2, 4, 6, 8, 10). Moreover, It has been detected also the time every two rotation.

Tests have highlighted a good repeatability with all tested materials independently of the number of rotations or the rotation time of the metering unit drive shaft (CV max = 6% for corn flour, glass microspheres and plastic granules; CV max = 5% for rubber granules). In addition, a good linearity in relation with metering unit regulation, independently of the materials and the number of rotations, was pointed out. Considering that the rubber granules are hydrophobic (they are not Influenced by relative humidity of the air or by water) and show a low cost (about 2-3,00 €/kg), this material seems the more suitable inert compound , between those tested to be use in the periodical mandatory inspections of micro granulators.

Introduction

Micro-granulators are substantially composed by: one or more hoppers for containing the granules of chemical product; some metering units able to deliver a determined amount of granules. As required by the EU Directive 128/2009/EC (adopted in Italy with Dlgs n.°150 of 14/08/2012) and by the Italian National Action Plan (NAP), these type of equipment are subject to a mandatory functional inspection as for all the other type of Pesticide application equipment (PAE) with the exclusion of the knapsack sprayer . However, due to the lack of standardized test procedures to make functional inspection of these equipment, the Italian NAP establish only the interval between inspections that shall not exceeded six years, but it doesn't define the deadline for starting the mandatory inspections (DM n.4847 del 03/03/2015). Also in the others EU Members State it is still not possible to fully comply with the EU Directive 128/2009/EC requirements because of the lack of information also on how to make the inspection of this type of PAE

With the aim to try to find a solution to this situation SPISE have establish a specific technical working group (TWG 9) witch goal was to define an advice on how to inspect microgranulator and at the same time has ask CEN TC 144 to promote a specific EN standard related to this topic.

The present draft version of the SPISE Advice contain a description of the functioning, the usage and the working principle of micro-granulators, but has also a list of requirements and test methods of testing micro-granulators in use. At this regards, the goal of this experimentation was to find an appropriate inert with physical-dimensional properties as close as possible to those of the granules of the plant protection products (PPP) to be used during the inspections because of the considerable operator and environmental risks when chemical granules are used.

Materials and Methods

The present draft version of the SPISE Advice contain a description of the functioning, the usage and the working principle of micro-granulators, but has also a list of requirements and test methods of testing micro-granulators in use. At this regards, the goal of this experimentation was to find an appropriate inert with physical-dimensional properties as close as possible to those of the granules of the plant protection products (PPP) to be used during the inspections because of the considerable operator and environmental risks when chemical granules are used.

Table 1. Main physical properties of the PPP on the market and of the four inert materials used in the tests

Material	Density (g/cm^3)	Granules size (mm)
Chemicals (granules) on the market (survey)	*0,6 - 1,4*	*0,3 – 1,2*
Rubber granules	0,6	0,4 – 0,9
Corn flour	0,8	0,2 – 0,5
Glass microspheres	2,6	0,4 – 0,8
Plastic granules	1,1	0,6 – 0,8

For the tests was used mechanically driven micro-granulators mainly mounted by the three more important seeders manufacturers in Italy.

These three micro-granulators (X, Y e Z) are composed by: a plastic hopper with a nominal capacity between 12 and 25 l; some metering gravity units - consisting in a cylindrical small rotor with some teeth on its surface - located under the hopper.

The granules flow rate is regulated by the rotation of the rotor and by the opening present at the bottom of the hopper. During the distribution the granules are taken from the rotor and conveyed inside a PVC pipe that carries them close to the ground. In all 3 types of microgranulators tested , the adjustment of the opening width at the bottom of the hopper is guaranteed by a slide valve with a shutter connected to a special toothed ring nut keyed on a threaded shaft: screwing or unscrewing the ring nut it is possible to open or close the opening. With the flowrate regulation system of the micro granulators used in the tests it is possible to perform 5 macro adjustments (A, B, C, D and E) and for each of them 5 micro adjustments (0, 1, 2, 3, 4, 5, 6, 7, 8, and 9) (Table 2).

Table 2. Main technical features of micro granulators used in the tests

Microgranulator	Nominal capacity of the hopper	Metering unit	Activation mode	Macro-adjustments	Micro-adjustments
X	12	rotor	mechanical	5	10
Y	25	rotor	mechanical	5	10
Z	25	rotor	mechanical	5	10

For all the metering units, with the "A0" adjustment the opening at the bottom of the hopper is in a close position.

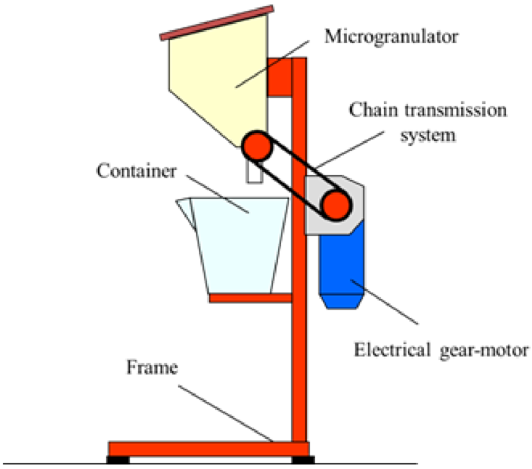
The distribution uniformity of each micro granulator has been evaluated according to the different settings of the flow rate regulation system reported into the instruction handbook of the equipment.

For each setting (A0, B0, C0, D0, E0), the quantity of output granules was measured by making several rotations of the drive shaft (2, 4, 6, 8, 10). In this way, the minimum number of rotations to be performed during a functional inspection with the micro-granulator mounted on the seeder, has been measured. To verify the results repeatability (CV) has been carried out tree repetitions for each test.

For the tests, a specific experimental test device has been realized. It is consisting of: a steel frame with a fastening bracket for the micro-granulators; an electric gear motor with a chain drive system that activates the metering unit for a set time (Figure 1).

During the tests, granules were collected in a container and subsequently were weighed with a three decimal precision digital scale (accuracy: 0.005 g).

Figure 1. Experimental test device realized for the tests



In order to check the correspondence between the quantity delivered with the different micro granulators used (X, Y and Z) with the same setting, a comparison was made between the three equipment tested using the rubber granules and making two rotations with the drive shaft of their metering units.

Data collected was analysed using IBM SPSS Statistics SSPS (Statistical Package for the Social Sciences). The tests repeatability was evaluated by the coefficient of variation (CV). Eventual differences between tests were checked by performing Tukey's multiple

Results

I All types of inert used in the tests have highlighted a good repeatability of the results independently from the rotations number of the micro-granulator drive shaft and the metering unit setting. The coefficient of variation (CV) for all the tests made was always below 5%. (Tables 3, 4, 5, 6).
Only the corn flour has highlighted some problems, showing a high propensity to packing. When the amount of flour in the hopper was low, the dust get stuck to the hopper walls cause a significant reduction of the material delivered with an incorrect final dosage.

Table 3. Mean value of amount of corn flour (g) recorded according to the rotations number of the X micro-granulator drive shaft (2, 4, 6, 8 e 10 rotations) and to the setting of metering unit (A0, B0, C0, D0 e E0) and variability of the data value collected (CV).

Rotations	A0		B0		C0		D0		E0	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2	0	0	3,642	5%	8,165	4%	13,225	5%	17,910	5%
4	0	0	7,383	6%	16,830	5%	26,550	4%	36,490	4%
6	0	0	11,052	5%	24,865	5%	40,215	5%	53,740	4%
8	0	0	14,493	5%	33,435	5%	53,485	5%	71,630	3%
10	0	0	18,223	6%	41,725	5%	66,460	5%	89,680	4%

Table 4. Mean value of the rubber granules distributed (g) according to the rotations number of the X micro-granulator drive shaft (2, 4, 6, 8 e 10 rotations) and to the setting of metering unit (A0, B0, C0, D0 e E0) and variability of the data value collected (CV)

Rotations	A0		B0		C0		D0		E0	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2	0	0	2,088	5%	5,235	4%	7,745	2%	10,785	4%
4	0	0	4,172	4%	10,450	3%	16,065	2%	21,760	3%
6	0	0	6,433	5%	15,735	3%	24,030	3%	32,380	4%
8	0	0	8,318	2%	20,815	2%	31,945	1%	43,270	2%
10	0	0	10,192	1%	26,295	5%	39,865	1%	53,630	4%

Table 5. Mean value of the amount of plastic granules distributed (g) according to the rotations number of the X micro-granulator drive shaft (2, 4, 6, 8 e 10 rotations) and to the setting of metering unit (A0, B0, C0, D0 e E0) and variability of the data value collected (CV)

Rotations	A0		B0		C0		D0		E0	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2	0	0	7,805	6%	12,645	5%	18,055	5%	23,650	4%
4	0	0	15,490	4%	25,450	4%	36,360	5%	47,955	3%
6	0	0	22,945	5%	36,480	4%	54,975	6%	72,300	3%
8	0	0	30,445	5%	51,040	6%	73,220	4%	96,495	2%
10	0	0	38,085	3%	63,925	3%	92,225	5%	120,400	1%

Table 6. Mean value of the amount of glass microsphere distributed (g) according to the rotations number of the X micro-granulator drive shaft (2, 4, 6, 8 e 10 rotations) and to the setting of metering unit (A0, B0, C0, D0 e E0) and variability of the data collected (CV) .

Rotations	A0		B0		C0		D0		E0	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2	0	0	20,765	5%	31,715	4%	43,370	5%	56,805	4%
4	0	0	42,085	5%	63,090	6%	87,530	5%	112,470	5%
6	0	0	63,240	5%	95,400	6%	131,800	5%	169,930	5%
8	0	0	84,745	4%	126,565	5%	176,475	6%	225,315	2%
10	0	0	105,945	5%	158,670	3%	222,135	4%	281,900	2%

The collected data also showed a good correlation between the amount of inert delivered and the different number of rotations of the drive shaft of the metering unit of the microganulator X. In fact, for the different adjustments the regression value obtained is close to 1 for all types of inert tested (Figures 2, 3, 4, 5).

Figure 2. Comparison between the amount of rubber granules distributed and the rotations number of the X micro-granulator drive shaft

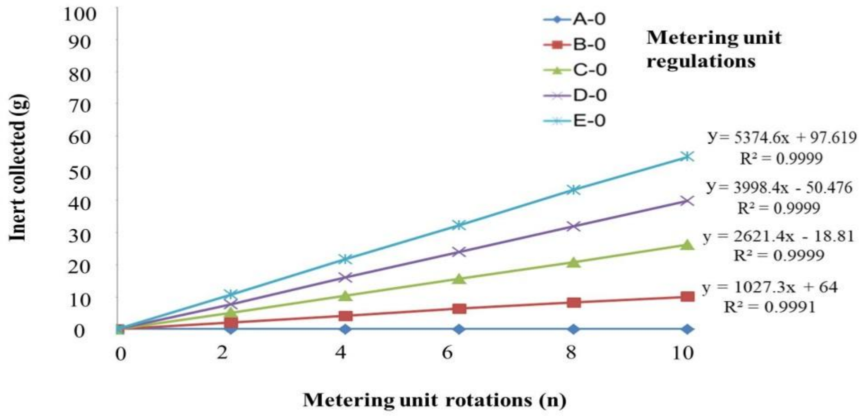


Figure 3. Comparison between the amount of corn flour distributed and the rotations number of the X micro-granulator drive shaft.

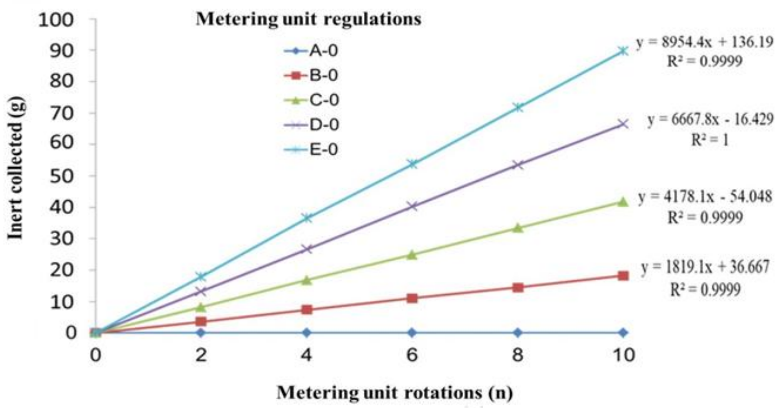


Figure 4. Comparison between the amount of plastic granules distributed and the rotations number of the X micro-granulator drive shaft.

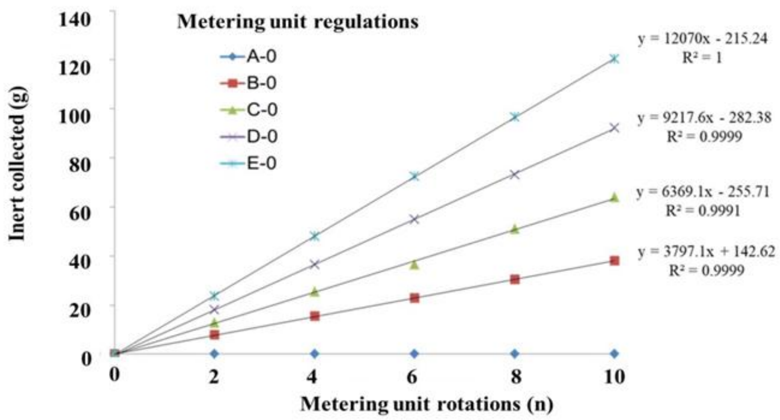
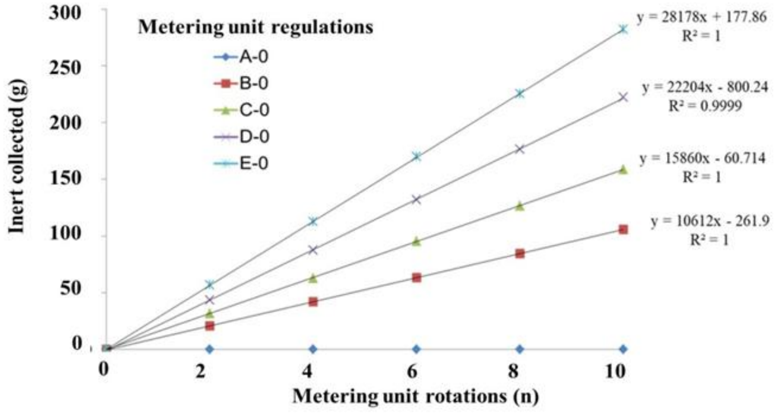
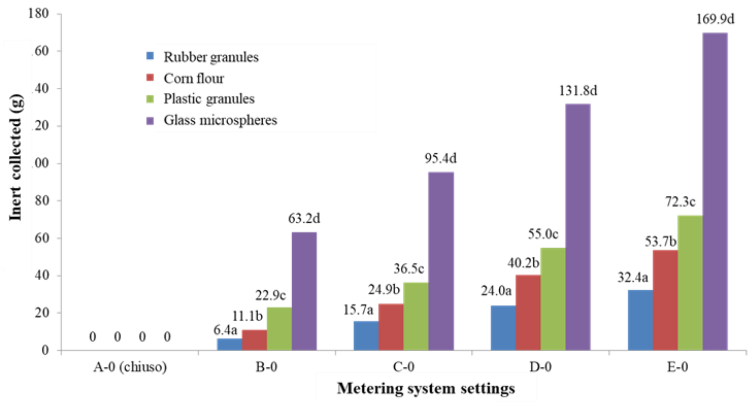


Figure 5. Comparison between the amount of glass microspheres distributed and the rotations number of the X micro-granulator drive shaft



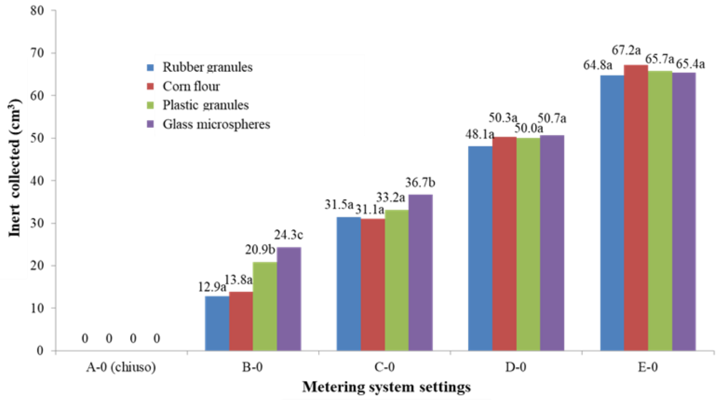
Comparing the mass (g) of material delivered using the different materials tested with the different settings of the flow rate regulation system, a significant difference were show (Figure 6). This trend can be attributable to the different density of the materials used; in fact, that difference is reduced if the amount of inert material collected is expressed in terms of volume (settings Do and Eo) (Figure 7).

Figure 6. Mass (g) of material delivered using the four tests materials with the different settings of the flow rate regulation system (Ao, Bo, Co, Do, and Eo) and 6 rotations of the micro-granulator drive shaft.



Notes: Different letter indicate the eventual difference between values in each metering system setting.

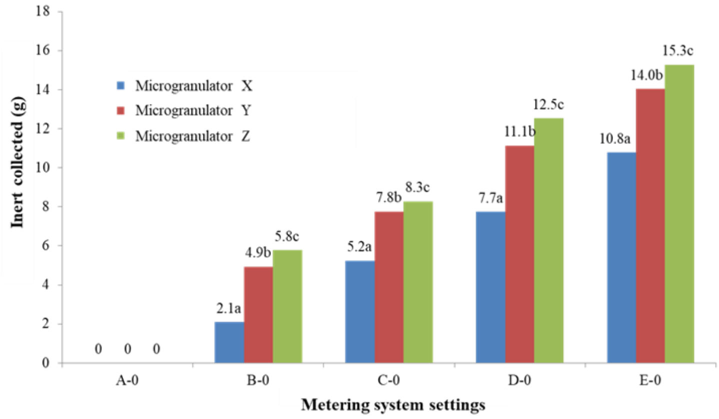
Figure 7. Volume (cm3) of materials delivered using the four tests materials and the different settings of the flow rate regulation system (Ao, Bo, Co, Do, and Eo) and 6 rotations of the micro-granulator drive shaft.



Notes: Different letter indicate the eventual difference between values in each metering system setting.

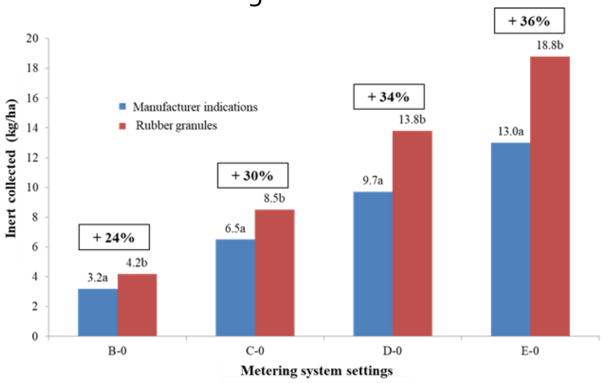
Regarding the quantity of material distributed by the three different micro-granulators, tests have highlighted some differences for the X micro-granulator, especially when rubber granules was used (Figure 8). However, also the amount distributed by this micro-granulator at the different settings were proportional to those indicated by the manufacturer (Figure 9).

Figure 8. Mass (g) of rubber granules distributed by the three types of micro-granulators (X, Y e Z) using the different settings of the regulation system.



Notes: Different letter indicate the eventual difference between values in each metering system setting.

Figure 9. Difference in percentage between the quantity indicated by the manufacturer and that obtained with the rubber granules.



Notes: Different letter indicate the eventual difference between values in each metering system setting.

Conclusion

The tests carried out show a good performances of all the four different inert materials used with no significant differences emerged as regards the tests repeatability. Nevertheless, corn flour showed some problems due to a considerable sensitivity to humidity and to a high propensity to the packing with a limit amount of material in the hopper. Moreover, it is important to underline the potential abrasive effect on the micro- granulator dosage devices when glass microspheres are used. Therefore the rubber granules appear the most suitable inert material for this type of test to be done following the incoming SPISE Advice on the inspection of this type of PAE, also if the main physical characteristic of this material are not always comparable with those of all the granular insecticides present today on the market. For this reason, it is suggest to evaluate the relationship between the amount distributed using the rubber granules and that declared by the manufacturer before beginning the functional inspection and to perform this comparison in relative terms by calculating the difference in percentage between the two types of quantities.

References

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