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Procedure for Testing Field, Orchard and Vineyard Sprayers to Improve the Spray Distribution Uniformity

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Abstract: The large variety of phyto-sanitary equipment and plants existing on the Romanian market (various brands, various levels of wear), the users' training level and the requirements Romania had for its accession to the EU demand the adoption of some precise regulations concerning the control of the spraying equipment according to the present-day international norms. This paper presents the spraying testing equipments in INMA Bucharest, using the specifically modern equipments, which let the checking respect of the European norms from domain. The tests looking the verification of requirements from SR EN 13790 for plants protection machines have pursued:
- the determination of transversal distribution uniformity on the test bench for spraying machines in the base crops;
- the determination of distribution uniformity on the test bench for spraying machines in vineyards an orchards;
- the determination of nozzle flow and of flow coefficient;
- the determination of pressure drop.
The paper refers itself especially to the conditions which have to be respected by the plant protection machines relating to the dangers at which is exposed their operator and to the danger of contaminating the environment and to the optimal plants protection by applying a minimal quantity of phyto-sanitary substances.
Key words: plants protection, distribution, uniforemity, nozzle.

INTRODUCTION

The consume of phyto-sanitary substances in Romania, comparative with the one in the European countries is 10 to 15 times smaller because of the fact that the majority of the agricultural producers are practicing a subsistence agriculture due to the multiple problems specific to transition period. Evolution of agricultural surfaces repartition, after the using pattern is presented in figure number 1:

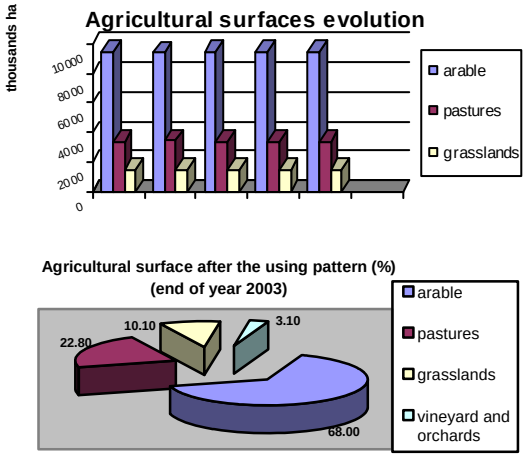

Fig. 1. Agricultural surfaces after the using pattern
Source: *Romanian Statistic Annual*

Agricultural surfaces variation, after the using pattern, is up to 14 thousands ha - arable terrains, up to 20 thousands ha - pastures and up to 10 thousands ha- grasslands.

It's remarked a diminution in case of occupied surfaces with vineyards and orchards surface, in 2003 the surface occupied by vineyards was of 230,5 thousands ha, and the one occupied by orchards was of 227,2 thousands ha.

Regarding the park of spraying and powdering machines with mechanical traction, the situation until 2003 is presented in figure 2, remarking a diminution of the specific equipments number.

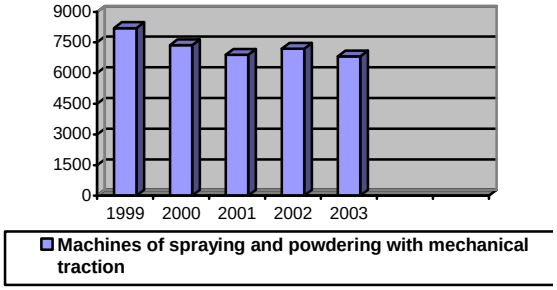

Fig. 2. Evolution of spraying and powdering machines with mechanical traction

METHODOLOGY

The tests looking the verification of requirements from SR EN 13790 for plants protection machines have pursued:

- the determination of transversal distribution uniformity on the test bench for spraying machines in the base crops;
- the determination of distribution uniformity on the test bench for spraying machines in vineyards an orchards;
- the determination of nozzle flow and of flow coefficient;
- the determination of pressure drop.

For doing these determinations it has been used a stand composed of the following principal parts:

- ***Entrainment part*** which consist of a gearmotor of 7,5 kW with elastic coupling which assures at its way out a rotative speed of 550 rot/min and which is coupled at the pump axle by a universal joint. This reduction gear substitutes the power shaft of the tractor when tests are made in laboratory conditions;
- ***The liquid alimentation part*** (at wanted pressure and flow) with the frames on which are mounted de spraying equipment (nozzles), composed of:
  - ✓ 300 l basin with its afferent structure;
  - ✓ 140 l/min pump at 50 bar;
  - ✓ electro-valves;
  - ✓ low pressure distributor;
  - ✓ triple nozzles;
  - ✓ double nozzles;
  - ✓ ventilator case of 32";
  - ✓ rotative speed multiplier with 2 speeds;
  - ✓ 800 mm propeller with 9 blades and clutch;
  - ✓ pressure distributor of 50 bar;
  - ✓ filters.
- **Measuring and testing part,** composed of:
  - ✓ manometers tester;
  - ✓ pumps tester;
  - ✓ electronic tester for measuring of liquid distribution variation at spraying machines in base crops;
  - ✓ electronic tester for measuring of liquid distribution variation at spraying machines in vineyards and orchards;
  - ✓ gauge manometers;
  - ✓ collector tray and liquid recirculation;

The stand for testing of spraying machines was designed and realized for two situations:

a) testing in laboratory;
b) testing at beneficiary.

a*) Testing in laboratory* presumes verification, at flow and pressure specified by beneficiary, of nozzles or of ramps with nozzles which are mounted on the stand. Verification of liquid distribution variation is made using one of the electronic testers, (for spraying machines for base crops or for vineyards and orchards). If the verification of manometers and their pumps it's wished for, those will be verified using the two specialized testers.

b) *Testing at beneficiary* presumes verification of the manometers and the pump with which is fitted the spraying machine with the two specialized testers and the verification of liquid distribution with one of the electronic testers (for spraying machines for base crops or for vineyards and orchards).

VERIFICATION OF SPRAYING EQUIPMENTS

For verifying a spraying machine, we need to follow the next steps:

- ***Determination of transversal distribution uniformity at spraying machines in base crops*** was made on a test stand formed of a 12 m ramp with reservoir, pump, electro-valves and measuring equipment composed of a scanner with 8 flutes of 100 mm width and 80 mm depth (distance measured between the superior edge and the bottom of the flute), figure 3.

Figure 3. Equipment for verification of transversal distribution uniformity at spraying machines in base crops

The scanner width is 1,5 m, and its 8 cylinders are of the same type and size and have a capacity of 500 ml. The scanner is moving on rail tracks under the spraying ramp, collecting and measuring the volume of sprayed liquid, covering this way the total working width of the spraying machine. The measured values are transmitted by radio-link to the computer which process them and creates graphic results.

On ramp were mounted three types of nozzles ALBUZ AXI with codes ISO 11002; ISO 11003 and ISO 110015 with spraying angle of 110° at 50 cm. distance between them. The determinations were made on two sections (left -right) at working pressures of 2; 2,5; 3; 3,5 and 4 bar. At each working pressure and each type of nozzle were made at least 3 repetitions. Results are presented in figure 4.

By analyzing the results it's observed that the transversal distribution uniformity at spraying machines in base crops decreases with the diminution of the working pressure, and it's not between the ± 10% limit admitted by SR EN 13790-1: 2004.

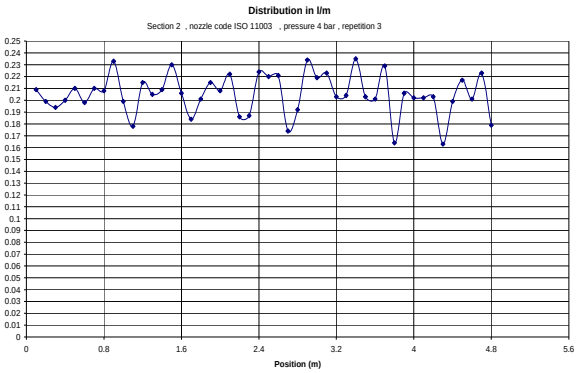

Figure 4.

It was also observed that the measuring equipment performed well at testing, notifying the operator about all the accidental malfunctions of the installation (nozzle blockage, pressure drops).

Determination of distribution uniformity at spraying machines in vineyards and orchards was made on a test stand formed of two circular ramps with 7 nozzles each, reservoir, pump, electro-valves and a scanner with 24 couplings which are fixed on the spraying ramp nozzles. The liquid is collected by hoses in separated cylinders for each nozzle, after that being measured. The values of the measurements are transmitted by radio-link to the computer, which process them and creates graphic results, figure 5.

Figure 5. Equipment for determination of distribution uniformity at spraying machines in vineyards and orchards

On ramps were mounted two types of nozzles with codes 005812 and 005815.

Determinations were made on all 14 nozzles at working pressures of 5; 10; 15; 20 and 25 bar. At each working pressure and each type of nozzle were made 3 repetitions. Results are presented in figure 6.

Analyzing the results we observe that the distribution uniformity at spraying machines in vineyards and orchards is relatively constant at working pressure variations, the values being situated between ± 10% of the admitted limits, according to SR EN 13790-2: 2004.

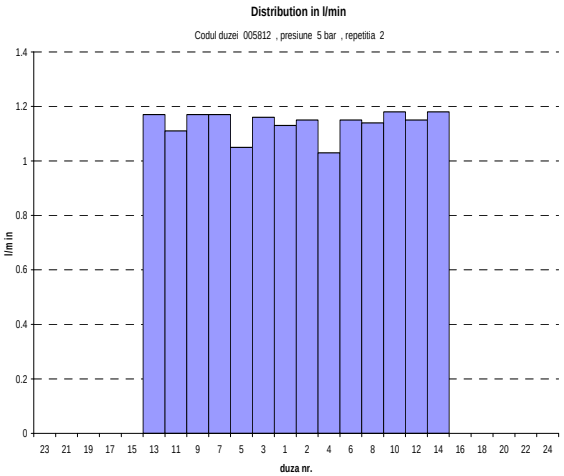

Figure 6.

It was also observed that this measuring equipment too performed well at tests, notifying the operator about all the accidental malfunctions of the installation (couplings wrong mounted, nozzle blockage, pressure drops).

Determination of nozzle flow and of flow coefficient

The nozzle flow, both of the spraying machine for base crops and for vineyards and orchards was determinated by volumetric method for each type of nozzle, collecting for 1 minute the liquid from one nozzle, at working pressures of 2; 2,5; 3; 3,5 and 4 bar.

For each pressure and type of nozzle, were made 5 measurements. The quantity of liquid which is leaked by the nozzle for 1 minute represents the real flow for the respective nozzle, value necessary at flow coefficient calculation.

The flow coefficient represents the rapport between the real flow and the theoretical flow and was calculated with the relation:

$$\mu = q_r / q_t = q_r / f \cdot \sqrt{2gH} \cdot 6 \cdot 10^2$$

in which:

q_r = real flow determinated by measurements [l/min]

q_t = theoretical flow calculated [l/min;];

f = section of nozzle pinhole [dm^2];

g = gravity acceleration [9,81 m/sec^2];

H = pressure [bar];

μ = flow coefficient.

With the help of this coefficient it will be established the relation which determines the real flow by calculation:

$$q_r = \mu f \sqrt{2gH}$$

Results are presented in Table no. 1 and 2.

Table 1. Flow coefficient at spraying machines in base crops

Nozzle [code]	Pressure [bar]	Flow measured value [l/min]	Flow nominal value [l/min]	Flow coefficient [μ]
ISO 110015	2	0,485	0,490	0,989
	2,5	0,538	0,540	0,996
	3	0,576	0,600	0,960
	3,5	0,636	0,640	0,993
	4	0,650	0,690	0,942
ISO 11002	2	0,737	0,660	1,117
	2,5	0,793	0,730	1,086
	3	0,913	0,800	1,141
	3,5	0,947	0,860	1,101
	4	1,020	0,91	1,120
ISO 11003	2	1,078	0,98	0,101
	2,5	1,120	1,100	1,018
	3	1,226	1,200	1,021
	3,5	1,346	1,300	1,035
	4	1,387	1,390	0,997

Table 2. Flow coefficient for spraying machines in vineyards and orchards

Nozzle [code]	Pressure [bar]	Flow measured value [l/min]	Flow nominal value [l/min]	Flow coefficient [μ]
005812	5	1,42	1,50	0,946
	10	1,26	2,00	0,930
	15	2,37	2,48	0,955
	20	2,92	2,88	1,013
	25	3,46	3,64	0,950
005815	5	2,30	2,37	0,970
	10	3,63	3,48	1,043
	15	4,25	4,32	0,983
	20	5,27	5,16	1,021
	25	5,56	5,88	0,945

Analyzing the results, we observe that the tolerance of the nozzles flow value isn't bigger than ±10% towards the nominal values (of the producer) according to SR EN 13790-1:2004 at spraying machines in base crops, or than ±15% according SR EN 13790-2:2004 at spraying machines in vineyards and orchards.

REFERENCES

1. Bolintineanu Gheorghe, a.a. - *Experimentations for verifying the methodology, Tests report*, INMA Bucharest, 2007;
2. SR 11833:1995 – *Machines and equipments for plants protection. Technical conditions of quality*;
3. xxx – *Romanian Statistic Annual*, 2004.
   *** internet

Pressure drop determination

At the end of the ramp segments were mounted in place of the nozzles, standard manometers of 25 bar at spraying machine in base crops and of 60 bar at spraying machine in vineyards and orchards. The manometer was set up at reference working pressures of the nozzles, respective 2; 2,5; 3; 3,5 and 4 bar at spraying machine in base crops and at 5; 10;15;20 and 25 bar for spraying machine in vineyards and orchards.

The values indicated by the equipment manometers were compared with the values indicated by standard manometer. Results are presented in Table no. 3.

Table 3. - Determination of pressure drop at spraying machines in base crops

Equipment	Regulated pressure [bar]	Measured pressure (bar)	Drop value [%]
		Mean	
spraying machine in base crops	2,0	1,82	9,10
	2,5	2,30	9,20
	3,0	2,76	9,20
	3,5	3,34	9,54
	4	3,72	0,30

The pressure drop between the measuring point of the machine and the last nozzle isn't bigger than 10% according to SR EN 13790-1:2004.

CONCLUSIONS

The equipments bought by INMA for testing of spraying equipments represent a major step for introduction and application in Romania of the working European norms in domain. The benefits of using these equipments are: growing of measurement precision, reducing the testing time, confidence growing in the obtained values, automated printing of the *test bulletin* with the test results and the possibility of verifying the machines directly at beneficiary location.