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REDUCING SOIL AND ENVIRONMENT POLLUTION BY SPRAYER MACHINES USING MONITORING SYSTEM

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Abstract: *Agriculture is a basic economic branch through its impact on social life and the environment. We can speak of agriculture without having to refer to environmental consequences. Super intensive agriculture practiced due to technological level reached, has led to increased degradation of the environment and human life, requiring the concept of sustainable agriculture, in which the resource conservation is a fundamental condition. System of sustainable agriculture is increasingly accepted as an alternative to conventional agriculture, rational use of resources ensuring productivity, profitability and environmental protection. Agricultural productivity is influenced by the applied work technology, phyto-sanitary protection occupying an important place in these technologies. Combating pests and diseases is an important link in the process of growing plants. Use of new plant varieties and applying new technologies in preparation of germinative bed would not give the desired results without the application of phyto-sanitary appropriate treatments. Running with superior quality indices, of this work, influence decisively the production obtained per hectare. It is a fact accepted by everybody that phyto-sanitary treatments in agriculture, including fruit growing, namely fertilizers, herbicides, pesticides and other substances, chemicals, led to a considerable increase yields, improving their quality. In Romania, the treatment plant or some fazes fertilization works only with liquids that are prepared with water or conditioned with some particular organic ingredients, to be applied as such.*

Keywords*: environment, monitoring, protection, plant, soil, system*

INTRODUCTION

Fighting against pests and diseases is an important link of the technological process of plants growing. Using new plant varieties and applying new technologies within the preparation of the germinating bed would not give the expected results without the application of appropriate phyto-sanitary treatments. Performing this work with superior quality indices influences decisively the production obtained per hectare. Wherever possible, chemical fertilizers will be replaced by organic fertilizers, respectively well fermented manure [1, 4, 5, 7].

Performance can be expected only by respecting the conditions referring to the quality / quantity ratio. Homogenous distribution of phyto-sanitary solutions on target objects surfaces, along with strict dosage respecting, which ensures necessary biological effects means ensuring the suitable quality, and depends on the following factors:

- jet flow of liquid sprayed, essential component of the working rate;
- degree of fineness of the sprayed liquid flow;
- weather conditions;
- degree of coverage and penetration of plant mass (homogeneity of deposit);
- uniformity of distribution in space of jet fluid, related to performance of spraying heads;
- spatial arrangement of target objects or areas to be covered.

The considerations above have shown that the factors responsible for work quality are the spraying heads, therefore they represent the main components of any spraying machines.

This explains the wide variety of spraying systems. Sprayers improperly called nozzles perform the spraying, which is a physical phenomenon of liquids spraying division in drops of various diameters, which are then projected on target object surface.

The main direction for improving the plant protection machinery is the improvement of their design (including control and measuring equipment) for automatically adjust the quantity of liquid per hectare, increase the quality of treatment and reduce residual soil pollution by keeping the original technical features [6, 8].

Within monitoring system of spraying machines the following aspects are checked: pump operation (speed, flow, pressure), the substance level in the tank, nozzles functioning.

In case of state-of-the art equipment, these controls do not have spectacular effects, but for other equipment upgrading work is necessary for improving qualitative indicators and thus, reducing the amount of pesticide applied, diminishing the cost of work and, not least, reducing environment pollution.

Establishing a centralized system of monitoring and warning for plant protection spraying machines aims at watching their functioning for ensuring uniformity of spraying as a compulsory requirement and reducing the risk of pollution of soil and agricultural products due to persistence in soil of phyto-sanitary substances improperly applied.

MATERIAL AND METHODS

Phyto-sanitary treatments efficiency can be appreciated through some physical measurable values, such as the liquid jet characteristics and the constructive-functioning parameters of the working technical equipment. Any inefficient treatment, no matter what the cause, leads to increment of environment pollution, modifications of characteristics of diseases, pests and weeds populations, by raising their resistance to pesticides action and, finally to important economic losses [8].

The main improving direction for plants protection machines, is constituted by their constructive improvement (including the measuring and control equipment) for controlling the liquid quantity per hectare, treatments quality rising and soil remnant pollution reduction, by maintaining the initial technical characteristics. Performing a monitoring and warning centralized system (Fig. 1) for the plants protection spraying machines aims at controlling their functioning for ensuring the uniformity requested by the agro-technical requirements and reducing the soil and agricultural products pollution risks because of remanence in soil of phyto-sanitary substances inappropriately applied [3, 6].

The most important characteristic of pest and disease control works is related to obtaining a good quality of phyto-sanitary treatment, existing a strict dependence between the biological effects and quality, which depends on:

- performances of machine's spraying heads, installation, equipment;
- application volume at the surface unit;
- climatic conditions in which is performed the application;
- nature and shape of the target objects which could facilitate or hamper the fragmentations homogenous deposit;
- subjective factor depending on the operator's skill, etc.

Within monitoring at which are subjected the spraying machines, by means of some transducers have been verified the following aspects: pump functioning (flow, pressure), level of substance in tank, nozzles functioning.

Warning and monitoring centralized system is designed at supervising the good working conditions of spraying machines for plant protection and warning the operator about deficiencies or disturbances that may appear. The warning and monitoring system is composed out of the following constructive elements: flow rate transducers for each nozzle; total flow rate transducers; pressure transducer; reservoir liquid level transducer plc; touch screen operating terminal.

Powering the system was made through the electric installation of the tractor. The main functional and technical characteristics of the system were:

- feeding tension, Vcc 24
- working pressure, bar max 6;
- total flow rate, l/min max 160;
- flow rate per nozzle, l/min max 20;

Total flow rate transducer was mounted downstream of the spraying machine pump and had the role of measuring total liquid quantity that passed through the pump and nozzles.

Flow rate transducers through the nozzle were mounted in upstream of each nozzle with adaptors. These transducers had the role of monitoring the liquid flow through each nozzle and transmitting this information to the automatic program.

Pressure transducer was mounted on the hydraulic circuit. This transducer monitored the pressure in the machine's hydraulic circuit and transmitted this information to the automation program. The level transducer was mounted on the tank with liquid, being aimed at monitoring the liquid quantity remained in the tank and, implicitly the consumed liquid quantity.

Before using the spraying machine, through a digital display the input data concerning the machines functional characteristics were introduced: nominal work flow rate and work pressure.

After starting, the program gathered information about nozzle flow rate, total liquid flow rate, pressure, reservoir liquid level and machine's current position, travel speed and space covered from the afferent transducers mounted on the spraying machine. These data have been analyzed and compared to the input data previously introduced by the operator, and then displayed on the digital display.

Regarding the possibility of warning the operator on a nozzle disturbances (or multiple nozzles simultaneously), the PLC program was set to permanently compare the current recorded value by the flow rate transducer with two calculated values according to SR EN 13790-1:2004. These values represent ±10% out of the value introduced by the operator at the beginning of equipment use. If the current recorded value of flow rate meter is not found within the limit of ±10% nozzle nominal flow rate then intermittent warning lights appear on the display, showing which nozzle does not function normally.

a) b)

Fig. 1. Monitoring and Warning Centralized System

a) command panel; b) flow rate transducers

The warning and monitoring system could be mounted on the ramp of a spraying machine in field. The tests which the equipment was subjected to were seeking the equipment capacity verification for measuring flow rate on the spraying machine's nozzles. At the same time, the pressure transducer's linearity and the level transducer's proper functioning were verified.

RESULTS AND DISCUSSION

The monitoring and warning system was mounted on the ramp of a spraying machine in the field, tests on this one being performed with three nozzles types ALBUZ AXI with codes ISO 11002; ISO 11003 and ISO 110015, with spraying angle of 110º at a distance of 50 cm between them, at working pressures of 2, 3, 4 and 5 bar. For each pressure and each nozzle type there were performed 10 trials, in laboratory conditions. The liquid used at tests was industrial water, because its properties resemble very much to the ones of the fluids used in plants treatments.

For flow meter accuracy checking on each nozzle we have monitored:

- for each test of the machine the working pressure was set according to the testing program;
- the liquid which was sprayed within the chosen time unit was measured for each volume nozzle, using the 1000 ml cylinder and the chronometer.
- it were recorded in the measuring file the values of the liquid volumes for each nozzle and also the working pressure;
- in parallel was recorded the flow displayed on the operating terminal for each nozzle;
- after the tests the data processing was performed and their framing within the appropriate limits.
- For pressure checking:
- the transducer from the spraying machine was dismounted;
- the transducer was mounted on the hydraulic testing stand in parallel with a standard air gauge;
- the hydraulic stand was loaded from 0.2 to 0.2 bar until the maximum pressure measurable by the transducer;
- both values of pressure transducer were recorded within measuring file, displayed on the operating terminal and the standard air gauge;
- after the test, data were processed and it was checked their framing within the appropriate limits.

For level sensor functioning check:

- the level sensor was mounted so as to sense the minimum quantity from which the user warning is required;
- the values were recorded when the sensor indicated the liquid tank values over and under the minimum limit.

For ISO 11002 AG 02 nozzle type at work pressure of 2 bar results are shown in table nr. 1 and figure 2 [2].

For ISO 11002 AG 02 nozzle type at work pressure of 3 bar s results are shown in table nr. 2 and figure 3 [2].

For ISO 11002 AG 02 nozzle type at work pressure of 4 bar s results are shown in table nr. 3 and figure 4 [2].

For ISO 11002 AG 02 nozzle type at work pressure of 5 bar s results are shown in table nr. 4 and figure 5 [2].

Table 1.

Results obtained for ISO 11002 AG 02 type nozzles at working pressure of 2 bar

Rep. No.	**Working pressure (bar**	**Nozzle Flow Rate no. 1 (l/min)**		**Nozzle Flow Rate no. 2 (l/min)**		**Nozzle Flow Rate no. 3 (l/min)**		**Nozzle Flow Rate no. 4 (l/min)**		**Nozzle Flow Rate no. 5 (l/min)**		**Nozzle Flow Rate no. 6 (l/min)**		**Nozzle Flow Rate no. 7 (l/min)**	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1	**2**	0.62	0.64	0.54	0.57	0.54	0.53	0.56	0.60	0.56	0.54	0.58	0.60	0.54	0.54
2		0.64	0.64	0.54	0.57	0.54	0.53	0.58	0.61	0.58	0.54	0.6	0.60	0.56	0.55
3		0.62	0.65	0.54	0.58	0.52	0.53	0.56	0.60	0.58	0.55	0.58	0.60	0.56	0.55
4		0.63	0.66	0.53	0.58	0.53	0.52	0.57	0.60	0.57	0.54	0.59	0.61	0.54	0.54
5		0.65	0.65	0.54	0.57	0.54	0.54	0.58	0.61	0.57	0.54	0.59	0.61	0.55	0.55
6		0.63	0.64	0.55	0.56	0.52	0.53	0.56	0.60	0.58	0.55	0.58	0.60	0.54	0.54
7		0.64	0.64	0.54	0.57	0.54	0.53	0.56	0.60	0.56	0.54	0.6	0.60	0.56	0.55
8		0.62	0.64	0.54	0.57	0.53	0.52	0.58	0.60	0.56	0.55	0.58	0.60	0.56	0.55
9		0.62	0.64	0.54	0.57	0.54	0.54	0.56	0.61	0.57	0.54	0.58	0.60	0.54	0.54
10		0.64	0.64	0.54	0.57	0.53	0.53	0.57	0.60	0.56	0.54	0.58	0.60	0.54	0.55
Average		*0.63*	*0.64*	*0.54*	*0.57*	*0.53*	*0.53*	*0.57*	*0.60*	*0.57*	*0.54*	*0.59*	*0.60*	*0.55*	*0.55*

Rep. No.	**Working pressure (bar**	**Nozzle Flow Rate no. 8 (l/min)**		**Nozzle Flow Rate no. 9 (l/min)**		**Nozzle Flow Rate no. 10 (l/min)**		**Nozzle Flow Rate no. 11 (l/min)**		**Nozzle Flow Rate no. 12 (l/min)**		**Nozzle Flow Rate no. 13 (l/min)**		**Nozzle Flow Rate no. 14 (l/min)**	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1	**2**	0.4	0.39	0.6	0.64	0.56	0.56	0.72	0.73	0.64	0.66	0.70	0.70	0.76	0.77
2		0.4	0.39	0.6	0.63	0.54	0.55	0.74	0.74	0.68	0.66	0.70	0.70	0.76	0.77
3		0.4	0.4	0.6	0.63	0.54	0.55	0.74	0.74	0.68	0.66	0.70	0.72	0.76	0.77
4		0.5	0.39	0.5	0.64	0.55	0.56	0.73	0.73	0.65	0.65	0.69	0.71	0.76	0.77
5		0.4	0.39	0.6	0.63	0.54	0.56	0.72	0.73	0.67	0.66	0.70	0.71	0.75	0.76
6		0.4	0.4	0.5	0.63	0.55	0.55	0.74	0.74	0.65	0.66	0.70	0.70	0.75	0.77
7		0.3	0.39	0.5	0.63	0.54	0.55	0.73	0.73	0.68	0.65	0.69	0.70	0.76	0.77
8		0.4	0.39	0.4	0.63	0.56	0.55	0.74	0.74	0.65	0.66	0.69	0.70	0.76	0.76
9		0.4	0.39	0.5	0.63	0.56	0.55	0.72	0.74	0.67	0.66	0.70	0.72	0.76	0.77
10		0.4	0.39	0.6	0.63	0.55	0.55	0.73	0.74	0.66	0.66	0.71	0.70	0.76	0.77
Average		*0.4*	*0.39*	*0.6*	*0.63*	*0.55*	*0.55*	*0.73*	*0.74*	*0.66*	*0.66*	*0.70*	*0.71*	*0.76*	*0.77*

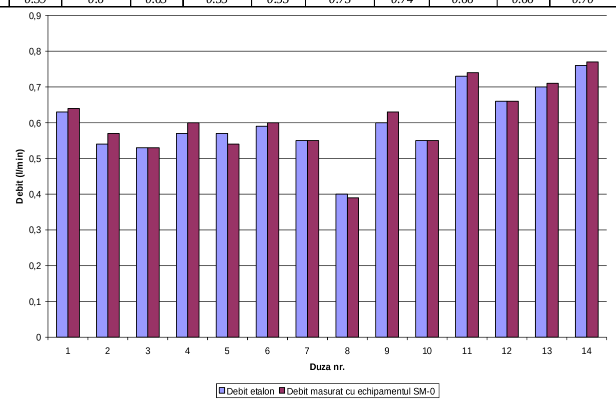

Fig. 2. AG 02 type nozzle flow rate, working pressure 2 bar

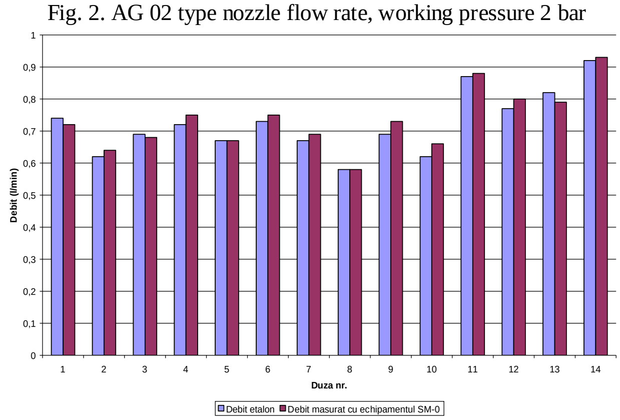

Fig. 3. AG 02 type nozzle flow rate, working pressure 3 bar

Table 2.

Results obtained for ISO 11002 AG 02 type nozzles at working pressure of 3 bar

Rep. No.	Working pressure(bar)	Nozzle Flow Rate no. 1 (l/min)		Nozzle Flow Rate no. 2 (l/min)		Nozzle Flow Rate no. 3 (l/min)		Nozzle Flow Rate no. 4 (l/min)		Nozzle Flow Rate no. 5 (l/min)		Nozzle Flow Rate no. 6 (l/min)		Nozzle Flow Rate no. 7 (l/min)	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.72	0.70	0.62	0.64	0.68	0.69	0.72	0.75	0.66	0.68	0.7	0.74	0.68	0.69
2		0.78	0.74	0.64	0.64	0.7	0.68	0.72	0.74	0.68	0.68	0.74	0.76	0.66	0.69
3		0.72	0.72	0.60	0.64	0.68	0.68	0.72	0.75	0.66	0.67	0.74	0.75	0.66	0.69
4	**3**	0.76	0.74	0.60	0.63	0.68	0.69	0.73	0.74	0.67	0.67	0.74	0.74	0.68	0.69
5		0.74	0.72	0.64	0.65	0.7	0.68	0.71	0.75	0.66	0.68	0.7	0.76	0.67	0.69
6		0.73	0.70	0.62	0.64	0.68	0.68	0.72	0.75	0.68	0.68	0.74	0.75	0.66	0.69
7		0.74	0.72	0.62	0.64	0.7	0.68	0.72	0.75	0.67	0.67	0.73	0.74	0.66	0.69
8		0.74	0.72	0.64	0.64	0.68	0.68	0.72	0.75	0.67	0.68	0.73	0.76	0.67	0.69
9		0.74	0.74	0.60	0.64	0.69	0.68	0.72	0.75	0.66	0.68	0.73	0.75	0.67	0.69
10		0.74	0.72	0.62	0.64	0.69	0.68	0.72	0.75	0.68	0.68	0.73	0.75	0.67	0.69
Average		*0.74*	*0.72*	*0.62*	*0.64*	*0.69*	*0.68*	*0.72*	*0.75*	*0.67*	*0.68*	*0.73*	*0.75*	*0.67*	*0.69*
Rep. No.	**Working pressure (bar)**	**Nozzle Flow Rate no. 8 (l/min)**		**Nozzle Flow Rate no. 9 (l/min)**		**Nozzle Flow Rate no. 10 (l/min)**		**Nozzle Flow Rate no. 11 (l/min)**		**Nozzle Flow Rate no. 12 (l/min)**		**Nozzle Flow Rate no. 13 (l/min)**		**Nozzle Flow Rate no. 14 (l/min)**	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.58	0.57	0.7	0.73	0.62	0.67	0.86	0.88	0.78	0.8	0.82	0.79	0.9	0.94
2		0.58	0.58	0.68	0.72	0.62	0.65	0.86	0.88	0.76	0.81	0.82	0.79	0.94	0.92
3		0.58	0.59	0.7	0.73	0.62	0.65	0.88	0.89	0.78	0.79	0.82	0.79	0.92	0.93
4	**3**	0.58	0.57	0.69	0.74	0.61	0.66	0.87	0.88	0.77	0.8	0.82	0.79	0.9	0.94
5		0.57	0.58	0.69	0.72	0.63	0.67	0.86	0.89	0.76	0.81	0.82	0.79	0.94	0.92
6		0.59	0.59	0.7	0.73	0.62	0.65	0.86	0.88	0.78	0.79	0.82	0.79	0.92	0.93
7		0.58	0.58	0.68	0.73	0.62	0.65	0.88	0.88	0.78	0.8	0.82	0.79	0.92	0.93
8		0.58	0.58	0.7	0.73	0.62	0.66	0.87	0.88	0.77	0.79	0.82	0.79	0.92	0.93
9		0.58	0.58	0.68	0.73	0.62	0.66	0.87	0.88	0.77	0.81	0.82	0.79	0.92	0.93
10		0.58	0.58	0.69	0.73	0.62	0.66	0.87	0.88	0.77	0.8	0.82	0.79	0.92	0.93
Average		*0.58*	*0.58*	*0.69*	*0.73*	*0.62*	*0.66*	*0.87*	*0.88*	*0.77*	*0.8*	*0.82*	*0.79*	*0.92*	*0.93*

Differences between standard flow rates and the flow rates recorded with flow rate transducers were approximately smaller than 2%, the recorded values of each flow rate transducer ranging within the sensibility limits of ±2.5% of the measured value. The nozzles behavior was not uniform (due to their high wear), so that the monitoring system of flow rate per each nozzle has been efficient for identifying the disturbed nozzles and replacing them.

The verification of pressure transducer linear characteristic (fig. 6) has determined some measurements in parallel with a standard gauge, on the stand of gauge calibrating.

Table 3.

Results obtained for ISO 11002 AG 02 type nozzles at working pressure of 4 bar

Rep. No.	Working pressure(bar)	Nozzle Flow Rate no. 1 (l/min)		Nozzle Flow Rate no. 2 (l/min)		Nozzle Flow Rate no. 3 (l/min)		Nozzle Flow Rate no. 4 (l/min)		Nozzle Flow Rate no. 5 (l/min)		Nozzle Flow Rate no. 6 (l/min)		Nozzle Flow Rate no. 7 (l/min)	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.92	0.95	0.82	0.8	0.8	0.82	0.86	0.87	0.64	0.67	0.92	0.94	0.82	0.84
2		0.92	0.95	0.82	0.8	0.8	0.82	0.86	0.87	0.64	0.65	0.92	0.96	0.82	0.84
3		0.92	0.93	0.8	0.8	0.82	0.84	0.88	0.87	0.64	0.66	0.92	0.96	0.82	0.84
4	**4**	0.92	0.93	0.81	0.8	0.81	0.83	0.87	0.87	0.64	0.67	0.91	0.95	0.81	0.84
5		0.91	0.95	0.83	0.8	0.8	0.82	0.86	0.87	0.64	0.67	0.93	0.94	0.83	0.84
6		0.93	0.93	0.82	0.8	0.82	0.84	0.88	0.87	0.64	0.66	0.92	0.96	0.82	0.84
7		0.92	0.94	0.82	0.8	0.81	0.83	0.87	0.87	0.64	0.65	0.92	0.96	0.81	0.84
8		0.92	0.94	0.81	0.8	0.8	0.83	0.87	0.87	0.64	0.65	0.92	0.95	0.83	0.84
9		0.92	0.94	0.83	0.8	0.82	0.82	0.87	0.87	0.64	0.67	0.92	0.95	0.82	0.84
10		0.92	0.93	0.82	0.8	0.81	0.84	0.87	0.87	0.64	0.66	0.92	0.95	0.82	0.84
Average		*0.92*	*0.94*	*0.81*	*0.8*	*0.81*	*0.83*	*0.87*	*0.87*	*0.64*	*0.66*	*0.92*	*0.95*	*0.82*	*0.84*
Rep. No.	**Working pressure (bar)**	**Nozzle Flow Rate no. 8 (l/min)**		**Nozzle Flow Rate no. 9 (l/min)**		**Nozzle Flow Rate no. 10 (l/min)**		**Nozzle Flow Rate no. 11 (l/min)**		**Nozzle Flow Rate no. 12 (l/min)**		**Nozzle Flow Rate no. 13 (l/min)**		**Nozzle Flow Rate no. 14 (l/min)**	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.72	0.6	0.9	0.9	0.68	0.67	0.9	0.93	0.88	0.88	0.98	1.01	1.14	1.16
2		0.72	0.76	0.92	0.89	0.76	0.69	0.9	0.92	0.86	0.89	0.96	1.01	1.12	1.16
3		0.72	0.74	0.9	0.89	0.76	0.72	1	1.02	0.9	0.89	0.96	1	1.14	1.14
4	**4**	0.71	0.75	0.91	0.89	0.73	0.69	0.9	0.93	0.86	0.88	0.97	1.01	1.13	1.15
5		0.73	0.76	0.91	0.9	0.74	0.67	0.9	0.92	0.88	0.89	0.96	1	1.12	1.15
6		0.72	0.76	0.91	0.88	0.72	0.72	1	1.02	0.9	0.89	0.98	1.01	1.14	1.14
7		0.71	0.74	0.9	0.88	0.73	0.69	0.9	0.96	0.89	0.88	0.96	1.01	1.12	1.16
8		0.73	0.75	0.92	0.88	0.73	0.69	1	0.96	0.89	0.89	0.97	1	1.14	1.16
9		0.72	0.75	0.91	0.89	0.73	0.69	0.9	0.96	0.89	0.89	0.97	1.01	1.13	1.14
10		0.72	0.75	0.91	0.89	0.73	0.69	0.93	0.96	0.89	0.89	0.97	1.01	1.13	1.15
Average		*0.72*	*0.75*	*0.91*	*0.89*	*0.73*	*0.69*	*0.93*	*0.96*	*0.89*	*0.89*	*0.97*	*1.01*	*1.13*	*1.15*

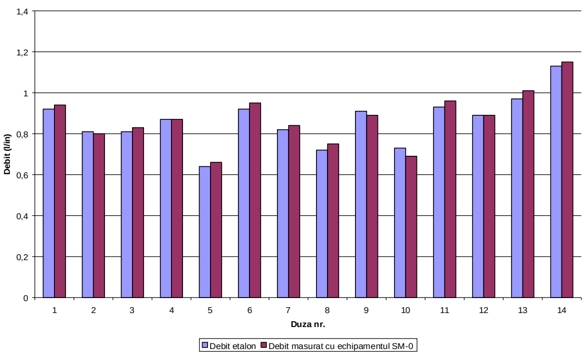

Fig. 4. AG 02 type nozzle flow rate, working pressure 4 bar

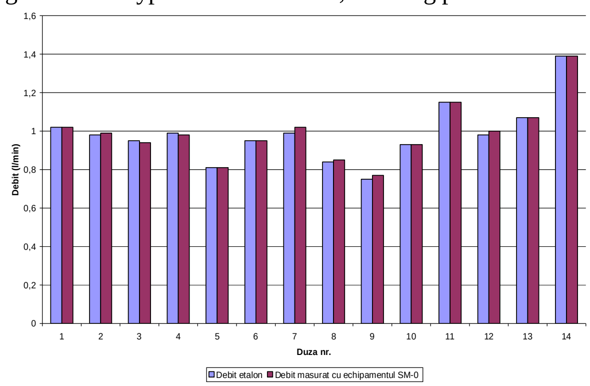

Fig. 5. AG 02 type nozzle flow rate, working pressure 5 bar

Table 4.

Results obtained for ISO 11002 AG 02 type nozzles at working pressure of 5 bar

Rep. No.	Working pressure(bar)	Nozzle Flow Rate no. 1 (l/min)		Nozzle Flow Rate no. 2 (l/min)		Nozzle Flow Rate no. 3 (l/min)		Nozzle Flow Rate no. 4 (l/min)		Nozzle Flow Rate no. 5 (l/min)		Nozzle Flow Rate no. 6 (l/min)		Nozzle Flow Rate no. 7 (l/min)	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.9	0.92	1	0.99	0.92	0.94	0.9	0.93	0.82	0.81	0.9	0.94	1.02	1.02
2		1.08	1.06	0.96	0.99	0.96	0.93	1.04	1.01	0.82	0.81	0.9	0.94	0.98	1.02
3		1.08	1.07	0.98	0.99	0.96	0.94	1.04	1.01	0.78	0.81	1.04	0.98	0.98	1.01
4	**5**	0.9	0.92	0.98	0.99	0.92	0.93	0.99	0.93	0.80	0.81	0.9	0.95	1.02	1.01
5		1.08	1.07	0.96	0.99	0.95	0.94	1.04	1.01	0.82	0.81	0.9	0.98	0.99	1.02
6		1.08	1.06	1	0.99	0.96	0.94	0.9	1.01	0.81	0.81	0.95	0.94	0.98	1.02
7		1.02	1.02	0.98	0.99	0.96	0.93	1.04	0.98	0.81	0.81	1.04	0.94	0.98	1.02
8		1.02	0.92	0.98	0.99	0.95	0.94	0.99	0.98	0.82	0.81	0.95	0.95	0.99	1.02
9		1.02	1.06	0.98	0.99	0.95	0.94	0.99	0.98	0.78	0.81	0.95	0.95	0.99	1.02
10		1.02	1.07	0.98	0.99	0.95	0.94	0.99	0.98	0.82	0.81	0.95	0.95	0.99	1.02
Average		*1.02*	*1.02*	*0.98*	*0.99*	*0.95*	*0.94*	*0.99*	*0.98*	*0.81*	*0.81*	*0.95*	*0.95*	*0.99*	*1.02*
Rep. No.	**Working pressure (bar)**	**Nozzle Flow Rate no. 8 (l/min)**		**Nozzle Flow Rate no. 9 (l/min)**		**Nozzle Flow Rate no. 10 (l/min)**		**Nozzle Flow Rate no. 11 (l/min)**		**Nozzle Flow Rate no. 12 (l/min)**		**Nozzle Flow Rate no. 13 (l/min)**		**Nozzle Flow Rate no. 14 (l/min)**	
		Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display	Measured with graded cylinder	Shown on the display
1		0.84	0.86	0.8	0.8	0.94	0.93	1.12	1.12	0.98	1.00	1.08	1.09	1.4	1.38
2		0.84	0.86	0.72	0.76	0.92	0.93	1.16	1.16	0.98	1.00	1.06	1.08	1.38	1.4
3		0.84	0.84	0.72	0.76	0.94	0.93	1.16	1.15	0.98	1.01	1.08	1.06	1.38	1.39
4	**5**	0.84	0.86	0.8	0.8	0.93	0.93	1.15	1.15	0.97	1.00	1.06	1.09	1.39	1.39
5		0.84	0.86	0.72	0.76	0.93	0.93	1.15	1.12	0.99	1.00	10.8	1.08	1.39	1.39
6		0.84	0.84	0.72	0.76	0.93	0.93	1.12	1.16	0.98	1.00	1.07	1.06	1.4	1.4
7		0.84	0.85	0.75	0.77	0.92	0.93	1.16	1.15	0.98	1.00	1.08	1.07	1.38	1.38
8		0.84	0.85	0.74	0.77	0.94	0.93	1.16	1.15	0.98	1.01	1.07	1.07	1.38	1.38
9		0.84	0.85	0.76	0.76	0.94	0.93	1.15	1.15	0.98	1.01	1.07	1.07	1.39	1.39
10		0.84	0.85	0.75	0.77	0.93	0.93	1.15	1.16	0.98	1.00	1.07	1.07	1.39	1.39
Average		*0.84*	*0.85*	*0.75*	*0.77*	*0.93*	*0.93*	*1.15*	*1.15*	*0.98*	*1.00*	*1.07*	*1.07*	*1.39*	*1.39*

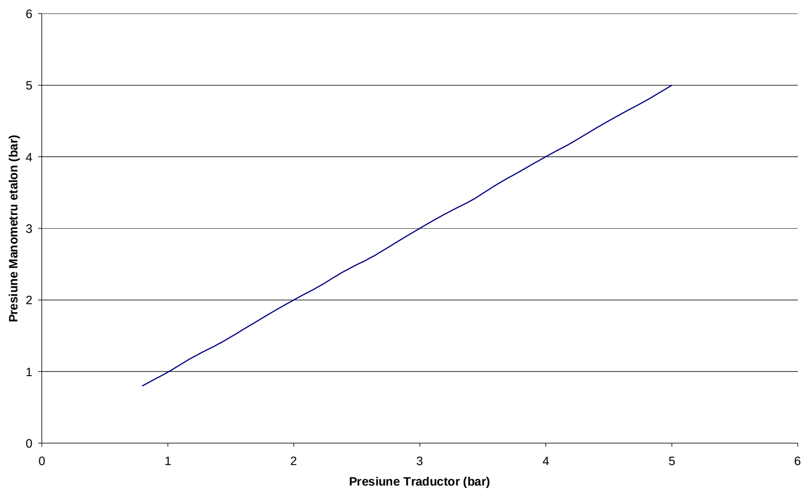

Fig. 6. Diagram transducer pressure / standard gauge pressure

There has been found the linearity of pressure transducer, which allowed a precise monitoring of working pressure and active substances distribution in compliance with rate per hectare.

CONCLUSIONS

In order to comply with the European Union legislation, the modern spraying and herbicide applying machines have to ensure a corresponding dosage of active substances, so that the hectare norms should not be exceeded. Through this approach it will be achieved both active substance saving and especially a protection of the environment by avoiding excessive treatment with phyto-sanitary substances.

The monitoring and warning system achieved has controlled the spraying and sprinkling process and announced any abnormal functioning, warning the user by means of last generation transducers and other electronic components (including GPS), which allowed ensuring the appropriate conditions for practicing a precision agriculture.

Through the monitoring and warning system there have been created the premises for obtaining phyto-sanitary treatment equipment able to ensure the uniformity requested by the agro-technical requirements and reduce the environment pollution risks (air, water and soil) and agricultural products as a result of remanence in soil of phyto-sanitary substances inappropriately applied.

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