THE ELECTRONIC IN THE SPRAY EQUIPMENTS USED IN DOURO REGION VINEYARDS

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Abstract
The fungicides application in Douro Region vineyards is on of the most expensive operation and one of lower efficiency. The use of conventional sprayers, having always the same spray output, makes that when the tractor - sprayer speed changes, some vine parts are overdosed and other underdosed. The use of DPA systems (debit proportional to the variable speed) correct this variation increasing or decreasing the sprayer pressure, keeping the output constant independently the speed variation.
Using different situations (slopes, ploughed and non ploughed soil, nozzles sizes and spray pressure) trials were done to compare output variation with and without DPA system. For a output of 500 L/ha, different soil conditions, slopes varying from -18 to 18 %, nozzles of 1.0 and 1.2 mm and spray pressure of 3 and 5 bars, the range variation with DPA were 494.7 to 510.7 L/ha and without from 405.3 to 793.1 L/ha.

1- Introduction
The use of electronic devices and computing have been improving the agricultural equipments performance, namely in spray equipments, making more precision the spraying application reducing the cost and the environmental impact.
In vines installed in sloppy regions, with stony soils, like Douro, where the plants row distance only allow the use of vineyards tractors, the speed variation can be important what makes unadvisable the use of conventional sprayers.
The DPA system, which can be adapted in any sprayer is a good solution to minimize the spraying cost and the environmental impact, why the farmers must be encouraged to buy it.

Key words: viticulture, sprayers, electronic devices.

2- The news technologies in fungicides applications

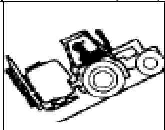
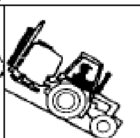
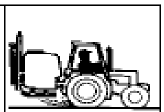
The monitoring of plants heath allow to know the pest potential infection, and give some indications about the right time to apply the pesticides and the amount of product to be used, to improve the operation efficiency and reducing the environmental impact (Morgan, 1977).

In the traditional sprayers, that works with a constant pressure, the debit depend of speed why to have the same spray output the velocity has to keep unchanged. As the work conditions, namely that ones relatively to the environment and equipment, are always changing, it is fundamental to use regulation devises that can correct that variations.

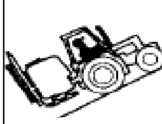
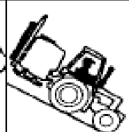
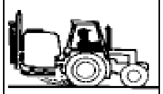
Among this devices the most used are:

- the systems in which the spray concentration is proportional to the speed (CPA);
- the systems in which the debit is proportional to the engine regime (DPM);
- The systems in which the debit is proportional to the tractor speed (DPA).

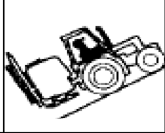
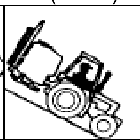
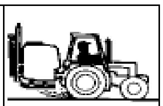
Constant pressure (PC)

			
Terrain	Go up	Go down	Slip
Engine rpm	↘	↗	→
Speed	↘	↗	↘
Debit (l/min)	→	→	→
Volume (L/ha)	↗	↘	↗
Pressure	→	→	→
Product /ha	↗	↘	↗
Result	Dose >	Dose <	Dose >

Debit proportional to engine speed (DPM)

			
Terrain	Go up	Go down	Slip
Engine rpm	↘	↗	→
Speed	↘	↗	↘
Debit (l/min)	↘	↗	→
Volume (L/ha)	→	→	↗
Pressure	↘	↗	→
Product /ha	→	→	↗
Result	Dose =	Dose =	Dose <

Speed debit proportional (DPA)
Electronic debit proportional (DPE)

			
Terrain	Go up	Go down	Slip
Engine rpm	↘	↗	→
Speed	↘	↗	↘
Debit (l/min)	↘	↗	↘
Volume (L/ha)	→	→	→
Pressure	↘	↗	→
Product /ha	→	→	→
Result	Dose =	Dose =	Dose =

Speed proportional concentration (CPA)

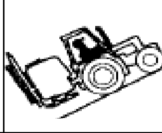
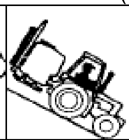
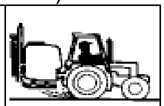
			
Terrain	Go up	Go down	Slip
Engine rpm	↘	↗	→
Speed	↘	↗	↘
Debit (l/min)	→	→	→
Volume (L/ha)	↗	↘	↗
Pressure	→	→	→
Product /ha	→	→	→
Result	Dose =	Dose =	Dose =

Figure 1- Comparison among systems regulation (Origin: BOISGONTIER, 1990)

The use of electronic devices in this equipments, that had begun in 1975 (Authelet, 1989), together with other innovations, have been allowing a important improvement in the disease control, in spray saving, in the work efficiency and in the environmental impact associated with this operation.

In DPA systems one of the most used device is the debit electronic calculator - regulator (CRED) that calculate the debit using electronic components mounted in the spray circuit that makes de debit correction using the information given by a Debit measure and a radar to get the real speed.

3- Material and methods

In the trial tests it was used a 4 RM tractor, a nine tine cultivator, a sprayer where was installed the debit electronic calculator - regulator (CRED). The measure speed system is a Doppler effect radar, mounted in front tractor.

The CRED, using an electric valve mounted in the pressure system, control the debit maintaining it in a value previous established. This system use continuously the tractor speed and pressure sprayer, measured by a captor, to control the debit; the values of these parameters and the debit hectare chosen by the operator permit to determine the debit hectare applied at each moment.

Besides these elements, its connections and a circuit breaker, which permit the spray interruption, this equipment has:

- a Custom Monitoring System (CMS), that function using a pressure transducer, consists of a console, ground speed sensor, implement lift switch and main harness, that woks either in operate or setup mode. When working in operate mode the display gives information about speed, field area sprayed, total area sprayed, area sparayed per hour, distance, in meters, travelled between the counter start and stop, field product (litres applied), etc,. Setup mode permits the parameters introduction indicated in table I.

- a Custom Calculator - Regulator System (CCS), that consists of a console, a command module, a monitored valve, a pressure transducer and a speed sensor, can woks to in either operate or setup mode, as it is indicated in table I. In operating mode, used during the spraying operation, is displayed in the console the pressure work and the instantaneous Debit / ha. After switch it is displayed the spray debit programmed and the lower and upper speed allowed to keep the Debit chosen (figure I).

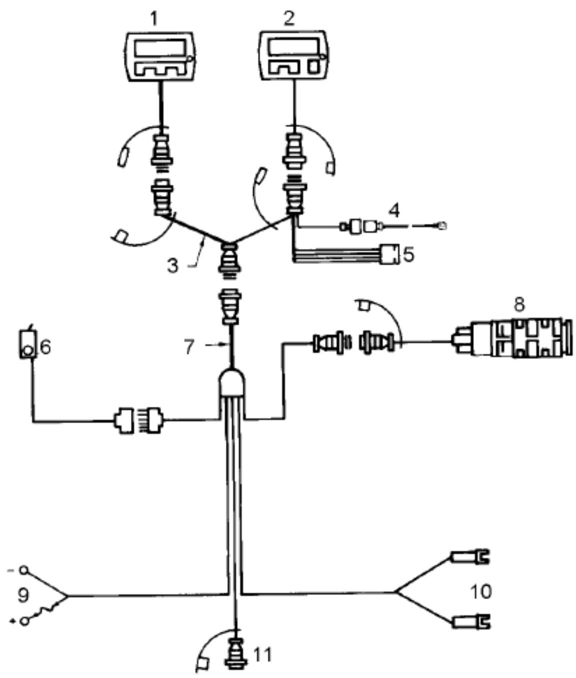


Figure 1- Pressure monitoring system (Dickey-JONH, 1995)
1- Calculator - regulator console; 2- Monitoring console 3- Main harness 4- Harness from ignition 5- Boom section 6- Switch 7- Main harness 8- Radar ground speed; 9- Battery 10- Optional connections 11- Auxiliary harness

The methodology followed in the trials consisted in a previous determination of necessary data to equipment characterisation, mainly the nozzles debit at different pressure, to introduce in the CMS and CCS program. After the previous tests were done the field debit sprayer measurements witch the CRED system on and off, in the following conditions:

- different soil conditions (ploughed - mb and not ploughed - nmb);

- slope from - 18 to 18 %);
- using two nozzles size (1.0 and 1.2 mm);
- using two spray pressure (3 and 5 bar).

Notice that all trials were done with PTO normalised regime (540 rpm) and the selected gear that allow ± 4 km/h that is a average speed used in Douro vines; for the tests done in ploughed soils it was previous done a superficial mobilisation.

Table 1.- Parameters programmed in CCS e CMS

Setup Pos.	Constant	Values	Setup Pos	Constants	Values
A	Pressure	P	C0	Pressure	P
B	Application rate (L/ha)	500	C1	Conversion factor	1.0
C	Pplication rate (+/- (L/ha)	+/- 50	C2	Sum of nozzles capacity	Variable
D	Nozzles saping (m)	0.250	C3	Nozzle capacity pressure (bar)	3 or 5
E	Nozzle capacity pressure	3 or 5	C4	Pressure sensor offset (bar)	0.5
F	Nozzle flow capacity	Variable	C5	Tank level (/10)	30.0
G	Flush pressure (bar)	1.0	C6	Tank alarm level (/10)	5.0
H	Convertion factor	1.0	U6	Ground speed calibration	6096
I	Zero pressure (bar)	0.5	E0	Boomswitch sense	0.0
J	System response (s)	2.0			
A	Nozzle control set	0.0			
B	Ground speed calibration	6096			
C	Pressure limits set	Variable			

4- Results

In "se" situation, the slope, nozzles and spray pressure changes, the debits vary, relatively to the original one, in the follow way:

- varying the slopes from -18 to + 18 %, the debits vary positively from 8.51% to 2.49 %;
- changing the nozzles from 1.0 mm to 2.0 mm increase de debit scope from 21.90 to 33.48 %;
- changing the pressure from 3 to 5 bar there is a increase the debit from 15.10 to 41.20 %.

In "cm" situation the presented factors do not change significantly the debit, as its variations are minor than 1 %.

With CRED programmed to give 500 L/ha it was got, in "cm" situation, debits from 494.7 to 510.7 L/ha (average - 501.6 L/ha, $\delta = \pm 5.6$) and in "se" situation debits from 405.3 to 793.1 L/ha (average - 567.9 L/ha, $\delta = \pm 108.3$). See table 2 .

Table 2- Debit (L/ha) with 3 bar

se / ce	-18%		-8%		0%		8%		18%	
nmb/mb	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2
se-nmb	418,0	517,3	406,8	536,0	442,5	550,7	436,8	577,3	490,0	594,7
se-mb	405,3	550,4	424,5	537,3	466,0	558,7	446,5	568,0	472,7	593,3
ce-nmb	498,7	493,3	493,3	494,7	504,0	500,0	502,7	508,0	504,0	509,3
ce-mb	496,0	494,7	497,3	494,7	502,7	501,3	509,3	504,0	508,0	505,3

Table 3- Debit (L/ha) with 5 bar

se / ce	-18%		-8%		0%		8%		18%	
nmb/mb	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2
se-nmb	512,7	-	523,9	701,3	569,5	724,0	567,1	762,7	564,0	732,7
se-mb	552,7	717,3	554,0	708,0	589,5	728,0	595,0	752,0	606,0	793,1
ce-nmb	497,3	498,7	501,3	497,3	500,0	501,3	504,0	506,7	506,7	504,0
ce-mb	500,0	494,7	497,3	497,3	505,3	502,7	509,3	509,3	504,0	510,7

From the data variance analysis we can conclude that, with the selected variables in “se” situation, every, except the soil mobilisation, has influence in the final debit. We can confirm that the differences are significant and the nozzles and pressure are the factors that influence the final results.

For de “ce” situation the variables that has more influence in final debit are the slope and the pressure; the other variables hasn’ t a significant influence in the final results.

Conclusions

From the trial data can be concluded that:

- the CRED use permits to get, since it was respected the programmed conditions that are indicated in Custom Calculator - Regulator System (CCS), debits close to that chosen by the operator;

- the CRED use makes easy the spray operation as the equipment regulation is almost operator independent and he has access to important information about application spray conditions;
- the CRED use in not important when the tractor - sprayer speed is almost constant

The CRED system used in these trials reduce the rate application spraying variations but it is important to know the influence in the droplet size resulting from the pressure changes.

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