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Title:

Precision pesticides application

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Summary:

Over application of pesticides lead to environmental pollution and under application may lead to an inefficient treatments. Accurate application rates with standard PTO driven spraying equipment is difficult to attain due to changes in the forward speed imposed by variable field conditions.
Sprayers that automatically maintain application rates regardless of forward speed , are therefore the solution to the problem.
To demonstrate the advantages of this new technology tests were performed with a sprayer equipped with a package that allows the spraying debit to be proportional to the forward speed (DPA).
Tests were conducted on slopes varying from –18% to 18%, on mobilised and non-mobilised soil conditions. Nozzles with 1.0 mm and 1.2 mm diameter, as well as two working pressures, 300 and 500 kPa, were tried.
Field conditions that imposed speed variation resulted in changes in the spraying rate from 494.7 L/ha to 510.7 L/ha, with the DPA system and from 405.3 L/ha to 793.1 L/ha, without the DPA system.
The results show that whenever field conditions are such that variations in progress speed are foreseen DPA systems can substantially improve accuracy on application rates, without any significant changes in drop size.

Research purpose

The pesticides application is one of the technical operations that more problems present in Portugal, specially in vineyards, because the spray drift and draining represents a significant amount of the chemical product applied (Santos, 1996).

In order to improve the pesticides applications we can use several solutions, one of which is the electronic systems of debit control, that can be mounted in the most sprayers used in that culture.

As this kind of equipment is relatively expensive it is necessary to know how much we can save with his use and so, the area that justifies his acquisition.

The use of this kind of equipment is very important to keep the volume per hectare but, with a air sprayer carrier is fundamental to have the best performance of the fan in order to get a regular air distribution in the canopy (Santos, 1992). The easy way to be sure about this is to use sensitive paper regular distributed in the canopy, which are examined with an image analyse software.

Materials used

In this study we use a four wheel tractor, a air carrier sprayer with hydraulic nozzles and a control electronic system.

The four wheel tractor is a vineyard one, with 29 kW at 3000 rpm, a rigid chassis and 1160 kg weight.

The air carrier sprayer is a vineyard sprayer, with 11000 $m^3.h^{-1}$ air debit, 12 kW of power requirement and fives airblast nozzle for each side; the buses has a variable position, witch allow to spray with a 45º backside angle and in different vertical directions.

The control electronic system has a Custom Monitoring System (CMS), a Calculator - Regulator Control System (CCS), (Dickey-John, 1995).

The CMS consists of a pressure transducer (monitoring sensor), a console with a display and permanent memory, a ground speed sensor (radar of Doppler effect), a implement lift switch with three positions (ON, AUTO, FLUSH) and main harness. The radar is mounted in the tractor front side with a 45º angle related to the ground; the radar was previously calibrated driving the tractor over a known course.

This system has the following active modes:

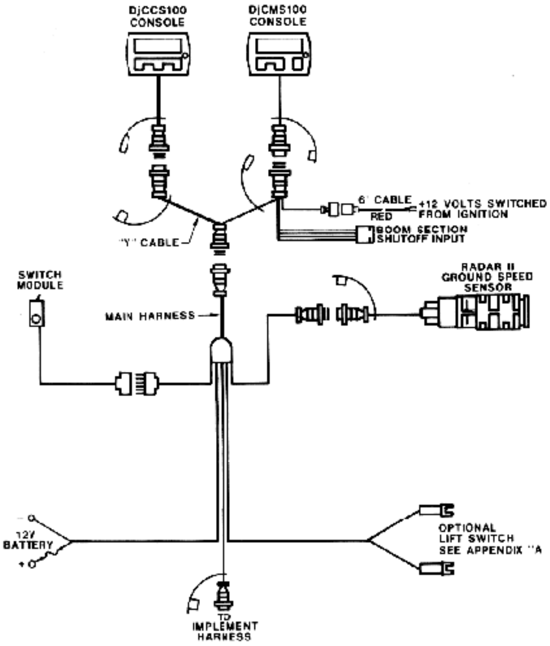
- operate mode which provides information during the field operation, as the vehicle ground speed, area covered, amount of product applied, distance counter and predicted application rate.
- set up mode, that allows to enter constants that will be used to describe the system to be monitored.

The CCS has, equally, a console with a display and permanent memory and the following active modes:

- operate mode that gives some information as the amount of applied spray and the allowed speed variation;
- set up mode that is used to introduce the parameters in the program.

As auxiliary material we used chronometers, tachometers, tape-measure, test glass, and so on.

Figure 1- The CMS harnessing diagram with CCS control diagram.



Dickey-john (1995)

Methodology

Before the field tests several measures was done to know the tractor speed and spray debit. Before the tractor speed determination is necessary to do some regular operations (Santos, 1992), as calibration pressure tyres, half fill spray tank, etc.

To measure sprayer debit the sprayer fan was disconnected and flexible tubes was connected to the buses in a way to direct the water to a reservoir; only four buses from each side was used.

The field tests consists in the spray determination with the sprayer working with the electronic equipment (CE) and without it (SE), in different situations as:

- soil conditions (mobilized soil (mb) and no mobilized soil (nmb);
- slope (-18, -8, 0, 8, 18 %)
- nozzle diameter (1.0 and 1.2 mm)
- rate pressure (300 kPa and 500 kPa).

The negative values correspond to the down slope and the positives ones to the rising slope.

All tests have been done at normalized PTO regime, the speed was ± 4 km/h, and the soil was mobilized with a tine cultivator at 100 – 150 mm deep.

Figure 2- Constant decals used in field tests for the CCS and CMS

	CCS - Sprayer Control			CMS - Custom Monitoring	
Set up	Sprayer constants	Value	Set up	Sprayer constants	Value
A	Forma de funcionamento	P	C0	Pressure	P
B	Aplication rate (l/ha)	500,0	C1	Conversion factor	1,0
C	Aplication rate +/-(l/ha)	+/- 50	C2	Sum of nozzles capacity	Variable
D	Nozzles spacing (m)	0,250	C4	Nozzle capacity pressure	3 ou 5
E	Nozzles capacity pressure (kPa)	300-500	C5	Pressure sensor offset (kPa)	50
F	Nozzle flow capacity	Variable	C6	Tank level (/10)	30,0
G	Flush pressure	1,0	C7	Tank alarm level (/10)	5,0
H	Conversion factor	1,0	U6	Ground speed calibration	6096
I	Zero pressure	0,5	E0	Applicator switch sense	0,0
J	System response (s)	2,0			
A	Nozzles monitor set	0,0			
B	Ground speed calibration	6096			
C	Pressure limits sets	Variable			

Results

The present results was got from debit variance analysis and average determination from the distinct values measured.

In the SE situation the main results were:

- reducing the negative slope (down slope) and increasing the positive one (rising slope), the increase sprayed varied 2.49 – 8.51 %;
- changing the nozzles from 1.0 to 1.2 mm the increased sprayed varied from 21.90 to 33.48 %;
- changing the pressure, from 300 to 500 kPa, the increased sprayed varied from 15.1 to 41.2 %.

In CE situation all the variations weren´t significant (minor than 1%).

Figure 3- L/ha got at 300 and 500 kPa, in the different situations.

	-18%		-8%		0%		8%		18%	
	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	536.8	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
cm - nmb	498.7	493.3	493.3	494.7	504.0	500.0	502.7	508.0	504.0	509.3
cm - mb	496.0	494.7	497.3	494.7	502.7	501.3	509.3	504.0	508.0	505.3

	-18%		-8%		0%		8%		18%	
	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	723.0	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
cm - nmb	497.3	498.7	501.3	497.3	500.0	501.3	504.0	506.7	506.7	504.0
cm - mb	500.0	494.7	493.3	497.3	505.3	502.7	509.3	509.3	504.0	510.7

With the electronic system programmed for a spray debit of 500 L/ha, we got, in the CM situation values from 494,7 to 510,7 L/ha (average 501,6) (δ = ± de 5,6), and in the SE situation, values from 405,3 to 793,1 L/ha (average 567,9) (δ = ± de 108,3).

Considering a 65 L/ha difference, a useful life of 6 years and the average costs of pesticides and equipment in Portugal, we can say that the electronic equipment can be justified for more than 28 ha if we make three treatments and 21 ha if we make four.

Conclusions

The main conclusions were:

- the electronic system, since we respect the programmed variables, allow to keep the spray debit almost unaltered;
- the use of a electronic system is very proper for the farmer as he does not need to care a lot about the regulations;
- the use of an electronic system is more important for the situations where the speed variations are bigger;
- taking in consideration only the economical aspects we can conclude that, actually, this kind of equipment has little interest for the majority of the Douro region vineyards, where the farm average area is too short.

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