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TENDINŢE MODERNE ÎN APLICAREA TRATAMENTELOR FITOSANITARE ÎN PLANTAŢIILE POMICOLE

MODERN TRENDS IN APPLYING PHYTOSANITARY TREATMENTS IN ORCHARDS

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Abstract

Fruit tree culture is of particular importance as food source, from socio-economic and environmental point of view. The fruits of fruit-bearing trees and shrubs are one of the healthiest foods that are indispensable in making an optimal food ration for the human body. Through the cultivation of trees, the best use is made of hilly areas, inclined terrains in the lowland area, as well as sandy soils in Oltenia, North-Western Transylvania and Southern Moldavia. Fruit growing is the livelihood of a significant part of Romania's population. Orchards balance the composition of the atmosphere by CO_2 consumption and oxygen release, attenuate thermal extremes, increase air relative humidity, reduce wind speed. Moreover, orchards have an important anti-erosion role. As a result, the fruit growing development programs in our Country include priority measures and actions, among which the promotion of organic tree cultivation technologies. Directive 2009/128/EC of the European Parliament and of the Council of the European Union, establishes a framework to achieve a sustainable use of pesticides by reducing the effects of pesticide use on human health and the environment and promoting the use of integrated pest management (IPM - ***Integrated Pest Management*****) and of alternative approaches or techniques such as non-chemical alternatives to pesticides, all of which are part of the UN 2030 Agenda for Sustainable Development. Currently, low and ultra-low consumption technologies are being promoted when applying phytosanitary treatments. A way to reduce the consumption of a plant protection products is the punctual application of spraying, a component of the "precision agriculture" system. In the case of the punctual spraying application system, the command of sprayers opening or stopping is controlled, depending on the plant mass within the range of the machine. The purpose of the paper is to study technological solutions for punctual application of spraying in fruit plantations.**

Cuvinte cheie: plantaţii pomicole, tratamente fitosanitare, agricultură de precizie, normă variabilă
Keywords: orchards, phytosanitary treatments, precision agriculture, variable rate

1. Introduction

Variable Rate Technology (VRT) is a concept of best practice in precision agriculture. There are two ways to apply this technology: map-based and sensor-based. In the map-based system, the applied rule is changed according to predefined maps (Giles et al., 1989). Due to the ever changing characteristics of a fruit plantation, maps need to be updated frequently, making map-based technology very expensive. In the sensor-based system, sensors mounted on spraying equipment provide information about the structure of the plantation, information that is processed by a computer and used to control spraying in real time (Escolà et al., 2007). This sensor-based technology is more likely to be used in fruit-growing plantations rather than map-based one. Developing sensor-based technology is done in two steps. The first step is to use different types of sensors, such as ultrasound, infrared or radar sensors, to detect the characteristics of the target tree. This step involves acquiring and processing data to obtain information about target characteristics. The second step is to adapt spraying equipment by implementing sensors and controllers. Selective application with a precise target zone detection system should ensure uniform deposition and that the significant reduction in volume of the substance will not affect the biological efficacy of the treatment. This hypothesis was confirmed by tests using different electronic control strategies, resulting in significant differences between classical and sensor-based technology in favour of sensor-based technology.

2. Material and methods

One of the most advanced systems for applying phytosanitary treatments in fruit plantations is the environmentally responsible one, EDAS - Environmental Dependent Application System (Fig. 1), which identifies the environmental conditions and adjusts the spraying regime to reduce drift and protect adjacent surfaces (Doruchowski et al., 2009).

The environmental parameters monitored by the EDAS system are:

- wind speed and direction, measured with an ultrasonic anemometer;
- the position of the equipment relative to the edges of the fruit plantation or the areas to be protected from the contamination, controlled by GPS.

Depending on them, the EDAS system regulates:

- droplet size (coarse or fine spraying);
- fan air flow.

In order to adjust the spray quality, double-nozzle holders with a fine spray and a coarse spray nozzle, individually controlled by “on/off“ pneumatic valves, are assembled at the air spouts (Fig. 2). Figure 3 shows an example of a spraying scenario using nozzle closing or alteration (fine spray vs. coarse spray) depending on wind conditions, the position of the sprayer in relation to the orchard edge, and the distance to a PPP (Plant Protection Product)-sensitive area (i.e., a well). The nozzles were closed when the sprayer entered into no-spray buffer zones, and when it made a U-turn at the headland (Fig. 3 C, D, G). This function was used to comply with legal regulations regarding buffer zones and to meet the requirements of “Good Practice in Plant Protection”. The fine spray nozzles were changed to coarse spray nozzles when the spray was applied on the first row in the orchard, when the sprayer entered a defined low-drift zone and when the wind velocity exceeded a certain, pre-defined value (Fig. 3 A, F, B, E, I, J, L). Position A, coarse spray applied on row 1 from the outer side. Position F, coarse spray / fine spray applied on row 1 / row 2, respectively. Positions B, E, I, J, coarse spray applied in low-drift zone. Positions C, D, no spray applied in buffer zone attributed to water well. Position G, no spray applied during a U-turn at the land edge. Positions H, K, fine spray applied inside the orchard (from row 2 onwards) under a low wind velocity situation (wind speed < 2 m/s). Position L, coarse spray applied under a high wind velocity situation (wind speed > 2 m/s). This function was used to mitigate spray drift in situations of high risk of contamination to sensitive areas. In order to minimise the spray drift towards sensitive areas, yet to ensure adequate and appropriate spray distribution in the fruit tree canopy, the assisting air jets (left and right) produced by the fan were adjusted individually for the left-hand and right-hand sections of the sprayer by manipulation of the airflow on the inlet.

Having obtained a uniform air distribution from the collector, an adjustable air vane was assembled inside the collector in order to adjust or to close the airflow, individually, to the left or right sections of the sprayer (Fig. 4 A). In each scenario, closing the airflow to one section (left or right) resulted in an increase in air velocity to the other section by 30-40 %. In order to avoid this, a diaphragm-leaf-shutter was designed and fixed to the fan inlet (Fig. 4 B). Once the collector vane had closed or reduced the airflow to one section, the leaf-shutter restricted the flow of air sucked in by the fan, accordingly, so that the air velocity remained constant or increased at a relatively low rate in the other section.

In order to determine the tree canopy geometry, a crop identification system, CIS - Crop Identification System (Balsari et al., 2008), based on ultrasonic sensors, is used to adjust the volume of the substance and schedule the nozzle opening relative to the vegetation density (Fig. 5).

The presence or absence of the target is perceived by the time interval between the moment when the ultrasonic packet is emitted and the echo signal is received. Combining this information with that offered by the GPS system embedded in the EDAS system, the average distance to the canopy can be determined. Estimating the density of vegetation requires an echo analog signal analysis (Figure 6). The density of the vegetation is directly proportional to the amplitude of the received signal (A - higher amplitude signal, corresponding to a thicker tree canopy, B - lower amplitude signal, corresponding to a thinner one).

3. Results and discussions

The measurements made show that, the separate airflow for the left side of the equipment and for the right side (in the forwarding direction) could be adjusted to a drift-reducing margin (drifting effect), to eliminate any risk of contamination with phytosanitary substances of the areas neighbouring the treated orchard. Four distinct situations arise applying the scenarios of phytosanitary treatments (Fig. 7):

- Spraying on one side, oriented directly towards the interior of the orchard, when the first two rows are treated at the first two passages;
- Asymmetric distribution: full flow towards the plantation inside and 50% of flow to the outside at the third passage;
- Symmetric flow distribution, starting with the fourth passage;

- Asymmetric distribution: when the wind speed exceeds 2 m/s, the airflow in the opposite direction to the wind direction is increased by 20% and the airflow in the same direction is reduced by 20%.

The EDAS software, installed on the computer of the equipment, integrated with the GPS system, allows the operator to track the machine path and monitor real-time variation of the spray parameters. The EDAS control unit records the phytosanitary treatment process, allowing the record to be re-played. This makes possible to verify whether the environmental parameters were accurately acknowledged and whether the response was adequate.

The coarse spray that was applied by the EDAS system to the boundary row, in a low-drift zone and under high wind conditions (Fig. 3. A, B, E, F, I, J, L), produced a poorer spray coverage on the target, compared to fine spray, and arouse increasing fears of reducing the biological efficacy of the treatment. However, in many experiments (Koch et al., 2001; Knewitz et al., 2002; Friessleben, 2003; Jaeken et al., 2003) no significant differences in the biological efficacy of treatments were found between applications made with a coarse or a fine spray. Wenneker et al. (2008) also reported on the lack of influence of droplet size on pesticide residues on fruit. These results could encourage growers to use coarse spray nozzles, locally, with greater confidence and without compromising fruit quality. The field tests showed that the EDAS sprayer, equipped with a wind sensor and a GPS navigation system, enabled real-time adjustments in application parameters such as spray quality and air flow velocity, depending on environmental conditions.

Comparison of the profiles of the canopy thickness acquired for the same row in three different passages showed quite similar output, even if the point to point comparison often presented some discrepancies (Fig. 8), mainly due to the difficulty to repeat exactly the same path in the field.

4. Conclusions

The EDAS system offers to fruit growers an opportunity to adjust their spray application parameters automatically, in order to apply PPPs with respect to the environment and local regulations. This may be especially useful for growers who have orchards next to areas that need to be protected from PPP contamination.

The CIS system is suitable to distinguish the presence and characteristics of the target to be sprayed and, as previous studies have already indicated (Zaman and Salyani, 2004) is not significantly influenced by the forward speed adopted, working in the range (2-8 km/h) commonly used during orchard treatments. No interferences were found between the three ultrasonic sensors that were mounted on the same sprayer side.

The result of the two systems, implemented on the same equipment, is a modern, performant technology of phytosanitary treatments, with significant reductions in the volume of the applied substance, without affecting leaf deposition and maintaining biological effectiveness, while reducing to a minimum environmental pollution.

5. Acknowledgements

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Figures

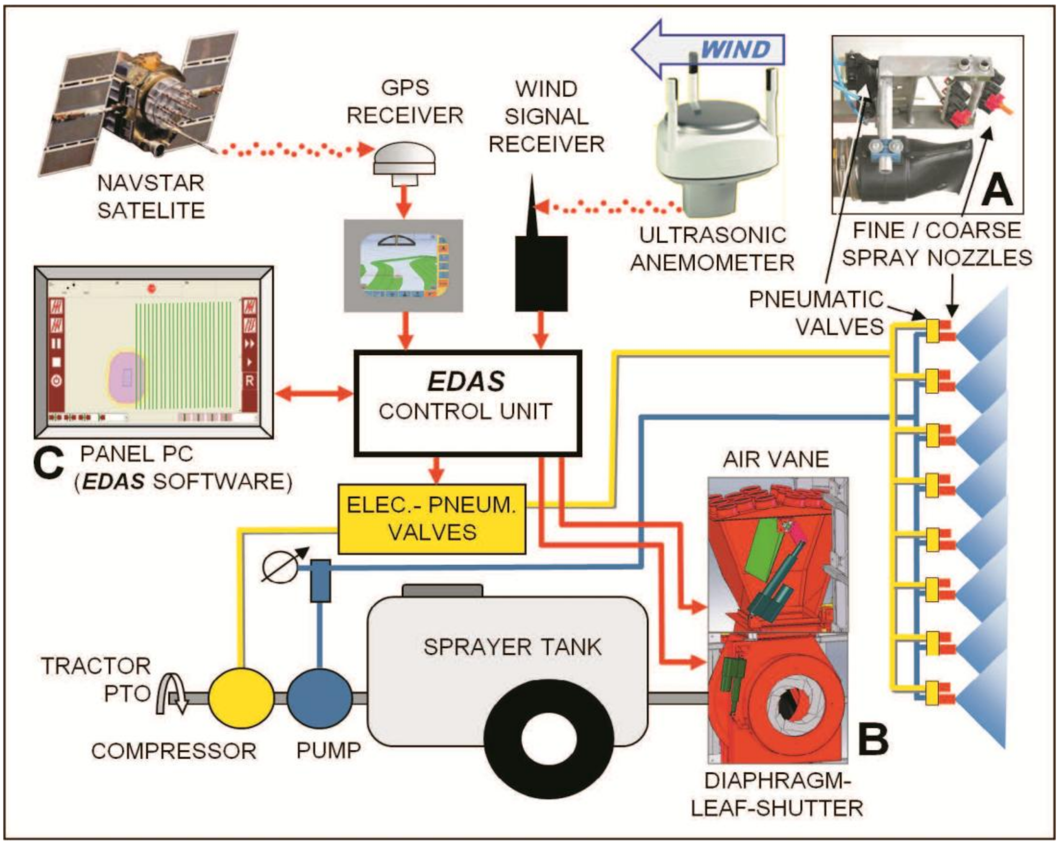

Fig. 1. Orchard sprayer with an EDAS system. Panel A, spray quality adjusted by the alteration of nozzles (‘fine spray’ *vs*. ‘coarse spray’). Panel B, air velocity adjusted by manipulation of the diaphragm-leaf-shutter on the inlet and the air vane on the outlet of the radial fan. Panel C, system controlled by the panel PC with EDAS software (Doruchowski et al., 2009)

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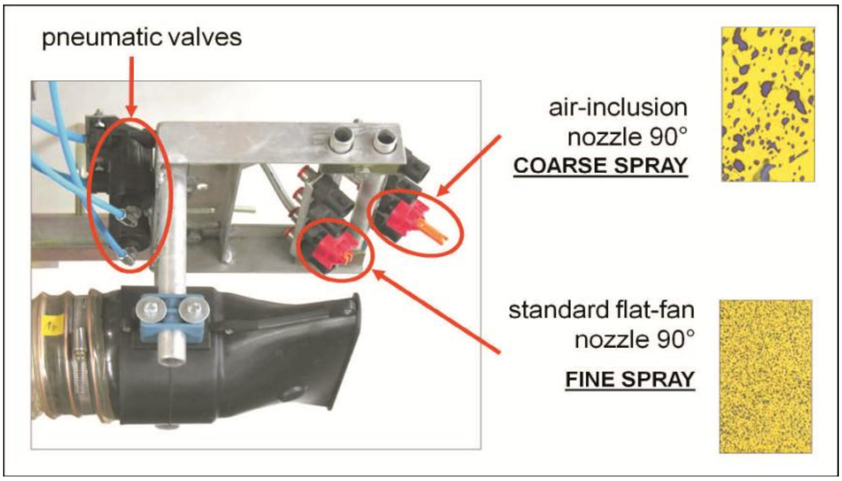

Fig. 2. Double-nozzle holder for alterations between fine spray and coarse spray nozzles controlled by pneumatic valves (Doruchowski et al., 2009)

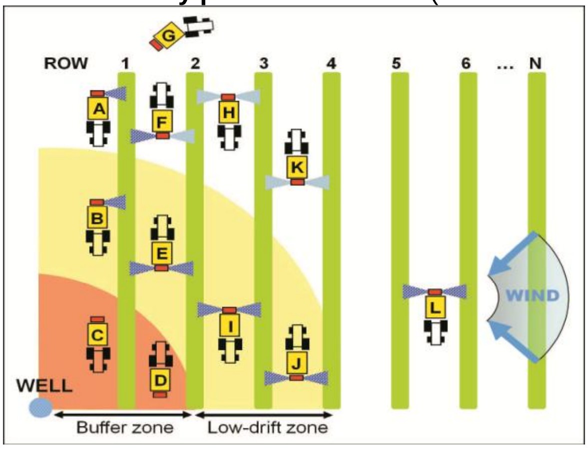

Fig. 3. Scenarios of spray applications controlled by the EDAS system (Doruchowski et al., 2009)

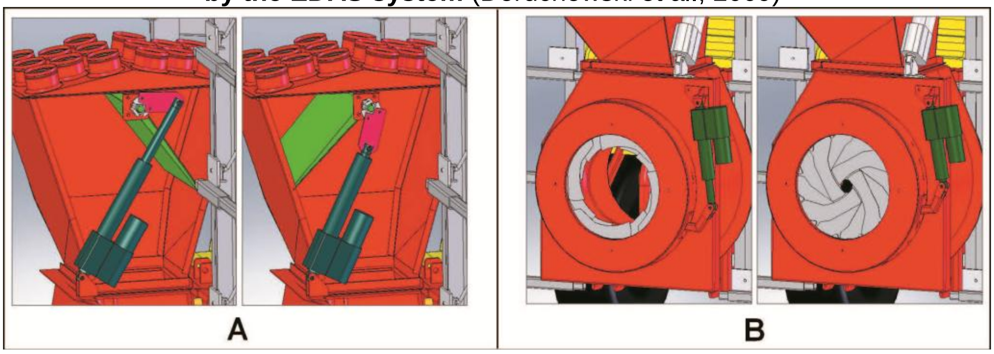

Fig. 4. Airflow adjustment system on the EDAS system (Doruchowski et al., 2009)

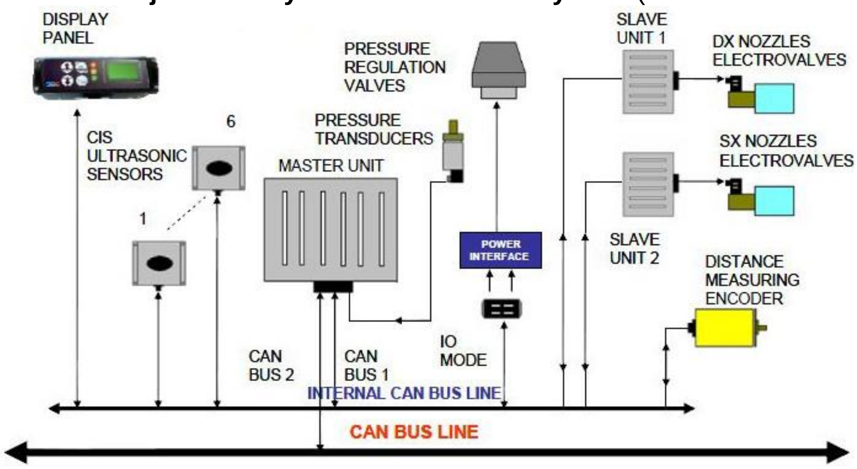

Fig. 5. Scheme of the Crop Identification System layout (Balsari et al., 2008)

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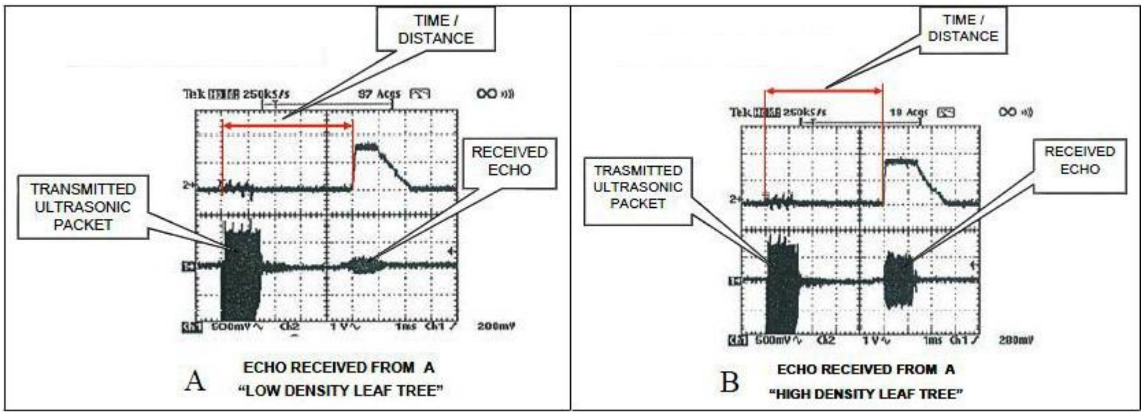

Fig. 6. Examples of ultrasonic signals transmitted and received echoes from different canopy targets (Balsari et al., 2008)

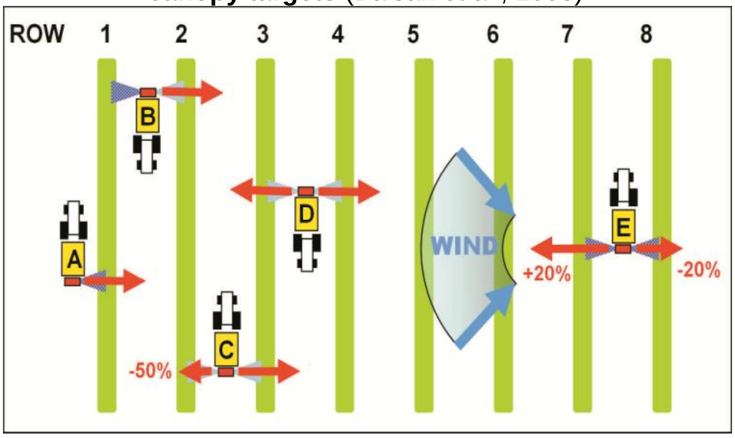

Fig. 7. Situations arisen while applying the scenarios of phytosanitary treatments (Doruchowski et al., 2009)

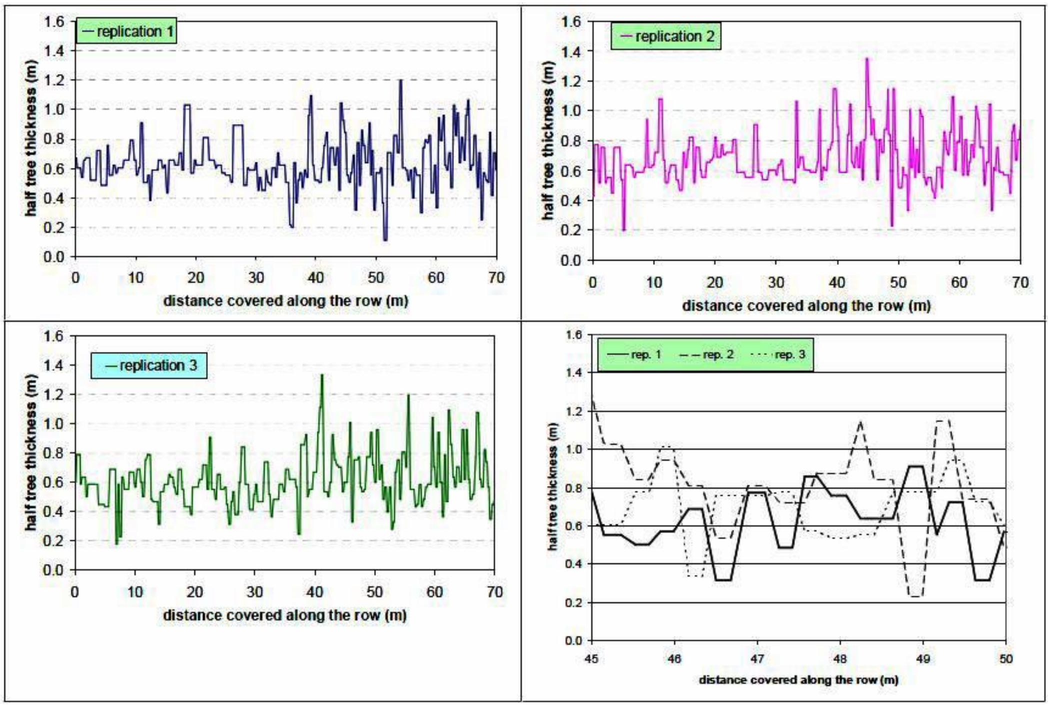

Fig. 8. Profile of the canopy size detected by the ultrasonic sensor for the same orchard row (Balsari et al., 2008)