ABSTRACT

Keywords: sprayers, pesticides, pollution, recovery, soil.

Pollution with pesticides from diseases and pests combat treatments in vineyards and orchards leads to decreasing of food, water and even soil quality. Soil pollution with pesticides had a negative impact on micro-flora and micro-fauna from soil, of plants, by limiting the nutritive availability, being able to destroy a long chain of eco-systems.

Decreasing of soil pollution degree aimed to maintain an optimal correlation between quantity, quality and food structure and preservation of the environment.

During working process of the spraying machine a part of the applied pesticide liquid is lost due the gaps between plants, due to the flow of liquid on leaf surface, due to penetration of plants' rows and due to derive of dispersed liquid droplets. In these conditions a part of the pesticide liquid reaches in the air, waters and on soil as well on the neighbouring plantations.

The aim of the PhD thesis is to reduce soil pollution with pesticides provided by diseases and pests control treatments by spraying in vineyards and orchards, through realization of some equipment for recovery of dispersed liquid excess as well as through optimization exploitation of the machines which realize those works.

Starting from the analysis of actual stage of knowledge regarding technologies and machines for diseases and pests combat in vineyards and orchards, aiming the decreasing of soil pollution degree, was designed and realized an equipment which will recover and recycle the excess of pesticide liquid dispersed by TARAL 200 PITON TURBO spraying machine.

Also during research were estabished technological condition for exploitation optimization of the spraying machine.

PhD thesis is structured on two parts „***Actual stage of knowledge***" and „***Own research***", being composed by 7 chapters. The first part of the work refers to the actual stage of knowledge regarding the proposed theme, having an introduction and 2 chapters, in the second part are presented the own research, structured in 5 chapters followed by the list of references.

In **1st chapter** of PhD thesis entitled „***General notions regarding diseases and pests control technologies in vineyards and orchards***" are presented the importance and the necessity of application of phytosanitary treatments, the negative effects of pesticide application and especially to soil pollution with them. Also are presented the methods and means of application of combat treatments for diseases and pests in vineyards and orchards, as well as the prevention modalities of soil pollution with pesticides.

2nd chapter of the doctoral thesis deals with aspects regarding „***Actual stage of knowledge regarding technologies and machines for mechanized application of phytosanitary treatments in vineyards and orchards***". The first subchapter is referring at the actual tendencies regarding construction of equipment and machines utilised for diseases and pests control in vineyards and orchards. The second subchapter deals with the theoretical approaches of working process of the machines for diseases and pests control in vineyards and orchards for prevention of soil pollution. Here are mentioned the particularities of the dispersed liquid jet, derive phenomenon of dispersed droplets and the actual tendencies regarding construction of liquid dispersion devices, inclusively nozzles. The last subchapter aims with the actual tendencies, at world level, regarding the construction of machines equipped with devices for recovery of pesticide liquid excess, utilised in diseases and pests combat in vineyards and orchards.

In **3rd chapter** entitled „***Aim and goals of PhD thesis***" is defined the aim of doctoral thesis resulted after documentation, which is of a great actuality, as well as the goals tracked for its realization. To reduce soil pollution degree with pesticides from combat treatments of diseases and pests in vineyards and orchards, through exploitation optimization of machines which realise those works, were followed the following objectives:

- analysis of the importance and necessity of application of diseases and pests control treatments in vineyards and orchards;
- establishment of pesticide impact on soil, through its pollution;
- identification of actual stage and tendencies in domain of mechanization technologies for diseases and pests combat in vineyards and orchards, construction of equipment for liquid dispersion for reducing derive, as well as of machines equipped with installations for recovery of excess of administrated pesticide liquid;
- design and realization of an device for recovery of dispersed pesticide liquid excess, which was mounted on the universal spraying machine TARAL 200 PITON TURBO utilised for diseases and pests combat in vineyards;

- carrying out of research in laboratory and field conditions for establishing the recovery degree of pesticide liquid excess by the designed device;
- effectuation of research in laboratory conditions for mathematical modelling through CFD simulations, working process for dispersal of pesticide liquid by TARAL 200 PITON TURBO spraying machine provided with the designed and realised device through the current doctoral thesis;
- effectuation of experimental research to establish the qualitative working, energetic and exploitation indexes of TARAL 200 PITON TURBO spraying machine, equipped with a device for recovery of dispersed liquid excess, utilised for disease and pests combat in vineyards;
- processing and interpretation of the obtained experimental results;
- elaboration of some conclusions and recommendations regarding exploitation optimization of TARAL 200 PITON TURBO spraying machine, equipped with an device for recovery of dispersed pesticide liquid excess, utilised for diseases and pests combat in vineyards.

4th chapter of doctoral thesis treats aspects regarding „***Material and research method***" utilised to achieve the PhD thesis' goals, as well as the characterization of general natural frame in which experiments took place, those one being carried out both in laboratory conditions and also in field on a vine plantation, Chasselas doré sort from „Vasile Adamachi" Farm from Iaşi.

In this chapter is presented the equipment for pesticide liquid recovery mounted on TARAL 200 PITON TURBO spraying machine, device composed by two panels placed on each side of the vine row which recover the pesticide liquid which didn't remain on the plants' foliar system and passed over vine plant, flowing in the troughs from the base of panels from which is collected by pumps and transported in the spaying machine tank.

At the same time with the recovery degree of the dispersed pesticide liquid, determined in laboratory and field conditions, in different vegetation stages of vine plantation, for different working parameters (pressures between 0.2; 1.4 MPa, rotations of axial fan being between 800 and 1400 rpm, exposure distances of panels face to spaying machine axis being between 1500 and 2100 mm, as well for different mounting high of panels face to soil, between 300 and 700 mm), were also determined qualitative, energetic and exploitation indexes of the spraying machine, provided with the new device, for pressures of 0.4; 0.6 and 0.8 MPa, fan rotation being 1400 rpm, aggregate velocities of the being 2, 4 and 6 km/h, at a disposal distance of the panels face to spraying machine axis of 1900 mm and a height from soil of its of 300 mm.

For determining the dispersal uniformity of liquid, were utilised two constructive types of nozzles, a nozzle with full cone jet AMT 1.2 from ALBUZ and a nozzle with flat jet and air absorption IDK 120-02 from LECHLER. In this way was designed a vertical stand provided with 18 inclined troughs, and at their base were mounted recipients. So from the level of each through was determined the recovered liquid in one minute, for all the working parameters of the spraying machine.

To determine the size of liquid droplets, covering degree and covering uniformity with liquid, which reached the surface of vine leaf, in field conditions, was utilised a liquid mix formed by Cropmax foliar fertilizer, wet lime and a yellow colorant, because the droplets of this liquid presented a very good adherence at the surface of plants' foliar system. After tests effectuation were gathered the leaves sprayed, by the machine equipped with those two nozzle types, from upper, median and lower part of vine plant. Leaves sprayed, at different working parameters of the spraying machine, were scanned and analysed using the Image J programme to determine the minimal and maximal diameter of droplets, their surface and leaf surface.

5th chapter of doctoral thesis „***Modelling and simulation of spraying process with pesticide liquid***" aims with mathematical modelling and CFD simulation of working process for pesticide liquid dispersion, by TARAL 200 PITON TURBO spraying machine in intensive vineyards and orchards, equipped with a liquid recovery device, in laboratory conditions, using nozzles with full cone jet AMT 1.2 – ALBUZ. From this simulation could be observed that velocity vectors had a stagnation point the upper third part of collecting panel, showing a ramification of air flow on two directions (up/down), with a more intense circulation of air in the upper part of collecting panel. In median vertical plane of collecting panel, representation for velocity vectors show that air jet at contact with panel splint in two, on vertical direction, having the stagnation point in the panels' centre, with a more intense circulation of air in the upper half of collecting panel. Velocity vectors, at the second edge of panel are up oriented on the most part of height and down at inferior part, without a clear distinguishing of a stagnation point.

At the inferior end of collecting panel velocity field is presented under the form of a „horseshoe", due to the panel concave form. Air average velocity in the lower part of collecting panel is 3 m/s, and air circulation is uniform on all the panels' width. Velocity vectors present air flow direction in this plane, with a stagnation point decentred face to middle and a ramification of air current predominant to the left side of panel, from nozzle direction. Air velocity at exit from machine, at nozzle level, is greater to deflector and decrease from nozzles to fan. Average air velocity at exit from spraying machine is 20.5 m/s, at a rotation of fans' rotor of 1900 rpm.

At the upper part of collecting panel and above spraying machine, velocity field suffer a modification regarding velocity distribution and size. Maximal air velocity above spraying machine is 13 m/s, and on central nucleus, placed between machines and collecting panel, is 8 m/s. Velocity profile at collecting panel level has the shape of „L" letter. Stagnation point is placed in the panels' right corner, fact which makes that a part of air to circulate on the panel on all its width, from right to left, from direction of spraying machine, and another part to be deviated by the panel to the external environment. Air turbulence degree is maximal at the upper and lower part of spraying machine, as a result of geometrical shape of superior deflector and due to end effect at the lower part of machine. Average air velocity at nozzles' level is 20 m/s, gradually decreasing till the level of collecting panel. Air lines began to „wash" the collecting panel on its diagonal, diagonal obtained through union of all stagnation points.

Trajectory of pesticide liquid droplets is influenced by air flow. CFD simulation is realised starting from the hypothesis the liquid droplets are transported by air flow, which was presented both by velocities field and also by current line. Distribution of liquid droplets gathered from the superior nozzle of spraying machine is influenced by air flow around nozzle, by a light deformation of droplets' cone, and distribution of droplets on collecting panel surface show a partial covering degree, a number of droplets exceeded panel at its upper part and on sides, but most of them reach to the colleting panel. In the case of nozzle with a median disposal, droplets' cone is not deformed by air flow, and droplets' dispersion on collecting panel is almost totally realised, a reduced number of droplets exceeded the panel at sides and very few droplets exceeded the panel at the upper part. At nozzle disposed at the lower part of spraying machine are not observed deformation of droplets' jet due to air flow and droplets' dispersion is totally realized on panel.

Velocity of droplets on collecting panel varies having values between 0.5 and 18 m/s. Area with average values of 15 m/s for velocity follows almost the same trajectory formed by current lines. Movement tendency of droplets on panel is from right to left. Droplets average velocity is 14 m/s on the right side of machine and collecting panel, decreasing to 3.5 m/s on the left side. Droplets, which reached the panel, are moving to left side of the panel washing it, and due to weight are getting down to the collecting zone. This fact was also remarked through the research carried out in field conditions.

In **6th chapter** of doctoral thesis „***Experimental research regarding exploitation optimization of TARAL 200 PITON TURBO spraying machine equipped with a device of***

partial recovery of dispersed pesticide liquid" are presented obtained results for research carried out in laboratory and field conditions. So, in the first subchapter are presents the results regarding recovery degree of the dispersed pesticide liquid in laboratory and field conditions. Experimental research in field conditions were carried out in different vegetation stages of vine plantation from „Vasile Adamachi" Farm from Iaşi, Chasselas doré sort, using nozzles with full cone jet AMT 1.2 from ALBUZ and nozzles with flat jet and air absorption IDK 120-02 – LECHLER. In the second subchapter are presented the obtained results for establishment of qualitative, energetic and exploitation indexes for the spraying machine equipped with a partial recovery device for dispersed pesticide liquid, in order to decrease soil pollution degree. In the third subchapter was realised the processing and statistical interpretation of experimental data obtained at determination of recovery degree for dispersed pesticide liquid in field conditions, for different vegetations stages of vine plantation.

For both nozzles' types utilised in experimental research for determination of partial recovery degree of dispersed pesticide liquid, using the designed equipment, aiming to reduce soil pollution degree, could be observed an increase of dispersed liquid flow at the same time with increasing of working pressure. Pesticide liquid flow dispersed by nozzle with full cone jet AMT 1.2 – ALBUZ is 3.65 L/min at a pressure of 0.2 MPa and increase till 7.65 L/min at pressure of 1.4 MPa. The flow of nozzle with flat jet and air absorption IDK 120-02 – LECHLER is lower than the case of AMT nozzle and increase at the same time with pressure increasing, from 2.05 L/min at pressure of 0.2 MPa till 4.60 L/min at pressure of 1.4 MPa. The flows of IDK nozzle are lower than the ones realized by AMT nozzle with *43.84%* for pressure of 0.2 MPa, with *37.78%* for 0.4 MPa, *37.50%* for 0.6 MPa, *36.07%* for 0.8 MPa, *37.59%* for 1.0 MPa, *36.62%* for 1.2 MPa and *39.87%* for 1.4 MPa. This thing is due to IDK nozzles' construction.

The flow of recovered liquid through the designed equipment realised in the current PhD thesis in laboratory conditions depends by the pressure of hydraulic installation and by the rotation of spaying machine fan, for both nozzles' type. So, recovering degree of pesticide liquid decrease at higher pressure, in the case of both nozzles' type, due to an excessive dispersion of the liquid in droplets with more and more lower dimensions, and a part of water is evaporated before reaching the recovery panels. At nozzle AMT 1.2 – ALBUZ, with full cone jet, is realised a liquid recovery degree of **59.32%** at pressure of 0.2 MPa, fan rotation is 1400 rpm, at a panel disposal at 300 mm face to soil and at 1500 mm face to machine axis. For nozzle IDK 120-02 –

LECHLER, with flat jet and air absorption, is realised a liquid recovery degree of **75.61%** at pressure of 0.2 MPa, fan rotation of 1400 rpm, for panels disposal at 300 mm face to soil respectively at 1500 mm face to machine axis. In case of nozzle IDK 120-02 – LECHLER is realised a liquid recovery degree with till 16.29% higher face to classical nozzle AMT 1.2 from ALBUZ, for the same working parameters, due to technology of air absorption, with creation of droplets with air bubbles, which are resistant to evaporation.

Was observed, for both nozzles' type, that a higher fan rotation, which realise an increasing of air flow and air current velocity, determine a higher recovery degree of pesticide liquid. This thing is due to the fact that droplets are transported by air flow in a lower time to the panels and evaporation and derive phenomena are more reduced.

By increasing the mounting height of panels face to soil, for both nozzles' type, recovery degree of pesticide liquid decrease significantly, due to the fact that a part of droplet jet produced by nozzle isn't collected by the panel.

By increasing the disposal distance of panels face to spraying machine axis, for both nozzles' types, recovery degree decrease, due to the fact that droplets must travel a longer distance, and chances to reach the panel decrease, being more intense subjected to evaporation and derive phenomena.

In case of experiments in field conditions nozzle with full cone jet AMT 1.2 – ALBUZ realize the highest recovery liquid degree, of **43.98%**, obtained in the first stage of vegetation, at pressure of 0.4 MPa, for an aggregate movement velocity of 2 km/h. Recovery degree of pesticide liquid progressively decrease, in all situations, at the same time with the development of vegetal mass, because liquid remain on the plants' foliar system, especially in the last vegetation stages (grains of pea size and bunch with natural sized grains). At nozzle with flat jet and air absorption IDK 120-02 – LECHLER is realized a higher recovery degree of liquid than at nozzle with full cone jet AMT 1.2 – ALBUZ, for the same vegetation stages. This thing happens especially at pressure of 0.4 MPa and movement velocity of 2 km/h.

At stage II of vegetation development (emergence and shoots growth) for pressure of 0.4 MPa and velocity of 2 km/h was obtained a liquid recovery degree of **41.97%**, decreasing till 27.21% at stage V (grains' growth). It must be remarked that for nozzle AMT and for same vegetation stages, pesticide liquid recovery degree is higher with 1.48%, respectively 0.37%.

As a general conclusion, pesticide liquid recovery degree decrease at the same time with pressure increasing, due to the droplets with more and more smaller dimensions, with increased risks for derive and evaporation. Also, was established that recovery degree of pesticide liquid decrease insignificantly at the same time with increasing of aggregate movement velocity, and in the last two vegetation stages (grains of pea size and bunch with natural sized grains) could be observed a stabilization of liquid recovery degree, because by the maintenance works, vegetation starts to keep the same dimension and density, differences being insignificant.

No matter of working pressure (0.4; 0.6 and 0.8 MPa) and aggregate movement velocity (2; 4 and 6 km/h), for both type of tested nozzles, nozzle with flat jet and air absorption IDK 120-02 – LECHLER and nozzle with full cone jet AMT 1.2 – ALBUZ, the highest number of droplets is between the sizes of 100 ... 150 µm and in interval 150 ... 200 µm. In case of nozzle with full cone jet AMT 1.2 – ALBUZ was established that the number of droplets in interval 200 ... 300 µm increase face to nozzle with flat jet and air absorption IDK 120-02 – LECHLER, but not so much. This thing is due to the construction of nozzle AMT 1.2, which realise bigger droplets than in the case of nozzle IDK, which produce smaller droplets, even if are filled with air bubbles. Mean diameter of tracks of liquid droplets which reach the superior surface of leaves is between 160.12 and 196.76 µm for nozzle with full cone jet AMT 1.2 – ALBUZ and between 148.78 and 194.01 µm for nozzle with flat jet and air absorption IDK 120-02 – LECHLER. Mean diameter of droplets' tracks which reached the back part of leaves was between 156.48 and 200.32 µm for nozzle AMT and between 157.03 and 196.15 µm for nozzle IDK, being optimal for an efficient treatment.

Average covering degree with droplets is greater on leaves' face than on back of them both for nozzle with full cone jet AMT 1.2 – ALBUZ and also for nozzle with flat jet and air absorption IDK 120-02 – LECHLER.

Distribution uniformity of droplets on leaves, for the both nozzle types, is higher at the hub middle, after that follows the lower part and at the end the upper part. For nozzle AMT is obtained a uniformity maximum of 95.29% for leaves in hub middle, at a working pressure of 0.6 MPa and an aggregate movement velocity of 2 km/h, and a maximum of 91.86% for back of the leaves from lower part, at a working pressure of 0.8 MPa and a movement velocity of 6 km/h. At nozzle with flat jet and air absorption IDK 120-02 – LECHLER is obtained a uniformity maximum of 95.01% for the face of the leaves from the hub middle, at a working pressure of 0.6 MPa and an aggregate movement velocity of 4 km/h, and a maximum of 91.27% for the back side of leaves from lower part, at a working pressure of 0.6 MPa and a movement velocity of 6 km/h.

Liquid flow uniformity for spraying machine TARAL 200 PITON TURBO is optimal for all nozzles (optimal constant for liquid flow must be less 95%).

Specific fuel consumption of aggregate is of 1.99 L/ha for velocity 1.89 km/h, of 1.89 L/ha for 3,67 km/h and of 1.14 L/ha for 5,62 km/h. Time utilisation coefficients per working shift were in normal limits.

In case of nozzle with full cone jet AMT 1.2 – ALBUZ was observed that from all nine variants only variants V4 and V7 had very significant results for all those seven vegetation stages, and variants V5 and V8 had insignificant results. Also variants V2, V3, V6 and V9 had results with different levels of signification function of vegetation stage, staring from very significant, distinct significant, significant and insignificant. For nozzle with flat jet and air absorption IDK 120-02 – LECHLER was established that from those nine variants only variants V4 and V7 had very significant results for vegetation stages II, III, IV and significant for stage V, and variants V5 and V8 had insignificant results. Also, variants V3, V6 and V9 had results with different signification degrees function of vegetation stage, starting from very significant, distinct significant, significant and insignificant.

At nozzle with full cone jet AMT 1.2 – ALBUZ could be observed that the dispersion of recovery liquid flow variation is explained in a percent of 96.1% by velocity and working pressure variation. It was established that 93.4% from dispersion of recovery liquid flow variation is explained by velocity variation and only 2.7% from dispersion of recovery liquid flow variation by variation of working pressure. This thing shows a greater influence of velocity in comparison with pressure, on flow of recovered pesticide liquid. In case of nozzle with flat jet and air absorption IDK 120-02 – LECHLER could be observed that variation of recovered liquid flow is explained in a rate of 94% by variation of velocity and working speed. It was established that 88% from dispersion of recovered liquid flow could be explained by velocity variation and only 6% from dispersion of recovered flow by variation of working pressure.

For AMT nozzle regression slope velocity/recovered liquid flow present a decrease of average recovered flow for those seven stages of vegetation with around 130.5 L/h at increasing of velocity of spraying machine from 2 km/h to 6 km/h. For IDK nozzle regression slope velocity/recovered liquid flow present a decrease of average recovered flow for those four stages of vegetation with around 90.5 L/h at increasing of velocity of spraying machine from 2 km/h to 6 km/h. At AMT nozzle regression slope pressure/recovered liquid flow present an increasing of average recovered flow for those seven stages of vegetation with around 23 L/h at increasing of working pressure from 0.4 MPa to 0.8 MPa. This shows a higher recovery degree when pressure is doubled. For IDK nozzle regression slope pressure/recovered liquid flow present an increasing of average recovered flow for those four stages of vegetation with around 17 L/h at increasing of working pressure from 0.4 MPa to 0.8 MPa.

Aggregate movement velocity had a greater influence on pesticide liquid recovery degree in comparison with working pressure.

In **7th chapter** of PhD thesis entitled „***Conclusions and recommendations***" were established the final conclusion and recommendations for reducing of soil pollution degree with pesticide liquid, as well as the optimal conditions for exploitation of spraying machines in vine plantations.

Equipment with recovery of pesticide liquid dispersed by TARAL 200 PITON TURBO spraying machine reduce the cost in effectuation of phytosanitary treatments by decreasing the quantities of utilised pesticide and fuel, diminishing at the same time soil pollution degree.