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NOZZLE WITH AUTOMATIC ADJUSTMENT OF THE JET POSITION

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Abstract

In the paper the authors made a presentation of a nozzle that can endow the machines and equipment for combating diseases and pests, as well as chemical control of weeds by spraying. After describing the communications in which these treatments are performed, conditions presented in the literature, the authors refer in particular to the phenomenon of droplet drift when the speed of displacement of the aggregate exceeds certain limits or when the velocity of the air current increases accidentally during the treatment. Derivatives to spills may lead to phytotoxicity phenomena or the destruction of other cultures that do not support the active substance in the solution. It has thus determined the velocity of the air currents and dynamic wind pressure, moment and torsional force at which is subjected to the nozzle arc and the magnitude of the derivation and the random dispersion of the droplets, was the way the nozzle can be used.

Key words**:** *phytotoxicity phenomena, dynamic, dispersion*

INTRODUCTION

The chemical weed control is the second most important work in the technology of any agricultural technology. When executing the herbicide work, for example, in addition to the weather conditions and the sprayer, it is necessary to pay particular attention to the nozzles and substances used.

For proper and effective treatment, weather conditions should not exceed certain wind speeds below 6 m / sec, a temperature below 20° C and a relative humidity of more than 60% [11].

Therefore, pesticide application equipment must be tested and diagnosed with the implementation of Directive 2009/128/EC.

The inspection procedure has been developed in accordance with the following reference documents: SR EN 13790-1: 2004 Agricultural machinery. Spraying machines. Examination of spraying machines during operation. Part 1: Sprayers used for basic crops.

The inspection shall determine:

-Pump pump [l / min];

-Diff via nozzle [l / min];

- Uniformity of transverse distribution [%];

- Normal's of substance [l / min].

In practice, it is no longer recommended to use nozzles that produce very fine splashes, but those nozzles that produce droplets larger than 100 microns. Thus, a drop that has 100 microns is transported five meters at a wind speed of 3 m / sec, while a droplet that has 20 microns is driven by wind up to 125 meters. Very small spraying droplets mean pollution and inefficient treatment [11].

A drop of solution having a diameter of less than 100 microns lives for 12 seconds and takes 22 seconds to reach the ground. If the relative humidity is less than 60% and the temperature is higher than 25° c, the drop evaporates [8].

In order to have a successful treatment and lead the solution where necessary, where necessary, we need to reduce the drift, ie the lateral transport of the particles, reduce soil contamination and optimize consumption [9].

Prior to using the equipment, we know the exact flow rate, spray angle and distribution uniformity of each nozzle (Fig.1). Nozzles for agriculture and accessory are synonymous with efficiency and economy, while also taking into account environmental issues by reducing the yield, in particular.

Fig. 1. Bank for determining the working indices of spraying machines
Source: [9]

Spraying and spraying angles are dependent on the working pressure and viscosity of the liquid to be sprayed. Flows are set very accurately using the inductive measurement method. The spray angle is determined from the nozzle opening (Fig.2).

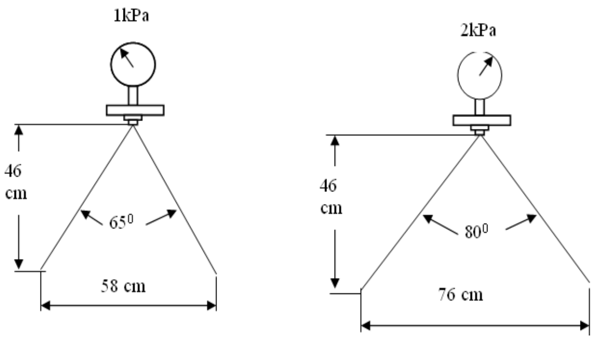


Fig. 2. Spray nozzle angle
Source: [6].

The spray width and the coating surface are based on the distance from the nozzle hole.

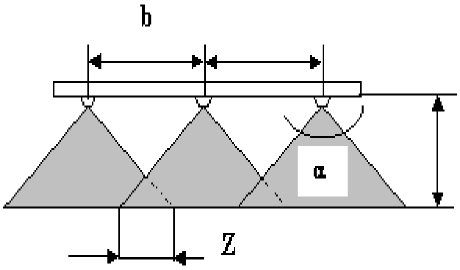


Fig. 3. The distance between the spray heads is selected according to the angle of the drop of the droplets
Source: [5]

For a better uniform distribution of the pesticide, the droplet jets of two neighboring nozzles must overlap on about Z = 15% of the surface. In this sense, the ramp has possibilities of adjusting the distance from the ground. The height h from the ground is calculated with the relation:

$$h = \frac{b+z}{2} \cdot ctg\frac{\alpha}{2} \text{ [mm]} \quad (1)$$

where:
b = 500 mm; α = 65°; 80°; 110° [12].
The flow of liquid passing through the calibrated orifice (nozzle) is given by:

$$q = 6 \cdot 10^{-2} \mu f \sqrt{\frac{2p}{\rho}} \text{ [l/m]} \quad (2)$$

where:
p - working pressure [N/m^2];
ρ - density of the liquid [kg/m^3];
f - the section of the hole [mm^2];
μ - the flow coefficient.
At the ends of the tangential sprayer μ = 0.24-0.45 and at the ends of the fan sprayer μ = 0.6-0.85.
It can be observed that q at the same section f varies with p, and the pressure p and the section f influence the fineness of the droplets (their diameter).
The amount of liquid administered per hectare of the sprayer (liquid standard per hectare N) is determined with the relation:

$$N = \frac{600Q}{B \cdot v} \text{ [l/ha]} \quad (3)$$

where:
Q is the total flow rate in l / min;
B - working width, in m;
v - travel speed in km / h [10].
The Q flow that passes through the segments of the spray nozzles is provided by the relationship:

$$Q = c\sqrt{p} \text{ [l/min],} \quad (4)$$

where c is a characteristic constant of the nozzle and the liquid used, and the working pressure, in bars.

From the previous relationships, there are two distinct possibilities to maintain precise rules per hectare; constant maintenance of the Q / v ratio, i.e. the change of flow rate Q in proportion to the speed of the machine; keeping the report steady $\sqrt{p}/v_r$, i.e. changing the system pressure in such a way that the value of that ratio is constant [7].

Depending on the two, there are different machine adjustment processes, their role being always to ensure the uniformity of liquid distribution in the direction of displacement and compliance with the solution standard per hectare.

A decrease in the spray angle value by 2 .10% leads to a non-uniform distribution over the length of the spraying lance [1].

The most favorable decomposition of the jet is for the ratio: λ/dc = 4.42

where:

λ - the wavelength of the oscillation

dc - jet diameter.

MATERIALS AND METHODS

-Laser-Doppler Particle Analyzer, 3D presentation jet measuring device, liquid distribution systems, and more are essential conditions for accurate data measurement.

-To measure wind speed with greater precision, digital anemometers are used that measure and accurately measure the speed and direction of the wind.

-The gyro automatically controls the lowering of the small nozzle support system, the nacelle is automatically rotated by the wind direction by means of the girder, without the need for an additional swivelling system. This in turn rotates in the opposite direction to the direction of the wind holding the nozzle a few degrees keeping approximately the same position of the jet to the foil surface or ground surface, compressing the spring that supports the position of the nozzle holder.

- Flat jet nozzles.
- Bank for testing sprinklers.
- The aerodynamic tunnel [4] as presented in Fig.4.

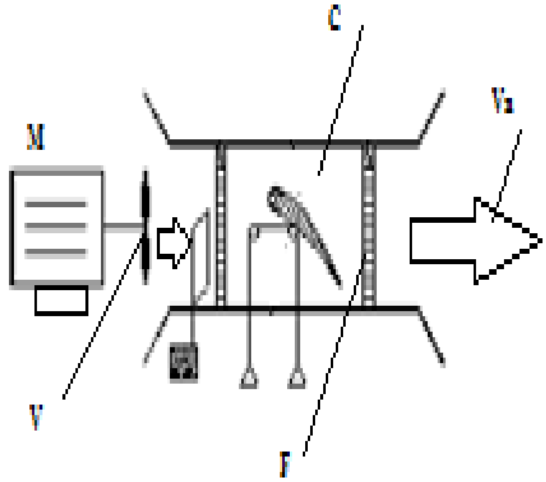


Fig. 4. Aerodynamic tunnel M- electric motor, axial V-fan, C-test chamber, F-filter, direction and speed of airflow
Source: [3].

The method used to determine the characteristics of the soil dispersal dispersion process is presented in the literature [2].

The study of the liquid cluster decomposition can be done by the small perturbation method, the probable hypothesis method and the method dimensional analysis.

Test data:

Test pressure [bar]: 2.0; 2.5; 3.0; 3.5; 4.0;

Pump Flow [l / min] 25.0; 27.5; 28.8; 31.1; 33.2;

Nozzle flow [l / min] between 1.04 to 1.44;

Unit speed [km / h] - 6 to 16 [10].

In order to have a successful treatment and lead the solution where necessary, we must reduce the drift effect, i.e. the lateral or longitudinal transport (in the direction of movement of the aggregate) of the particles, reduce soil contamination and optimize the intake of the solution.

For this purpose, the authors propose to make a device consisting of easy-to-find elements on the plate to rotate the nozzle in the opposite direction to the air flow when its speed exceeds the maximum admissible limit for the treatment [6].

The components of this device are shown in Fig.4, 5 and 6 presented below.

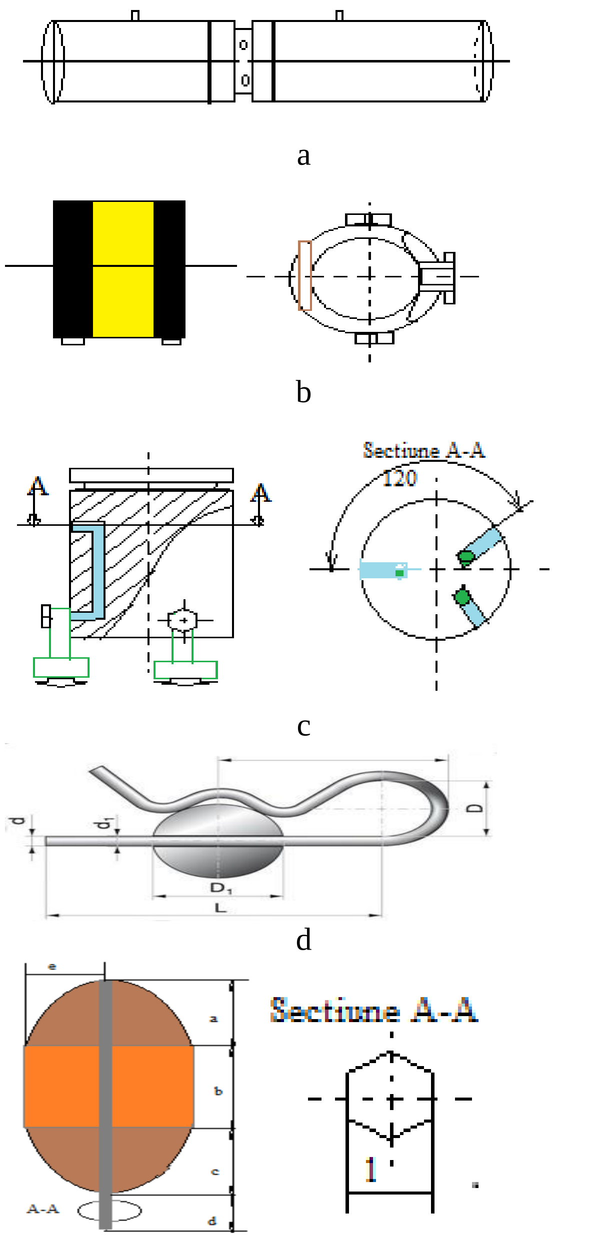


Fig. 4. Components of the nozzle jet model: a-duct, b-nozzle support, c-body distributor, d-safety, e-pellet winding
Source: authors' results.

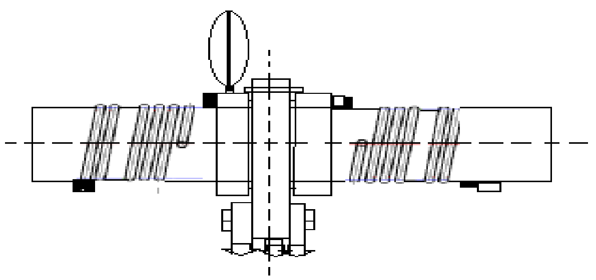


Fig. 5. Nozzle jet routing equipment
Source: authors' results.

The torsion cylindrical helical arc (Fig.6).

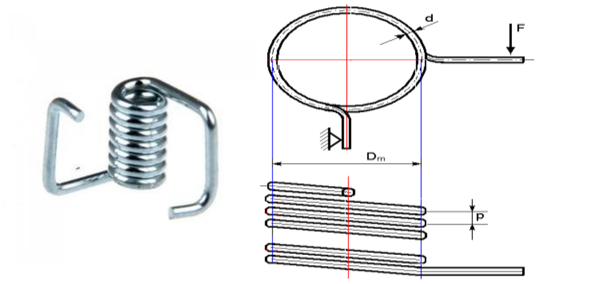


Fig. 6. Torsional cylindrical spiral arc
Source: authors' results.

In the technical field the springs are used for the property of having, in the elastic field, large deformations under the forces or moments.
Due to the large deformations of the spring under the action of forces and moments of action, the bow has the ability to store a large amount of energy.
The accumulated energy is released when the action of forces and active moments becomes zero, and the arc returns to its original shape and dimensions.
Mt is the moment of torsion requesting the arc springs;
M1, M2 are bending moments that require arc springs

$M1 = Mt \cdot \sin\alpha$ (5)

$M2 = Mt * \cos\alpha$ (6)

$D = Dm / \cos\alpha$

$i = Dms / d$

where:
Dm is the mean winding diameter of the spring;
Dms is the mean diameter of the spindle measured in the plane of the spindle;
i is the dimensional factor [5].

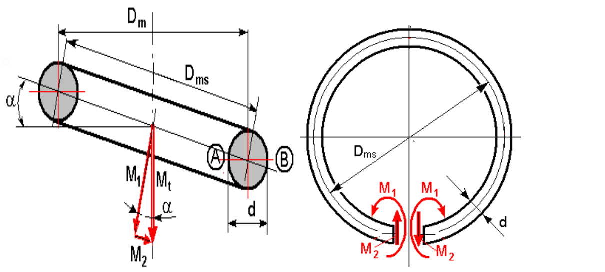


Fig. 7. Calculation of the cylindrical torsion spring, torsional stress
Source: [5]

Reference values of wind speed and dynamic pressure. The wind speed reference value

(wind speed), v_b is the characteristic wind speed averaged over 10 minutes, determined at a height of 10 m, independent of the direction of the wind in the open field (category II land with the conventional roughness length, z_0 = 0.05 m) and having a one-year probability of 0.02 (which corresponds to a median recurrence interval of IMR = 50 years). The action of the wind is considered horizontal and directional. In the case of directional expression, the wind velocity reference value v_b is multiplied by a directional factor, which takes into account the distribution of wind speed values in different horizontal directions. In the absence of directional wind velocity measurements, the directional factor is considered to be 1. 0.
The dynamic wind pressure reference value (wind reference pressure) is the characteristic value of the dynamic wind pressure computed with the wind speed reference value [4]:

$$q_b = \frac{1}{2}\rho \cdot v_b^2 \tag{7}$$

where ρ is the air density that varies with altitude, temperature, latitude and seasons. For standard air (ρ = 1.25 kg/m^3), the reference pressure (expressed in Pascali) is determined with the relation [4]:

$$q_b\,[\mathrm{Pa}] = 0{,}625 \cdot v_b^2\,[\mathrm{m/s}] \tag{8}$$

The dynamic wind pressure reference value, qb in kPa for the southern area of the country is 0.5 [4].

RESULTS AND DISCUSSIONS

When a flow of liquid is forced to disintegrate in more or less fine droplets, it is called atomization or hydraulic dispersion.
By narrowing the cross-sectional cross-section of the passage in the douse, the flow rate increases.
Static energy turns into kinetic energy (speed). When tension is released at the nozzle edge of the nozzle, a laminar flow of the fluid with aerodynamic waves occurs, causing the flow of liquid to disintegrate in droplets of different sizes (Fig.8).

a b c

Fig. 8. Spray of the flat-jet nozzle has a strong boundary line (a, c) and the nozzle (b)
Source: The authors' results.

The flat jet spray nozzle model has a strong bounded line because of the functionality features. The width of the coating can be varied by altering the geometry of the nozzle holes, where the liquid can be melded into a jet up to a flat line.
The flat fluid has a laminar shape and disintegrates with increasing distance from the nozzle opening.
The impact areas may be parabolic, trapezoidal or rectangular depending on the geometric and functional dimensions of the nozzle.
Loss of air friction and ballistic phenomena influence the spray behaviour and impact area size according to the chosen working pressure.

Table 1. Plant operating parameters

Specifications		
Speed (rot/min)	**Pressure (bar)**	**Pump Flow (l / min)**
	2.0	25.5
	2.5	27.7
550 rot/min	3.0	29.0
	3.5	31.4
	4.0	33.5

Source: authors' results.

Table 2. Flow through the nozzle

Nozzle flow rate [l / min] Pressure [bar]				
2.0	2.5	3.0	3.5	4.0
1.04	1.16	1.24	1.36	1.41
1.05	1.12	1.21	1.30	1.43
1,0	1.10	1.16	1.23	1.34
1.1	1.17	1.25	1.34	1.47
1.05	1.15	1.24	1.31	1.45
1.05	1.13	1.20	1.30	1.42 *

*Mean
Source: authors' results.

Calculation of wind and spring force [4]:

$$F_w = \text{¥}_w * c_d * c_f * q_p * A_{ref} \qquad (9)$$

where:
q_p - the dynamic pressure reference value
q_p = 0.5 or 0.7

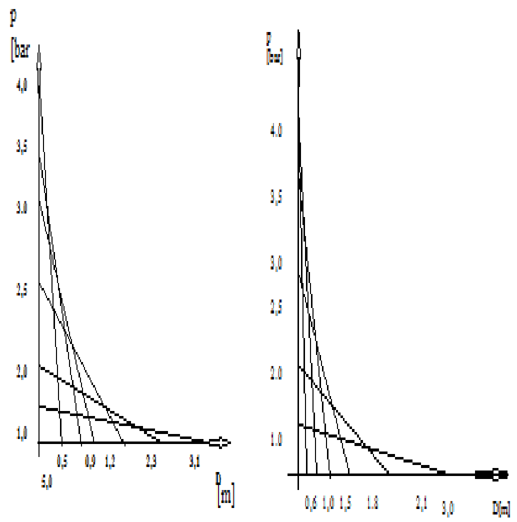
$$q_p = 0.625 * V_b^2 \text{ [m/s]} \qquad (10)$$

c_d - dynamic response rate of about 0.95;
c_f - aerodynamic coefficient according to the ratio b / d ≤ 0.25 is between the values -0.5 and -1.1.
A_{ref} - Reference area [m^2]

$$A_{ref} = S_1 + S_2 + S_3 \qquad (11)$$

A_{ref} = 44.6 [cm^2];
¥_w - factor of importance / exposure, for land the second category is = 2.2.
F_w = 2.2 * 0.95 * 0.8 * 18.9 * 0.0446
F_w = 1.4 [N]
M_T = 1.4 * 0.03 * 0.04 [N * m]

The diagrams of the longitudinal distribution of solution droplets at the working pressure, the nozzles being placed 0.5 m from the ground (Fig.9).



a b

Fig. 9. Diagrams of the longitudinal distribution a- with an anti-wind direction, b- with motion in the direction of the wind
Source: authors' results.

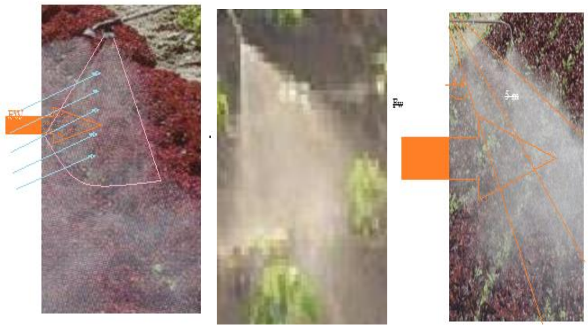


Fig. 10. Deviation of solution jet by wind speed
Source: authors' results.

Fig. 11. The distribution of droplets on the surface according to the deviation of the jet
Source: authors' results.

Very small droplets, obtained by fine and very fine spraying, can be moved by the wind and the air currents during the treatment.
Their uncontrolled movement makes them no longer attain to the desired target. In this situation, the biological effect of the treatment can be seriously diminished.
In the case of long-distance drift of very small droplets, there is a risk of contamination of neighbours (adjacent crops, water courses, lakes, etc.).
Even medium droplets can be moved by wind if it has speeds of certain values. Optimal wind speeds up to which spraying treatments can be performed are between 2 and 6.5 km/h [12].

CONCLUSIONS

Carrying out work to control diseases and pests and weeds by means of liquid solutions requires knowledge of the solution, knowing the environmental conditions knowledge of the machine or the equipment used.
The importance of the treatment is greatly dispersed and the design of the drops at the treatment site.

The speed of movement of the aggregate but also the velocity of air currents are of great importance in the phenomenon of dripping droplets of solution.

By using the nozzle model proposed to carry out the spraying work in general, the drip drift effect can be diminished, and it is also possible to perform the works in other environmental conditions than those presented in the literature

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