THEORETICAL ASPECTS ON OPTIMIZING THE QUALITY INDICES OF MACHINES FOR APPLYING PHYTOSANITARY TREATMENTS IN THE FIELD

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ABSTRACT

The correct application of phytosanitary treatments depends on several parameters influencing the quality indexes when applying phyto-sanitary treatments in a culture. The paper presents a few aspects regarding the quality indices of plant protection equipment treatments applied which directly influence the uniformity of the field distribution

INTRODUCTION

For applying phytosanitary treatments successfully, the paths on which the active substance moves and the ways the biological effect is carried out must be know.

In this sense, the notion of agro-availability was defined, representing the quantity of the dose (proportion, percentage) of product applied in an agrocenosis that gets on/in the harmful organisms and produces the biological effect or the combating effect. [1]

Depending on the applying mode, agro-availability can be classified thus:

- the substance gets directly on the harmful organism;
- the substance is taken by the harmful organism through the surface of the plant or soil, through ingestion or contact;
- the substance in taken by the harmful organism indirectly through the sap of the grown plants. [4]

After the analyses in the lab it resulted that, compared to the dose applied with phytosanitary substances, the agro-available dose is only a small portion namely 0.01…0.001% of the recommended combating dose. The rest 99.9…99.99% is lost on the plants, on the soil, in the air, representing waste and a source of contaminating the environment.

The modern method of applying phytosanitary treatments is characterized by the fact that the drops are distributed directed towards the plants, leading to a growth in agro-availability of almost 2 times compared to usual sprayings, resulting the possibility to reduce the dose with 30…50%, ensuring an efficiency resembling to applying the whole dose in normal sprayings. [2]

In our country, losses in production due to harmful organisms can reach, in some cases, 35%, the reduction of specific losses and energy consumption being able to be reached, mainly by reducing the liquid dose per hectare.

The higher the work load, the larger the drops obtained in the spraying process, and the losses on the soil are directly proportional to them, the foliage of the plants having a limited capability to retain the drops. Exceeding this capacity leads the leaking of the drops of the leaves, which causes soil pollution and substance losses.

MATERIAL AND METHOD

Following research (where average values of the parameter were considered), it results that, on reduced liquid doses, the losses on the soil are smaller (table 1).

Table 1

Liquid losses depending on the dose

Value of the liquid dose [l/ha]	Share from the dose retained by the leaves [%]	Liquid losses by leaks on the soil [%]
200	70	30
500	68	32
750	65	35
1000	61	39
1500	50	50
2400	30	70

These leaks represent, in fact, losses of active substance that influences the treatment costs on one hand, and on the other, is a polluting factor. [3]

When applying phytosanitary treatments, the main objective is to distribute the active product on the surface of the plant or soil. This requirement is still hard to meet, the active substance has to be distributed on all the surface of the plant so that the losses will be as small as possible. If the substance spread could be pulverized in uniform drops of a given dimension, the theoretical drop density could be calculated. Table 2 shows the coverage that can be achieved with uniform drops, when the treatment is made using a 2l/ha dose.

Table 2

Number of drops per cm^2 depending on the diameter of the drop

Drop diameter [μm]	Number of drops per cm^2 [drop/ cm^2]	Drop diameter [μm]	Number of drops per cm^2 [rop/ cm^2]
20	4768	110	28
40	596	120	22
60	176	140	14
70	116	160	10
80	74	180	6
90	52	200	5
100	38	220	3

In general, from the point of view of the initial availability of phytosanitary substances against pests, the higher drop density or the smallest drop dimension is preferred. The situation is complicated in the case of large widening of the specter of drop sizes, because of their physical behavior in the air. When the drops fall free under the effect of gravity, they can gain a certain speed, which is proportional with the size of the drops, as resulting from table 3.

Table 3

Drops falling speed depending on its diameter

Drop diameter [μm]	Falling speed [m/sec]
500	2.08
250	0.94
100	0.27
50	0.07
10	0.003

It results that drops smaller than 50 μm are carried for a longer period of time by the air. This phenomenon is called "drift" and is undesired because the drops do not reach the target objects.

Figure 1 shows the way the moving distance varies on horizontal for drops pulverized from a height of 3 m, without initial speed in a not turbulent air, at a wind speed of 1.4 m/sec.

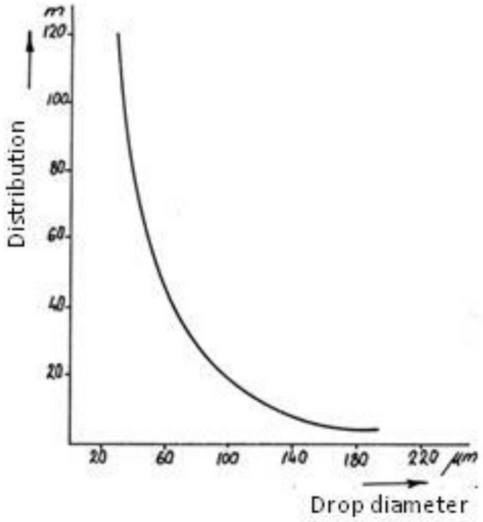

Fig. 1 - Variation of floating distance of drops in the air depending on the diameter [3]

The reduction of liquid volume is made on the basis of increasing the spraying degree. There is an inferior limit for the size of the drops under which a high number of drops will have an insufficient impact on the plant and tend to be carried away by the wind.

Within experimental research resulted that on machines for applying phytosanitary treatments by spraying, one of the most important elements are the spraying ends that, depending on the purpose of the work, have a specific construction and are based on working principles, also specific.

For phytosanitary treatments by spraying, the nozzle fabrication, but also their position on the boom, the adjustments of the distance from the soil or the surface of target objects and other working parameters, must be inscribed in severe exigency conditions.

RESULTS AND DISCUSSIONS

Theoretical research on nozzles most frequently used, namely nozzles with a fan type spray with an angle of 110°. [5]

This study was based on the observation on the sequential deviation for distributing the fragmentation, depending on the hypothetical values of the theoretical curve, which represent a sequence from a cone curve function, defined on a continuous values interval, symmetrical to a median axis, this theoretical curve, by overlapping, ensuring the smallest theoretical deviations in applying spraying liquid, which are inscribed in the in the requirements of the quality standards, under 5%.

The theoretical curve was generated on the computer for a specific nozzle flow, a flow that was determined as an average of at least five tests of the same type and in the same conditions, its value being 1892.56 l/min for a nozzle of the type Albuz Tifone – ISO 11005 at a pressure of 0.31 MPa.

Among other indices, the value of the respective curve appears like it is shown in table 4.

Table 4

The values of the theoretical curve and the Drs index

TC for Q_{med}/1892,56	TC_{n-1}/TC_n	D_{rs}
113.82		
113.04	1.0069002	1.0169277
110.64	1.0216919	1.0623949
106.05	1.0388732	1.132009
100.82	1.056338	1.2247272
93.7	1.0759871	1.3440447
85.26	1.0989913	1.4933316
75.48	1.11295707	1.6813644
69.68	1.1669758	1.9117039
52.92	1.2222222	2.2095786
40.35	1.3115241	2.6197748
27.2	1.4834558	3.2742406
13.67	1.98897525	4.8487183
4.31	3.1716937	8.5207633
0.8	5.3875	15.926338

The sequential distribution index (D_{rs}) represented a first calculation step in the theoretical research for observing the degree of significance of the specific deviation, which emerges from comparing real values obtained on stand during tests to the theoretical values for a single nozzle. It was chosen to determine the maximum deviation values inscribed in the ± 5% range out of the total distribution from overlapping the sprays because there are situations in practice when, by fitting the nozzles on the boom, the positive deviations in the nozzle's spray asymmetry can compensate the negative deviations of close asymmetry values of the neighboring nozzle.

$$\frac{CT_{n-1}}{CT_n} = I_{CT} \qquad (1)$$

where:

CT_n= sequential value of the theoretical curve.

CT_{n-1}= anterior sequential value of the theoretical curve.

I_{CT} = differentiation index for the distribution of fragmentation in the theoretical curve

and: $D_{rs}=I_{CT}\ I_{drs}$ (2)

where:

D_{rs}= differentiation value of the sequential distribution.

I_{drs}= differentiation index for the sequential distribution of depending on the value of *arctg* (centesimal).

The second element taken into consideration was the ratio between the central angle made by the nozzle's slit and the edges of the gutter situated under this slit and the similar neighboring angles as shown in figure 2.

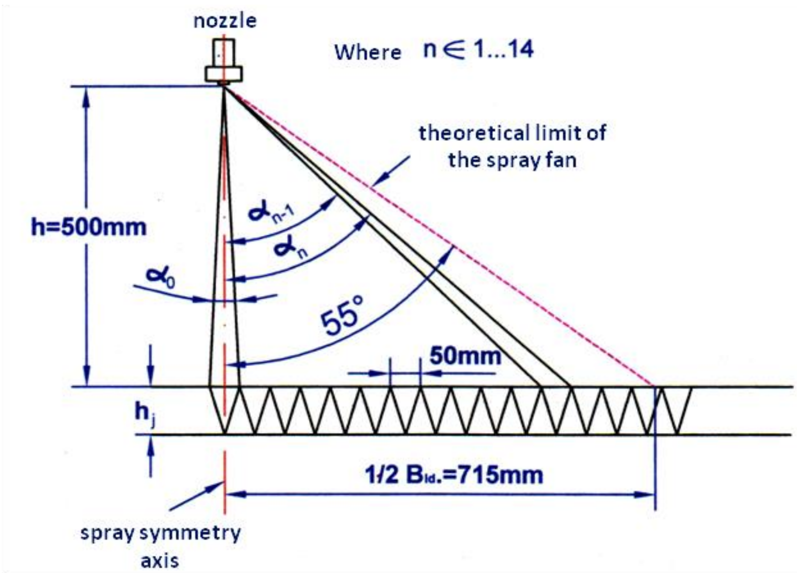

Fig. 2 – Schematic representation of the angles delimited between the nozzles slit and the gutter's edges [5]

From the idea mentioned above, the I_{drs} index was calculated with the following relation:

$$I_{drs} = \frac{\alpha_0}{\alpha_n - \alpha_{n-1}} \quad (3)$$

The values presented in table 5 help calculate the D_{rs} index (table 4).

Table 5

Calculation mode for the index of differentiation of sequential distribution (I_{drs})

Angle	I_{drs}
α_0	-
α_1	1.0099880
α_2	1.03983897
α_3	1.08965082
α_4	1.15940853
α_5	1.24912720
α_6	1.35882035
α_7	1.48849861
α_8	1.63816937
α_9	1.80783714
α_{10}	1.99750416
α_{11}	2.20717109
α_{12}	2.43683756
α_{13}	2.68650259
α_{14}	2.95616490

In practice, the nozzles mounted on the boom at a 50 cm distance, at a height from the ground of also 50 cm, overlap their sprays double or triple as shown in figure 3.

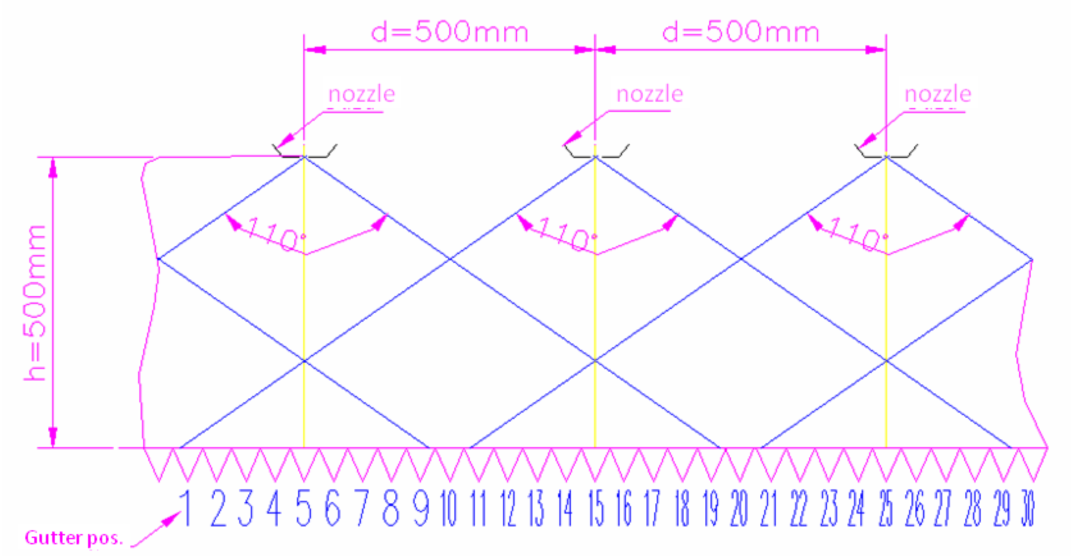

Fig. 3 – Sprays overlapping from neighboring nozzles

The calculation formula (that we propose as a substantive theoretical contribution) for the maximum lateral sequential deviation values specific to a nozzle is the following:

$$V_{aa} = CT_n \pm \frac{CT_n \cdot D_{rs}}{100} [ml], \quad (4)$$

where:

V_{aa} = allowable deviation values

Applying these deviation values in sequential distributions resulted from overlapping sprays as shown in figure 3, the results from table 6 are obtained:

Table 6

Theoretical inscribing of the value V_{aa} (all positive) in the maximum deviation of 5% of the average flow for the nozzle Albuz Tifone 11005

Stand pos.	Partial theoretical flows for three neighboring nozzles			Summed theoretical Q	Theoretical V_{aa} for each nozzle			Cumulated V_{aa}	Q summed + V_{aa} cumulated
5	40.35	40.35	113.82	194.52	1.06	1.06	-	2.12	196.64
6	52.92	27.2	113.04	193.16	1.17	0.9	1.15	3.22	196.38
7	69.68	13.6	110.64	193.92	1.33	0.67	1.18	3.18	197.1
8	75.74	4.31	106.05	186.1	1.27	0.37	1.2	2.84	188.94
9	85.26	0.2	100.82	186.88	1.27	0.14	1.23	2.64	189.52
10	93.7	-	93.7	187.4	1.26		1.26	2.49	189.89
11	100.82	0.8	85.26	186.88	1.23	0.14	1.27	2.64	189.52
12	106.05	4.31	75.74	186.1	1.2	0.37	1.27	2.84	188.94
13	110.64	13.67	69.68	193.92	1.18	0.67	1.33	3.18	197.1
14	113.04	27.2	52.92	193.16	1.15	0.9	1.17	3.22	196.38
Q_{med}.				190.2					
Q_{med} + 5%				199.71					

where:

Q_{med} + 5%= the average flow of the sequential theoretical values increased by 5%.

It was found from table 2.6 that the values V_{aa} (all positive) in Q_{summed} its sequantial values are smaller than Q_{med} + 5%.

In practices, positive or negative deviations are made on certain segments of the distribution width of the fragmentation specific to the nozzle and the calculated values for V_{aa} have a coefficient increasing as we depart from the spray's median, a fact that occurs because the values of the theoretical curve decrease scaled in a similar way. For the values of the theoretical curve from the center of the fan, positive or negative deviations can be taken into consideration, but not more than ± 1.5%, otherwise the specific maximum ± 5% deviation can be exceeded due to the overlapping of sprays.

In practices, even if we equip a machine for applying phytosanitary treatments with a set of new nozzles, we do not have the guarantee that the fragmentation distribution is an acceptable one, reason for which every nozzle in the set must tested individually.

The maximum sequential deviation values determined on stand, compared to the values from the specific theoretical curve, cannot exceed the values calculated for V_{aa} taken positively or negatively. [5]

CONCLUSIONS

- Researches on plant protection and on mechanizing plant protection works must lead to the elaboration of new principles of applying chemical and microbiological products, in such a manner that especially the harmful organisms are treated, and less the plant and the soil. This is a task for the future, hard to resolve, but necessary for the plant and environment protection.
- Herbicides have the largest share compared to insecticides and fungicides. In a modern agriculture, the value invested in herbicides is double compared to the one invested in insecticides and 3÷4 times bigger than the one for fungicides.
- A condition for manufacturing machines for plant protection is the reduction of pesticide and water consumption. The benefic implications are: economic efficiency and reduced environment pollution.
- Throughout conducting the treatment will be followed permanently the values of the wind speed and direction, as well as the level of air temperature, the maximum values of the respective parameters being of 3 m/s for the wind speed and 30° C for the air temperature.
- In the case of spraying, depending on the type of machine, different ranges of drops are achieved. Thus, in the case of machines equipped with pneumatic spraying ends, the range is from 10…20 µm to 800…1000 µm. The drop range is smaller for hydraulic high pressure spraying ends namely between 100…500 µm.
- The industry manufacturing machines for plant protection tries to obtain machines that reduce to a minimum the losses of pesticides. This is made by limiting the drops specter, by reducing to a minimum the number of drops that are to small (20…30 µm) that lead to losses by exodrift (they drift outside the treatment area) and the number of drops that to big causing losses by endodrift (leaks in the soil where the treatment is made).
- Worldwide, the evolution of quality parameters of the spraying process conducted by spraying machines is very fast, due to the large progresses in the chemical industry and in the agricultural research, as well to the current acute necessities to reduce the specific consumption of fuel, pesticides, work force and environment pollution.

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