# ASPECTS ON OPTIMIZING THE QUALITATIVE INDICES OF THE WORK OF SPRAYING FIELD CROPS

***NIŢU (ROŞU) M.[1], CĂSĂNDROIU T.[3], MATACHE M.[1] CUJBESCU D.[1], MARIN E.[1], VLĂDUŢ V.[1], MATEI GH.[2], BORUZ S.[2], UNGUREANU N.[3]***

*[1]INMA Bucharest / Romania; [2]University of Craiova / Romania; [3]University POLITEHNICA Bucharest*
*E-mail: rosumihaelan@yahoo.com*

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## *ABSTRACT*

*In the context of continuous development and improvement of machinery for applying phytosanitary treatments, the increase of precision of the dose applied to crops has become a target for major manufacturers of such equipment, the solutions applied on machinery aiming to improve the application technology, using automation and control systems driven from the operator cabin. This paper presents the most important aspects to be taken into account when working with a machinery for applying phytosanitary treatments, in order to obtain an optimization of qualitative indices of the spraying work of field crops.*

## INTRODUCTION

The realities of nowadays show that the XX century is the period of greatest discoveries and transformations of human civilization, and also the most complex and sometimes unexpected effects on life.

Agricultural productivity is influenced by the level of the applied working technologies, phytosanitary protection occupying a very important place in these technologies. Current studies and research on the methods and equipment for the application of phytosanitary treatments are part of the new trends for practicing sustainable agriculture, knowing that phytosanitary protection is one of the main sources of reducing environmental pollution by chemical substances.

An important aspect of the policy of continuous increase of products quality achieved by each economic agent, is the *maintaining of machinery compliance* for plant protection machinery and the increase of achievement premises under conditions of repeatability of these products. [7]

The purpose of a spraying work is to deposit uniformly an maximum amount of phytosanitary product at the combat place (target), respectively on the sprayed surface.

The working process of the machinery for applying phytosanitary treatments in the field is a complex process, and the beginning of each work requires a preparation stage in which is controlled the proper functioning of the machinery and are made specific adjustments for the work to perform.

The machinery for applying phytosanitary treatment in the field, generally consists of: clean water tank, solution tank, stirrer, pump, valves, distributor, gauge, pipelines, spraying boom, and of major interest are the spray heads (spray nozzles), which directly influences the quality of the working process.

## MATERIAL AND METHOD

Optimizing the qualitative indices of the spraying work of field crop has three stages to be addressed chronologically, so that in the end the results to be accepted as suitable, as follows:

- Research on the optimization of qualitative indices of the spraying works;
- Research on correlating the qualitative indices of working with the functional parameters of the spraying equipment;

• Theoretical balance of the use of phytosanitary substances for spraying in field crops.

## RESULTS AND DISCUSSIONS

### 1. Research on the optimization of qualitative indices of the spraying works

Experimental research is one of the main ways to approach the problems of basic or applied scientifical investigation. In the scientific research is necessary to have an indissoluble unity between theoretical studies and experimental research, this unit indicating the surest way to solve a scientific problem, which, in most cases, is shorter and cheaper.

Theoretical studies allow to establish the interdependence between different parameters of technical processes, laws underlying the phenomena, using the mathematical apparatus and the achievements in basic sciences of nature; physics, chemistry, biology etc.

Experimental research aim, on the one hand, to verify the truth of hypotheses and theories that formed the basis of studies on the studied processes, and on the other hand, they allow the investigation of phenomena for which there cannot be achieved results with practical applicability on theoretical way, because of their complexity or the lack of knowledge in sufficient measure of some laws that determine the evolution of the studied phenomenon. [2]

All experimental research involve the measurement of physical measures, mechanical or otherwise, under static or dynamic regime, using appropriate equipment and measuring instruments, processing of the data obtained and finally, drawing conclusions based on which it can pass on the capitalization of the results.

The successful application of phytosanitary treatments to combat pest requires the knowledge of the paths on which it moves the active substance and the embodiments of the biological effect.

Agro-availability is the amount of the dose (proportion, percent) of product applied in a agrocoenoses, that gets in / on pests and produces biological effect or control. [1]

Depending on the application mode, the manifestation of biological activity and the form of conditioning, the agro-availability is of type [1; 3]:

I – when the substance reaches directly on the harmful organism;

II – when the substance is taken by the harmful organism through the surface of plant or soil, by ingestion or contact;

III - when the substance is taken by the harmful organism indirectly by sap crops. [13;14]

Laboratory tests showed that, compared to the applied dose of chemical substances for plant protection, the agro-available dose is only a small part, namely 0.01 ...0.001% of the recommended combat dose. The remaining 99.9...99.99% is lost on the plants, soil, air etc., being considered waste and a source of environmental contamination (pollution). The method of modern spraying is characterized by the fact that drops are distributed in a conducted manner (directed) towards the plant, leading to an increase in agro-availability of almost 2 times compared to the usual, classical sprayings [5].

Hence, it results the possibility to reduce the dose by 30...50%, ensuring efficiency similar to the application of the full dose in normal sprayings. Long experimental research conducted so far have revealed that the systematic application of triazine herbicides generates phenomenon of soil degradation, disrupting their physical, chemical and biological characteristics, with direct effects on the quantity and quality of production.

Various researchers have shown that pesticides affect in quantity and quality terms the edaphic microorganisms (Audus., 1976, Kearney P.C. and Kaufmann D.G., 1977, Hance R.J., 1980), which is reflected in the conduct of biological processes in the soil (Malkomes and Pestemer, 1981). Research on pesticides action on soil microflora was conducted in our country, highlighting the limits above which their negative effect is particularly high.

Knowledge of all aspects related to the impact of pesticides into the soil may lead to the reduction of the risk of pollution, and the acceleration of recovery processes of fertility and structure of degraded soils. [10]

In forecasting of recommendations, an essential place has the maintaining at the same level or a higher level of the fertility index, and strict control of waste into useful agricultural process, their reminiscence and influence on the ecological balance of flora and fauna [6; 11]. It is estimated that in our country production losses due to harmful organisms may reach, in some cases, 35%. Reducing losses and specific energy consumption can be achieved mainly by reducing the norm of liquid per hectare.

Using low norms per hectare also leads to the increase of the working capacity of the aggregate, which allows the enrollment in the warning period. As the norm of work is higher, the drops obtained in the spraying process are higher; and losses on the soil are directly proportional to them.

It is known that the foliage of the plants has a limited capacity for retaining the drops. Exceeding this capacity leads to drops leakages from the leaves, which causes soil pollution and loss of substance. [8]

Based on the experimental research carried out for a long time, are taken into account the average values of this parameter, which are specified in Table 1.

**Table 1** [4]

***Loss of liquid depending on the norm***

| Value of liquid norm, l/ha | The share of norm retained on leaves,% | Loss of liquid by leaks on the soil,% |
|---|---|---|
| 200 | 70 | 30 |
| 500 | 68 | 32 |
| 750 | 65 | 35 |
| 1000 | 61 | 39 |
| 1500 | 50 | 50 |
| 2400 | 30 | 70 |

From Table 1 it can be seen that for reduced norms of liquid, losses on the soil are lower. These losses are actually losses of active substance that, on the one hand, influences the cost of treatment, and on the other hand, is a pollutant factor. [4]

Any application of phytosanitary substances can be studies by various methods:

• physical measurements, consisting in the determining of coverage (number of drops/cm$^2$), of spraying (quantity of product, in mg/cm$^2$ or l/ha) on natural or artificial target objectives;

• evaluation of biological effects, which consists of measuring the reduction degree of harmful organisms and assessing damages or efficiency. The ultimate goal of a treatment is to reduce the number of pests below the economic damage level (PED). Extraction of biological data is tiresome and usually requires a long time. [9]

Physical measurements do not show inconveniences and they are currently performed. They only make sense if they can predict the biological effectiveness of a treatment.

An effective application can be defined as: application at the right time (1) with a optimum "density" of product (2), of the required quantity of substance (3) on the target.

The three keywords are:

1 = timing (time and frequency of application);

2 = coverage (density of number of drops);

3 = dose.

**The timing** is the time and frequency of application of phytosanitary substances and is the most important aspect of the treatment. An application can only be effective if it is done in the most favorable time, depending on the stage of development of parasites, insects and phytopathogens etc. [2; 16]

Usually, for pests the intervention should take place in the first and second larval stage. When the treatment program is well optimized it can make significant savings both as number of applications and as the product used.

A well-studied treatment program is essential in tackling and mastering parasites with an economic quantity of the product and its rational use.

**The coverage** is the degree of coverage with drops (density or number of drops / specific area). As there are several drops per unit of area, the effectiveness will be higher. This basic principle applies to insecticides, herbicides and fungicides. [2; 16]

**The dose** is the recommended amount of liquid. Results of experimental research clearly show that a biological effectiveness can only be achieved if there is applied a sufficient quantity of product / unit area. Lower doses of product applied do not sufficiently protect the crop to achieve the best efficacy, while higher doses show no additional benefit. [16; 18]

In conclusion, treatment factors (parameters) must be selected such as:

• coverage (density of drops) counted on the target surfaces should be:

- 20…30 drops/cm$^2$ at the application of herbicides;
- 50…70 drops/cm$^2$ at the application of insecticides;
- 50…70 drops/cm$^2$ for fungicides;

• the volume of norm should be adequate to obtain a good coverage, without causing leakage of leaves.

When applying by spraying treatments with insecticides-fungicides and herbicides, the main objective is to distribute the active product on plant or soil surface. This requirement is difficult to achieve even when using large quantities per hectare.

However, the active substance must be distributed over the entire surface of the plant so that losses can be as small. [12]

**1.2. Research on the correlation of qualitative indices of work with functional parameters of spraying equipment**

Intervention means specific to plant protection, to limit the levels of development of populations of phytopathogenic organisms are contained in integrated or rational combating. These, according to the principles of combat are physical means of plant protection (mechanical, belonging to sonic wave physics, quantum, etc.); chemical means of plant protection (synthesized substances with metabolic action, fitoalexines, chitin inhibitors, pheromones etc.); biological means of plant protection (artificial products based on phytopathogenic bacteria, fungi cryptopathogenic and entomopathogenic fungus, entomophagus predators, zoofags etc.). [22; 23]

Depending on the application possibilities of combating substances, there is a wide range of devices, equipment, machinery, installations, carried and driven by man, tractors, chassis with engines etc. A task of perspective in the manufacture of machinery for the protection of plants consists, as mentioned, in the reduction of pesticide use and working norm. The beneficial implications are economic efficiency and reduced environmental pollution. [18]

The manufacturing industry of spraying machinery for plant protection aims to obtain a physical technique of work to reduce to the minimum pesticide losses. This is done by limiting the spectrum of drop size, by minimizing the number of too low drops (20...30 μm) by which are avoided exodrift losses (drift outside the treatment site), the number of too high drops causing endodrift losses (leaks into the target soil) and by introducing anti-dropping.

Hence, it aims to obtain nozzles to eliminate the droplets at the edges of spectrum and to ensure enhancing of retention degree. A special progress was achieved by introducing special rotating nozzles, which lead to the obtaining of a controlled regime of droplet size and density. It remained to be solved the loss of substance by exodrift. This can be done by introducing electrostatic spraying, which makes the droplets with a VDM (volume median diameter) of about 100...120 μm to be loaded with a positive electrical charge. This attraction is valid on relatively quiet weather without air currents exceeding 2 m/sec. [17]

Intense air currents can overcome the force of electrostatic attraction resulting in production of losses by exodrift and reduced efficacy of spraying. Ensuring maximum efficiency of insecticide and fungicide treatments in the vineyard and orchard, it is possible, first, by making sprayer machinery fitted with spraying systems with superior parameters in the working process.

Worldwide, the evolution of qualitative parameters of spraying process for sprayers is very fast, due to great progress in chemical industry and agricultural research, and also due to the current needs to reduce the specific consumtion of fuel, pesticides, labor force and environmental pollution.

The reduction of liquid norm per hectare below 100 1 / ha for field crops is possible through:

- decreasing the average diameter of liquid droplets sprayed at values of 150…200 μm;
- reducing the dimensional dispersion of droplets (the size spectrum) to values as low possible, reduction possible using mechanical spraying devices (centrifugal);
- reducing of relative speed (towards the atmosphere) of droplets in order to reduce the evaporation speed, by using systems with portal agent;
- reducing of evaporation losses, by forming mixtures with anti-evaporants, or mixtures based on insolvent oils. [15]

As specialists in foreign companies and in our country are cautious about reducing the amount of pesticides per hectare while reducing the norm of liquid per hectare, because, given that the doses of pesticide remain constant, the concentration of spraying liquors increases in inverse proportion with the norm of liquid per hectare. Therefore, to avoid risks of injury or environmental pollution, functional reliability of spraying machines should be much higher, and human and environmental protection measures should be more drastic.

Given the requirements and operating conditions specific to this machinery, different from the usual ones and fitted with perfected spraying systems, it should initiate some extensive research to achieve them, research to consider not only the obtaining of the required performance but also to achieve high economic efficiency.

### 1.3. Theoretical balance of prytosanitary substances use for spraying in field crops

All resources participating in the achievement or save of crop enter the material circuit of the agro-system are used with a certain yield. If natural resources are typical of this circuit, conventional resources are atypical, and of these the lowest yield of use have the corrective resources [20].

For spraying, the allocated dose of spraying liquid (*Q*), in liters per unit of surface, is divided into various categories, according to the equation:

$$Q = Q_u + Q_{en} + Q_{ex} + Q_{eva} + Q_a \quad [l/ha], \qquad (1)$$

where:

$Q_u$ – useful fraction reralned on the target objects (similarly to the R coefficient);

$Q_{en}$ - fraction lost inside the crop (endodrift);
$Q_{ex}$ - fraction lost outside the crop (exodrift);
$Q_{eva}$ – fraction lost by evaporation;
$Q_a$ – other losses.

Each term in equation (1.1) has a certain proportion that depends on the conditions of exploitation of the working technique, its performances, atmospheric conditions, subjective factor etc.

• From the *useful fraction*, $Q_u$, which is used, in the end, under the form of pesticide quantity that gives the biological effect, only represents the equivalent of bioavailability, a small fraction, the rest being lost in the material circuit of the agro-system (specific circuit). Within the mentioned circuit, fractions subsequently formed circulate in several ways: taking into living tissues of the organisms within the agro-system, conveying water from rainfall or irrigation, loss by degradation due to physical or chemical agent activity etc.

• *Losses inside the crop* ($Q_{en}$) not only refers to the fraction that falls on the soil ($Q_{ens}$) but also the losses by overdose ($Q_{enp}$) or under-dosage ($Q_{enb}$), and losses occurring due to deposition on some dead surfaces of plant or inactive surfaces, such as suberificate surfaces, lignified, waxed etc. ($Q_{eni}$), according to equation:

$$Q_{en}=O_{ens}+Q_{enp}+Q_{enb},+Q_{eni} \quad [l/ha]. \tag{2}$$

• *Losses outside the crop, $Q_{ex}$, are* produced entirely of small droplets released after fragmentation in the ends of spraying heads or resulted later from the shrinkage of volume of larger droplets after evaporation. These drops are circulated outside the agricultural system and are considered as fraction for unsuitable materials circuits of the mentioned agro-system.

A small part can be circulated by the organisms crossing the agro-system, which, incidentally come into contact with the pesticide.

• *Losses by evaporation of the active substance* ($Q_{eva}$) are achieved from the substance included in the volume of water used to prepare the emulsion and launched as spray, if it has a volatile character. Volatilization losses of the active substance can be produced by droplets forming the useful fraction ($O_{uv}$), of droplets lost inside ($Q_{env}$) or drops subjected to drift ($Q_{exv}$), according to the equation:

$$Q_{eva}=O_{uv}+Q_{env}+Q_{exv}. \tag{3}$$

Currently, the majority of pesticides for application by spraying have active substances whose vapor stress is very low or negligible. Losses through evaporation of water are also important. These losses are the object of a correction factor ($k_i$) for accurate establishing of the volume of working norm.

All fractions mentioned so far mean the object to systematic losses of product. The *fraction* ($Q_a$), other losses, has an accidental character and occurs due to breakage, cracking or lack of tightness of the hydraulic system or the elements that ensure closure of hydraulic circuits (anti-dropping valves, closing valves, one-way valves etc.).

Anti-dropping valves open and close the circuit at a pressure ranging usually between 0,06…0,07 MPa. These theoretical aspects, regarding the fractions of working norm, are the basis of the problem of implications of phytosanitary treatments, both in ecological and economic terms.

Currently, in our country the treatment for controlling harmful organisms is achieved with spraying systems that do not fully meet requirements for reducing pollution of soil and environment. Although the proportion attributed to this type of pollution (chemical substances - pesticides) at global level, is only 2%, there are serious reservations where it can intervene to decrease it. [19; 21]

Due to the accumulation of pesticides into the soil and into the groundwater, and to the requirements that are imposed in relation to environmental protection, we can say that in the future, it is mandatory to develop spraying systems to solve these problems.

The most important element for reducing pollution is to reduce the norm of liquid per hectare, so generalizing treatments with low and ultra low volume. It is known that the foliaceous apparatus of plants has a limited capacity for retaining the droplets. Exceeding this quantity results in leakage of liquors from the leaves, which leads to soil pollution, and leakages directly proportional to the size of working norm. [22]

Reducing the volume of liquid per hectare shall is done by increasing the spraying degree. However, even in these circumstances, there is a lower limit of droplet size that can use this type of spraying, because below this size all drops will have insufficient impact on plants and tend to be airborne, meaning that drift occurs.

Historical development of treatment methods shows that the area of dusting combat was greatly reduced, instead being developed seed treatment, application of granules and microgranules, treatments by direct spraying. [4; 17]

## CONCLUSIONS

Improvement of machinery led to an increase of treatment accuracy, it has greatly contributed to reducing of pollution and increasing of effectiveness and efficiency. A task in the manufacture of machinery for the protection of plants is the reduction of pesticide and water consumption. Beneficial implications are: economic efficiency and reduced environmental pollution.

The manufacturing industry of spraying machinery for plant protection aims to obtain equipment that minimizes pesticide losses. This is done by limiting the spectrum of drops, by minimizing the number of too low drops (20...30 μm) resulting in exodrift losses (drift off treatment site) of the number of too high drops causing endodrift losses (leaks into the soil on which the treatment is made) and by introducing anti-dropping.

Ensuring maximum efficiency of treatments with phytosanitary substances in agricultural field crops is possible by developing sprayers fitted spraying systems with superior parameters in the working process.

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