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Scientific and technical preconditions of electric field application at plants protection

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Abstract. The questions of application of nutrient solutions in an electric field, which contribute to the stimulation of plant growth, reduce electrical and raw losses.

Key words: electric field, electric charge, dispersity, surface tension, nutrient solutions, plants.

INTRODUCTION

Application of traditional technologies for plants protection, and first of all, by means of spraying of the differently applied aerosols plays an important role in the agricultural production, especially in the field of hothouse vegetable-growing. Such technologies embrace the process of additional unroot plants fertilizing, sprinkling and pollination with different nourishing and antidotic solutions, disinfestation and disinfection of enclosed spaces etc., which largely contribute to the creation of favourable terms for development and growth of plants.

However, in the course of such technologies analysis in the light of modern requirements, it becomes possible to ascertain, that these technologies are characterized in terms of high losses of working solutions, inequality of sedimentation on green mass of plants, create comparatively bad terms for absorption of solutions by the surface of plants, increase the losses of energy and water, promote ecological restrictions.

Practical applications reveal that in the course of traditional technologies exploitation, a high polydispersity of spraying is observed (from 30 up to 700 µm (micrometres)), the ratio of the useful settling of working solutions on green mass does not exceed (25-35)%, the inequality of sedimentation arrives at (45-60)% with norm, according to international standards, being set at the level of 15 %.

High polydispersity of spraying contributes to appearing of the phenomenon that large drops (>300..350 µm) do not hold back on a surface and fall on soil, drops (<15...50 µm) are either taken by air, or, having high volatility, evaporate and only part of drops of working solutions with diameter of (50..200) µm (not more than 30-35 %) arrives at the surface of green mass.

The performance of existing methods is largely determined by the possibility of specific terms creation for maintenance of drops of working solutions on all surfaces of green mass of plants, including the reverse part, which would accelerate the process of penetration of substances in the tissues of plants. Unfortunately, at application of these methods, results cannot be examined as positive. For instance, the inequality of sedimentation from both parties of surface of leaves arrives at (55-60)%, that is explained by sedimentation effect on the leaves of drops only under the action of attractive and inertia powers and presence of the so-called "hollows" here.

The foregoing features of existing methods as well as the defects which take place during their realization especially with the increasing value of plants protection and requirements to energy-and-resources saving, stipulate the necessity of development of new technological processes as well as the engineering and constructive decisions or improvements of the already applied technologies.

MATERIALS AND METHODS

Basing on the theory adhesion [5] it is possible to ascertain that the penetration of operating substances in tissue of plants is normally carried out only in the liquid state and determined by the phenomenon of humidity, i.e. by pin cooperation on a limit: a solid (leaves, green mass) - liquid (working solution). Thus the retention of drops correlates with the phenomenon of moistening, which has a primary value in the processes of plants defence. It is known that the best molecular cooperation which determines humidity takes place under the next condition [4]:

$$\sigma_{s.b.} \geq \sigma_{w.s}, \tag{1}$$

where: $\sigma_{s.b.}$, $\sigma_{w.s.}$ - surface-tension of accordingly solid body and working solution.

The products of plant-growing are characterized by the considerable range of humidity and considerable vibrations of surface-tension. For example, green mass of bow, carrot, cabbage have the moisture content : Θ = 120...170° and surface-tension: σ = (65…75) N·m·10^{-3}. Moreover, some plants have a difficult structure of epidermis, microlevel inequality, presence of lanate fibres, that contributes to the diminishing of humidity.

Taking into account that many of working solutions have a considerable surface-tension (>75 N·m·10^{-3}) and, first of all, due to the fact that they present hydrogens solutions, possibility of moistening diminishes (1).

It is experimentally set that a surface-tension of working solutions must be within the limits of (30…40) N·m·10^{-3}, with the moisture content being set < 90°. Undoubtedly, the achievement of such values in case of application of traditional technologies causes considerable difficulties, generally it is practically impossible.

The solution for this problem may be found either by means of implementing of substantial changes in compounding of existent working solutions, by previous treatment of surface of green mass with the aim of humidity level control and management and surface-tension or development of fundamentally new decisions, which would stipulate not only the implementation of condition (1) but also even sedimentation on the surface of plants with minimum losses which is not still provided by currently existing technologies. The first couple of the above mentioned decisions, in our view, can solely contribute to the increase of price and further complication of process of treatment, introduction of additional technological operations etc. and cannot be examined as perspective and competitive. The most prospective technology of protection and cultivation of plants, in our view, especially for a hothouse vegetable-growing may be considered the application of electric-field, i.e. electrostatic method of spraying, which expediency is stipulated by physical essence, possibility of losses diminishing in quantity of working solutions up to (8-10)%.

The main feature of electrostatic method is that the charged particles of working solutions (pesticides, nourishing solutions etc.), moving along the lines of force of electric-field which is in turn created by the system of electrodes: a crowning electrode (nebulizer) and sedimentated electrode (plant) are evenly precipitated both on overhead and on the bottom (reverse) surface of leaves.

Previous experimental researches [4] in the sphere of nourishing solutions deposition on leafy mass of plants (growing in flowerpots) showed that on an overhead and reverse surfaces, sedimentation arrives at (90-92)% and (75-85)% accordingly. The conferring of the liquid to the solution of high potential (40..60 kW) on the crowning edge of nebulizer contributes to diminishing of surface-tension of drops of liquid, their durability and sizes, that in turn, stipulates the increase of spreading process and creation of the even placing of solution on the moistening surface of plants.

Thus a surface-tension is determined by the following expression [3]:

$$\sigma_{st} = \sigma_d - \frac{\varepsilon_k \cdot \varepsilon_o \cdot U^2}{4r_d} \tag{2}$$

where: σ_d - surface-tension of drop of liquid; ε_k - an inductivity of liquid; ε_o - an inductivity of vacuum; r_d - a radius of drop of liquid; U - electric potential of drop.

High potential on the crowning edge of nebulizer increases the specific electric charge of drops of solution, which in turn stipulates the creation of a more developed surface of drops and as a result greater contact with the surface of plants, increasing the spreading of all leafy (vegetable) cover, its maintenance on the surface.

An electrostatic method facilitates the change of dispersion of drops (by 1,2…10 times). Thus, according to [4], there is a connection between the surface-tension and sizes of drops.

$$r_p = r_0 e^{-\frac{4\pi\sigma_p \cdot \mu_p \cdot \mu_\Pi \cdot N \cdot L}{\rho_p \cdot \varepsilon_0 \varepsilon_p RTE^2 r_0}} \,. \tag{3}$$

RESULTS AND DISCUSSION

Analysing expressions (2, 3) it is possible to assert that the change of surface-tension (σ_{pp}) and radius (r) of drop of working solution in the electric field takes place similarly and determined by the value of electric potential of drop (U^2). This, in turn, gives grounds to do an important conclusion: the losses of mass of working solutions are proportional to the surface-tension and tension of electric-field, which is the power description of the field and determines the trajectory of motion i.e.:

$$\Delta m_{ws} \approx \sigma_{pp} \cdot \frac{1}{E^2}, \tag{4}$$

where: Δm_{ws} – losses of working solution; E – voltage of electric field.

Expression (4) has a conclusive value at the determining of the modes of treatment of plants and at developments of structural parameters of electrostatic installations for plants protection, highlights meaningfulness of parameters E and fully accedes to principles of motion and charging of particles in the electric field.

Relations (2, 3, 4) stipulate the terms not only for the receipt of the homogeneous and monodispersible spraying but also for adjusting a process with determination of optimal sizes of drops of working solutions subject to the concrete state of plants and agrotechnical demands.

It is experimentally set that at application of working solutions in the electric field, for example, the aquatic solutions of mineral fertilizers, a size of drops must be

70… 120 μm, spraying (monodispersion) homogeneity presents ≥75-82 %.

The indicated parameters contribute to the even sedimentation on the green mass of plants, create favourable terms for the effective spreading on their surface and penetration in tissues of plants. The previous results showed that such treatment stimulated the increase of the productivity for 8-12 %.

High economic (diminishing of charges of working solutions), functional (physical grounds, equality of deposition and sedimentation) and ergonomics (diminishing of energy losses, increase of productivity, protection of environment) advantages of electrostatic method in comparison to existing technologies stipulate its efficiency, processing ability and perspective.

However, there are problems, such as an absence of the single theory of penetration of working solutions in tissues of plants, presence of contradictions in the presentation of physical aspects of processes of charging, motion and sedimentation in the electrostatic field of aquatic solutions of working substances on green mass of plants, the heterogeneous level of researches, empiric character of some conclusions, restrain development and introduction of modern developments.

Development of this direction, for example, in home plant growing, is restrained by inadequacy of level of scientific and technical, technological and designer decisions, absence of producing of corresponding technological equipment and, first of all, small high-voltage sources and nebulizers, parameters and physical possibilities of which would meet the requirements, that are inherent to the processes of plants protection and contributed to the practical realization of hothouse vegetable-growing.

The indicated scientific and technical aspects of the problem and advantages of application of electric field, as a working instrument for deposition of nourishing and antidotal preparations in the course of plants protection, in our view, must contribute to the appearance of attention and interest to the considered questions from research and technical workers, who are engaged in the problems of energy and resource saving in plant growing.

CONCLUSIONS

Application of such a perfect method as electrostatic approach stipulates high efficiency and creates more favourable terms for plants protection in a wide range according to the existing agri-technical requirements.

Development and realization of the method, without regard to its economic and technological advantages, in the national agrarian production is restrained by practical absence of researches of suitable quality and especially insufficient attention to the developments in the sphere of creation and production of special electrotechnical equipment.

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