Scientific and technical preconditions of electric field application at plants protection

GEORGIY B. INOZEMTSEV
National University of Life and Environmental Sciences of Ukraine

Abstract: Scientific and technical preconditions of electric field application at plants protection. Possible application of electric field in plant protection is discussed, against disadvantages of traditional spraying method: poor settling of working solution on plants (25–35%), inequality of sedimentation, falling of large drops off plants etc. However, it would call for consideration of economic and technological effects of new technique implementation. The author points out at the lack of research in this field and insufficient attention to development of special electro-technical equipment.

Key words: plant protection, electric field application.

INTRODUCTION

Application of traditional technologies for plants protection, and first of all, by means of spraying of the differently intended aerosols plays an important role in the agricultural production, especially in the field of hothouse vegetable-growing. Such technologies embrace the process of additional on-root plants fertilizing, sprinkling and pollination with different nourishing and antidote 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, 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 processability of existing methods is largely determined by possibility of specific terms creation for maintenance...
of drops of working solutions on all surfaces of green mass of plants, including the reverse part, that would accelerate the process of penetration of substances in the tissues of plants. Unfortunately, at application of these methods, results can not 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 so-called “hollows” here. The foregoing features of existing methods as well as the defects which have 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 and both engineering and constructive decisions or improvements of already applied technologies. Basing on the theory adhesion [5] it is possible to ascertain that 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 retaining of drops correlates with the phenomenon of moistening, which in the processes of plants defense has a primary value. It is known that the best molecular cooperation which determines humidity takes place under the following condition [4]:

\[ \sigma_{s.h.} \geq \sigma_{w.s.} \]  

where \( \sigma_{s.h.} \), \( \sigma_{w.s.} \) – 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 an angle of moistening: \( \Theta = 120–170^\circ \) and surface-tension: \( \sigma = 65–75 \text{ N·m} \cdot 10^{-3} \). Moreover, some plants has a difficult structure of epidermis, micro level inequality, presence of lanate fibers, 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 fact that they present hydrogen 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 angle of moistening 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 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 can not be examined as perspective and competitive. The most perspective technology of protection and cultivating of plants, in our view, especially for a hothouse vegetable-growing may be considered the application of electric-field id est 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 sediment 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]:

$$\sigma_{st} = \sigma_d - \frac{\varepsilon_k \cdot \varepsilon_o \cdot U^2}{4r_d}$$  \hspace{1cm} (2)

where:
- $\sigma_d$ – surface-tension of drop of liquid;
- $\varepsilon_k$ – inductivity of liquid;
- $\varepsilon_o$ – inductivity of vacuum;
- $r_d$ – 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, that in turn, stipulates creation of 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 (in 1, 2–10 times). Thus, according to [4], there is connection between a surface-tension and sizes of drops.

$$r_p = r_0 e^{\frac{4\pi\sigma_u \cdot \mu_o \cdot \rho_k \cdot N \cdot L}{\rho_p \cdot \varepsilon_0 \cdot \varepsilon_{r_0} \cdot R^2 \cdot E}}$$ \hspace{1cm} (3)

Analyzing expressions (2, 3) it is possible to assert that the change of surface-tension ($\sigma_{pp}$) 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 ($U^2$). It, in turn, 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.:

$$\Delta m_{w_s} \approx \sigma_{pp} \cdot \frac{1}{E^2}$$ \hspace{1cm} (4)

where:
- $\Delta m_{w_s}$ – 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 mono-dispersible 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 agro-technical 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 (mono-dispersion) homogeneity presents ≥75–82%. The indicated parameters contribute to the even sedimentation on green mass of plants, create favourable terms for the effective spreading on their surface and penetration in tissues of plants. 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, processability and perspective. However a list of problems, such as an absence of the single theory of penetration of working solutions in tissues of plants, presence of contradictions in 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 a 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 technicians, who are engaged in the problems of energy and resource saving in plant growing.

CONCLUSIONS

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

2. Development and realization of 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.

REFERENCES


Streszczenie: Naukowe i techniczne przesłanki zastosowania pola elektrycznego w ochronie roślin. Przedyskutowano możliwości zastosowania pola elektrycznego w ochronie roślin, zwracając uwagę na wady tradycyjnej techniki opryskiwania: słabe i nierównomierne osadzanie się cieczy roboczej na roślinach, spadanie większych kropli z roślin itp. Autor zwraca jednak uwagę na potrzebę przeanalizowania ekonomicznych i technologicznych skutków wprowadzania nowej techniki, a także na brak badań w tym zakresie oraz niedostateczne zainteresowanie konstrukcją specjalnego sprzętu electrotechnicznego.

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Author’s address:
National University of Life and Environmental Sciences of Ukraine
str. Geroev Oborony 15
03041 Kiev
Ukraine