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Modeling of the processes of nutrient assimilation of soil and cotton plants after exposure to ultraviolet radiation

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Abstract. This article presents preliminary theoretical calculations for selecting the power of a bactericidal lamp for ultraviolet irradiation of the "seed-soil-plant" system during cotton cultivation.

Keywords. Ultraviolet, radiation, exposure, system, seed-soil-plant, technology, cotton, cotton, plants.

Based on existing theoretical research and analysis of existing agricultural technologies for preparing soil for sowing cotton seeds, sowing seeds, and growing cotton, the technology of electrical influence on the "seed-soil-plant" system with ultraviolet equipment, i.e., ultraviolet irradiation, has been developed.

At the Research Institute of Cotton Breeding, Seed Production and Growing Agrotechnologies, agrotechnical methods of cotton cultivation were developed, and at JSC "BMKB-Agromash," electrotechnological equipment and their optimal operating modes were developed as a result of many years of research.

The stages of electrotechnological ultraviolet treatment for cotton cultivation are carried out simultaneously with plowing, before sowing seeds, simultaneously with sowing the soil and seeds, simultaneously with fertilizing the soil and plants (seedlings) and during chemical treatment to protect plants from diseases and pests.

The transformation of the UFN flux by the soil medium occurs with greater absorption and less reflection. In this case, the absorbing component is converted into thermal energy and causes various physicochemical processes in the soils. The optical properties of soils are determined by the presence of a complex of absorbents. Its absorbing base consists of humic substances, iron, and manganese compounds.

Increased humidity activates the process of soil absorption of UV rays.

One of the positive effects of soil treatment with ultraviolet rays during sowing can be the heating of the soil layer, which subsequently leads to an increase in the intensity of plant roots' respiration. Heating the root layer serves as an additional factor for reducing osmotic pressure.

The magnitude of osmotic pressure depends on the composition of the solution and the temperature.

Its relationship to the activity of water in solution can be expressed in the simplest way:

$$-RT\cdot lna_w = \int_{\pi}^{p+\pi} U_w dp$$

where: p -hydrostatic pressure, Pa;
π - osmotic pressure, Pa;
U_w - molar volume of water, kg/mol.

Due to the low compressibility of water, the right integral can be replaced by the difference. When the molecular mass of water is equal to 0.018 kg/mol (d - solution density, kg/m^3):

$$\pi = \frac{RT\cdot d}{0.018}\cdot lna_w$$

Earth's equilibrium temperature depends on the radiation flux density is determined by the formula:

$$\bar{h}_c\cdot(T_\infty - T_p) = \cdot\Theta\cdot(T_p{}^4 - T_o{}^4)$$

where: hc - heat transfer coefficient;
T_∞ - ambient temperature, ^{o}C;
Q - Stefan-Boltzmann constant;
T_r - equilibrium temperature, ^{o}S.

H = $\frac{\lambda_2}{\lambda_1}$ where: - thickness of the soil layer exposed to ultraviolet radiation (cm), soil surface temperature:

$$T_n = \frac{T_c\xi}{\xi + H}$$

where: ξ - temperature gradient to soil

On the other hand, in our case, the method and calculation of ultra-violet irradiation or disinfection of a biological object (soil, sown fodder crops and plant seeds) from diseases is based on determining the absorption coefficient of the bio-object a, radiation dose N_{norm}, bactericidal irradiation Yebk, processing time t and effective bactericidal flux of ultraviolet radiation Fe .

T.n. According to S.V. Oskin, the main characteristic of the process of disinfection from diseases with ultraviolet radiation, which determines the degree of reduction in the number of microorganisms during the irradiation process, is the standardized radiation dose - $N_{norm} = 16\ m\ J/cm^2$.

The process of disinfecting (or intensifying) bio-objects from diseases under the influence of ultraviolet radiation (in our case, seeds of agricultural crops, soil and vegetation period plants, as well as various microorganisms in seeds, soil and plants themselves) obeys an exponential law:

$$N_{в} = N_{0} \cdot e^{\frac{E_{,бк} t}{H_{норм}}}$$

where: N_b - permissible number of surviving bacteria on the surface of seeds (or soil) after disinfection;

N_0 - the initial number of these bacteria before UV disinfection.

From the previous formula, taking into account the reserve factor (Kz):

$$E_{бк} = -K_{з} \cdot H_{норм} \cdot t^{-1} \cdot \frac{lnN_{в}}{N_0}$$

In our case, the outer diameter of the lamp d=25 mm, the length of the working part υ = 890 mm, and the illuminated surface of the lamp:

$$K_{з} = 2{,}2; \qquad \frac{lnN_{в}}{N_0} = -2{,}3; \qquad t = 1 \text{ c.}$$

Тогда: $E_{бк\ ср} = 81\ mW/cm^2$

$$S_{mp} = \pi \mathrm{d} \cdot b = 699\ cm^2$$

The bactericidal flux of the lamp (F_{bk}) is found by the formula:

$$\Phi_{бк} = E_{бк} S_{mp} = 81 \cdot 699 = 56619\ mW \approx 57 \text{ W.}$$

Based on the theoretical calculations performed above, we assume the bactericidal current power of the lamp (F_{bk}) to be 60 W for our case.

In addition, it should be noted that such bactericidal lamps
BL-60 are currently produced industrially, they are mainly used in medicine, as well as in other sectors of the national economy.

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