

Pre-sowing activation of seeds by ultraviolet (UV) radiation

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Abstract. The mechanism of influence the UV- radiation biological processes into seeds of agricultural plants is considered. The technical parameters of installation for pre-sowing treatment seeds with ultraviolet radiation lamps for increasing the permeability of biological membranes of cells in seed are defined. The results of experimental researches on have established that for processing of seeds cotton pre-sowing treated with ultraviolet rays, increasing of their germination and productivity of agricultural crops are shown.

1 Introduction

The current state of the agro-industrial complex requires the use of new environmentally friendly technologies for growing grain, vegetables and melons [1]. One of these technologies is pre-sowing activation of seeds by ultraviolet (UV) irradiation [2]. Presowing UV irradiation of seeds has a positive effect on increasing the yield of agricultural crops, increases their resistance to various diseases and unfavorable climatic factors (including drought, soil salinity). High processing efficiency depends on the use of special UV - emitters and automation of monitoring and control of the intensity of the radiation flux [3].

The mechanism of interaction of ultraviolet (UV) radiation on seeds has three components biostimulating, bactericidal and stress [4]. Under ultraviolet irradiation of seeds, the permeability of biological membranes of cells changes, which leads to stimulation of the initial growth processes [5]. The biostimulating effect of UV radiation on seeds is based on photoresonant rearrangement of their cellular structure and intracellular organelles [6]. As a result of UV irradiation in seeds, the level of lipid oxidation, pH and ATP activity change, which leads to an increase in bioenergetic and biosynthetic processes, which leads to an increase in the energy potential of seeds [7].

In addition, irradiation of seeds with ultraviolet radiation leads to the destruction of phytopathogens, i.e. to disinfection of seeds (ecologically safe analogue of traditional dressing) [8]. However, it should be borne in mind that low doses of UV radiation do not have a significant effect on the microflora of seeds and cause a slight increase in germination, while high doses of UV radiation provide a more effective destruction of phytopathogens [9].

Along with this, high-intensity UV irradiation mobilizes genetically inherent growth reserves in seeds, which are due to the centuries-old adaptation of plants to solar radiation [10]. Under UV irradiation, seeds receive an unusually powerful informational effect, which introduces them into a state of stress [11]. As a result, the seeds mobilize their hidden resources, which are used to enhance the growth and development of plants [12]. Pre-sowing irradiation of seeds with ultraviolet radiation (UV) has a positive effect on increasing the yield of agricultural crops, increases their resistance to various diseases and unfavorable climatic factors, including drought and soil salinity [13-14].

2 Research Methods

The installation consists of a stand, a box for collecting the processed product, a gear motor, a drum (irradiation chamber) [15]. A loading hatch is located on the cylindrical side of the drum. A UV source is located inside the drum. The seeds are poured into the drum through the loading door (to ensure uniform irradiation of the entire product, the drum should be filled no more than 30% of its nominal volume). After finishing loading and closing the loading door, the drum is set in rotation. In this case, the UV radiation source located inside the drum is automatically switched on. The configuration of the UV lamps and the rotation speed of the drum are selected in such a way that uniform irradiation of all seeds loaded into the drum is achieved. The installation is controlled from the control case in automatic mode.

The design parameters of the installation have been determined, which is intended for pre-sowing activation of seeds of grain and vegetable crops with ultraviolet radiation.

The installations consist of one or several irradiation modules fixed on the frame of the vibrating belt conveyor. Irradiation of seeds occurs during their passage through the irradiation zone. It is desirable to equip the conveyor with a vibrator for uniform irradiation of seeds. The design of the installation provides for the regulation of the suspension height of the irradiation modules, which allows for efficient seed treatment (Table 1).

Table 1. Design technical characteristics of the plant for UV irradiation of seeds

| | |
|--|-------------------|
| Irradiation chamber volume, m ³ | 0.25 |
| One-time loading volume, dm ³ | 75 |
| Productivity (nominal), kg / h | 250 |
| The duration of the irradiation cycle, min | 2 ÷ 3 |
| Power consumption, kW | 0.4 |
| Average resource of UV lamps, h | 9000 |
| Irradiation module dimensions, mm | 1850 × 650 × 1420 |
| Control cabinet dimensions, mm | 400 × 250 × 600 |

3 Results

According to the materials of Table 2, the lower the temperature is from 15÷16⁰C, the more time is spent on germination of cotton seeds, and vice versa.

Table 2. Influence of temperature on the distribution of biomass and the number of cotton roots in the depth of the soil [16].

| Day/night temperature, °C | Soil depth, sm | | |
|---------------------------|---|--------|-----------|
| | <20 | 20-40 | > 40 |
| | % to the total dry weight | | |
| 20/12 | 96.2 | 3.3 | 0.5 |
| 30/22 | 93.3 | 4.4 | 2.3 |
| 35/27 | 94.8 | 2.8 | 2.4 |
| 40/32 | 88.7 | 7.4 | 4.0 |
| | % of the total number of root processes | | |
| 20/12 | 71 ± 3 | 29 ± 2 | 0.1 ± 0.0 |
| 30/22 | 64 ± 7 | 36 ± 4 | 0.1 ± 0.0 |
| 35/27 | 58 ± 3 | 40 ± 3 | 2.0 ± 0.3 |
| 40/32 | 63 ± 5 | 35 ± 2 | 2.0 ± 0.3 |

The same temperature limit is required from seedlings until the first true leaf appears. From the time of the appearance of the first leaf to the budding of cotton, an average daily temperature of at least 18⁰C is required; in the period from budding to flowering and from flowering to ripening for a medium-fiber variety, the average daily temperature should be approximately above 20⁰C [17]. Studies carried out on a number of cotton varieties have established that agricultural crops for seeds treated with ultraviolet rays, their germination increased by an average of 20%, and the yield increase was 35 ÷ 40%.

Table 3. Results of UV treatment of crops (dry year)

| | Various varieties of cotton | | | | | | Improvement of indicators, % |
|----------------------|-----------------------------|--------------|-------------|--------------|-------------|--------------|------------------------------|
| | unprocessed | UV treatment | unprocessed | UV treatment | unprocessed | UV treatment | |
| Germination,% | 72 | 93 | 71 | 90 | 72 | 92 | 21 ÷ 22 |
| Germination energy,% | 70 | 72 | 69 | 73 | 92 | 79 | 3 ÷ 5 |
| Productivity, c / ha | 22 | 37 | 23 | 35 | 39 | 39 | 35 ÷ 40 |

There is shown by the results of experiments on seed treatment carried out in the experimental field base “BMKB-Agromash” (Table 3).

According to the researches [18–19], the lower the temperature is from 15–16⁰C, the more time is spent on germination of cotton seeds, and vice versa. The same temperature limit is required from seedlings until the first true leaf appears. From the time of the appearance of the first leaf to the budding of cotton, an average daily temperature of at least 18⁰C is required; in the period from budding to flowering and from flowering to ripening for a medium-fiber variety, the average daily temperature should be approximately above 20⁰C.

Presowing UV treatment of seeds also has a positive effect on increasing the yield of other cereals, melons and vegetables. Experimental studies have shown that UV treatment of wheat seeds increases its yield by an average of 30%, corn by 40%, barley by 10%, pepper by 65%, eggplant by 50%, cucumber by 30%, sugar beet - by 25%, watermelons and melons - by 30% [20]. Along with this, the treatment of seeds with UV radiation has a positive effect

on the increase in the content of sugar, vitamin C, carotene, etc. In addition, there is an acceleration of the maturation of agricultural crops during 3÷15 days [21-25].

4 Conclusions

Experimental studies have shown that the design technical characteristics of the plant for UV irradiation of plant seeds provide a good efficiency of the processes of their electrical treatment. Also a significant factor is the low price of UV equipment and the cost of pre-sowing seed treatment. Specific energy consumption for the technology of UV activation of seeds does not exceed 1 kW/1 ton of seeds

Thus, considering the profitability of this process, several components of the economic efficiency of pre-sowing treatment of seeds with ultraviolet radiation can be distinguished:

- the germination of plant seeds increases
- a significant increase in the yield of agricultural crops;
- increasing the export potential of grown products due to the lack of chemical stimulating reagents. In fact, the transfer of products to the category of organic farming is ensured.

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