Effect of treatment of seeds of grain crops by ultraviolet radiation before sowing

N P Kondrateva1*, N I Kasatkina2, A G Kuryleva1, K A Baturina1, I R Ilyasov1 and R I Korepanov1

1Department of Automated Electric Drives, Izhevsk State Agricultural Academy, 11 Studencheskaya Street, Izhevsk 426069, Russian Federation
2Udmurt Federal Research Center of the Ural Branch of the Russian Academy of Sciences, 34 Baramzina Street, Izhevsk, 426067, Russian Federation

*E-mail: aep_isha@mail.ru

Abstract. Cereals form the most important group of plants cultivated by man. The aim of the work is to study the effect of ultraviolet led emitter in the processing of seeds of grain crops to improve sowing performance. The objects of the study were the seeds of winter and spring wheat, winter triticale, naked oats. Seeds were treated with ultraviolet LEDs in the range of radiation in the UV zone for 5, 10 and 15 minutes, with average illumination energy of 3.137 W/m². Growth strength, laboratory germination, shoot height, primary root length and root rot infestation were evaluated. In the course of studies, a positive effect of ultraviolet treatment of seeds of winter wheat, winter triticale and oats was established. Ultraviolet radiation with a dose of 1882 J/m² (seed treatment for 10 minutes) increased the growth strength and germination of winter wheat. Shoot height and root length were better when irradiated for 5 min with a dose of 941 J/m². The proposed UV treatment of seeds improves the technology of production of hydroponic feed, taking into account modern requirements for energy conservation and obtaining environmentally friendly products.

1. Introduction
Grain crops form the most important group of plants cultivated by man, from which basic human food products in the form of cereals and sprouted grain, raw materials for many industries and feed for farm animals are obtained. The article shows the effect of ultraviolet radiation on the seeds of winter and spring wheat, triticale and gymnosperm oats.

Wheat is the most cultivated cereal on Earth. The second place is corn, the third is rice. At present, Russia has become the largest producer of wheat, second only to the United States of America, India, and China.

The flour produced from wheat grains is used in baking bread, making pasta and confectionery. Wheat is also used as a feed crop, it is included in some recipes for making beer and vodka, as well as whiskey.

An important advantage of winter wheat is the possibility of cultivating it in regions with different climatic conditions, as well as a high yield of 15 ... 25% compared to the springform.

Triticale ... (Lat. × Triticosecale, from lat. Triticum - wheat and lat. Secale - rye) is a hybrid of wheat and rye, created at the end of the XIX century. It is grown mainly for animal feed. 1 kg of green mass of triticale is 0.3 feed unit, while for winter wheat - 0.18. The world leader in the cultivation of
triticale is Poland, where 840 thousand hectares of all grain crops have been allocated for it. The average yield of triticale (for grain) in Poland is 30 c/ha. It is planned to further expand its area to 1.2 million hectares. Among the CIS countries, Belarus ranks first in terms of triticale (more than 350 thousand ra, or 15 - 17% of the sown area). In Russia, triticale is used in the production of animal feed for pigs, broilers, etc., and alcohol, since its output from triticale grain is 3-5% higher than from wheat and other cereals. A special place of triticale is in the manufacture of dietary bread for persons suffering from metabolic disorders. Bakery products baked from the flour of several cereals (with the participation of triticale) are gradually becoming widespread.

**Oats Vyatka bare-grained** does not contain gluten and is a promising culture for the production of dietary, functional and specialized foods. Analysis of grain of 13 varieties of bare oat selection by the Research Institute of Agriculture of the North-East (Kirov) showed that they all belong to gluten-free raw materials. Therefore, the malt produced from these varieties, as well as the products of its processing, can be used for the category of people with celiac disease.

The second promising direction of application of grain and fodder crops is the cultivation of hydroponic feed from them. This technology is currently experiencing its rebirth. This is green fodder produced on nutrient media using modern environmentally friendly and economical LED radiation sources that maintain illumination within 1500 ... 2000 lux with a photoperiod of 12 ... 14 hours per day. This technology allows for seven days getting a complete green fodder from wheat, oats, tertiary and other crops, which has a high biological activity, as it contains natural vitamins (in particular carotene), minerals and essential amino acids. This green food is harvested at the peak of enzyme activity. Improving the technology of hydroponic feed has broad prospects. In winter, this method of obtaining high-quality food allows one to improve the usefulness of feeding and speed up metabolic processes, helps to maintain animal health and increase fertility. Thus, it can be considered that the improved technology of hydroponic feed production, taking into account modern requirements for energy saving and obtaining environmentally friendly products, is advanced and very promising for almost all branches of animal husbandry. It is of particular importance for the organization of animal feeding in farms and zoos.

In order to obtain friendly shoots, increase the germination energy in the work, it was proposed to treat the seeds before sowing with ultraviolet radiation (UV). To this end, an environmentally friendly, energy-saving UV emitter was manufactured, in which 90% of the energy is in the UV-A zone.

Ultraviolet irradiation of seeds (UV, photostimulation) refers to "green technologies" and provides activation of biological parameters of the processed material. The basis of UV irradiation of seeds is based on the method of presowing photostimulation under the influence of solar radiation, known to our ancestors. Only instead of the sun is used for artificial UV radiation. Ultraviolet irradiation of seeds provides activation of hidden biological reserves of plants, and this in turn has a positive effect on their germination and germination intensity.

Seed growth processes can be activated in various ways. There are different ways to affect seeds. The effects of ambient and filtered solar UV-B radiation and of selenium treatment on respiratory potential measured by electron transport system (ETS) activity in pumpkins (*Cucurbita pepo* L.) were studied in the work [1]. The results suggested that the solar UV-B radiation impaired flow of electrons in the respiratory chain. Song L et al. [2] investigated the effect of g-irradiation on the energy of rice seeds, estimated using infrared spectroscopy. Results showed that with an increase of irradiation dosage and storage age, seed injury increased resulting in reduced seed vigor and seedling height. In the paper of Hassan et al. [3] study was aimed at investigating the effect of gamma irradiation at various doses (0.5, 1.0, 1.5 and 2.0 kGy) on protein characteristics and functional properties of sesame seeds. It is concluded that gamma radiation improves the protein and functional properties of sesame flower and, thus, can be used as an effective method of preserving sesame flower and its products. Effect of X-ray irradiation on wheat seed growth characteristics was studied in [4]. The results show that increasing the radiation dose leads to a decrease in seed energy. Mutagenic potential of lettuce grown from irradiated seeds was studied by Franco et al. [5]. The study was aimed at analyzing the mutagenicity of *Lactuca sativa*, developed in a greenhouse and obtained from gamma-irradiated seeds.
Based on these results, it has been established that, although radiation is a useful method in plant breeding programs, it is extremely important to estimate the dose of radiation that guarantees the welfare of the end user. According to the study of the mutagenic potential of lettuce grown from irradiated seeds irradiated at doses of 25, 50, 75, 150 and 300 Gy [6], it was concluded that in plant breeding programs, it was extremely important to estimate the radiation dose.

The aim of the work is to study the effect of ultraviolet led emitter in the processing of seeds of grain crops to improve sowing performance.

We propose to irradiate seeds before sowing with ultraviolet LEDs. This is not expensive, environmentally friendly, electro-safe, energy-saving method, which is based on natural mechanisms and therefore does not cause harm to human health. We used this method to irradiate spruce seeds, and it showed positive results [7-9].

2. Materials and methods

Seeds of grain crops were used for research: winter and spring wheat, winter triticale, bare oats. Seeds for the experiment were provided by the structural unit of the Udmurt Federal Research Center of the Ural branch of the Russian Academy of Sciences. For the analysis, an average sample was taken from the batch, 100 seeds were taken from a random sample. Seeds were treated with ultraviolet (UV) radiation from a UV emitter comprising 200 LEDs (figure 1).

![Figure 1. Experimental setup: a) Emitter with 200 UV LED; b) UV irradiation plant.](image)

The TCA-ABC instrument (TKA, Russia) measured the energy illumination. On December 3, 2018, ultraviolet light from LEDs was measured. The results are shown in table 1.

| The type of UV radiation | Measuring time | Average value | % |
|--------------------------|----------------|---------------|---|
| UV-A                     | 18:41          | 3.300         | 3.100         | 3.010         | 3.137         | 95.67         |
| UV-V                     | 0.117          | 0.110         | 0.109         | 0.112         | 0.112         | 3.41          |
| UV-S                     | 0.020          | 0.040         | 0.030         | 0.030         | 0.030         | 0.91          |

Table 1 shows that more than 90% of the radiation falls on the long-wave radiation of the UV-A zone.

According to the average energy illumination, the doses of UV irradiation (H, kJ/m²) of seeds for 5, 10 and 15 minutes were calculated.

\[ H = E \cdot t, \]

where E is the radiation power, W/m²;  
\( t \) – irradiation time in seconds.

The results of the calculation of the dose of UV radiation are shown in table 2.
Table 2. Calculation of UV radiation dose, J/m².

| The type of UV radiation | Average value W/m² | Radiation time |
|--------------------------|---------------------|----------------|
|                          |                     | 5 min  | 10 min | 15 min |
|                          |                     | 300 sec | 600 sec | 900 sec |
| UV-A                    | 3.137               | 941    | 1882   | 2813   |
| UV-V                    | 0.112               | 33.6   | 67.2   | 100.8  |
| UV-S                    | 0.030               | 9      | 18     | 27     |

In December 2018, studies were conducted on the effects of ultraviolet radiation on seeds of winter wheat of the ‘Moskovskaya 39’ variety, winter triticale ‘Cornet’, spring wheat of the ‘Svecha’ variety and oat of the ‘Vyatsky’ variety (table 3). All seeds were divided into four groups of 100 seeds each. Seeds were irradiated with three doses of UV radiation; control variant - unirradiated seeds. Repeat the experiment 4 times. Seed germination was carried out at a temperature of 20°C in the climatic chamber KBWF 720 Binder (Germany).

Seed quality was evaluated by ISF (1994) [10, 11] laboratory germination – state standard GOST 12038-84. The strength of the growth of seeds prepared for sowing and morphological parameters of seedlings were determined by the Method of the State seed inspection [12] sprouting by the roll method the strength of the initial growth by the method of B. F. Germanov [13].

The results of the research are processed by the method of dispersion analysis according to the algorithms described by B.A. Dospekhov [14] using the program "Microsoft Office Excel 2010".

Table 3. Dates of irradiation and planting of crops.

| Culture                  | UV irradiation | Date of planting |
|--------------------------|----------------|------------------|
| Winter wheat ‘Moskovskaya 39’ | 05.12.2018     | 11.12.2018       |
| Winter triticale ‘Cornet’ | 08.12.2018     | 12.12.2018       |
| Spring wheat ‘Svecha’    | 10.12.2018     | 14.12.2018       |
| Naked oats ‘Vyatsky’     | 08.12.2018     | 12.12.2018       |

Indicators of germination energy, germination, length of roots and seedlings were determined on the seventh day. The length of sprouts and roots was determined by a ruler (figure 2).

Figure 2. Trial establishment of crops 6-7 day: (a) trial establishment; (b) 6-7 day trial establishment; c) determining the length of the germ and the length of the root.
Figure 3 shows a photo of oat naked on the seventh day with irradiation for 10 minutes and 15 minutes.

![Figure 3. Photo of germinated seeds of bare-grain oats: a) irradiation time 10 min. and b) irradiation time 15 min.](image)

3. Results and discussion

Germination energy is one of the main parameters of seed viability, which characterizes amicability and seed germination rate. However, in agronomic practice, the laboratory germination rate serves as the main criterion for assessing the quality of the seed material, as this result of laboratory testing shows the percentage of seeds that gave sprouts in standard substrate conditions, humidity, temperature (figure 4).

![Figure 4. Definition of laboratory germination grains.](image)

As a result of the studies, it was found that the positive effect of ultraviolet treatment of seeds was obtained for winter wheat, winter triticale and oats. It is noted that irradiation does not affect the strength of the initial growth of seeds of all tested crops. The index of initial growth strength in winter crops had values of 4.28-4.99%; in spring cereals - 4.82-4.92% (table 4).
### Table 4. Growth strength and parameters of seedlings of grain crops after irradiation.

| Option   | Winter wheat ‘Moskovskaya 39’ | Winter triticale ‘Cornet’ | Spring wheat ‘Svecha’ | Naked oats ‘Vyatsky’ |
|----------|-------------------------------|---------------------------|-----------------------|----------------------|
|          | The strength of initial growth, % | Germination, % | Height of sprouts, cm | Length of primary roots, cm | Infection with root rot, % |
| Control  | 4.44                          | 89.50                    | 5.27                  | 9.54                 | 40.75                |
| 5 min    | 4.38                          | 85.50                    | 5.49                  | 10.48                | 37.23                |
| 10 min   | 4.48                          | 92.00                    | 5.27                  | 9.79                 | 51.20                |
| 15 min   | 4.28                          | 85.50                    | 5.43                  | 8.91                 | 39.38                |
| The least significant difference | $F_r < F_t$ | $F_r < F_t$ | $F_r < F_t$ | 8.70 |

| Option   | Winter wheat ‘Moskovskaya 39’ | Winter triticale ‘Cornet’ | Spring wheat ‘Svecha’ | Naked oats ‘Vyatsky’ |
|----------|-------------------------------|---------------------------|-----------------------|----------------------|
| Control  | 4.92                          | 91.50                    | 10.04                 | 4.46                 | 33.92                |
| 5 min    | 4.82                          | 89.75                    | 9.16                  | 4.28                 | 29.16                |
| 10 min   | 4.85                          | 89.75                    | 9.50                  | 4.44                 | 31.11                |
| 15 min   | 4.83                          | 92.00                    | 8.97                  | 4.48                 | 30.63                |
| The least significant difference | $F_r < F_t$ | $F_r < F_t$ | $F_r < F_t$ | $F_r < F_t$ | 4.30 |

Irradiation of winter wheat for 10 min (1882 J/m²) positively affected the germination energy, respectively, and laboratory germination, exceeding by 2.80% and 2.50% relative to the control (growth energy - 87.20%, germination - 89.50%, with least significant difference (95%) = 2.20 and 2.30%). Treatment with ultraviolet LEDs of winter triticale seeds with a dose of 941 and 2823 J/m² (for 5 and 15 minutes) increased the germination energy by 0.9 and 0.5%, and, accordingly, the laboratory germination of seeds by 2.2 and 3.7% (growth energy of the control variant - 91.80% and germination - 92.00%). The seeds of naked oats had the worst sowing qualities with laboratory germination - 60%. When exposed to ultraviolet irradiation in 1882-2823 J/m² (for 10-15 minutes) a significant increase in the growth energy and laboratory germination of seeds of naked oats relative to the control by 15.80-26.20% and 13.75-24.25%, respectively, is monitored. No positive and negative effects on the seeds of spring wheat have been identified.

The effect of UV irradiation on the increase in the average length of the sprout and roots in winter crops was not revealed. Seeds of naked oats reacted positively to irradiation at a dose of 941 and 2823 J/m² by increasing the average length of the roots by 11-21%.
Treatment of seeds with ultraviolet light, both winter cereals and oats, provoked the development of the fungus *Bipolaris sorokiniana* Shoemaker (*Helminthosporium sativum* P., K. et al.). Ultraviolet irradiation of winter triticale seeds at a dose of 941 J/m² (seed treatment for 5 minutes), winter wheat at a dose of 1882 J/m² (seed treatment for 10 minutes) and oats at a dose of 2823 J/m² (seed treatment for 15 minutes) provoked an increase in the development of seed infection by 9.39, 10.45 and 10.20% (The least significant difference (95%) – 4.30, 8.70 and 6.70%, respectively).

Treatment of spring wheat seeds with UV-A rays had neither positive nor negative effects.

**Conclusion**

Ultraviolet treatment of seeds of winter wheat, winter triticale and oats is a promising environmentally friendly and cheap way to increase the energy of seed germination.

The influence of UV radiation on the increase in the average length of the sprout and roots in winter crops was not detected. Seeds of naked oats reacted positively, increasing the average root length by 11-21%.

Ultraviolet treatment of spring wheat seeds had neither a positive nor a negative effect.

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