

Experimental studies on vegetable marrow seeds ozonation using laboratory equipment

*Andrey V. Bogdanov*¹, *Victoria V. Evchenko*¹, and *Svetlana Yu. Popova*^{1,*}

¹FSBEI HE South Ural State Agrarian University, 454080, Chelyabinsk, Russia

Abstract. A set of measures is taken to protect plants against various diseases and to prevent yield losses. One of the components of such actions is a pre-sowing seed treatment. One of the effective ways of pre-sowing treatment is seeds ozonation, which stimulates their germination and provides the prevention of plant diseases, hence this process increases the germination and the yield of agricultural crops. Our laboratory equipment was made to substantiate the ozonation regimes. Experimental studies on seeds ozonation were carried out for agricultural crop (the zucchini variety Zebra), which is widely used in Russia, particularly in the natural-climatic areas of the Urals. Taking into account that high ozone concentrations are dangerous to human health and life (to service personnel), pre-sowing seeds treatment was carried out at relatively safe concentrations (up to 10 mg/m³), paying attention to the tightness of the equipment. Ozone concentrations of 3 mg/m³, 6 mg/m³ and 9 mg/m³ and seed treatment time of 120 min, 240 min, 360 min and 480 min were chosen. The experimental studies have shown, that a rational regime of seeds treatment for obtaining the maximum germination (79.1%), is observed when ozone concentration is 9 mg/m³ and treatment time is 247.7 min. Thus, the developed laboratory equipment helps to determine the rational ozonation regimes for zucchini seeds. It can also be used to determine the rational ozonation regimes for seeds of other crops.

1 Relevance

At present, a set of measures is taken to protect plants from various diseases acquired mainly through infected seed material and thus to prevent yield losses [1-11]. This set of measures includes pre-sowing seeds treatment. According to the results of numerous studies, seeds ozonation is one of the effective ways of pre-sowing treatment [12-20]. This process stimulates seeds germination, it helps to prevent and to treat diseases, it ensures plants protection, and thereby it increases the germination and the yield of agricultural crops.

To substantiate the ozonation regimes, special laboratory equipment for seed ozonation was made in South Ural State Agrarian University at the Department "Processing of agricultural products and life safety" [21].

* Corresponding author: vetochnka.79@mail.ru

2 Test object and equipment

At the initial stage the experimental studies on seeds ozonation were carried out using a crop (the zucchini variety *Zebra*), which has been widely used in Russia in the natural-climatic area of the Urals.

Considering that ozone is dangerous to human health and life (to service personnel), pre-sowing seeds treatment was carried out at relatively safe concentrations of ozone (up to 10 mg/m³) while paying attention to the tightness of the equipment. Ozone concentrations of 3 mg/m³, 6 mg/m³ and 9 mg/m³ and seeds treatment time of 120 min, 240 min, 360 min and 480 min were chosen.

When conducting experiments, seeds were placed in Petri dishes (four samples of 50 seeds each). The control group was not exposed to ozone treatment (treatment time was 0 minutes). Seed germination after ozonation was determined according to state standard (GOST) 12038-84 "Agricultural seeds. Methods for determination of germination" [22].

The research results show that when ozone concentrations are 3 mg/m³ and 6 mg/m³, the germination of zucchini seeds practically does not increase as compared with the control group of seeds that were not treated with ozone. When ozone concentration was 9 mg/m³, a significant increase in the germination of zucchini seeds was identified. Therefore, the summary Table 1 presents the results of experimental studies of the zucchini seeds (the variety *Zebra*) when ozone concentration is 9 mg/m³.

Table 1. The results of experimental studies of the zucchini seeds (the variety *Zebra*) when ozone concentration is 9 mg/m³

Seeds treatment time	Total amount of seeds, pcs.	Amount of seeds with sprouts, pcs.	Germination, %	The average height of sprouts on the 10th day, cm	The average width of the leaf plate on the 10th day, cm
Control group (without seeds treatment with ozone), processing time is 0 min	200	82	41.0	1.34	0.34
Seeds treatment with ozone, processing time is 120 min	200	111	55.5	3.50	1.04
Seeds treatment with ozone, processing time is 240 min	200	175	87.5	7.17	2.24
Seeds treatment with ozone, processing time is 360 min	200	148	74	5.30	1.85
Seeds treatment with ozone, processing time is 480 min	200	84	42.0	4.07	1.25

From Table 1 it can be seen that the largest amount of seeds with sprouts (175 seeds) is observed when they are treated with ozone for 240 minutes. In this case the seed germination has a maximum value of 87.5%. When the time of ozonation is 240 min, the highest values of the average sprout height on the tenth day (7.17 cm) and the average width of leaf plate (2.24 cm) are also observed.

For example, Fig. 1 shows containers with the sprouts of seeds on the tenth day from the seeds of the control group (without ozonation) and the seeds treated with ozone when ozone

concentration is 9 mg/m^3 for 120 minutes, 240 minutes, 360 minutes and 480 minutes. As you can see from the photo (Fig. 1), in the first row of four containers, where the seeds from the control group were planted, only two seeds have sprouted. In the second row (seed treatment with ozone for 120 minutes), only one seed has sprouted. In the third row (seed treatment with ozone for 240 min) all seeds have sprouted. In the fourth row (seed treatment with ozone for 360 minutes), three seeds have sprouted. In the fifth row (seed treatment with ozone for 480 minutes), two seeds have sprouted. Thus, the most developed sprouts are observed in the third row (all seeds have sprouted), when the processing time is 240 minutes.



Fig. 1. Containers with sprouts from the seeds of the control group (without ozonation) and the zucchini seeds (the *Zebra* variety) treated with ozone when ozone concentration is 9 mg/m^3 (from left to right): 1 is a row of four containers with sprouts from the seeds of the control group (without ozonation); 2 is a row of four containers with sprouts from the seeds treated with ozone for 120 minutes; 3 is a row of four containers with sprouts from the seeds treated with ozone for 240 minutes; 4 is a row of four containers with sprouts from the seeds treated with ozone for 360 minutes; 5 is a row of four containers with sprouts from the seeds treated with ozone for 480 minutes

3 Theoretical substantiation

Based on the experimental data shown in Table 1 and using MS Excel, we have made a graph of changes in the germination of zucchini seeds depending on the time of their treatment when ozone concentration is 9 mg/m^3 (Fig. 2).

The graph shows that with an increase in treatment time, the germination of zucchini seeds of the zucchini variety *Zebra* increases. At a certain time value, the germination reaches its maximum. Then, if ozonation continues, seed germination decreases.

The regression equation for the experimental curve (Fig. 2) is as follows:

$$G_{erm}^e = -0.0007 \cdot t_{tr}^2 + 0.3468 \cdot t_{tr} + 36.114, \tag{1}$$

where G_{erm}^e is the germination value according to the results of the experiment, %; t_{tr} is the time of seed treatment with ozone, min.

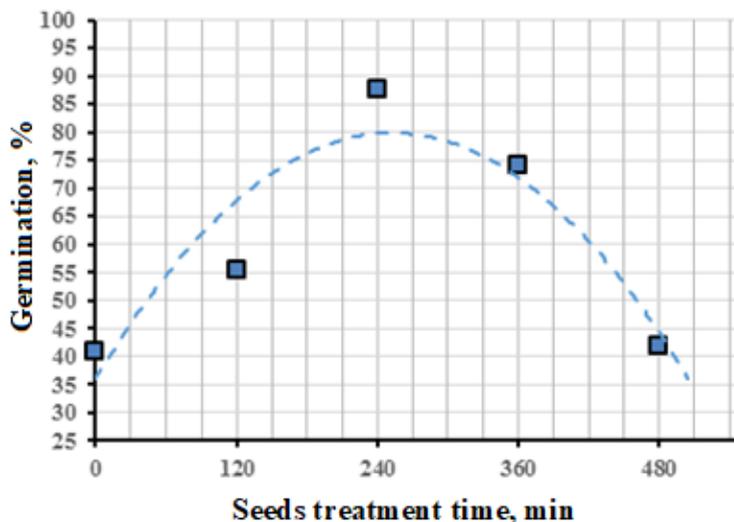


Fig. 2. Dependence of seed germination of the zucchini variety *Zebra* on treatment time when ozone concentration is 9 mg/m^3 : ---- is the average values according to the regression equation; ■ is the average values according to the results of the experiment

Let us analyze the expression (1). To determine the extremum of function (1), we find its derivative and equate it to zero:

$$-0.0014 \cdot t_{tr} + 0.3468 = 0. \quad (2)$$

From the expression (2) we determine the time of seed treatment with ozone t_{tr} with maximum germination ($t_{tr} = 247.7 \text{ min}$).

Substituting the determined time value of seed treatment with ozone at maximal germination $t_{tr} = 247.7 \text{ min}$ in the expression (1), we get the maximum germination which is equal to 79.1% ($G_{em}^e = 79.1 \%$).

4 Conclusion

Our experimental studies have shown, that with relatively safe ozone concentrations a rational regime for seed treatment is observed provided the maximum germination rate is 79.1%, the ozone concentration is 9 mg/m^3 and the treatment time is 247.7 minutes. Thus, the developed laboratory equipment helps to determine the rational ozonization regimes for zucchini seeds. It can also be used to determine the rational ozonization regimes for seeds of other crops.

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