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INFLUENCE OF CLIMATE CONDITIONS AND ELECTROMAGNETIC RADIATION ON THE PRODUCTIVITY OF THE BUCKWHEAT (*FAGOPYRUM ESCULENTUM* MOENCH.) IN BELARUS

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ABSTRACT

The influence of climatic conditions from 2017 to 2019 years and pre-sowing treatment with low-intensity electromagnetic radiation (EMR) in three modes (R), which differ in the exposure time of 20, 12 and 8 minutes on the sowing quality of seeds and the formation of productivity elements of the diploid buckwheat Kupava variety (*Fagopyrum esculentum* Moench.) is discussed in the article. Seed treatment was carried out at the Institute of Nuclear Problems of BSU. It was revealed that climatic conditions had a significant impact on germination, plant height, the number of productive shoots and the mass of 1000 seeds. The shifts after exposure by the EMR regimes in the parameters under discussion depended on the year of research. The additive effect of the individual EMR modes and climatic conditions on the formation of productivity elements of these buckwheat Kupava variety was established in 2018. The most optimal regime of EMR exposure for the Kupava variety of buckwheat which can be proposed in the technology of its industrial cultivation was revealed in the Republic of Belarus.

Key words: electromagnetic radiation, buckwheat, germination, survival rate, mass of 1000 seeds, mass of seeds per plant, productivity

INTRODUCTION

Increasing the production and productivity of agricultural products in the Republic of Belarus is a priority direction for the economic development of our country (Sazanowa 2012). Modern varieties of legumes and cereals crops cultivated in the Republic of Belarus have a high potential yield. However, in the production conditions of our country, it is not always possible fully realize their productive potential. In this regard, it is important to use all available reserves, among which methods of improving the quality of seeds are of particular importance (Erohin 1997). High-quality seeds material must have high germination and be free from pathogens (Babenko 1993).

Wildlife used natural electromagnetic fields (EMF) of the environment as sources of information, ensuring the organism's adaptation to environmental factors changes. This led to the EMF's use as the information carriers, providing interconnections at all levels of the hierarchical organization of living nature - from the cell to the biosphere (Chyornaya 2005).

Therefore, in recent years, studies aimed at scrutiny of the EMF's effect on seeds and the plant organism as a whole has become particularly relevant (Shish 2015). The seed of each plant contains in compact form genetic information about the future plant and a program for its development, instructions of responding to certain external factors (Chyornaya 2005). The seed is a complex formation, containing for all its smallness hundreds of thousands of cells. Each cell has thousands of sensors perceiving changes in the external and internal environment. As a rule the sensors "trigger" a complex of multi-stage reactions, the result of which is visible changes in the growth and development of plants.

Recent studies have shown that it is possible to achieve a positive effect by using electromagnetic and plasma methods for processing seeds and planting material of various crops (Sazanowa 2012; Kalje, Vliyanie 2010; Bingi 2003; Gerasimov 1993). According to the results of numerous studies, it has been shown that physical presowing, namely electromagnetic treatment (EMT) of seeds positively affects their sowing qualities, growth and development, plant resistance to adverse factors and, ultimately, the crop and its quality (Gerasimov 1993).

Presowing EMT in the most cases gives positive results and is of great importance in connection with adverse conditions for the formation of high-quality seeds. It is established that all types of electromagnetic radiation have a stimulation and inhibition zone, depending on the exposure dose when it exposed on plant seeds (Antonov 2012). Thus the widespread use of EMR is constrained by the lack of a clear understanding of the mechanism of its action and the low reproducibility of the processing results (Martinkov 2012). This can be explained by the lack of sufficiently deep theoretical and experimental studies of the mechanism of various physical factors action on seeds.

Buckwheat (*Fagopyrum esculentum* Moench.) is a valuable cereal and fodder crop, widely used in food, medical industry and agriculture (Maloizvestnye fakty…). However, in the Republic of Belarus, the territories occupied by its crops are declining. So over the past 3 years, buckwheat was grown on an area of the 14-20 thousand hectares. In the 60's of the last century, buckwheat was cultivated on an area of more than 300 thousand hectares, in the 70-80s – 100 thousand hectares, at the beginning of this century (2003-2012) – on an area of the 8 to 44 thousand hectares. In recent years, the cultivated area of this crop has decreased and in 2016 amounted to only 11.4 thousand hectares (Ministerstvo selskogo hozyaistva…). This is due to the low productivity and the extended vegetative period of this crop, because of which full grain does not have time to ripen. Therefore, it is important to search for the exposure methods that activate earlier and friendly germination, shorten the growing season. In this regard, it seems relevant to study the effect of electromagnetic radiation (EMR) on the agronomic quality of seeds and the final yield of the buckwheat diploid variety.

The aim of the work is to evaluate the effect of low-intensity electromagnetic radiation of the microwave range and climatic conditions on growth, development, formation of productivity elements and final productivity of the diploid buckwheat Kupava variety.

Objectives of work:

- to establish the effect of electromagnetic radiation and climatic conditions on field germination and survival of the control and experimental seeds of the buckwheat (*Fagopyrum esculentum* Moench.) Kupava variety in the field experiments of 2017-2019;
- to study the influence of EMR and climatic conditions on the growth processes of the Kupava variety of *Fagopyrum esculentum* Moench. in the field experiments of 2017-2019;
- evaluate the effect of electromagnetic radiation and climatic conditions on the formation of productivity elements (the number of productive shoots, the mass of 1000 seeds and the mass of seeds from the plant) diploid buckwheat Kupava variety in the field experiments of 2017-2019.

MATERIAL AND METHODS

The object of the study was the buckwheat (*Fagopyrum esculentum* Moench.) Kupava variety from the collection of the Scientific and Practical Center of the National Academy of Sciences of Belarus on agriculture. It is interesting to note that during the growth and development of the buckwheat, the following phases pass: seedlings, branching, budding, flowering, fruit formation and ripening (Elagin 1984; Nikolaev 1990, 2012; Vildflush 2005). However, the buckwheat characterized in that all phases, with the exception of seedlings, overlap one another and continue until the harvest itself (Elagin 1884; Yakimenko 1982). The Kupava variety belongs to mid-season one. It is included in the list of the most valuable varieties in quality of cereal crops (RUP…; Brestskaya…).

For research, buckwheat seeds of Kupava variety were treated with 3 modes (R) of electromagnetic radiation at a processing frequency of 64-66 GHz for 20 minutes (R2), 12 minutes (R2.1) and 8 minutes (R2.2). Processing of the buckwheat seeds with a low-frequency electromagnetic radiation of the microwave range was carried out using a laboratory installation in a wide frequency range (from 37 to 120 GHz) with continuously adjustable power from 1 to 10 mW (Fig. 1) at the Institute of Nuclear Problems of BSU (Pushkina 2012).

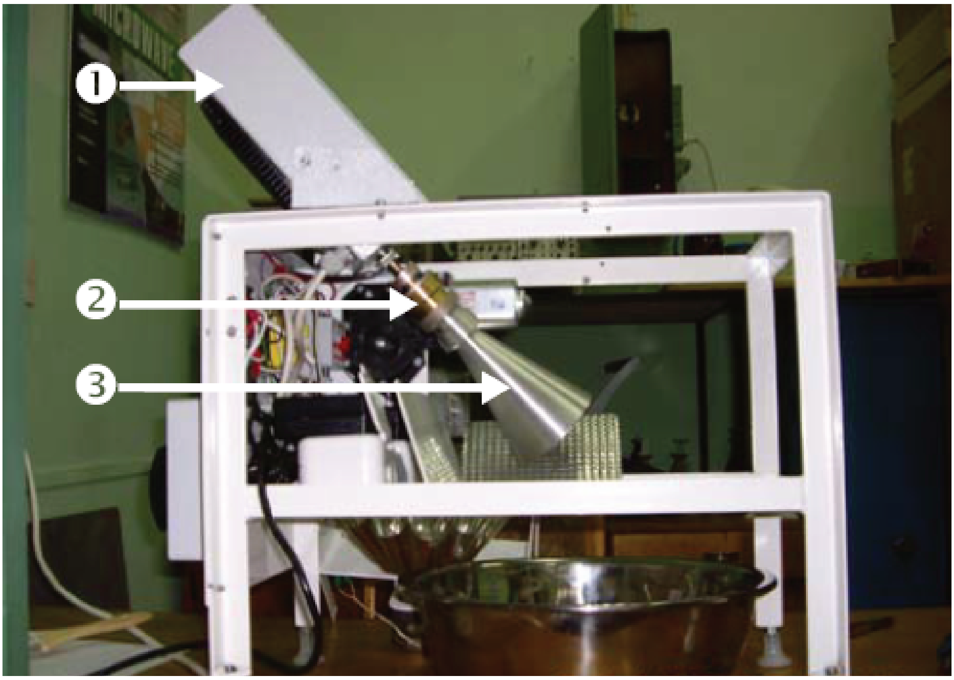

Fig. 1. Laboratory installation for microwave pre-sowing seeds treatment: 1 – microwave module; 2 – polarization converter; 3 – horn conical antenna

Source: Pushkina 2012

The installation (Fig. 1) consists of two microwave modules operating in different frequency ranges and consisting of a microwave generator with a tunable frequency and adjustable power, a valve and a horn pyramidal antenna, a loading hopper with a tray for loading and unloading seeds to be processed and rotating by the table. Despite the fact that the device uses two microwave modules for seed's treatment, their antennas emit linearly polarized waves with an uneven distribution of energy. In this regard, a certain amount of seeds are located on a rotating table in areas of weak values of the levels of electromagnetic fields, and additional time is required to ensure the specified processing conditions (Pushkina 2012).

Untreated seeds served as a control. The choice of EMR modes is due to previously performed theoretical and experimental studies (Karpovich et al).

The small-scale field experience was laid on the basis of the Zelenoe agrobiostation of the Maxim Tank Belarusian State Pedagogical University in 2017, 2018 and 2019 years. An experimental field was developed for the culture under study; plots of 1m × 100m in size (loamy soil) were divided. Seeds of buckwheat were planted 30 pieces in a row in four repetitions for each version of the experiment and control. The field germination, plant height during the growing season, the number of lateral shoots, the mass of seeds from the plant, the mass of 1000 seeds, and plant survival for the studied culture were taken into account during the experiment. Plant height was measured during the growing season (before mass flowering, during mass flowering, at the end of the growing season). Plant survival (the number of plants remaining at the time of harvesting) was calculated at the end of the growing season (Dospehov 1978). The buckwheat vegetation period covers – May – September and averages 123 days. In the field experience in 2017 the growing season of the buckwheat Kupava variety was 137 days, in 2018 – 131 days, in 2019 – 118 days.

Statistical analysis. The results were statistically processed using M. Excel, STADIA programs, and parametric tests were used: descriptive statistics, correlation (Dospehov 1978).

RESULTS AND DISCUSSION

It is important to note differences in meteorological conditions in the years of research. May 2017 was characterized by unstable temperature conditions and a precipitation deficit led to the loss of soil moisture, especially from the upper layers. June was characterized by unstable temperature conditions and a lack of precipitation in most of the country. Frosts observed at the beginning of June damaged buckwheat, corn, potato tops, and leaf surfaces of spring crops in some places. The average air temperature in July was +16 – +19°, which is mainly for 1° below the climatic norm. A moderate temperature regime and in most areas sufficient moisture supply contributed to the pouring of an ear of grain crops, seeds of cereals and legumes. The second decade of September was warm. The national average air temperature was +15.0°C (Belgidromet…).

May 2018 was characterized by an increased temperature regime (from +15° to +18°) and a precipitation deficit. The last one in combination with high temperature conditions caused an intensive loss of soil moisture. June 2018 was characterized by unstable temperature conditions (the average monthly temperature was +15.5°) and a precipitation deficit. July 2018 was generally warm and characterized by unstable weather with frequent rains. Already in the first decade, heavy rains eliminated soil drought. In August, warm weather prevailed on some days. September was characterized by the prevalence of warm summer weather.

May 2019 was characterized by cold weather in the first decade and the prevalence of warm weather in the second and third decades. The average temperature background was +8 to +13°, which is 1-5° lower than the average long-term values. The rains in May were short-lived. June 2019 was the warmest in the history of meteorological observations and was accompanied by a precipitation deficit. July and August were characterized by the prevalence of unstable cool and rainy weather (Belgidromet…).

Germination in a field experiment was evaluated on the 7^{th} day. This indicator was expressed as a percentage of germinated seeds to the total number of seeds in the sample (Alekseichuk 2005). Also, observations were made of the intensity of growth processes during the growing season, the ontogenesis stages time, taking into account the survival of plants, the formation of productivity elements (the number of productive shoots, the mass of 1000 seeds, the mass of seeds per plant), and yield.

A precipitation deficit and increased temperature regime had a significant impact on the values of the field germination of plants of the Kupava varieties (control) in May 2017-2019. It was noted that in 2017, R2 and R2.1 did not have a significant effect on the studied parameter of Kupava varieties (Fig. 2). Under the conditions of 2018 and the influence of EMR, the field germination values remained at the level of control values. An increase in germination under the influence of R2 and R2.1 was observed in 2019 on 7% and 5.2% relative to the control, but statistical methods have not confirmed the presence of significant differences with control.

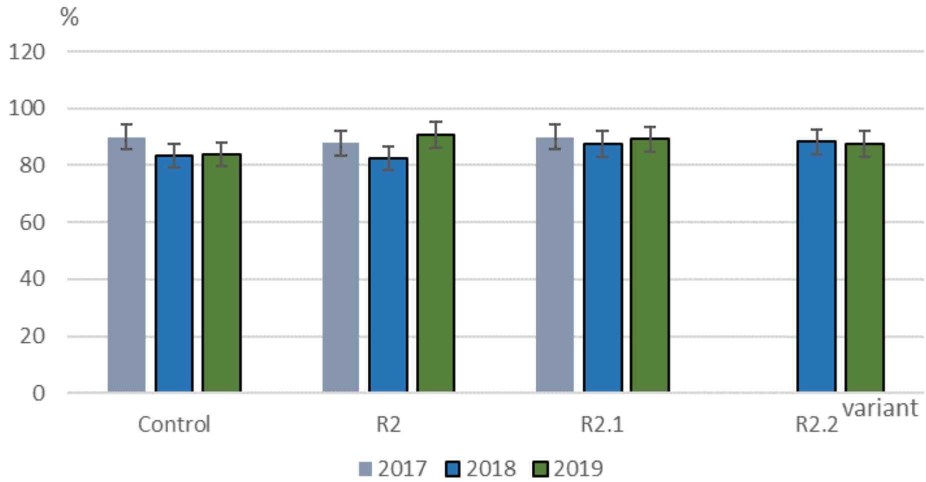

Fig. 2. Field germination of *Fagopyrum esculentum* Moench. Kupava varietiy in 2017-2019

Source: own research

The survival of the buckwheat plants of the Kupava variety under the conditions of 2017 and the EMR influence remained at the level of control values (Fig. 3). In 2018, under the influence of R2 and R2.2, survival increased on 9.5% and 8.6% relative to the control. Under the field experience of 2019, the diploid buckwheat plants survival of the Kupava variety remained at the control level.

The conditions of 2017-2019 were characterized by a deficit of precipitation in combination with an increased temperature regime, which caused a deficit of soil moisture. These conditions were reflected on the height of the plants and the number of lateral (productive) shoots of the buckwheat.

An increase in the final plant height by 10.3% (R2) and 14.2% (R2.1) was observed relative to the control under the influence of EMR in 2017 in the buckwheat of Kupava variety (Fig. 4). In 2018, it was noted that under the influence of R2.1, the height of plants increased by 8.5%, and under the influence of R2.2 it decreased by 11.4%. In 2019, an increase in the final height of the buckwheat plants of Kupava variety was observed by 7.2% (R2.1) and 9.9% (R2.2).

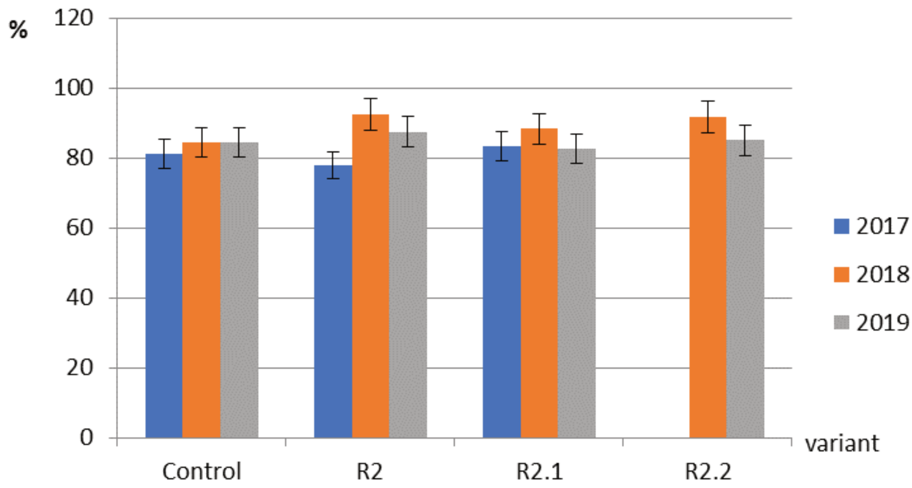

Fig. 3. Plant survival of *Fagopyrum esculentum* Moench. under the influence of EMR in the conditions of field experiments 2017-2019

Source: own research

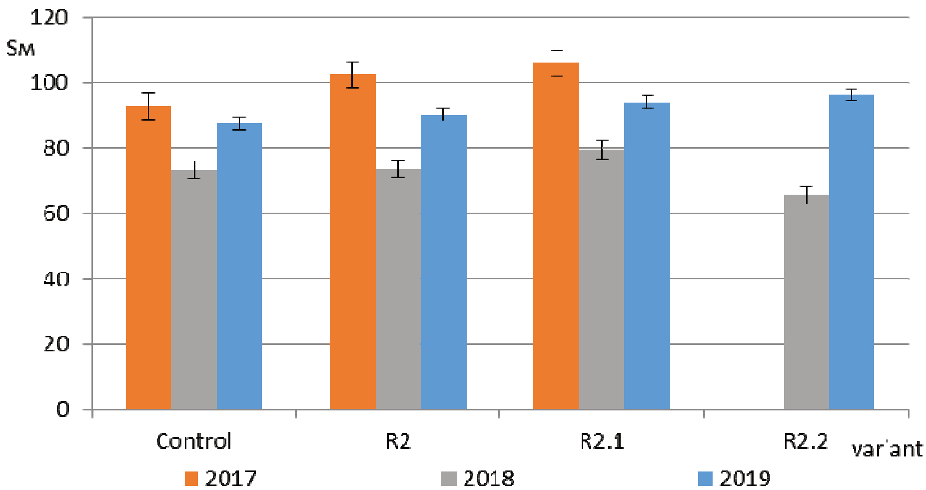

Fig. 4. The effect of low-intensity electromagnetic radiation on the height of buckwheat plants of the ordinary Kupava varieties in 2017-2019

Source: own research

It is established that in 2017 R2 stimulated the growth of the Kupava variety side shoots by 6% (Fig. 5). 2018 was characterized by an increase in the number of productive shoots relative to control values under the influence of R2 and R2.1 by 9% and 15%, respectively. In 2019, EMT did not affect this indicator of the buckwheat Kupava variety.

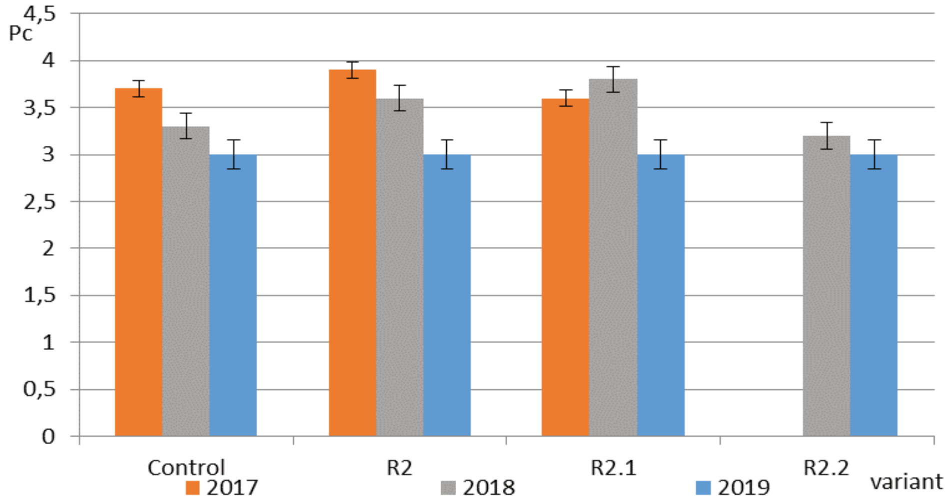

Fig. 5. The effect of EMR on the number of lateral (productive) sprout of ordinary buckwheat Kupava varieties

Source: own research

Sufficient temperature and moderate moisture supply in July 2017-2018 contributed to longer ripening of the buckwheat seeds.

It was established that under the influence of EMR in the conditions of 2017 the mass of 1000 seeds was at the level of control values of the Kupava variety (Fig. 6). It was revealed that under the influence of EMR modes, the values of 1000 seeds mass were at the control level for the studied variety in 2018. Under the conditions of 2019 and the influence of R2.1, an increase in the mass of 1000 seeds was observed on 6.1% in Kupava variety.

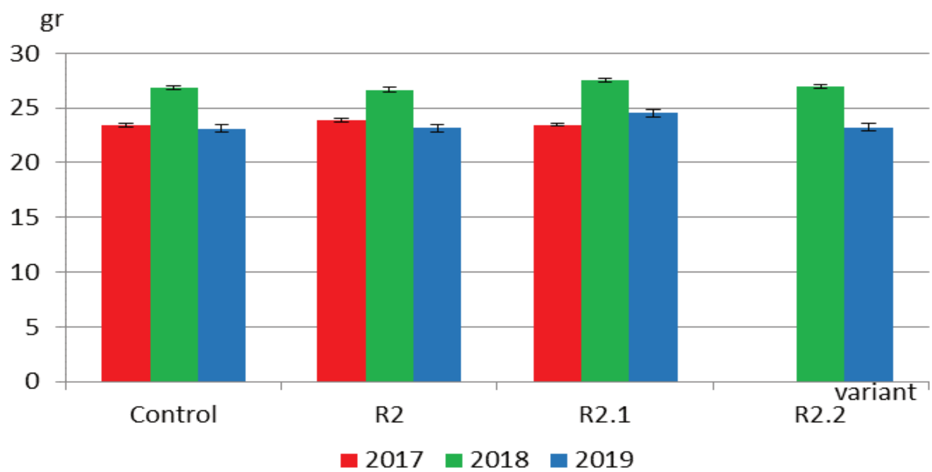

Fig. 6. The mass of 1000 seeds of the buckwheat Kupava variety under the influence of EMR

Source: own research

Heavy rains and moderate temperature in the late summer of 2018 contributed to a longer ripening of buckwheat seeds.

It was revealed that in the field experiment of 2017 the mass of seeds from the plant increased in the plants of Kupava variety treated with EMR in the case of R2.1 and R2.2 on 42.4% and 98% respectively (Fig. 7), but decreased under the influence of R2 on 11%. Grain immaturity was noted in the control samples. Under the conditions of 2019 and the influence of R2 and R2.1 a decrease in the seeds' mass from the plant was observed by 38% and 19%, respectively, and R2.2 increased the parameter under study on 86.5%.

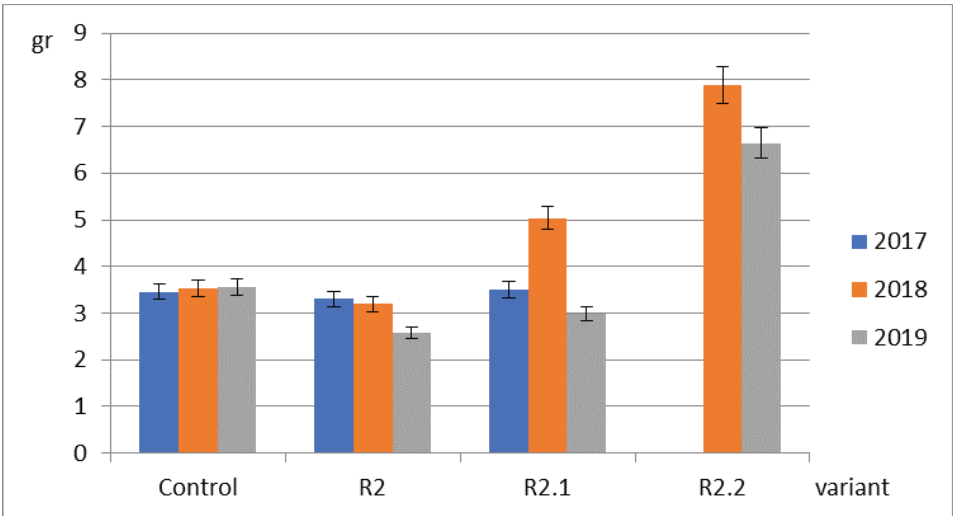

Fig. 7. The mass of seeds from plant of the buckwheat Kupava variety under the influence of EMR

Source: own research

It was noted that in the field experiment of 2017 under the influence R2.1 and R2.2 of EMR increased yield of the buckwheat Kupava variety on 21% and 16% respectively relative to the control. In 2018 R2.2 increased Kupava variety productivity on 61%. In 2019 under the influence of R2 and R2.1 the yield decreased on 34% and 22% respectively and under the influence of R2.2 it increased on 87% in this variety.

CONCLUSIONS

Thus, the selective reaction of buckwheat plants to the modes of electromagnetic exposure and weather conditions was noted. It was revealed that climatic conditions had a significant impact on germination, plant height, the number of productive shoots and the mass of 1000 seeds. The shifts after exposure by the EMR regimes in the parameters under discussion depended on the year of research. The additive effect of the individual EMR modes and climatic conditions on the formation of productivity elements of the buckwheat Kupava variety was established in 2018. The most optimal regime of EMR exposure for the Kupava variety of buckwheat was R2.1. It can be proposed in the technology of industrial cultivation of the buckwheat Kupava variety in the Republic of Belarus. It would be unfair not to mention that fact the type of pre-sowing treatment of seeds is specific and must be taken into account when recommending it for the industrial cultivation of any crop including buckwheat.

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SUMMARY

Increasing the production and productivity of agricultural products is a priority direction for the economic development of each country. Recent studies have shown that it is possible to achieve a positive effect by using various impact methods on seeds and plants in general for the most complete realization of the genetic potential inherent in plants. Many positive reviews received electromagnetic and plasma methods for processing seeds and planting material of various crops (Babenko 1993; Chornaya 2005; Shish 2015; Bingi 2003). But the widespread use of EMR is constrained by the lack of a clear understanding of the mechanism of its action and the low reproducibility of the processing results (Martinkov 2012). The object of the research is buckwheat (*Fagopyrum esculentum* Moench) Kupava variety. Buckwheat is a valuable cereal and fodder crop, widely used in food, medical industry and agriculture. However, in the Republic of Belarus, the territories occupied by its crops are declining. This is due to the low productivity and the extended vegetative period of this crop, because of which full grain does not have time to ripen. Therefore, it is important to search for the exposure methods that activate earlier and friendly germination, shorten the growing season. In this regard, it seems relevant to study the effect of electromagnetic radiation (EMR) on the agronomic quality of seeds and the final yield of the buckwheat diploid variety. For research, buckwheat seeds of Kupava variety were treated with 3 modes (R) of electromagnetic radiation at a processing frequency of 64-66 GHz for 20 minutes (R2), 12 minutes (R2.1) and 8 minutes (R2.2) at the Institute of Nuclear Problems of BSU. Untreated seeds served as a control. The experience repetition was four. The results were statistically processed using M. Excel, STADIA programs, and parametric tests. The small-scale field experi-

ence was laid on the basis of the Zelenoe agrobiostation of the Maxim Tank Belarusian State Pedagogical University in 2017, 2018 and 2019 years. The field germination, plant height during the growing season, the number of lateral shoots, the mass of seeds from the plant, the mass of 1000 seeds, and plant survival for the studied culture were taken into account during the experiment. The buckwheat vegetation period covers – May – September and averages 123 days. In the field experience in 2017 the growing season of the buckwheat Kupava variety was 137 days, in 2018 – 131 days, in 2019 – 118 days. The duration of the vegetation period was largely determined by the climatic conditions. It was established that an increase in germination under the influence of R2 and R2.1 EMR was observed only in 2019 on 7% and 5.2% relative to the control. An increase in survival has been identified only in 2018 under the influence of R2 and R2.2 on 9.5% and 8.6% relative to the control. The height of the buckwheat Kupava variety plants changed most significantly under the influence of both the climatic factor and EMR. Changes in the number of lateral shoots under the influence of electromagnetic radiation regimes depended on climatic conditions. Shifts in the mass of 1000 seeds were noted only in 2019 under the influence of R2.1 on 6.1%. It was revealed that in the field experiment of 2017 the mass of seeds from the plant increased in the plants of Kupava variety treated with EMR in the case of R2.1 and R2.2 on 42.4% and 98% respectively, but decreased under the influence of R2 on 11%. Under the conditions of 2019 and the influence of R2 and R2.1 a decrease in the seeds' mass from the plant was observed by 38% and 19%, respectively, and R2.2 increased the parameter under study on 86.5%. It was noted that in the field experiment of 2017 under the influence R2.1 and R2.2 of EMR increased yield of the buckwheat Kupava variety on 21% and 16% respectively relative to the control. In 2018 R2.2 increased Kupava variety productivity on 61%. In 2019 under the influence of R2 and R2.1 the yield decreased on 34% and 22% respectively and under the influence of R2.2 it increased on 87% in this variety. It was established that the most optimal regime of EMR exposure for the Kupava variety of buckwheat was R2.1. It can be proposed in the technology of industrial cultivation of the buckwheat Kupava variety in the Republic of Belarus.