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WAYS TO INCREASE THE YIELD CAPACITY OF WINTER WHEAT AND SPRING BARLEY ON THE BASIS OF APPLYING PRE-SOWING SEED IRRADIATION WITH EXTRA HIGH FREQUENCIES MICROWAVE FIELD IN THE CONDITIONS OF EASTERN FOREST-STEPPE OF UKRAINE

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СПОСОБИ ПІДВИЩЕННЯ ВРОЖАЙНОСТІ ПШЕНИЦІ ОЗИМОЇ ТА ЯЧМЕНЮ ЯРОГО НА ОСНОВІ ЗАСТОСУВАННЯ ПЕРЕДПОСІВНОГО ОПРОМІНЕННЯ НАСІННЯ МІКРОХВИЛЬОВИМ ПОЛЕМ НАДЗВИЧАЙНО ВИСОКИХ ЧАСТОТ В УМОВАХ СХІДНОЇ ЧАСТИНИ ЛІСОСТЕПУ УКРАЇНИ

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The theoretical generalization and new practical solution of an important scientific problem regarding the improving and increasing the ecologically friendly technologies of winter wheat and spring barley cultivation in the Eastern part of the Forest–Steppe Zone of Ukraine by applying the pre-sowing microwave irradiation of seeds instead of chemical treatment have been done in the work. Based on the research the optimum modes of seed irradiation with the extra-high frequency microwave field (MWF of EHF) have been established. The irradiation was carried out using the installation of a microwave design of the "UMVK-1" brand developed by Kharkiv National Technical University of Radio Electronics in the following modes: in the range of 2,4–3,4 GHz with an energy consumption of 0,9 kw per 1 kg of seed at an exposure of 45 seconds or 1,8 kw per 1 kg of seeds at an exposure of 15–20 seconds depending on the crop. Such irradiation facilitates the increase in the sprouting energy, germinating power of seeds, and yield capacity. The ecologically safe methods of the complex pre-sowing seed treatment with MWF of EHF in combination with the plant growth regulators and reduced rates of a treatment agent have been developed.

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CONTENT

INTRODUCTION

Increasing the crop yield capacity and improving the product quality are one of the most important tasks for agricultural scientists in many countries all around the world. Cereal crops form the basis of the agricultural production. They are the most valuable and most common in the world among all field crops. The cereals and legumes make up about 70% in the structure of food products. Grain production in the world is increasing mainly due to the improvement of varietal resources and the modernization of zonal technologies for growing cereals, including wheat, barley, rye, and oats.

Wheat always has been and still remains the leading grain crop in the world and in Ukraine. The total area under this crop occupies about 240 million hectares in the world and 7 million hectares in Ukraine. In 2017 the world wheat production amounted to about 750,1 million tons, and in Ukraine it was 21 million tons. It is natural that wheat is a staple food product in 43 countries with a population of more than 1 billion people [1].

The total share of Ukraine in the world production of spring barley grain is about 8,2 % [2, 3]. Barley is an indispensable component for the production of mixed feed and raw materials for the food and brewing industries.

In Ukraine the stable grain production in the second half of the 1990s was characterised by an average annual bulk yield of 50–52 million tons, which is almost 1000 kg per capita [4, 5]. However, the sharp climatic changes (mostly in the form of temperature rise, a tendency that has been observed in the last two decades) have led to fluctuations in agro-meteorological conditions for growing cereal crops. During the droughts of 2008–2009 the world wheat grain production decreased significantly. The drought in these years has affected the countries that are the main exporters of grain, namely Australia, Argentina, Brazil, Canada, and Eastern Europe as well as Ukraine. As a result the global demand for food grains has increased. Only during the last seven years the food grain shortage has constituted 310 million tons on the average [6]. Therefore, grain production has been and still remains a priority in agricultural development.

The world experience shows that in the countries with high levels of agro-technical support the increase in grain yield reaches a critical limit. The use of “intensive” technologies in agricultural crop production since the 1980s of the last century has led to a sharpening of the contradictions between the economy and the environment. The intensive application of pesticides and mineral fertilizers in agriculture, including chemicals for the pre-sowing seed treatment, and increasing the productivity of plants inevitably cause a number of undesirable effects of ecological and economic characters.

One of the obligatory elements of the technological process of cultivating cereal crops, which affects the increase in the yield and quality of crop production, is the pre-sowing treatment of seeds with chemical and biological products of different origin. But today in Ukraine the problem of seed sanitation and selection of the most viable biotypes with high productive properties by the pre-sowing treatment with the ecologically friendly methods have not yet been solved.

The search for new alternative methods for seed disinfection in order to reduce the negative influence of agrochemicals on the environment has been recently carried out in Ukraine and abroad. The physical methods such as the treatment with ozone, microwave and ultrasonic radiation, etc. are of great interest [7, 8, 9, 10].

One of the most ecologically friendly and cost-effective methods of pre-sowing seed treatment is irradiation with extra-high frequency microwave field (MWF of EHF). Along with the physical method of seed treatment with the microwave field, the plant growth regulators and biological preparations which are used to increase the resistance of plants to the adverse factors and the yield capacity of many crops have become widespread in the agricultural practice [11, 12].

The results of the researches presented in the paper and their introduction make it possible to improve the methods of the pre-sowing seed treatment as an important element of increasing the realization of biological potential of cereal crops in the complex of agro-technical measures for winter wheat and spring barley cultivation while reducing the pesticide loading on the environment.

In the last decades the researches on stimulation and disinfection of the seeds using various pesticide-free methods, including physical factors, namely thermal energy, ozone, electromagnetic fields, etc. have been carried out in Ukraine and abroad. According to M.M. Havryliuk, M.O. Kindruk, and Yu. F. Melnyk [13, 14, 15] the influence of any of these factors on the seed as a biological object is manifested through the activation of the enzyme systems, which plays an important role in the destruction of phyto-pathogenic microorganisms, inactivation or inhibition of their development without using chemicals for the formation of sowing and productive qualities.

One of the modern methods of the pre-sowing seed treatment that has a positive effect on its sowing qualities is the irradiation with the microwave field (MWF) of extra-high frequency (EHF). The perspective of this method is the ecological safety and low energy costs. The mechanisms of seed stimulation are still poorly understood, especially regarding the questions about the response of the seed to microwave treatment depending on the conditions of its cultivation. There is almost no information on the efficiency of the pre-sowing seed treatment with a microwave field irradiation in combination with the subsequent incrustation with the mixtures of chemicals, plant growth regulators and biological preparations.

The following topical issue has been the basis of the research when working at this paper: to develop the ecologically friendly ways to increase the yield capacity of winter wheat and spring barley in the Eastern Forest-Steppe Zone of Ukraine by the pre-sowing irradiation of cereal spike seeds with a microwave field of extra high frequencies and its subsequent processing with plant growth regulators and seed treatment agent Vitavax 200 FF.

To achieve this goal it was necessary to solve the following problems:

1. To carry out screening of the modes for the microwave irradiation of winter wheat and spring barley seeds; to identify the optimum parameters that positively affect the sprouting energy and germination.

2. To determine the regularities of growth, development, formation of productive plant stand and basic elements of winter wheat and spring barley yield structure under the influence of the seed irradiation with

MWF of EHF and its subsequent processing with the plant growth regulators and chemical disinfectant.

3. To determine the degree of winter wheat and spring barley crops infection caused by the diseases during the vegetation period depending on the action of MWF of EHF in combination with the seed treatment and processing with the plant growth regulators.

4. To determine the influence of the pre-sowing seed irradiation with the microwave field of extra high frequencies in combination with the growth regulators and biological preparations treatment on the productive and the sowing qualities of seeds and the quality of winter wheat and spring barley commercial products.

5. To determine the economic efficiency of spring barley and winter wheat cultivation when using the ecologically friendly ways to increase the yield capacity on the basis of MWF of EHF.

CHAPTER 1. PRE-SOWING TREATMENT OF SEEDS AS AN OBLIGATORY ELEMENT OF TECHNOLOGIES FOR WINTER WHEAT AND SPRING BARLEY CULTIVATION (literature review)

1.1. Peculiarities of modern technologies of winter wheat and spring barley cultivation in the Eastern Forest-Steppe Zone of Ukraine

Cereal crops form the basis of human food production. The cereals are the most valuable and most common crops among all other field crops in the world where there is the crop farming. According to the sowing area, wheat occupies the first place in the world, and rice ranks the second place [16].

Obtaining high and stable grain yields depends on a number of factors and techniques needed to grow crops, beginning from soil preparation and sowing to harvesting.

Different technologies of winter wheat and spring barley cultivation are used in the modern plant growing of Ukraine; the most known of them are the intensive, resource-saving, biological (organic) and No-till ones.

It is the structure of the technology that influences the economic indices, the ecological situation and the soil condition. The main elements of cereal crops cultivation technologies are scientifically grounded crop rotations, the use of high-productive, adapted to the specific environmental conditions, resistant to lodging and seed shedding varieties as well as providing the plants with nutrients and protecting them from the diseases, pests and weeds [17]. All agro-technical techniques of spike crops cultivation should be rigidly differentiated depending on the soil and climatic conditions of the growing zone [18, 19].

The optimum selection of the best predecessors in crop rotation and their alternation allow regulating the nutritional and water regimes of the soil, which have a positive influence on the yield capacity and grain quality [20].

High and stable winter wheat yields in the Forest-Steppe Zone are provided by such predecessors in crop rotation as the fallow lands, perennial grasses for one mowing, vetch and oats mixtures for the green fodder and hay, corn for the green fodder, and peas for grain. It is also possible to sow cereals after buckwheat, oats, and sunflower.

Due to the proper placement of spring barley in the crop rotation, its yield capacity increases up to 37% on the average [21]. The best predecessors in crop rotation on the black soil are the hoed crops, namely sugar beet or corn for grain. It is not desirable to reseed brewing barley with the perennial legumes, as this leads to an increase in the protein content and a decrease in the starch content in the grain [22, 23, 24, 25, 26].

Improving the productivity of modern winter wheat and spring barley varieties in the conditions of unstable moisture depends on the rational use of mineral fertilizers. The terms and rates of the fertilizers applying are adjusted to weather conditions and vegetation phases. The optimum ratio of the separate elements is determined taking into account the agrochemical properties of the soil and the coefficients of nutrient removal by the cultivated plants [27, 28].

According to the scientific data the share of the fertilizers in the yield formation is 30–40%, which is much higher than the share of the seeds, plant protection measures or soil tillage [29].

When growing according to the intensive agricultural technology, winter wheat requires more nitrogen fertilizers than other crops. The potassium fertilizers in the whole amount, the main part of phosphorous fertilizers and 20–30% of nitrogen fertilizers from their total amount are applied before the basic tillage of the soil, since under their simultaneous embedding the efficiency increases 1,5 times in comparison with their separate application [30, 31].

Due to the significant leakage of the nutrients into the deeper soil layers the conducting of spring nitrogen fertilization of winter crops at a total rate of 100–130 kg/ha of active substance is a very important and obligatory measure [23, 32].

To obtain the winter wheat grain meeting the requirements of 1–-2 grades of quality, the optimum nitrogen nutrition at the beginning of the growing season and especially during the period when the intensive protein synthesis in the caryopsis is taking place is necessary. The basic application of the fertilizers and early spring nourishment contribute to the increase in the yield, but in most cases they do not provide plants with nitrogen enough to form high protein grains. It is possible to improve the grain quality due to the additional foliar fertilizing of plants with a solution of urea or urea and ammonia mixture at the rate of N_{15}-N_{20}, which allows to increase the content of crude gluten by 1,0–1,5 %. [23].

Spring barley is very fastidious as for the soil fertility, which is explained by the short vegetation period (up to 100 days) and the super-fast assimilation of nutrients, as well as by the underdeveloped root system with the low assimilation of inaccessible forms of nutrient compounds especially in the initial periods of growth and development. Therefore, an important condition for the intensive growth and development of the plants is their sufficient supply with the readily soluble compounds of nutrients at the initial stages of ontogenesis and application of the fertilizers under the barley crops beginning from the sprouting and to the stalk shooting.

Mainly simple mineral fertilizers such as ammonium nitrate, urea, ammonia water, ammonized superphosphate, and also the compound fertilizers, namely nitro-ammophoska, super-agro and others are applied into the soil under the spring barley crops before the pre-sowing tillage. The compound mineral fertilizers have the advantage when applying into the rows simultaneously with the sowing. For this purpose nitro-ammophoska, super-agro, nitrophoska, ammophoska and other fertilizers are applied. The compound mineral fertilizers of a pair combination (super-agro of $N_{20}P_{10}$ brand, ammophos of $N_{12}P_{50}$ brand, and ammophosphate $N_{16}P_{20}$ brand and others) are applied in the soils with high content of the exchange potassium [33, 30, 32].

The application of nitrogen at the early phases of plant development contributes to the accumulation of carbohydrates in the grain, and later (from the ear formation phase to the ripening one) it contributes to the accumulation of protein. But according to some authors any rate of nitrogen increases the protein content in the grain more than the yield capacity, especially on the black soils [34, 35, 36, 37, 38]. But other authors consider that nitrogen fertilizers are the most effective on the black soils [40]. Thus, with sufficient moisture the yield capacity increases sharply and the quality of the grain changes slightly; and in the years of droughts the reverse process is observed. Low rates of fertilizers help to increase the grain size, which is important for its brewing properties [30, 41].

The main task of soil tillage for the winter crops in the arid conditions of the autumn period is the accumulation and preservation of 20–30 mm of productive moisture in the arable layer of the soil in order to obtain even seedlings and subsequent tillering [42].

The modern soil tillage systems are an important component of the cultivation technology. The exacerbation of the environmental problems in

Ukraine and in several countries of the world dictates the necessity to look for the alternative crop farming methods. These are the transitional systems of crop farming, namely the grain, green manure, rotation cropping system, and grassland ones [42].

The saturation of crop rotations with the cereal crops which is characteristic of the intensive technologies, has led to a significant decrease in the soil fertility, weed infestation of the crops, and deterioration of the water regime of nourishment [43].

Surface soil tillage facilitates the more intensive work of cellulose-destroying bacteria, which increases the formation of the available nutrients for the plants, and therefore increases the reserves of the productive moisture and nutrients in the soil through the crop residues left in the field. At the same time the economic and energy indices of productivity are improving, but the crop infestation with the weeds, especially with the perennial offset weeds is increasing [44].

In the system of basic soil tillage for the spring barley crops the ploughing at the depth of 20–22 cm is carried out immediately after harvesting of the predecessor, namely the hoed crops; and the preceding soil disking is necessary after growing corn for grain aimed at better embedding of the crop residues [45].

After the soil mellowness in the spring the harrowing is done in order to save the water in the soil and then the pre-sowing tillage is carried out in the case of spring barley.

It is very important to prepare the soil for sowing in a quality and timely manner; it is an important element of the resource-saving technologies [27].

The pre-sowing soil tillage for all crops, and especially for the early-spring crops, should contribute to the maximum preservation of water and the destruction of weeds [33].

The proper selection of a variety takes an important place in the technology of growing winter wheat and spring barley in the conditions of the Forest–Steppe Zone of Ukraine. By selecting the most valuable varieties it is possible to significantly improve the yield capacity and quality of winter wheat grain [27, 46-50].

For the successful cultivation of spring barley it is necessary that the selected variety should have a number of characteristics that correspond to the soil and climatic conditions of the zone (drought resistance, length of the vegetation period, disease resistance, resistance to lodging, plant height, etc.) [51].

To obtain the high yields of winter wheat and spring barley it is necessary to provide the optimum number of plants and productive stems per unit area, which is achieved by the appropriate seeding rate depending on the cultivation area, the level of crop farming culture, the rate of fertilizers, soil fertility, variety and other factors [27]. The optimum plant density and sufficient number of nutrients in the soil are the most important conditions on which the sowing productivity depends [52, 53, 54]. It is known that the optimum seeding rate for the Forest–Steppe Zone is 4,0–5,0 million pieces/ha, but it can vary from 3,5 to 5,5 million pieces/ha. The seeding rate of spring barley in production varies from 3,0 to 7,0 million pieces/ha depending on many factors [27].

Timely sowing provides the most favourable conditions for the development of plants and the use of all factors in order to obtain a high grain yield with the best quality indices [55].

Over the past 10 years the tendencies regarding the rise in temperature have accelerated. According to the Kharkiv Regional Center for Hydrometeorology the average daily temperature in the region over the 17 past years has increased by 0,7–2,5 ºC depending on the month in comparison with the average data for the period of 1951–1993. The average daily air temperature in July–November (especially in October and November) also increased significantly during the above-mentioned period.

A rise in the sum of effective temperatures (above +10 °C) ranges from 5,1 °C in July to 103,7 °C in August. During the periods of sowing, sprouting and autumn development of winter plants (September–October) this index was 22–35 ºC above the norm [33].

In this connection the optimum sowing dates for winter wheat have shifted to a later period: from the 5th to the 20th of September, and the admissible dates are until the 25th of September [33].

The sowing of spring barley begins early in the spring when the mellowness of the soil is reached. One day delay from the optimum time leads to a shortage of 0,05–0,1 t/ha of grain, and in the arid spring the shortage increases by 2–3 times [33, 55].

The integrated plant protection from the weeds, pests and diseases is one of the priority tasks of the agricultural techniques complex that provides the fullest usage of the biological and climatic potential and genetic possibilities of the variety [56–59].

Its basic principles are as follows:

– high level of agricultural technology which provides the formation of healthy plants;

– use of varieties resistant to the adverse conditions;

– taking into account the economic thresholds of harmfulness.

This fact gives the opportunity to narrow the gap between the potential and actual plant productivity. The introduction of the integrated protection system provides obtaining the additional high quality grain yield up to 0,5–1,6 t/ha while reducing the application of chemicals by 15–30. At the same time the application of the biological stimulants is advisable [59, 60].

The methods for the protection of winter wheat and barley spring agro-biocoenosis are being sought; they suggest a significant reduction in the pesticide application. Thus, in the researches regarding the Myronivska 61 variety (1992–1995) the pesticide protection system (5 chemicals) provided an increase in the yield by 0,77 t/ha, and an alternative system (the use of the growth regulators and biological preparations AGAT-25, Biomix, Rizoplane and Tour as well as the Dialen herbicide) not only reduced the growth, but also provided its increase of up to 1,08 t/ha [61].

According to the Myroniv Institute of Wheat named after V.M. Remeslo of the National Academy of Agricultural Sciences the yield capacity under the common technology (without applying pesticides) was 5,79 t/ha, and under the intensive technology (7 chemicals) it increased up to 6,92 t/ha, and under the resource-saving technology, when two pesticides were used, the yield capacity decreased by only 0,22 t/ha and amounted to 6,7 t/ha [62].

The research carried out by V.V. Likhochvor showed that in 1991–1993 while using the intensive technology, the yield capacity was 7,23 t/ha on the average, and while using the resource-saving technology it was 7,16 t/ha [63]. In the latter technology the rate of the fertilizers is reduced by half, and only the chemical preparations Dialen and Retardant Tour have been applied.

The most important feature of the intensive technologies today is the biologization of the technological processes; it is the use of the crop rotation opportunities, variety, rational fertilization system, integrated plant protection, soil preparation depending on its fertility, as well as the use of plant growth regulators [62–71].

The pre-sowing seeds infestation with the chemical plant protection agents or seed treatment is one of the obligatory elements of all technologies of growing the cereal crops in the Eastern Forest–Steppe Zone of Ukraine.

Seed treatment is an effective way of protecting plants from the seed and soil infections, and at early stages of plant development it is a measure preventing the aerogenic infection [57, 58]. However, as a number of the results of the scientific researches and the experience of their practical use indicate, the chemical measures of protection should be limited, and they can be used only if objectively necessary [23].

Over the last 30 years the significant increase in the yield capacity of the agricultural crops while using the intensive technologies has led to a threatening environmental problem, namely a contradiction between the economy and the environment. The widespread application of the fertilizers and chemicals for the protection of plants against the pests, diseases and weeds has caused the environmental pollution, and as a result there were the deterioration of the quality of the crop production and a negative impact on human health [72].

In this connection today the pre-sowing seed treatment is one of the most important methods directed at the relatively smaller number of the applied active substances providing the necessary crop protection and it has the greatest protective effect against a wide range of the pathogens and insect pests.

The pre-sowing seed treatment is interesting not only from the standpoint of economy, but also it is interesting from the standpoint of ecology: in comparison with spraying the area under cultivation is significantly reduced. For example 10,000 m^2 of soil is processed when spraying 1 hectare; at the same time the active substances are applied in a continuous manner while under the soil treatment the area is significantly reduced.

In addition the seed treatment influences the objects not having a special purpose to a less extent; it is not wind-blown, that is, less weather dependent and is an important element of the integrated plant protection.

At the same time despite all the advantages over other methods of pesticide application, the pre-sowing treatment of seeds with the chemical disinfectants remains a source of the environmental pollution in Ukraine.

1.2. Theoretical bases, tasks and development of technologies of pre sowing seed treatment in Ukraine

The history of the world agriculture shows that fungi, bacterial and viral diseases, weeds, harmful insects and nematodes can dramatically reduce the gross production and product quality, and in some cases even completely destroy the crop. According to FAO the world crop losses of basic crops caused by the harmful organisms amount to 21% regarding the diseases; the losses caused by the pests constitute 11%, and in the case of weeds this figure reaches 24 % [73].

In Ukraine, the average annual crop losses caused by the diseases, pests and weeds make up 20–30 %; in the case of wheat it is 27 %. Therefore, even partial loss prevention is an important factor in significant improvement of the crop productivity.

According to the Institute of Plant Protection of the National Academy of Agrarian Sciences of Ukraine, the fungi of the *Alternaria, Fusarium, Drechslera, Bipolaris, Penicillium* genera and others are present on the seeds [74]. Very often there are two or more types of fungi on one seed, but the features of their development are quite different, so they do not allow introducing the thresholds of harmfulness [75, 76].

The phytosanitary situation is so unpredictable that to leave the seeds thrown into the soil without treatment, means to brush 60–70% of the future yield aside. The pathogenic organisms that are capable of generating a number of plant diseases at the initial stage of plant development and growth, most notably bacterioses and mycoses, cause the most significant losses to the farmer [77].

For the first time the seed treatment (probably with sodium chloride) against Common smut of wheat was described by Remnet in 1637. In 1733 Briton Tell mentioned the treatment of cereal crops seed with the salty seawater. It happened by accident. In 1660 a ship carrying a load of wheat sank near Bristol. Some of the grain was rescued but, since it had been soaked in the salt water, it was not ground into flour, but used as the sowing material. So the peasants noticed a profitable difference between "salty" and ordinary crops [78].

In addition to copper, mercury compounds and formaldehyde, quite a large number of the chemical compounds (acids, alkalis, salts of light and heavy metals, phenols, cresols, resins, organic paints, and the substances that released active chlorine) were used as the treatment agents. On the 1st of September 1926 the "Plant Protection Service" of Germany made a list of 14 trade marks deserving the attention (in general, the Germans began to hold such a competition since 1923). Essentially, it was the first recommended list of the treatment agents, a prototype of our domestic "List…" [79].

Dry, semi-dry, wet seeds and wet treated seeds are used in practice depending on the preparation, the biology of the pathogen, the structure and other features of the seeds [77, 78, 81–85].

The dry disinfection is the uniform application of dry powdered preparations to the seed surface. The advantages of this method are the easiness of execution and the disadvantages are the poor technical efficiency due to poor adhesion of the treatment agent to the seed and keeping on it. This method is the most ecologically dangerous and leads to the significant environmental pollution [86].

The semi-dry treatment is the application of water suspensions or disinfectant solutions to the surface of the seeds at the rate of 20–30 L/t, followed by 3–4 hours of soaking, ventilation and drying. The advantage is the high efficiency of infection elimination and the disadvantages are the increase in water content in the seed, considerable labour intensity and low productivity [86].

The wet treatment involves strong moistening or soaking in a liquid (solution, suspension, or emulsion) of the treatment agent, followed by 2-hour soaking, ventilation, and drying. The advantage of this method is the high technical efficiency, and the disadvantages are the necessity for further drying, and high labour intensity [86].

Nowadays in many countries of the world the seed treatment is not only a necessary but also a legally obligatory measure of agricultural crops protection. According to the Irish experts up to 50% of winter wheat seedlings in the region die because of the root rots since they were not treated before sowing [81].

The treatment with the modern preparations makes it possible to disinfect the seed from the external and internal infection, protect it and the seedlings from the soil pathogens, as well as to reduce the negative effect of traumatic injury due to the activation of its protective properties and prevent the pathogens development [78].

Back in the 80's of the last century, unlike the existing technologies of the pre-sowing seed treatment, more ecologically-friendly technologies were developed. The technology of the pre-sowing seed treatment called "incrustation" was developed at the Plant Production Institute named after V.Ya. Yuryev. It combined the treatment itself and creation of a protective seed coat [82]. The efficiency of treatment under this technology is substantiated not only by the influence of the treatment agent, but also by the formation of a protective coating on the surface of the seed, which prevents the access of soil microorganisms to the seeds through the micro-trauma of the endosperm or germ.

According to the authors of the researches carried out using the Vitavax 200 FF and Raxil Extra seed treatment agents, the development of root rots at the stage of autumn tillering of winter wheat in the cases without any treatment was higher than the economic threshold of harmfulness (ETH); it was in the range of 18,5–19,7 %. In the arid years in the cases when using the Vitavax 200 FF and Raxil Extra treatment agents this figure was lower by 15–34 % respectively, and in the humid years it was 60–65 % lower. Thus, when sowing the treated seeds, the development of root rots was lower or close to the economic threshold of harmfulness [83].

Some researchers point out that the fungicides contribute to the growth and development of plants, while others in their work show a negative influence of systemic fungicides on germination and the intensity of the initial plant growth [84]. M.I. Zazimko and others indicate that during the researches carried out for 11 years with 47 field experiments, only 12 of them gave the significant increase in the crop yields after the pre-sowing treatment of winter wheat seeds [85].

At the same time the treatment agents provide quite effective protection of plants at the beginning of the vegetation period but remaining a source of the environmental pollution; they are absorbed by the grain and stored products and have a negative affect on human health [86].

According to a number of authors the use of chemicals for the pre-sowing seed treatment inhibits the vital activity of the germ, weakens the productivity of plants and creates an environment for lowering the immunity during the vegetation period [87, 88]. Such measures are not compatible with the environment and the quality of food products.

Therefore, the problem of developing and researching new ecologically friendly methods for the pre-sowing seed treatment allowing to minimize the energy costs and to achieve an increase in the yield capacity is still quite urgent. Particularly in Ukraine, almost all territory of which is declared a zone of environmental disaster, the widespread use of chemicals can lead to the unpredictable results [89].

In practice there is a separation of the pre-sowing treatment methods depending on the functions they perform. To activate the growth processes in the seeds the electro-physical methods are used; to remove the viral infections and at the same time to improve the sowing qualities the thermo-chemical methods are used; to sanitise the seeds from the fungal and bacterial pathogens the chemical method is preferred [90].

Among the ecologically friendly methods of the pre-sowing seed treatment are the thermal methods that are applied to the seeds of different agricultural crops in order to increase their germination and reduce the infection caused by the pathogenic microflora. This type of action includes the hydrothermal treatment of seeds and stratification (keeping the seeds at a constant temperature for a long period).

Due to the heat treatment of seeds (1–2 hours at a temperature of 70–80 °C) their infection with the virus, alternaria blight, bacteriosis and phomosis decreases; the germinating power and sprouting energy increase.

The seed treatment with the heated steam at a temperature of 150°C also improves the germinating power. But the disadvantage of the thermal method is the processing time of the sowing material (from several hours to several months), as well as the high energy intensity and multistage process [91].

The photo-energy methods, which are used to stimulate the growth processes, are applied both to the seeds and to the vegetative plants. The pre-sowing seed treatment with the pulsed focused solar irradiation increases the yield capacity up to 11 %, and treatment of the vegetative plants increases the intensity of the photosynthetic processes [92].

The photo-energetic methods also include laser treatment of the plant seeds during the vegetation period [93, 94].

There are also other ecologically friendly, highly effective methods of the seed treatment. They are low-frequency electro-magnetic field (the Tbilisi State University); pulse concentrated sunlight (the Kazakh Agricultural Institute); infrared radiation (the Siberian Research Institute of Mechanization and Electrification of Agriculture); hydrogen and plasma treatment (VSRI of Agricultural Electrification); gradient magnetic field (Joint Institute for Nuclear Research, APhI), and others [95]; extra high frequency (EHF) of microwave field irradiation (MFI) (the Odessa Selection and Genetic Institute, the Kharkiv National Technical University of Radioelectronics and the Plant Production Institute named after V.Ya. Yuryev of NAAS) [96–11, 112–115].

The effect of the EMF of EHF range on the agricultural crops seed leads to the activation of biosynthesis processes and the accelerated cell division processes, as well as to the restoration of the connection and functions disturbed by the diseases [116, 117].

The advantages of using the microwave energy in agriculture are explained by the selectivity of the conversion of the electromagnetic energy into the thermal one, by greater depth of the field penetration, efficiency and economy [116].

The method is ecologically safe because the irradiation absorbed by the treated plant directly influences the processes of the plant vital activity, but at the same time no ecologically harmful substances get into the environment [118].

Depending on the irradiation rate applied to the seeds, the enzyme reactions can cause both stimulatory and inhibitory effects. The stimulating rates accelerate the growth, and change the physical and chemical state of the cells, the air-tightness of the seed coat and other metabolic reactions. Overrates cause the disruption of the intracellular structures, which requires some cost to restore them [118, 119].

The mechanism of energy transmission by the electric and magnetic fields is associated with the free and bound water in the seed, which are the receiver and transmitter of the irradiation energy. The peculiarity of the water activated with the magnetic field is the presence of freely directed energy with the random nature of changes in magnitude and frequency in it.

The method of the pre-sowing seed treatment with MWF of EHF is founded (based) on the stimulation of the regulatory system of the germ, which allows removing the seeds from the state of physical rest, resulting in the accelerated cell division during germination of the seeds. The treatment of cereal crops seeds with the EHF rays is considered to be one of the most promising agricultural measures that stimulates the plant growth and development, increases plant resistance to stress factors, and increases the soil nutrient utilization coefficient, which leads to the increase in the yield capacity [120].

When an object is subjected to the action of a high-frequency electromagnetic field, a process with a significant heat release occurs in it due to the phenomenon of dielectric polarization, which makes a stimulating effect on the seed during its treatment [121, 122].

The seed moisture helps to increase the level of selective absorption of moisture by the seeds proper and by the parasitic microorganisms that are inside the seed; these microorganisms have stronger absorption capacity and they absorb the moisture flowing along the capillaries dozen times more rapidly than the intracellular seed structures. At the same time they swell, their humidity reaches 80-90%, while the moisture content in the seeds does not increase, but remains at the previous level. The electromagnetic processing of such seeds selectively warms the moistened microorganisms, because due to the high heating rate, the temperature of any biological object, regardless of its size, increases in proportion to its humidity [123, 124].

According to the basic idea of seed disinfection with the energy of HF and EHF fields, the properties of the seeds and parasitic phyto-pathogens are separated when moistening them [123, 124, 125].

The pre-sowing treatment of wheat seeds with EHF has provided an increase in the yield capacity by 23 % and at the same time the seeds were completely rendered the sanitary from the fusariosis infection in comparison with the control (the untreated seeds) and standard (the seeds treated with the fungicides). When treating the barley seed there is three times reduction in the leaf-blight helminthosporiosis infection in comparison with the control [122, 123].

The combination of the ultrasonic seed treatment at the initial stage and subsequent treatment with EMF of EHF increases the humidity, germinating power and sprouting energy due to the ultrasound; it also reduces the infestation and stimulates the seed growth quality due to EMF of EHF. The use of this method of treatment allows refusing the use of the chemicals harmful both to the environment and human beings [123].

1.3. Formation of yield and quality of winter wheat and spring barley under different methods of pre-sowing seed treatment

Increasing the productivity of cereal crops and obtaining environmentally friendly products requires the improvement of the cultivation technology, especially in the system of plant protection against the harmful components of agrocenosis [23, 126].

The pre-sowing seed treatment helps to reduce the negative impact of trauma, improves the yielding properties of seeds through the application of physical, chemical, biological and other measures to disinfect, improve the germination and increase the productivity.

In the existing plant protection system the methods of the pre-sowing seed treatment by nature of influence are divided into the following basic methods: chemical, biological and physical ones.

The winter cereal crops treatment provides not only the effective protection of seeds, seedlings, and shoots from the infections, but also improves the hibernation of plants in the conditions of the unfavourable autumn and winter periods. The disinfection of seeds makes it possible to preserve up to 12 % of the grain yield of winter cereal crops, up to 15 % of spring barley at the crop yield capacity of 4,0–5,0 t/ha [127, 128].

Nowadays the seed treatment with the preparations of not only fungicidal but also insecticidal action is becoming more widespread [59].

According to the data of the Central Scientific and Research and Project and Technological Institute of Livestock Mechanization and Electrification the effect of the ultraviolet irradiation (UVI) provides the increase in the cereal crops yield by 10–12 % and an increase in the protein content of the green mass of corn by 6–10 %; sugar content increases by 12–16 %. The efficiency of this method of the pre-sowing seed treatment is confirmed by testing at the seed research stations [129].

The short-term and repeated short-term treatments of seeds with the focused wave of UVI raise the yield capacity of cereal crops up to 10–15 % [130].

The mass use of the growth regulators became possible only after the creation of the preparations based on the analogues of the natural substances. The literature sources indicate that there are the preparations with the application rates of dozens of grams or milligrams per ton of seeds or hectare of crops [130].

The technology of the pre-sowing seed treatment with the growth regulators has its positive peculiarities. The preparations accelerate the development of the root system at the initial stages of development and such processing can be carried out in advance together with the treatment and coat-forming agents at the seed factories or on the farms [131].

As a result of the growth regulators action the mass of the root system increases to 57 % due to the greater number of the secondary roots of the cereal crops; the number of spikelets in the ear and the mass of 1000 grains also increase. The increase in the yield capacity of winter wheat amounts to 6–25 %, and the protein content in the grain is increased by 0,5–1,7 % [131].

O. Holovko found out that the use of the plant growth regulators enables to directly regulate the most important processes in the plant organism, to fully implement the potential possibilities of the variety inherited in the genome by nature and selection [132].

It was possible to achieve an increase in the agricultural production by 15–20 % or more by using a number of the growth regulators in several countries [133].

V.Yu. Sudenko notices that most preparations for the pre-sowing seed treatment have no mechanisms influencing the seed sprouting, shoots formation, density of the crops, and formation of the vegetative and reproductive organs of the plants [134].

According to the researches carried out by M.M. Marenych the positive influence of the preparations effecting the growth, stimulating the seed germination of winter crops and protecting the seedlings from the stress caused by the lack of moisture has been noted [133].

A.O. Shevchenko testifies that when using the pre-sowing application of biological stimulants, the field germinating power of winter wheat seed increases by 5 % on the average [135].

According to A.S. Merkushyna the effect of all phyto-regulators depends on their concentration; at the same time the increased concentration causes a sharp slowing-down of growth and death of the plants [136].

L.A. Anishyn notes that the wheat seed treatment with the winter growth regulator Emistim C significantly increases the processes of respiration, nutrition and photosynthesis and increases the accumulation of chlorophyll in the leaves [137]. In the CAE “Ukraine” of the Buchansk district in the Ternopil region, as well as on a number of other farms, the yield capacity of winter wheat increased by 0,5–0,6 t/ha when applying Emistim C [138]. At the same time it was found out that the rate of the treatment agents can be reduced by 25–30 % by combining the treatment of winter wheat seeds with the plant growth regulator Emistim C without reducing their protective effect, and this method can save money. The seed treatment with the growth regulators also significantly improves the baking quality of winter wheat grain [139].

According to L.Yu. Kerefov when treated the winter wheat seeds with Emistim C at a rate of 10 ml/t, there was an increase in the yield by 0,36 t/ha, and treating with Agrostimulin at the same rate gave an increase by 0,44 t/ha at the yield capacity under the control of 0,49 t/ha [140].

The pre-sowing seed incrustation with a tank mixture consisting of a coat-forming agent, a growth regulator and a treatment agent under modern technologies of cereal crops cultivation is a very important element of technology that contributes to increasing the resistance of plants to stress weather conditions, and as a result, to an increase in the productivity [141 142].

In the conditions of the unstable moistening of the Northern Steppe, the use of the plant growth regulators to treat the spring chaffy barley seeds before sowing helped to increase the crop productivity by 0,12–0,54 t/ha (3,1–13,8 %) [134].

According to the researches of S.P. Ponomarenko the high efficiency of the growth regulators is stipulated by the content of a balanced complex of the biological substances, which accelerates the growth of the green mass and the root system, and therefore the nutrients are more actively used, as a result of which the resistance to the diseases, stresses and unfavourable weather conditions increases [139].

O.V. Smetanko notes that the use of the biological preparations based on the microorganisms *Bacillus polymyxa, Enterobacter nimipressuralis, Aehromopacter album* have a positive influence on the quality indices of winter wheat grain. Thus, against the background of nitrogen mineral fertilizer application when using the preparation based on *Bacillus polymyxa*, a mathematically significant increase in the gluten content was observed [128].

According to the researches of L.O. Chaikovska it is recommended to carry out the pre-sowing bacterization of winter wheat and spring barley seeds using the biological preparations that increase the protein and gluten content in the grain. When using Polymixobacterin, Albobacterin and Phosphoenterin the protein content amounted to 13,7 %, 13,2 % and 12,5 % (under the control it was 9,9 %), the gluten content amounted to 31,7 %, 30,0 % and 28,0 % (under the control it was 19,2 %) [143].

The most promising element of the modern technologies for growing winter wheat and spring barley is the pre-sowing seed treatment with the biological preparations that stimulate the germination, protect the seeds from the diseases, and eliminate the environmental pollution.

1.4. Development of ecological methods for increasing efficiency of pre-sowing treatment of cereal crop seeds and problems that need to be solved

Recently, due to the excessive pollution of the environment as a result of the widespread uncontrolled use of pesticides and mineral fertilizers it is very important to look for the alternative farming systems. They are based on biologization, which implies a restriction, and in the long term the refusal from using the chemicals, and the wide use of new methods of biological plant protection, especially under the unfavourable environmental conditions [144].

In the researches of the Plant Production Institute named after V.Ya. Yuryev of NAAS and other research institutions of Ukraine the influence of different methods of the pre-sowing seed treatment, including the use of the plant growth regulators, biological preparations, seed incrustation, ozonization, physical methods of treatment and their combination in comparison with the chemical disinfector on the formation of the yield capacity and quality indices of many agricultural crops has been studied for many years [145].

The intensive use of chemicals for the pre-sowing seed treatment while increasing the plants productivity inevitably causes a number of the undesirable effects of the environmental and economic characters. The environmental effects of applying pesticide are strengthened by their cumulative effect, which is very dangerous for the quality of the products obtained. These substances are not natural and therefore cause the carcinogenic and mutagenic effects. At the same time the seed disinfection is an obligatory agro-technical measure in the technology of crops cultivation, without which the problem of increasing their yield capacity cannot be solved. Therefore, the scientists and practitioners in several countries of the world are passing on to the alternative methods of the pre-sowing seed treatment [145].

One of the most environmentally friendly methods of the pre-sowing seed treatment is the irradiation with microwave field (MWF) of extra high frequencies (EHF).

The rates of chemicals in the agro-systems are significantly reduced with the development of the organic agricultural production in Ukraine. Since 2004 the EU has forbidden the use of the traditional methods for the chemical seed treatment in organic farming. This led to the search for the new methods of the pre-sowing seed treatment, primarily the physical ones as an alternative to the chemical methods [146]. However, the physical methods (high frequency, microwave and warm air or water treatment) compared with chemical disinfection do not influence the diseases communicated to the plants through the soil organisms.

The methods of the physical seeds treatment that can be used in practice include the long-known method of heat treating. The seeds are heated with water, steam or air. The main criterion for this is the combination of the temperature factor (critical for the pests and seeds). The main disadvantage of this method is the high water content in the seeds after treatment, which leads to significant energy consumption necessary for drying the seeds [147].

In recent years the methods using the electromagnetic field (EMF) of extra high frequency (EHF) range in the food industry (microwave ovens) and for the drying of food and agricultural products have become widespread.

The use of high-frequency electromagnetic waves in the microwave range for the seed treatment is characterised by a high intensity of heating, as well as the penetration of heat into the inner tissues of the grain [148]. The probability to reduce its sprouting increases significantly. This method is of little use in practice because when drying the surface of the seed, the pathogenic organisms die together with the seed.

Yet in 1956 the scientist A.S. Pressman proposed the action of the electric waves not only as the thermal energy but also as the processes taking place against the background of heating [149]. He made an assumption about the information influence of the electromagnetic field (EMF) on the biological objects.

At the present stage the possible mechanisms of EMF influence on the plant organisms are relatively divided into several levels [150, 151]. Firstly, it is the energy influence that has the physical and mechanical basis of the thermal effect (temperature rise, and local pressure) and is the most studied. The most uncertain level is the information one, when the flow of the external energy can not make significant changes in the thermodynamics of the biological processes, but can affect the processes of vital activity of the plant organisms. This approach is implemented at the cellular level and is linked to the biological structures. These are the elements of cell membranes that have a significant dipole electric moment (protein and enzymes molecules, etc.) [152].

Today it is the information component that has a great scientific interest for both the physicists and biologists.

The most promising among all physical methods of the pre-sowing seed treatment is the microwave (MW) technology; it is the result of many years of the researches of the scientists of the military and industrial complex and the branch science [153, 154]. Many years of the scientific experiments and experience of a number of the agricultural producers confirm that the microwave field suppresses the whole complex of seed infection, which creates an alternative to the chemical method of plant protection [147, 154, 155].

The use of the microwave complexes for seed stimulation by the specialists of the leading scientific and research institutions, both in Ukraine and abroad, made it possible to identify the reserves for increasing the yield capacity of the agricultural crops. According to the results of a number of authors, the attention to the physical method of the pre-sowing seed treatment with a microwave field is explained by the fact that a number of technological and economic issues can be solved [151, 152, 156-158]. The main ones are an increase in the laboratory and field germination of the seeds, the accelerated plant development and ripening, resistance to the frost, drought, pests and pathogens, increase in the biomass, improvement of the production quality (starch, protein, etc.), disinfection of seeds and obtaining the environmentally friendly products with the reduced nitrate and pesticide content. But the main thing is that the researches connected with testing MW seed stimulation technology occupy a special place in the problem of the significant increase in the yield capacity of the field crops [159-161], that is, they are used in order to increase the realization level of the plant productivity potential [144].

The results of the researches carried out at the Selection and Genetic Institute of NAAS indicate that when treated the elite seeds of three varieties of soft winter wheat with MW field, the laboratory germination has increased by 2–3 % at the initial indices of 95–96 %. The field germination has exceeded the control by 10–12%, and the crop capacity, depending on the variety, was exceeded by 12,1–33,6 %. The efficiency of MW treatment of wheat seeds has been confirmed in the researches at the genetic level [144].

The new technology of the pre-sowing seed treatment of winter cereal crops was tested under very severe Ukrainian conditions in the winter of 2002–2003, when winter crops were destroyed by frosts over a large area. According to the data of the Vinnytsia Research Station, the seeds of winter wheat of Donetska 48 variety, treated with MW field not only overwintered, but also yielded 2,5 t/ha, while under the control (the seeds without treatment) the plants died.

It is known that among the methods that stimulate the growth processes and accelerate the growth and development of plants are the physical, chemical and biological ones. According to the authors none of them has been used widely because they are insufficiently substantiated; the mechanisms of their action and aftereffect on the seeds have not been disclosed [162].

The effect of the biological stimulation of seeds with the energy of the microwave field is manifested in different ways depending on the genotype of the plants, variety reaction, as well as the initial quality of seeds. According to the data of the researches carried out with winter cereal crops (wheat, and barley) this effect is leveled by the conditions of autumn and winter period, but even in such years the increase in the yield was mostly reliable [163]. The spring cereal crops have a better effect from MW seed stimulation than the winter cereals, which is explained by more favourable conditions and a short growing season of the crops, when the energy of MW field has a greater aftereffect on the plant [103,105].

The arid summer conditions of the southern Ukraine are especially vulnerable for the spring cereal crops. The researches of the scientists of the Odessa Agrarian University carried out during the very hot summer of 2003 show that the yield capacity of nine varieties of spring barley obtained from the seeds treated with MW field exceeded the control crops by 0,3–0,5 t/ha with an average yield capacity of 0,83 t/ha as a result of the drought [147].

The authors investigated the possible mechanisms of MWF action on the biological objects at the functional level, the third after the energy and information ones [152]. The optimum EMF modes that activate the action of the enzyme systems of the agricultural crops seeds have been identified; at the same time the structural and functional integrity and biochemical composition of the treated seeds have not been damaged. During the vegetation period the intensity of assimilation processes has increased.

According to the authors the universal character and practical importance of the MW technology consist in the fact that along with the increase in the yield capacity of field crops, the technogenic load on the environment is reduced. The technology minimizes, and sometimes completely eliminates the application of toxic chemicals, among which the pesticides are especially dangerous. Their decomposition in the soil, plants and water is often accompanied by more stable and toxic elements in comparison with the initial compounds [104, 105].

The obtained data and the gained experience of using different modes of EMF have been widely tested in the laboratory conditions and at the experimental plots of different farms and are recommended to be used in the agricultural practice of the pre-sowing seed treatment.

At present the producers and various design offices propose a large number of installations for the pre-sowing seed treatment of the agricultural crops, as well as for drying seeds and other loose materials [164]. For example, the company “Vozrozhdeniie” (Odessa) has developed the equipment for the pre-sowing seed treatment “Microsteam–2M” (Figure 1.1).

Figure 1.1 Microwave installation “Microsteam-2M”

The limited partnership “Energopolis” (Dnipro) has developed the installation AST-3 (Figure 1.2).

Figure 1.2. Microwave installation “AST-3”

A microwave installation has also been proposed in Kharkiv by the limited partnership “AVIRON EHF Technology” (Figure 1.3), which has a well-developed technical and scientific base for mass production of the installation and its key elements.

Figure 1.3. Microwave installation AVIRON

Several types of the microwave installations (Figure 1.4) for the pre-sowing seed treatment of the agricultural crops on the basis of the microwave modules have been developed at the Belarus State University [5]. The parameters of the irradiation module are selected individually for each crop.

The biological preparations based on the beneficial microorganisms along with the physical methods for the seed treatment with the microwaves are becoming widespread in the agricultural practice [103, 163, 164].

The researches of the recent years testify that among the new nontraditional reserves for increasing the productivity of the cereal spike crops that do not require the significant extra costs there is a widespread introduction of the plant growth regulators of a new generation [165–171, 172–175].

Figure 1.4 Installations for pre-sowing seed treatment, drying and disinfection with MWF of EHF

The order of the Ministry of APC and UAAS №330/113 "On the Introduction of New Growth Regulators" dated 18.10.1999 emphasise that the Ukrainian preparations are the highly profitable reserves for increasing the yield capacity, especially in the conditions of the insufficient supply of soil with the nutrients and since 20000 it has been recommended to the specialists of the farms to apply the new growth regulators as an obligatory agricultural measure [165].

The growth regulators at very small rates help to accelerate the growth and development, increase the productivity and improve the quality of the agricultural plant products. Penetrating into the plants, they are involved in the metabolism, activate the biochemical processes, and increase the level of the plant vital activity. The regulators influence the system of hormonal regulation, which determines the nature of the most important physiological processes, in particular, accelerates the formation of new plant organs and the beginning of flowering and ripening [103].

On the experimental winter wheat crops of the Chernihiv Agricultural Station the number of the productive stems increased by 16,1–17,1% under the influence of the biological stimulants [166].

In the nearest future the combination of the microwave technology with the subsequent seed treatment with the plant growth regulators should become a perspective direction of science and practical agriculture since it gives the possibility to solve a number of problems of the agricultural production in a complex.

Conclusions to Chapter 1

1. The increase in the cereal spike crops yield capacity under the current change of the climatic conditions in Ukraine will have a positive tendency in the nearest future, but the sustainable grain production under sharp weather fluctuations is possible only with the improvement of the agro-technological systems.

2. The pre-sowing seed treatment with chemical synthesis pesticides remains the main method in the agricultural industry today. However, the pesticides inevitably have a negative influence on the ecosystem of any level.

3. A more environmentally friendly method of seed treatment under the intensive technology is the combination of the microwave seed irradiation and seed incrustation with the plant growth regulators that provide an increase in the cereal crops yield capacity up to 15–20%.

4. It is possible to reduce the negative influence of chemical measures on the quality of the cereal crops seeds by using for the seed

treatment a mixture of a treatment agent with the preparations having the stimulating properties.

5. The most promising among all physical methods of the pre-sowing seed treatment is the microwave technology which suppresses the entire complex of the seed infection and can become an alternative to the chemical method of plant protection.

6. The universal character and practical importance of MW technologies in combination with the growth regulating substances consist not only in the increase in the yield capacity of the field crops, but also in reducing the technogenic load on the environment.

7. The peculiarity of EMF of EHF application in the agricultural production is the necessity to take into account the specific electro-physical, technological and biological properties of the crops, which high heterogeneity greatly influences the action of the electromagnetic energy and the final result.

CHAPTER 2. CONDITIONS, MATERIAL AND METHODS OF RESEARCH

2.1. Soils

Our field experiments were carried out in 2010–2013 in the research field of the Plant Production Institute named after V.Ya. Yuryev, located at a distance of 10 km from Kharkiv. This area is a part of the Eastern Forest-Steppe Zone of Ukraine [176].

The soil of the researched area is predominantly typical chernozem. The total capacity of the soil profile is about 110–140 cm with a pronounced humus layer. In recent years the humus content, as the main index of soil fertility, has been gradually decreasing in the region [177, 178, 179].

The increase of humus content in the soil depends on the number of the organic substances and their mineralization. In addition to the mineralization, the humus losses are taking place due to water and wind erosion of the soils.

The crumble and cloddy structure of the humus layer determines the favourable water and air properties of the black soil, such as water permeability, moisture capacity, and aeration. Due to these properties up to 500 mm of water, that is, an annual amount of precipitation can be kept in the soil layer of 0–150 cm deep [176].

The black soils are also characterised by the favourable physical and chemical properties. They have a high absorption capacity of 30–70 mg-eq per 100 g of soil. They absorb mainly Ca ++ and Mg ++. These properties of the black soils determine the neutral pH response of the humus horizon water extract.

The arable layer of soil contains 1,9–2,0 % of potassium, 0,28–0,29 % of nitrogen, 0,17–0,18 % of phosphorus, 12 mg/kg of zinc mobile forms, 20 mg/kg of manganese mobile forms, and 0,17 mg/kg of molybdenum mobile forms; its pH is 6,8–7,5.

2.2. Materials of research

Two varieties of spring barley and one variety of soft winter wheat are the materials of the research.

The characteristics of spring barley varieties are given below.

The *Aspect* variety. The originator is the Plant Production Institute named after V.Ya. Yuryev of NAAS. It has been listed into the State Register of Varieties since 2007 and recommended for cultivation in the Forest-Steppe and Polissia Regions [180].

The distinctive feature is the nutans. The spike is tow-rowed, it has a moderate wax coating; it is cylindrical, loose (11,7 short segments of spike rachis per 4 cm), and of a medium length. The straw is of a medium length (51,4–89,0 cm), and it is very strong. The sterile spike occupies a position from parallel to slightly deflected. The floral glumes are fine-wrinkled, with a slight expression of venation, and gradual transition to the awn. The grain is elliptical, yellow and filmy. The main bristle is long-fibred. The weight of 1000 grains is 46–52 g.

Biological characteristics. The variety is semi-late; the duration of vegetation is 79–97 days. The resistance to lodging is 8,2–9,0 marks, the average drought resistance is 6,5–7,0 marks. The variety is a source of the group resistance to the powdery mildew infection (7 marks) and reticular helminthosporiosis (7 marks). It is suitable for the intensive cultivation technology.

The grain yield capacity is up to 8,5–9,0 t/ha. The grain has good brewing qualities: the extraction is 81,1 %, the protein content is 9,0–10,0 %, and the uniformity of seeds is 98,8 % [180].

The *Vyklyk* variety. The originator is the Plant Production Institute named after V.Ya. Yuryev of NAAS. It has been listed into the State Register of Varieties since 2008 and recommended for cultivation in the Forest-Steppe and Polissia Regions [180].

The distinctive feature is the nutans. The spike is tow-rowed, it has a moderate wax coating; it is cylindrical, loose (12,2 short segments of spike rachis per 4 cm), and of a medium length. The sterile spike occupies a position from parallel to slightly deflected. The floral glumes are fine-wrinkled, with a slight expression of venation, and gradual transition to the awn. The grain is elliptical, yellow and filmy. The main bristle is long-fibred. The weight of 1000 grains is 46–52 g. The variety has the high productive tillering capacity of 2,0 stems.

Biological characteristics. The variety is semi-early. The height of plants is 68–76 cm. The awns are jagged. The growing season is 88–96 days. The resistance to lodging is very high (9,0 marks). The drought resistance is high (9,0 marks). The variety is resistant to the infection caused by the reticular helminthosporiosis pathogen (7 marks).

The grain yield capacity is up to 8,5–9,5 t/ha. The grain has good brewing qualities: the extraction is 81,1 %, the protein content is 10,0–10,9 %, and the uniformity of seeds is 98,0 %

The characteristics of soft winter wheat variety are given below.

The *Astet* variety. The originator is the Plant Production Institute named after V.Ya. Yuryev of NAAS. It has been listed into the State Register of Varieties since 2005 and recommended for cultivation in the Forest-Steppe and Steppe Zones of Ukraine [180].

Its approbation signs are the *erythrospermum* variety. The stem has a medium wax coating on the upper internode. The spike has a slight spindle-shaped covering of 8–9 cm long; it is of a medium density. The awns are long (10 cm), jagged, and after the ear formation they have the anthocyanin colour. The grain is red, of a medium size, oval in shape with a broad pubescent tuft. The anthers have the anthocyanin colour. The weight of 1000 grains is 39–43 g.

Biological characteristics: the variety is mid-ripening; the ear formation and ripening take place in the terms close to the standards; the variety has short stems (the plant height is 79–85 cm), it is resistant to lodging. The stem is thin, has a good tillering capacity and can form 700 or more productive shoots per $1m^2$. The winter hardiness is quite high, it is 8,2–8,7 marks. In the field conditions it is tolerant to the main harmful diseases. It is suitable for the intensive cultivation technology.

The potential yield capacity is up to 9,5 t/ha. The grain, depending on the place and conditions of cultivation, contains 12,4–14,5% of protein and 25–29,9% of gluten; the strength of flour is 280–431 alveograph units, and the volume of bread is 660 $cm^{3.}$

The data on the factors regarding the pre-sowing seed treatment are as follows.

Seed treatment agents:

Vitavax 200 FF, manufactured by Crompton/Universal Chemical. It is a compound preparation, a factory mechanical mixture of two fungicidal active substances: carboxin, 200 g/L + thiram, 200 g/L. Vitavax 200 FF; it is a contact and systemic fungicide of protective and therapeutic action. It is designed for the destruction of fungal pathogens on the surface and inside the seeds; it prevents the infection of the crop seedlings on which it is applied. The preparation is characterised by a wide range of fungicidal action. It inhibits the development of pathogens of all kinds of smut, root and stem rots, seed snow mould, anthracnose and some other phyto-pathogenic fungi. The preparation is included into the List of pesticides and agrochemicals authorised for use in Ukraine.

The seeds of cereal crops were treated with the preparation at a consumption rate recommended by the producer, that is 2,5–3,0 L dissolved in 10 L of water per 1 ton of seeds. The reduced rates were also examined in the experimental cases.

Electro-technological factor:

Microwave field (MWF) of extra high frequency (EHF)

Plant growth regulators:

Mars EL contains Polyethylene oxide of 400 molecular weight (Emulsifier, Cryoprotectant) – 23,2 %; Polyethylene oxide of 1500 molecular weight (Coat-forming emulsifier) – 54,5 %; Endophyte L1 (Stimulant) – 5,0–10,0 %; Sodium humate – 1,2 %, and Potassium humate – 2,0 %.

The Radostim preparation. Its active ingredients are Emistim S 0,3 g/L, potassium salt of alpha-naphthylacetic acid – 1,0 mg/L and microelements. It is used for the pre-sowing seed treatment (250 ml/t) and spraying plants (50 ml/ha) of cereals, legumes, industrial crops and perennial legumes. It increases the yield capacity. Its producer is the National Enterprise Interdepartmental Science and Technology Centre “Agrobiotech”, Ukraine.

The Albit preparation contains the purified active substance poly-beta-hydroxybutyric acid from the soil bacteria *Bacillus megaterium* and *Pseudomonas aureofaciens*. In natural conditions these bacteria live on the roots of plants, stimulate their growth, protect against the diseases and unfavourable environmental conditions. The preparation includes the substances that enhance the effect of the main active substance; they are a balanced initial set of macro- and microelements (N, P, K, Mg, S, Fe, Mn, Mo, Cu, Co, B, I, Se, Na, Ni, and Zn) and the terpenic acids of the coniferous extract. Albit does not contain any living microorganisms (but only the active substances from them), which makes the preparation action more stable and less prone to the environmental conditions.

2.3. Methods of research

The irradiation of winter wheat and spring barley seeds with the electromagnetic fields of extra high frequencies (MWF of EHF) was carried out by using the equipment of Kharkiv Technical University of Radio Electronics (Figure 2.1).

Figure 2.1 Equipment for seed irradiation with MWF of EHF developed by Kharkiv National Technical University of Radio Electronics, installation of a microwave design of the "UMVK-1" brand

Treatment with the microwave oscillation of extra high frequency microwave field (MWF of EHF), which is widely used for many radio and household microwave devices, was carried out at the frequency range of 2,5–3,4 GHz at the power of 0,9–1,8 kw per 1 kg of seeds during 5–95 sec. The pre-sowing treatment of seeds with the irradiation (MWF of EHF) was carried out both separately and with the subsequent application of the Vitavax 200 FF seed treatment agent (at a half consumption rate of 1,25 L/t) or the plant growth regulators Radostim (250 ml/t) and Albit (30 ml/t) for spring barley and growth regulator Mars EL (200 ml/t) for winter wheat.

The sowing qualities of the seeds before and after treatment were determined according to the current State Standards of Ukraine 4138–2002 [181, 182, and 183] at the laboratory of Seed Production and Seed Science of the Plant Production Institute named after V.Ya. Yuryev. The samples of 100 seeds in quadruplicate recurrence for each treatment case were selected for this purpose. The germination was carried out in a thermostat at a temperature of +20°C on the moistened filter paper. The sprouting energy was calculated in 4 days and the laboratory germinating power was calculated in 7 days.

The field experiments were carried out in the crop rotation at the laboratory of Seed Production and Seed Science. The predecessor of spring barley was peas for grain, and the predecessor of winter wheat was the autumn fallow. The acreage of the examined plot during the experiments was 20 m^2, the quadruplicate recurrence was used and the plots were placed in a systematic character [183].

When cultivating spring barley on the experimental plots, the tillage of the soil involved disking the field immediately after harvesting the predecessor (pea for grain). After that the basic tillage to a depth of 20–22 cm was carried out. In the spring the soil preparation included the early spring harrowing across the plowing and the pre-sowing cultivation to a depth of 5–6 cm. The sowing to a depth of 5–6 cm (10 rows on each plot) was carried out using a sowing machine SCS-6–10. The seeding rate was 4,5 million germinating seeds per 1 ha with the subsequent covering with the 3RRC-6A rollers. The elite seeds were sown. During the tillering phase the barley crops were sprayed with the Grodyl Maxi 375OD herbicide at a rate of 100 ml/ha. The Karate Zeon insecticide 050 CS microcapsule water suspension at a rate of 0,15 L/ha was used when the pests exceeded the economic threshold of harmfulness.

When cultivating winter wheat on the experimental plots, the tillage of the soil involved disking the field immediately after harvesting the predecessor (sunflower). After that the basic tillage to a depth of 20–22 cm was carried out. The spring soil preparation included the early spring harrowing across the plowing, 4–5 spring and summer soil cultivations and the pre-sowing cultivation to a depth of 5–6 cm. The sowing to a depth of 5–6 cm (10 rows on each plot) was carried out using a sowing machine SCS-6–10. The seeding rate was 4,5 million germinating seeds per 1 ha with the subsequent covering with the 3RRC-6A rollers. The elite seeds were sown. During the tillering phase the winter wheat crops were sprayed with the Grodyl Maxi 375OD herbicide at a rate of 100 ml/ha. The Karate Zeon insecticide 050 CS microcapsule water suspension at a rate of 0,15 L/ha was used when the pests exceeded the economic threshold of harmfulness.

The harvesting was done by threshing the plants at full ripening of the grain; a single-phase harvesting was performed by the “Sampo 130” combine. The yield capacity from the parcel was made to the standard humidity and 100% purity and calculated in t/ha.

After harvesting the analysis of protein content in the grains and grain quality indices were determined at the Grain Quality Laboratory of the Plant Production Institute named after V.Ya Yuryev of NAAS.

The field germination of seeds was determined by the method of M.K. Yizhyk [184] after the emergence of seedlings and before the tillering (at the beginning of the phase there were 5–10% of plants and at the end –75%). The grounds were allocated along the diagonal with a total area of 1 m^2 in two incompatible recurrences cases of the experiment and the calculation of the germinating plants was made.

The leaf surface of winter wheat and spring barley crops was determined by multiplying the length of the leaf by its width and by a coefficient 0,65 according to the methodical recommendations of A.A. Nychyporovych [185].

The photosynthetic sowing potential was determined by the formula 2.2:

$$PSP = \left(\frac{(L_1 + L_2)}{2} \times D\right) + \left(\frac{(L_2 + L_3)}{2} \times D_2\right) + \left(\frac{(L_n + L_{n+1})}{2} \times D_n\right) / 1000$$

where PSP – photosynthetic sowing potential, million m^2 day/ha;

L – leaf surface according to the periods, thousand of m^2/ha;

D – duration of leaves work, days.

During the vegetation period the phytosanitary condition of the crops was recorded according to the methodical instructions. The degree of resistance of the agricultural crops to mass diseases was determined by the methodical recommendations [186].

The root rots were recorded 2 times during the growing season: 1) during the period of full sprouting; 2) in the phase of complete ripening.

The root rots were recorded in the tillering phase and in the phase of wax ripening of the grain. The samples from two adjacent rows of 0,5 meters in three triplicate recurrence were selected for this purpose. The sheath of the root leaves was removed from the stems and the total assessment of the infection degree as for the underground and terrestrial organs (root system, tillering node, and lower part of the stem) was given. The record was performed according to the modified scale of S.O. Triebel [187].

The structural analysis of spring barley and winter wheat yield capacity was performed according to the method of the state strain testing of the agricultural crops [188]. To do this, during the tillering, stalk shooting and ear formation phases the sheafy material from the area of 0,25 m^2 in triplicate was selected 1–2 days before harvesting and the biometrical analyses were performed.

The structure of the yield capacity was determined at the laboratory by analysing the experimental sheaves according to the indices:

– height of plants;
– a number of productive stems;
– a number of grains from one plant;
– weight of grains per plant;
– weight of 1000 grains.

The protein content (according to Kjeldahl) and starch content (State Standard 10845-76) in the grain, and the weight of 1000 grains (State Standard of Ukraine 4138-2002) were determined in order to assess the quality of the crops [189].

The experimental data were processed according to the method of variance analysis by B.O. Dospekhov [190].

The economic efficiency assessment of the examined cases was carried out according to the method developed by V.P. Martianov and V.I. Drobot [191].

The research program was aimed at determining the influence of the following factors on the yield capacity and quality of spring barley products:

Varieties, factor A:

1. Aspect,
2. Vyklyk.

Seed treatment, factor B:

Experiment №1. To examine the effects of the microwave fields (MWF) of extra high frequencies (EHF) and plant growth regulators on the sowing qualities and yield capacity of spring barley.

1. Control, without treatment
2. Vitavax FF, 2,5 L/t
3. Radostim, 0,25 L/t

4. Albit, 30 ml/t
5. MWF of EHF 0,9 kw/kg, 45 sec.
6. MWF of EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t
7. MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t
8. MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t
9. MWF of EHF 1,8 kw/kg, 20 sec.
10. MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t
11. MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t
12. MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t

Experiment № 2. To examine the effect of the microwave fields (MWF) of extra high frequencies (EHF) on the sowing qualities and yield capacity of the Astet winter wheat variety.

Control, without treatment
1. Vitavax 200 FF, 2,5 L/t
2. MWF of EHF 1,8 kw/kg, 15 sec.
3. MWF of EHF 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t
4. MWF of EHF 0,9 kw/kg, 45 sec.
5. MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL, 0,2 L/t

Conclusions to Chapter 2

1. The material for the research is the new high-productive registered varieties of brewing barley that significantly differ in their origin, variety and biological properties and are representative of the varieties of the Forest-Steppe Zone of Ukraine.

2. The used generally accepted and standard methods have made it possible to carry out the research at a high scientific level.

3. The statistical analysis involved in the processing of the experimental data allowed to give a reliable assessment of the results obtained and the conclusions made.

4. The research programme covers a great number of records, observations and analyses that allow to disclosure the effect of the investigated factors deeply and comprehensively.

CHAPTER 3. SCREENING OF MODES FOR PRE-SOWING TREATMENT OF WINTER WHEAT AND SPRING BARLEY SEEDS WITH THE EXTRA HIGH FREQUENCIES MICROWAVE FIELD (MWF OF EHF) AND OF THE WAYS TO INCREASE ITS EFFICIENCY

3.1. Sprouting energy and germinating power of winter wheat and spring barley seeds depending on the mode of treatment with extra high frequencies microwave field

The high sprouting energy characterises the ability of seeds to sprout quickly and all at once. The healthy seed, aligned with the physiological state has this property. Fast and even germination of seeds indicates that seedlings will be strong and resistant to the unfavourable environmental conditions during the sowing and germination [184].

The main manifestations of the electromagnetic field influence on the seed as a biological object are:

– thermal effect (temperature increase);

– functional effect (rupture of hydrogen bonds and emergence of starch hydration processes with the formation of the final biochemical components, namely glucose and fructose and other enzyme transformations, which in turn influences the stimulation and intensification of germination) [193, 194].

According to the authors the indicated effects are manifested simultaneously, but it is possible to make a conclusion about the degree of the biological effect due to the pre-sowing irradiation of seeds with the extra high frequencies microwave field only by determining the indices of the seed quality, and first of all, the sprouting energy and germinating power.

In this regard we have carried out the search experiments in order to determine the optimum modes for the irradiation spring barley and winter wheat seeds with the extra high frequencies microwave field at the range of 2,5–3,4 GHz using the equipment of Kharkiv National University of Radio Electronics. The optimum seed irradiation mode is one that does not lead to a decrease in the germinating power or causes its increase, but the effect of seed sanitation is preserved at the subsequent stages of the plant development.

The seed samples weighing 200 g each were irradiated with the extra high frequencies microwave field. The irradiation at the power of 0,9 or 1,8 kw per 1 kg of seeds at the variable exposure (duration of the irradiation) has been studied at the intervals of 5 sec. – from 5 to 95 sec. It has been found out that, depending on the exposure, the seed temperature increased from 20 to 87°C. 7 days after the irradiation the samples were sown to determine the laboratory germination according to the State Standard of Ukraine 4138–2002 [181–183].

The indices of the sprouting energy and germinating power of the irradiated barley and wheat seeds varied depending on the irradiation power and its exposure, and the sowing qualities of the seeds, to which the increased “a rate – an exposure” modes were used, reduced significantly, and even the death of the germs was noted (Appendix A).

According to the results of the research the regularities of the variability of the sprouting energy and germinating power of spring barley seeds of the Aspect variety depending on the temperature of seed heating and the irradiation exposure have been determined. As it is shown in Figure 3.1 at a power of 0,9 kw per 1 kg of seeds the slight fluctuations in the sprouting energy and germinating power are noted (Appendix A Table A 1). Thus, at the exposure from 5 to 40 sec. the sprouting energy was within the range of 88–92%, at the exposure of 45 sec. it was 93%. The further increase in the seed irradiation exposure up to 50–80 sec. led to a decrease in the sprouting energy of 88–92%. At the same time the seed germinating power at the exposure from 5 to 40 sec. was within the range of 90–93%, at the exposures of 45–50 sec. it was 93%. Further increase of seed exposure up to 55–80 sec. led to a decrease in the germinating power of 90–92%. Therefore, the highest rates of the sprouting energy and germinating power of seeds (93% each) at the power of 0,9 kw per 1 kg of seeds have been observed at the exposure of 45 sec. (Figure 3.1).

The seed sprouting energy of 89% and the germinating power of 91–92% have been obtained when irradiating the seeds in the mode at a power of 1,8 kw per 1 kg of seeds and at the exposure of 5 to 15 sec. The highest sprouting energy and germinating power have been obtained at the exposure of 20 sec. They were 91 and 92% respectively. The increase in the irradiation exposure from 25 to 50 sec. was accompanied by a sharp decrease in the sprouting energy and germinating power of the seeds – 88–45% and 89–55% respectively. Therefore, the exposure of 20 sec. has been chosen for the field researches under the irradiation of seeds in the mode with the power of 1,8 kw per 1 kg.

According to our research, the regularity inherent in each variety has been revealed; at a certain irradiation exposure, before the “threshold” of significant decrease in the germination, its maximum increase occurred, which in many cases exceeded the index of the control case [193, 194].

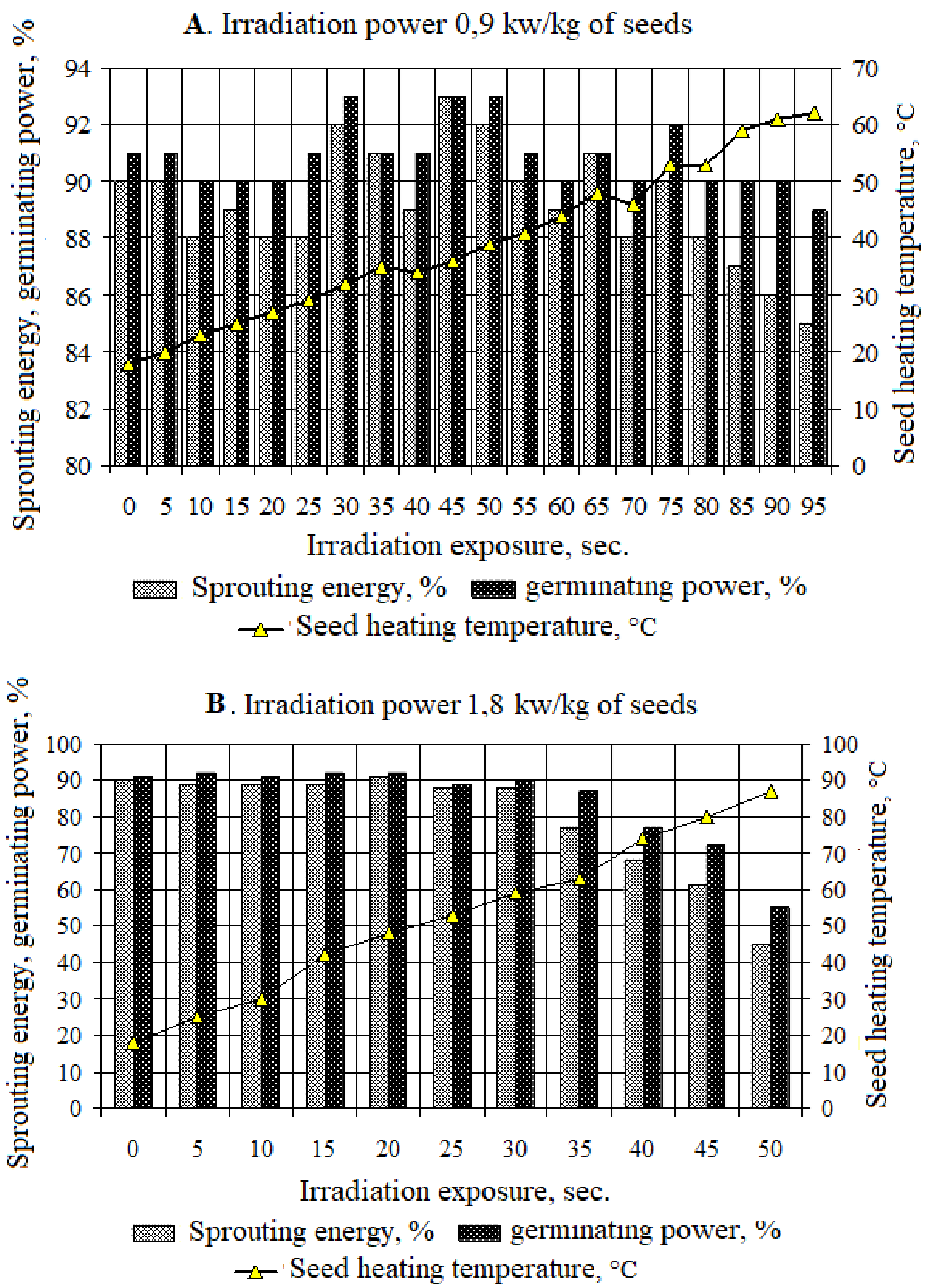
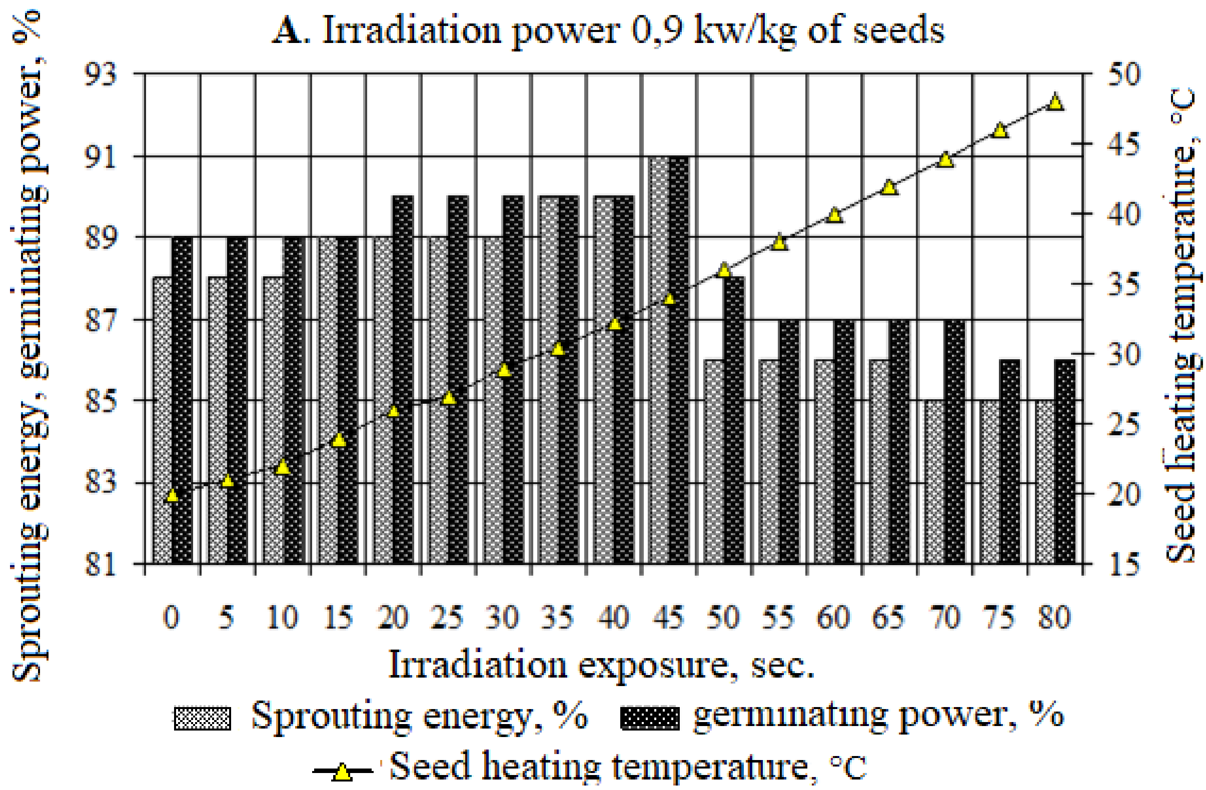


Figure 3.1 Sprouting energy and germinating power of spring barley seeds of Aspect variety after irradiation with MWF of EHF at different power and exposure modes, average for 2009, 2011 (A–0,9 kw/kg; B–1,8 kw/kg)



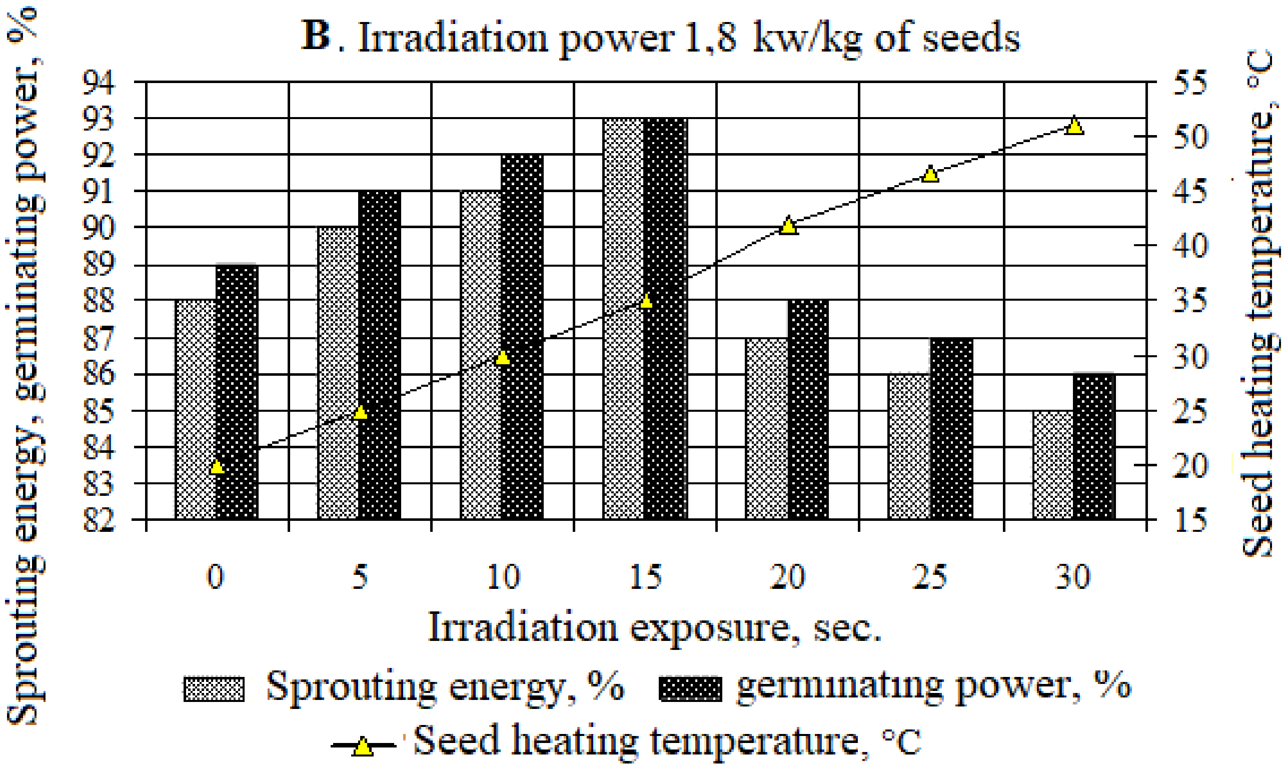


Figure 3.2 Sprouting energy and germinating power of winter wheat seeds of Astet variety after irradiation with MWF of EHF at different power and exposure modes, average for 2009, 2011 (A–0,9 kw/kg; B–1,8 kw/kg)

The pre-sowing seed treatment with MWF of EHF increased the laboratory germinating power by 2% under the irradiation mode of 1,8 kw per 1 kg of seeds and 20 sec. of exposure, and it increased the power by 4% under the mode of 0,9 kw per 1 kg of seeds and 45 sec. of exposure.

Thus, at the exposure from 0 to 30 sec. the sprouting energy was within the range of 88–89%; at the exposure of 35–40 sec. it was 90%, and at the exposure of 45 sec. it was 91%. Further increase in the seed irradiation exposure to 50–80 sec. resulted in a significant decrease in the sprouting energy up to 85–86%. At the same time the seed germinating power at the exposure from 0 to 15 sec. was within the limits of 89%, at the exposure from 20 to 40 sec. – 90%, at the exposure of 45 sec. – 91%. Further increase in the seed irradiation exposure to 50–80 sec. led to a significant decrease in the germinating power up to 86–88%. Therefore, the highest indices of the sprouting energy and germinating power of the seeds (at the level of 91%) at the power of 0,9 kw per 1 kg have been observed at the exposure of 45 sec.

The most optimum irradiation exposure of winter wheat seeds of the Astet variety with MWF of EHF in the mode at the power of 1,8 kw/kg of seeds is 15 sec. At this exposure the maximum indices of the sprouting energy and germinating power at the level of 93% were noted; under the control without any treatment these indices were 88% and 89% respectively. At the irradiation exposure of 5 to 10 sec. the sprouting energy and germinating power were lower than 90–91% and 91–92% respectively. The increase in the irradiation exposure from 20 to 30 sec. was accompanied by a sharp decrease in the sprouting energy and germinating power of the seeds of 85–87% and 86–88% respectively (Figure 3.2, Appendix A Table A 2).

3.2. Increasing the efficiency of pre-sowing treatment of winter wheat and spring barley seeds with MWF of EHF by subsequent treatment and application of growth regulators

The preparation of seeds for sowing is an obligatory component in the complex of the technological methods of the agricultural crops cultivation. Usually the pre-sowing preparation consists of seed disinfection with the treatment agents, as well as treating with the synthetic preparations of different origin, which stimulate the sowing and yielding qualities of the seeds [81, 195–198].

At the same time the researches to study the efficiency of the nontraditional ecologically friendly methods of the pre-sowing seed treatment are being carried out in Ukraine and in other countries of the world. One of such methods is the microwave irradiation of extra high frequencies. Buriak Yu.L, Ohurtsov Yu.Ye., Klimenko I.I., Krupchenko L.V., Bezpalko V.V., Soloshenko O.V., Khomenko H.V., Volkohon V.V., Shevchenko E.P., Levchenko Ye.A. and other authors think that the use of the microwave technology does not exclude the possibility of its combination with the seeds treatment with the biological and chemical preparations [103, 104, 199].

Therefore, the next stage of the laboratory research was to study the influence of the additional pre-sowing treatment of barley and wheat seeds irradiated with MWF of EHF, the treatment agent and plant growth regulators on the sprouting energy and germinating power indices.

For this purpose after the irradiation with MWF of EHF, the pre-sowing treatment of spring barley seeds of the Aspect and Vyklyk varieties with the growth regulators Radostim and Albit, and Vitavax 200 FF treatment agent has been conducted. The recommended consumption rates of the preparations, as well as the rates reduced by half have been tested during the researches [200].

It has been established that treating the seeds with Vitavax 200 FF at a rate reduced by half from the recommended one has led to 2 % increase in the sprouting energy and laboratory germinating power, whereas the total rate of the treatment agent did not provide the improvement in the sowing qualities (Table 3.1).

The application of the reduced rates of the plant growth regulators Radostim and Albit proved to be less effective; the germinating power increased by 1–3% in comparison with 2–4% when applied the total rate.

Therefore, for further laboratory and field research of the pre-sowing treatment of seeds irradiated with MWF of EHF, the treatment agent Vitavax 200 FF at the rate reduced by half, that is 1,25 L/t and the plant growth regulators Radostim and Albit at the total rates of 0,25 L/t and 30 ml/t respectively have been used. In the course of our research we examined the Mars EL plant growth regulator for treating winter wheat seeds at the rate recommended by the producer of 0,2 L/t.

3.1. Sowing qualities of spring barley seeds of Aspect variety depending on the application of MWF of EHF, different rates of treatment agents and plant growth regulators

№	Case of seed treatment		Sprouting energy, %			Germinating power, %		
	seed treatment mode with MWF of EHF	preparations, rates of application	2009	2010	average	2009	2010	average
1	Control, without treatment		90	89	90	90	91	91
2	0,9 kw/kg, 45 sec.	Vitavax 200 FF, 2,5 L/t	92[1)]	90	91	92[1)]	90	91
3		Vitavax 200 FF, 1,25 L/t	94[1)]	92[1)]	93[1)]	94[1)]	92	93[1)]
4	1,8 kw/kg, 20 sec.	Vitavax 200 FF, 2,5 L/t	89	88	89	90	89	90
5		Vitavax 200 FF, 1,25 L/t	91	90	91	92[1)]	91	92
6	0, 9kw/kg, 45 sec.	Radostim, 0,25 L/t	95[1)]	93[1)]	94[1)]	95[1)]	93[1)]	94[1)]
7		Radostim, 0,12 L/t	94[1)]	92[1)]	93[1)]	94[1)]	92	93[1)]
8	1,8 kw/kg, 20 sec.	Radostim, 0,25 L/t	92[1)]	91[1)]	92[1)]	93[1)]	92	93[1)]
9		Radostim, 0,12 L/t	91	90	91	92[1)]	91	92
10	0,9 kw/kg, 45 sec.	Albit, 30 ml/t	96[1)]	94[1)]	95[1)]	96[1)]	94[1)]	95[1)]
11		Albit, 15 ml/t	95[1)]	93[1)]	94[1)]	95[1)]	93[1)]	94[1)]
12	1,8 kw/kg, 20 sec.	Albit, 30 ml/t	93[1)]	92[1)]	93[1)]	94[1)]	93[1)]	94[1)]
13		Albit, 15 ml/t	92[1)]	91	92[1)]	93[1)]	92	93[1)]
	SSD_{05}		1,7	1,6	1,6	1,6	1,5	1,4

Note: [1)] – Significant difference

Conclusions to Chapter 3

1. According to the results of the researches it has been found out that the pre-sowing irradiation with MWF of EHF influences the sowing qualities of spring barley and winter wheat seeds in a different manner. The nature of this influence depends on the irradiation power and its exposure, as well as the associated heating temperature of the seeds.

2. The irradiation of spring barley seeds with MWF of EHF at the power of 0,9 kw/kg of seeds and the exposure from 5 to 50 sec. is accompanied by heating of seeds from 20 to 39°C. However, the sprouting energy and germinating power do not change significantly.

3. The irradiation of spring barley seeds with MWF of EHF at the power of 1,8 kw/kg of seeds and exposure from 5 to 50 sec. is accompanied by heating of seeds from 20 to 87°C. When the seeds are heated at a temperature from 53 to 87°C the sprouting energy and germinating power are reduced by 3–45 and 3–36 % respectively in comparison with the control case.

4. The irradiation of winter wheat seeds with MWF of EHF at the power of 0,9 kw/kg of seeds and exposure from 5 to 45 sec. is accompanied by heating of seeds from 20 to 34 °C. However, the sprouting energy and germinating power do not change significantly.

5. The irradiation of winter wheat seeds with MWF of EHF at the power of 1,8 kw/kg of seeds and exposure from 5 to 30 sec. is accompanied by heating of seeds from 20 to 51°C. At the same time the sprouting energy and germinating power are reduced by 1–3% when the seeds are heated from 42 to 51°C, compared to the control case.

6. The positive influence on sprouting energy and germinating power of spring barley seeds has been noted when irradiated with MWF of EHF at a power of 1,8 kw/kg of seeds and exposure of 20 sec., as well as 0,9 kw/kg of seeds and exposure of 45 sec.; as for the winter wheat seeds, the positive influence was noted at the power of 1,8 kw/kg of seeds and exposure of 15 sec., as well as 0,9 kw/kg of seeds and exposure of 45 sec. That is why, exactly these irradiation modes have been assumed as the basis for further research.

7. Treatment of the irradiated spring barley and winter wheat seeds with MWF of EHF or treatment with the growth regulators contribute to an additional increase in the sowing quality of seeds depending on the preparation and the rate of its consumption.

CHAPTER 4. REGULARITIES OF GROWTH AND DEVELOPMENT OF WINTER WHEAT AND SPRING BARLEY DEPENDING ON THE METHODS OF PRE-SOWING TREATMENT OF SEEDS WITH MWF OF EHF

The dependence of winter wheat yield capacity on agro-meteorological factors in the territory of Ukraine has been studied by several scientists (V.K. Dmytrenko, A.N. Krenke, etc.) [201, 202].

It is known that the rate of plant development is closely connected with the weather conditions of a particular year. The analysis of the features of agricultural crops development in interaction with the meteorological factors is a major part of agro-meteorological information. In this case the criterion for the evaluation of agro-meteorological conditions, in which the crop is grown, is the value of the grain yield capacity and its quality [201, 203].

The following indices were used to characterise the agro-meteorological conditions of winter wheat and spring barley cultivation during the research period: duration of interphase periods, average daily air temperature, sum of the effective temperatures (above 5 °C), and amount of precipitation in interaction with the crop productivity elements.

4.1. Agro-meteorological conditions for winter wheat cultivation

The sowing of winter wheat during the research period was carried out in the terms optimum for the Eastern Forest-Steppe Zone, namely in the second decade of September.

Characteristic for this zone a sharp change in weather conditions according to the seasons of the year influenced the duration of the winter wheat growing season, both over the years and over the interphase periods of plant growth and development.

The vegetation period of the Astet variety ranged from 153 days in 2011 to 148 days in 2013, with a minimum period of 115 days in 2012 (Table 4.1).

The autumn period, which conditions form the sprouting and tillering of the plants, is an important stage of winter crops development.

The duration of the interphase period of sowing – sprouting didn't change significantly over the years and was 6–7 days. Insignificant fluctuations in average daily air temperature amounted to 15–17 °C and sum of the effective temperatures was 86–99°C in 2011 and in 2012. The distribution of precipitation as a source of water replenishment in the soil during this period was uneven. The maximum amount of precipitation was 25 mm in 2010 and the minimum one was 5,3 mm in 2011.

The next interphase period of the autumn vegetation "sprouting – tillering" falls on the third decade of September and the first decade of October (Table 4.1). The duration of the period varied within 15–19 days over the years (Table 4.2). There was a significant fall in the average daily temperature to 10,7 °C and in the sum of effective temperatures up to 76 °C against the background of maximum precipitation of 81 mm, with a long-term rate of 20 mm in 2010. The optimum conditions for vegetation were noted only in 2012.

4.1. Phenological phases of development of winter wheat crops of Astet variety in 2010-2013

Sowing	Sprouting	Tillering	Stopping of autumn vegetation	Resumption of spring vegetation	Stalk shooting	Tillering	Full ripening
15.09. 2010.	21.09. 2010.	6.10. 2010	25.11. 2010	02.04. 2011	1.05. 2011	19.05. 2011	25.06. 2011
16.09. 2011	23.09. 2011.	12.10. 2011.	04.011. 2011	18.04. 2012	15.05. 2012	28.05. 2012	22.06. 2012
14.09. 2012	21.09. 2012	5.10. 2012	10.11. 2012	31.03. 2013	16.05. 2013	23.05. 2013	28.06. 2013

However, the agro-meteorological conditions for winter wheat cultivation varied significantly over the research period, which led to different duration of interphase periods of plant growth and development and ultimately to different levels of crop yield capacity over the years.

Thus, in 2010–2011 the vegetation period of the Astet winter wheat variety lasted 156 days (from the sowing date to full ripeness). At the same time during the growing season the sum of effective temperatures was 1302°C, and the amount of precipitation was 452,6 mm (Table 4.2).

4.2. Duration of interphase periods of winter wheat development depending on agro-meteorological conditions during the years of research, 2010–2013

№	Indices	Interphase period						sum of days over vegetation period	yield capacity, t/ha
		sowing-sprouting	sowing-tillering	tillering stopping of vegetation	RSV–stalk shooting	stalk shooting-ear formation	ear formation full ripening		
2010–2011									
1	Duration of interphase period (days)	6	15	51	25	18	38	153	4,44
2	Average daily air temperature, °C	15,0	10,7	7,0	11,2	17,5	20,6	12,9	
3	Sum of effective temperatures above 5°C	93,0	76,0	–	174,0	238,0	721,0	1302,0	
4	Amount of precipitation, mm	25,0	80,6	56,0	64,0	20,0	207,0	452,6	
2011–2012									
1	Duration of interphase period (days)	7	19	23	27	13	26	115	5,09
2	Average daily air temperature, °C	15,7	12,8	4,9	20,0	19,5	22,0	19,7	
3	Sum of effective temperatures above 5°C	86,0	148,0	–	405	189	408	1236	
4	Amount of precipitation, mm	0,0	12,2	20,0	0,3	25,0	29,0	86,5	
2012–2013									
1	Duration of interphase period (days)	7	15	36	46	7	37	148	6,63

2	Average daily air temperature, °C	16,9	15,6	9,4	16,6	22,1	22,7	15,1	
3	Sum of effective temperatures above 5°C	99,0	151,0	180,0	455,0	123,0	631,0	1639	
4	Amount of precipitation, mm	5,3	13,1	115,0	10,3	15,4	75,8	234,9	

A characteristic feature of winter wheat vegetation in 2010–2011 was the absence of the effective temperatures during the interphase period of “tillering – stopping of autumn vegetation”, which lasted 51 days, as well as their lack in the periods of “sprouting – tillering” and “spring vegetation resumption – stalk shooting”; the period lasted 25 days and the total sum of temperature was 76 and 174,0 °C respectively. The resumption of vegetation was noted on April 2, 2011.

Another feature of 2010–2011 was 46 % (207 mm) of the annual amount of precipitation during the interphase period of “ear formation – full ripening”.

In such conditions the winter wheat yield capacity of the Astet variety in 2011 was 4,44 t/ha on the average.

In 2011–2012 the vegetation period of winter wheat lasted 115 days at the sum of effective temperatures of 1236 °C. This period was the driest during the research; the amount of precipitation during the vegetation period of wheat was 86,5 mm. At the same time 62 % (54 mm) of precipitation has been distributed evenly during the interphase period of “stalk shooting – full ripening”.

It is noteworthy that winter wheat vegetation in the interphase periods of “sprouting – tillering” and “spring resumption of vegetation – stalk shooting” took place at the high average daily air temperatures; as the result the sums of the effective temperatures during these periods were 148,0 and 405 °C at the duration of the periods of 19 and 27 days respectively. The resumption of vegetation was noted on April 18, 2012.

The period of “stalk shooting – ear formation” lasted 13 days under the favourable conditions; the average daily air temperature was 19,5°C, the sum of the effective temperatures was 189°C and the amount of precipitation was 25 mm.

Therefore, in the period of 2011–2012 the agro-meteorological conditions of winter wheat vegetation were more favourable than in the previous period, which made it possible to obtain the yield capacity at the level of 5,09 t/ha.

The vegetation period of winter wheat in 2012–2013 should be noted as the most favourable during the field researches. Its duration was 145 days at the highest sum of the effective temperatures of 639 °C and the precipitation amount of 234,9 mm.

The duration of the interphase period of “sprouting – tillering” at high average daily air temperatures (15,6 °C on the average in comparison with 10,7 and 12,8 °C in the previous periods) was 15 days. In the periods of 2010–2011 and 2011–2012 the duration was 15 and 19 days and the sum of the effective temperatures was 151,0 °C.

It is noteworthy that the tillering of winter wheat took place under favourable conditions and lasted almost until stopping of autumn vegetation; the average daily air temperature was 9,4 °C and the sum of effective temperatures was 180 °C. During this period there were 115 mm of precipitation or 49 % of the total precipitation for the crop vegetation period.

The period of “resumption of vegetation – stalk shooting” was also favourable for the growth, development and formation of the generative organs of winter wheat. It was comparatively the longest (46 days) and the warmest (the sum of effective temperatures was 455 °C). The resumption of vegetation was noted on March 31.

The vegetation of the Astet winter wheat variety from the phase of stalk shooting to full ripeness took place at high average daily air temperatures. At the same time the sum of the effective temperatures was 754 °C, and there were 91,2 mm of precipitation.

One of the critical vegetation periods of winter cereals is the “tillering” phase. During this period the lateral shoots and a secondary root system are formed from the underground stem nodes, that is, the setting of organs that determine the crop yield is taken place. The indices of productive tillering depend on the conditions of autumn and winter periods. The water reserve is a major factor when it is quite warm (at air temperature of 15–18 °C) [204, 205, 206].

During the years of the research the interphase period of “sprouting – tillering” fell on the third decade of September and the first decade of October. According to the data (Table 4.2) the duration of the period varied over the years from 15, 19, and 13 days respectively. That period was characterised by the lowering of temperatures in 2010 and 2011; the temperatures were 10,7 and 12,8°C respectively, whereas in 2012 the lowering in temperature in comparison with the previous period was insignificant – 15,6 versus 16,9°C. In 2010 the sum of the effective temperatures was minimum (76°C) against a background of maximum precipitation of 81 mm at an average long-term precipitation of 20 mm. In the following 2011 and 2012 the same period was drier, the sum of the effective temperatures amounted to 148–151°C at a minimum amount of precipitation of 12,2–13,1 mm. As a consequence, the sharp fluctuations in the heat and humidity were not optimum for the intensive tillering during the examined vegetation period. It is known that the tillering phase of winter cereals continues until stopping of the vegetation that is until a steady rise in the average daily temperature above 5°C [207, 208].

The duration of the "tillering – stopping of vegetation" period varied significantly depending on the meteorological conditions of the autumn growing season. If the beginning of the "tillering" phase was noted almost simultaneously (the first decade of October), then the date of stopping of the autumn vegetation of winter wheat ranged within the limits of 15–20 days. The longest interphase period of tillering - stopping of vegetation (49 days) was observed in 2010, and was accompanied by a lowering in the average daily air temperature to 7 °C, the sum of the effective temperatures was 96 °C and the precipitation amount was 72 mm. Such weather conditions were in accordance with the climatic norm.

The minimum duration of this period (24 days) was observed in 2011. The temperature factor was crucial for the intensive growth and development of the plants. The lowering of air temperature up to 5°C and below in the absence of the effective temperatures and at a minimum precipitation of 20 mm (60% of the average long-term rate) influenced the shortening of the vegetation period.

The most favourable conditions during the period of "tillering – stopping of vegetation" were observed in 2012; the period lasted up to 36 days with a slower lowering of air temperature up to 9,4°C and the maximum sum of the effective temperatures of 180°C, which is 20% higher than in the previous period of "sprouting – tillering". The amount of precipitation was also above the long-term rate.

The considered periods of autumn vegetation showed that winter wheat significantly responds to the changes in weather conditions. The corresponding reaction of the plants influenced the field germination and tillering as the main elements of the yield structure.

Stopping of the autumn vegetation of winter wheat varied from the first to the third decade of November and depended on the temperature regime.

In the case of winter wheat the role of autumn and winter periods is also important for the formation of water reserve in the soil in early spring. The well-developed crops are intensively developing, forming the leaf tube and spikelets in the ear using mainly the spring water reserves.

During the research period the most favourable conditions of water supply at the beginning of spring were noted in 2013. The amount of precipitation in the period of November–March was 211 mm, which exceeded the average long-term rate by 15%. In 2011 and 2012 the amount of precipitation was significantly low and was 149 and 122 mm respectively, or 81 % and 67 % of the rate.

The terms of the spring vegetation resumption (SVR) of winter wheat, especially their extreme values, significantly influence the further development of plants up to the ear formation phase [208]. The main cause of spring crop losses is the late date of the vegetation resumption, when the plants were unable to adapt quickly to sudden temperature changes. According to our research (Table 4.1.) the earliest date of the vegetation resumption was observed on March 31, 2013 with a further maximum duration of the interphase period of “vegetation resumption – stalk shooting” of 46 days.

The date of early vegetation of winter wheat (April 2) was also observed in 2011. However, the duration of the interphase period from the vegetation resumption to the stalk shooting phase was 21 days shorter than in 2013. The shortening of the active vegetation period, when the main biomass is accumulated, influences the shortage of productivity.

The critical conditions of the period under consideration were observed in 2012, the date of the vegetation resumption fell on April 18, i.e. 15 days later than the earlier terms. The shortening of the interphase period of the “vegetation resumption – stalk shooting” up to 27 days was due to the rise in the temperature regime. The sum of the effective temperatures of 405–455°C exceeded the average long-term norm almost twice, and the amount of precipitation was two times lower.

The duration of the interphase period of “stalk shooting – ear formation” (Table 4.2) varied from 7 to 19 days against the background of the temperature rise. The average daily temperature was within the range of 17–22°C, the sum of the effective temperatures was 120–240°C, and the amount of precipitation was 15–25 mm, which corresponded to the average long-term rate.

A significant factor in the formation of the winter wheat yield capacity is the duration of the period from ear formation to full ripening. During the years of the research this period was minimum in 2012 – 26 days and maximum up to 37 days in 2011 and 2013 at an optimum temperature of 20–23°C. However, an uneven distribution of precipitation from 29 mm in 2012 to 207 mm in 2011 and its intensity led to a shortage in the yields up to 4,44 and 5,09 t/ha in 2011 and 2012 while in 2013 the yield capacity amounted to 6,63 t/ha.

Such agro-meteorological conditions during the vegetation period provided the highest winter wheat yield capacity in our research, it was 6,63 t/ha in 2013.

4.2. Agro-meteorological conditions for spring barley cultivation

The spring barley crop by its biological characteristics is not frugal of heat. The minimum temperature of seed sprouting is +1…2 °C; the seedlings can withstand the short-term light frosts up to –3…. – 4 °C. Such features determine the early terms of barley sowing [209].

In recent years the spring rise in the air temperature above 0 °C during 20–25 days and more has fluctuated sharply. Therefore, the sowing dates of the early ripening spring cereal crops need annual adjustments taking into account air temperature and water accumulation in the soil [210, 211]. Early sowing dates facilitate more efficient use of water accumulated in early spring; the plants are less damaged by the diseases and pests. It is very important that early sowing delays the transition to the generative phase of development and has a positive influence on the density of productive stems and the yield capacity [183].

Brewing barley is especially sensitive to late sowing, which leads to a deterioration of grain quality – the huskiness is increased, the size of grain and the starch content are reduced [207].

In agro-meteorological conditions of 2011 the sowing of barley was carried out on April 24. The vegetation period of spring barley irrespective of a variety lasted 91 days. The sum of the effective temperatures was

1308 °C, and the average daily temperature was 19,4 °C at an amount of precipitation of 292 mm (Table 4.1.2).

A characteristic feature of 2011 was 165,3 mm or 57 % of precipitation (mainly heavy showers) during the interphase period of “ear formation – full ripening”. In such conditions there was a significant lodging of spring barley plants on the experimental plots, which worsened the conditions of ripening and harvesting.

Another feature of spring barley vegetation in 2011 was the slow development of plants at the beginning of the vegetation period due to a fall in air temperature (Table 4.1.2). For example the “sowing – stalk shooting” period lasted 50 days, whereas the “stalk shooting – ear formation” period was shorter for the entire period of the research and lasted 14 days.

In such conditions of 2011 the Aspect variety produced a yield of 2,95 t/ha.

The agro-meteorological conditions in 2012 can be generally described as the most favourable for spring barley cultivation during the research period. The sowing was carried out on April 18. The vegetation period of barley irrespective of a variety was the shortest and lasted 83 days from the sowing to full ripening. Thus the interphase periods “sowing – sprouting” and “sprouting – tillering” were the shortest – 8 and 19 days respectively. In general the development of plants from sowing to stalk shooting lasted 35 days, which is 15 days less than in 2011.

The average daily temperature of the vegetation period in 2012 was 21,1 °C, which is 1,7 °C higher than in 2011, and the sum of the effective temperatures was 1335 °C.

In 2012 the amount of precipitation was 79 mm, the least during the entire period of the research while in the interphase period of “sowing – tillering” there was no precipitation at all.

However, the development of spring barley plants during the period from tillering to full ripening took place under the favourable conditions in terms of temperature and moisture, which made it possible to form the highest level of the yield capacity of barley varieties in our researches: Aspect – 4,72 t/ha and Vyklyk – 4,83 t/ha.

An earlier spring was observed in 2013, when the rise of air temperature above 0 and 5 °C took place almost at the same time and fell on the middle of the third decade of March. Under such conditions the sowing of spring barley was carried out earlier, namely on April 17.

In the agro-meteorological conditions of 2013 the vegetation period of spring barley lasted 87 days. The sum of the effective temperatures was 1390 °C, and the average daily temperature was 21,8 °C at an amount of precipitation of 95 mm (Table 4.3). At the same time the interphase periods “sowing – sprouting” and “sprouting – tillering” were the shortest – 9 and 12 days respectively. In general, the development of plants from the sowing to stalk shooting lasted 30 days, which is 5 days less than in 2012.

During the period of mass ear formation of barley the temperature factor significantly influences the final crop yield. The closest feedback between the yield capacity and average daily air temperature during this phase of development is observed in the areas where the temperature exceeds 20 °C [183, 204].

According to the results of the observations carried out in 2013 the yield capacity of spring barley was influenced by the high average daily temperature in the “ear formation” phase (21,8°C), the uneven distribution of precipitation during the vegetation period and the lowest sum of the effective temperatures in the “tillering – stalk shooting” phase (197,0°C) (Table 4.3).

4.3. Laboratory and field germination of winter wheat and spring barley depending on the mode of irradiation with MWF of EHF and method of pre-sowing seed treatment

An important prerequisite for cultivating a high yield is the timely obtaining of full, even and well-developed sprouting. The field germination is an integral index of seed quality and agro-technical level [212].

The reduction of field germination by even 1% leads to the over-expenditure of high quality seeds. In addition, a decrease in this index provokes a shortage of the winter wheat yield capacity by 1–1,5% and of spring cereal crops by 1–2%, which leads to a significant grain yield shortage. Therefore, obtaining high field germination is one of the most important tasks of agricultural technology, because the density of plants, tending of crops and the level of the future yield depend on it [174, 212].

4.3. Duration of interphase periods of spring barley development depending on agro-meteorological conditions, 2011-2013

№	Index	Interphase period					Sum for vegetation period	Yield capacity,t/ha	
		Sowing-sprouting	Sprouting-tillering	Tillering-stalk shooting	Stalk shooting-ear formation	Ear formation-full ripening		Aspect	Vyklyk
				2011					
1	Duration of interphase period (days)	10	20	20	14	27	91	2,95	-
2	Average daily air temperature, ^0C	14,4	16,1	21,0	20,7	21,8	19,4		
3	Sum of effective temperatures above 5 ^0C	94,0	222,0	320,0	220,0	452,0	1308		
4	Amount of precipitation, mm	2,0	32,0	15,2	77,2	165,3	292		
				2012					
1	Duration of interphase period (days)	8	8	19	20	28	83	4,72	4,83
2	Average daily air temperature, ^0C	15,6	19,4	22,5	19,5	23,3	21,1		
3	Sum of effective temperatures above 5 ^0C	85,0	116,0	332,0	289,0	513,0	1335		
4	Amount of precipitation, mm	0,0	0,0	15,2	32,4	31,0	79,0		
				2013					
1	Duration of interphase period (days)	9	9	12	33	24	87	2,69	2,60
2	Average daily air temperature, ^0C	14,1	18,0	21,4	21,8	23,4	20,9		
3	Sum of effective temperatures above 5 ^0C	82,0	116,0	197,0	554	441,3	1390		
4	Amount of precipitation, mm	0,0	0,0	4,0	58,0	33,0	95		

M.M. Kuleshov thinks that "the height of field germination is very closely connected with the height of the laboratory germination" [213]. Therefore, in our research we examined the influence of MWF of EHF and plant growth regulators on the sowing qualities of winter wheat and spring barley in the laboratory conditions before sowing the treated seeds on the experimental plots. Thus, it was found out that in 2011 and 2012 in most cases the pre-sowing treatment of winter wheat seeds of the Astet variety with MWF of EHF and Mars EL did not significantly influence the laboratory indices of sprouting energy and germinating power, which was due to the high sowing qualities of the seeds. For example, in 2011–2012 the sprouting energy amounted to 96 % and the germinating power was 97 % on the average (Table 4.4).

However, in 2010, when the sowing qualities of the seeds used in the experiment were reduced (the sprouting under the control was 81 %), the pre-sowing treatment depending on the method made it possible to increase the sprouting energy of winter wheat seeds by 3–7 % and the germinating power by 2–7 %.

In the cases when the seeds were treated with MWF of EHF the average laboratory indices of the sprouting energy and germinating power in 2010–2012 were slightly lower than in the case with Vitavax FF, 2,5 L/t.

At the same time after treating the seeds irradiated with MWF of EHF with the plant growth regulator Mars EL, in 2010–2012 the average sprouting energy and germinating power of winter wheat seeds were higher by 2%, which corresponds to the indices of Vitavax 200 FF case.

In the laboratory conditions it was found out that the sowing qualities of spring barley seeds varied depending on the method of the pre-sowing treatment and its variety (Appendix B Table B. 1, B. 2).

Thus, unlike winter wheat, treatment of seeds of the Aspect and Vyklyk barley varieties with Vitavax 200 FF at the recommended rate of 2,5 L/t led to a decrease in the seed sprouting energy in 2011–2013 on the average by 13 and 6 % respectively in comparison with the control cases (Table 4.5). At the same time the seed germinating power was 90 and 92 % respectively versus 91 and 93 % under the control, i.e. the deviation was not reliable.

4.4. Laboratory sprouting energy and germinating power of winter wheat seed of Astet variety depending on the methods of its pre-sowing treatment, 2010–2012

№	Cases of seed treatment	Sprouting energy, %			Average	Germinating power, %			Average
		2010	2011	2012		2010	2011	2012	
1	Control, without treatment	80	97	95	91	81	98	95	91
2	Vitavax, 200 FF, 2,5 L/t	86[1)]	96	97[1)]	93	86[1)]	97	97[1)]	93
3	MWF of EHF 1,8 kw/kg,15 sec.	83[1)]	95	95	91	83[1)]	97	96	92
4	MWF of EHF 1,8 kw/kg, 15 sec. + Mars EL	87[1)]	97	95	93	88[1)]	97	95	93
5	MWF of EHF 0,9 kw/kg, 45 sec.	85[1)]	97	94	92	86[1)]	98	95	93
6	MWF of EHF 0,9 kw/kg, 45 sec.+Mars EL	86[1)]	95	95	92	86[1)]	97	96	93
	SSD_{05}	2,15	1,90	1,97		1,95	2,5	1,92	

Note: [1)] – Significant difference

4.5. Laboratory sprouting energy and germinating power of spring barley seed depending on the methods of its pre-sowing treatment, 2011–2013

№	Cases of seed treatment	Spring barley varieties			
		Aspect		Vyklyk[2)]	
		sprouting energy, %	germinating power, %	sprouting energy, %	germinating power, %
1	Control, without treatment	89	91	91	93
2	Vitavax 200 FF, 2,5 L/t (standard)	76[1)]	90	85[1)]	92
3	Radostim, 0,25 L/t	90	91	92	94
4	Albit, 30 ml/t	88	91	93	96[1)]
5	MWFof EHF 0,9 kw/kg, 45 sec.	88	91	91	93
6	MWF of EHF 0,9 kw/kg, 45 sec.+ Vitavax 200 FF, 1,25 L/t	86	92	93	95[1)]
7	MWF of EHF 0,9 kw/kg, 20 sec. + Radostim, 0,25 L/t	90	92	94[1)]	95[1)]
8	MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	89	92	92	94
9	MWF of EHF 1,8 kw/kg, 20 sec.	90	92	92	94
10	MWF of EHF 1,8 kw /kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	92[1)]	94[1)]	85[1)]	91
11	MWF of EHF 1,8 kw/kg, 20sec.+ Radostim, 0,25 L/t	92[1)]	92	93	95[1)]
12	MWF of EHF 1,8 kw/kg, 20sec. + Albit, 30 ml/t	89	92	94	95[1)]
SSD_{05}		2,6	2,1	2,8	2,3

Note: [1)] – Significant difference; [2)] – Average in 2012–2013

When treating the seed with MWF of EHF at different power and exposure and with plant growth regulators the seed sowing qualities of barley varieties in most cases did not increase significantly. Only in the case when treated the seeds of Vyklyk variety with the Albit preparation, 30 ml/t the seed germinating power significantly increased on the average for three years and was 96% versus 93% under the control.

The combination of the pre-sowing seed irradiation with MWF of EHF with the subsequent treatment with a seed treatment agent and plant growth regulators in most cases had a positive influence on the sowing qualities of barley varieties seeds. In this case, the influence of the seed treatment method depended on the variety. Thus, in the case of MWF of EHF, 0,9 kw/kg, 45 sec. with the subsequent treatment with Vitavax 200 FF at half the rate of 1,25 L/t, the germinating power of the Aspect variety seeds increased by 1% on the average, while there were 91% under the control; and that of the Vyklyk variety seeds increased by 2%, while there were 93% under the control, i.e. it was within the limits of the experimental error [214].

Treating the seeds of barley varieties with Vitavax 200 FF at a rate of 2,5 L/t decreased the seed sprouting energy and seed germinating power, while applying the reduced rate of the treatment agent of up to 1,25 L/t with the pre-irradiation with MWF of EHF, 1,8 kw/kg seeds, 20 sec. the sowing qualities of the Aspect variety seeds exceeded the control. Thus, in the case with MWF of EHF, 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t the sprouting energy and germinating power of seeds of the Aspect variety increased by 3% on the average, while the indices under the control were 89 and 91% respectively, and the seed sowing qualities of the Vyklyk variety were lower than under the control.

Thus, it can be concluded that the combination of the pre-sowing seed irradiation with MWF of EHF with the subsequent treatment with the plant growth regulators in general has a positive influence on the sowing qualities of winter wheat and spring barley (Tables 4.1 and 4.2).

In the researches of 2010–2012 it was important to determine the influence of different methods of pre-sowing seeds of winter wheat and spring barley treatment on their field germination.

Winter wheat of the Astet variety was sown at a sowing rate of 4,5 million viable seeds per 1 ha. The determination of field germination was performed in the phase of full sprouting. At the same time it was found out that in 2010–2012 the average field germination under the control and in the case with the Vitavax 200 FF treating agent was practically the same and amounted to 90,0–90,2 %. However, under the unfavourable conditions of 2012 the field germination of winter wheat seeds in the Vitavax 200 FF case exceeded the control by 7,8 %.

The pre-sowing seed irradiation with MWF of EHF in the modes of 1,8 kw/ kg, 15 sec. and 0,9 kw/kg, 45 sec. increased the field germination of winter wheat by 6,9 and 7,4 % respectively. In the cases where the seeds were treated with MWF of EHF and Mars EL preparation it was higher by 9,1–11,8 %. This indicates that under the unfavorable conditions the influence of the pre-sowing seed treatment on field germination is more significant (Table 4.6).

4.6. Field germination of Astet winter wheat variety depending on the method of pre-sowing seed treatment, 2010–2012

№	Case of seed treatment	Number of plants, pcs/m^2			Average	Field germination, %			Average
		2010	2011	2012		2010	2011	2012	
1	Control,without treatment	412	412	393	405	91,6	91,6	87,3	90,2
2	Vitavax, 200 FF, 2,5 L/t	392	395	428[1)]	405	87,1	87,8	95,1[1)]	90,0
3	MWF of EHF 1,8 kw/kg, 15 sec	436[1)]	438[1)]	434[1)]	436[1)]	96,9	97,3[1)]	96,4[1)]	96,9[1)]
4	MWF of EHF 1,8 kw/kg,15 sec. + Mars EL	440[1)]	440[1)]	446[1)]	442[1)]	97,8[1)]	97,8[1)]	99,1[1)]	98,2[1)]
5	MWF of EHF 0,9 kw/kg, 45sec	440[1)]	436	439[1)]	438[1)]	97,8[1)]	96,9	97,6[1)]	97,4[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	435	420	434[1)]	425[1)]	96,7[1)]	93,3	96,4[1)]	95,5[1)]
	SSD $_{05}$	24,3	25,2	23,8	19,3	5,4	5,6	5,3	4,3

Note: [1)] – Significant difference

On the average over the years of the research the highest field germination of winter wheat of 98% was obtained in the case when the seeds were treated with MWF of EHF 1,8 kw/kg, 15 sec. + Mars EL, which is 8 % higher than under the control.

In the researches regarding spring barley the pre-sowing treatment of the Aspect seed variety with Vitavax 200 FF, 2,5 L/t, and the preparations Radostim 0,25 L/t and Albit, 30 ml/t and with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. and 1,8 kw/kg, 20 sec. caused the increase in the field germination by 5, 5, 7, 7 and 7 %, respectively (Table 4.7) (Appendix C Table C. 1).

Under such methods of the pre-sowing seed treatment of the Vyklyk spring barley variety the field germination was increased by 1, 2, 2, 1 and 4 %, respectively (Appendix C Table C. 2).

When combined the pre-sowing seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. and 1,8 kw/kg, 20 sec. with Vitavax 200 FF treating agent at the consumption rate reduced by half of 1,25 L/t, the field germination of the Aspect variety increased by 9 and 12 % respectively, and that of the Vyklyk variety increased by 4% in both cases.

The combination of the pre-sowing seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 20 sec. and treatment with the plant growth regulators Radostim, 0,25 L/t and Albit 30 ml/t increased the field germination of the Aspect variety by 11 and 8% respectively; the field germination of the Vyklyk variety seeds was increased by 4 and 3%. In the mode of 0,9 kw/kg, 45 sec. the field germination of the Aspect variety seeds increased by 5 and 6 % respectively, and the field germination of the Vyklyk variety seeds increased by 4 and 5% respectively. The significant increase of 5 % in the field germination of Vyklyk variety was observed only in the cases when the seeds were irradiated with MWF of EHF in the mode of 0,9 kw/kg 45 sec. with the subsequent seed treatment with the plant growth regulators Albit or Radostim. In other cases there was only a tendency to an increase in the field germination, which was connected with better field germination of seeds under the control. Thus, the combination of the pre-sowing irradiation with MWF of EHF with the subsequent treatment with the growth regulators had a positive influence on the field germination of winter wheat and spring barley seeds.

4.7. Field germination of spring barley varieties depending on the method of pre-sowing seed treatment, 2011–2013

№	Cases of seed treatment	Spring barley varieties			
		Aspect		Vyklyk[2)]	
		number of plants, pcs/m^2	field germination, %	number of plants, pcs/m^2	field germination, %
1	Control, without treatment	311	69	354	78
2	Vitavax 200 FF, 2,5 L/t (standard)	337[1)]	74[1)]	358	79
3	Radostim, 0,25 L/t	333	74[1)]	362	80
4	Albit, 30 ml/t	347[1)]	76[1)]	362	80
5	MWFof EHF 0,9 kw/kg, 45 sec.	345[1)]	76[1)]	359	79
6	MWFof EHF 0,9 kw/kg, 45sec.+ Vitavax 200 FF, 1,25 L/t	355[1)]	78[1)]	372	82
7	MWFof EHF 0,9 kw/kg, 20 sec. + Radostim, 0,25 L/t	332	74[1)]	375[1)]	83[1)]
8	MWFof EHF 0,9 kw/kg, 45sec. + Albit, 30 ml/t	339[1)]	75[1)]	375[1)]	83[1)]
9	MWFof EHF 1,8 kw /kg, 20sec.	344[1)]	76[1)]	363	82
10	MWFof EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	364[1)]	81[1)]	370	82
11	MWFof EHF 1,8 kw/kg, 20sec. + Radostim, 0,25 L/t	360[1)]	80[1)]	366	82
12	MWFof EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	346[1)]	77[1)]	369	81
	SSD_{05}	25,0	4,9	20,7	4,7

Note: [1)] – Significant difference; [2)] – Average for 2012–2013

4.4. Influence of pre-sowing seed treatment with MWF of EHF and plant growth regulators on the growth and development of winter wheat and spring barley

The formation of plant density is continuing throughout the whole vegetation period and is accompanied by the death of some of them before the harvesting period. Many factors, in particular weather conditions, sowing time, seeding rates, and agro-technical measures, especially in the period of tillering and ear formation influence the formation of the plant density [189, 205, 215–221].

The influence of the pre-sowing methods of treating the seeds with MWF of EHF on the formation of plant density and winter wheat and spring barley tillering depending on the agro-meteorological conditions of the growing year was examined during the researches of 2010–2013.

It is found out that the increase in the field germination of winter wheat and spring barley seed due to its pre-sowing treatment with MWF of EHF provides the preservation of higher plant density throughout the vegetation period.

Thus, during the period of winter wheat autumn tillering in the cases when the seeds were treated with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. or 0,9 kw/kg, 45 sec. the plant density was 416 and 425 pieces/m^2 on the average for three years, that is 4 and 7 % more than under the control (Table 4.8). In similar cases with the additional treatment of seeds with the growth regulator Mars EL, the plant density was significantly higher – 436 and 424 pieces/m^2 or 9,5 and 6,5 % more than under the control where it was 398 pieces/m^2.

When the record of plant density and the calculation of the formed shoots of winter wheat were carried out simultaneously, it was found out that the tillering factor in the control case amounted to 3,2 on the average for three years whereas in most cases of the pre-sowing seed treatment it was 3,3. The highest tillering factor (3,4) was observed while treating the seeds with MWF of EHF, 0,9 kw/kg, 45 sec. As a result, on the average for three years the number of shoots per 1 m^2 under different methods of MWF of EHF application significantly exceeded the control value by 122, 181, 162 and 142 respectively, and also had a tendency for increasing by 76, 135, 116 and 96 pieces respectively in comparison with treating the seeds with Vitavax 200 FF.

4.8. Density of winter wheat plants of Astet variety depending on the method of pre-sowing seed treatment and phase of plant development, 2010–2013

Cases of seed treatment	Autumn tillering			Stalk shooting		
	number, pcs/m^2		tillering factor	number, pcs/m^2		tillering factor
	plants	shoots		plants	stems	
Control, without treatment	398	1258	3,2	365	1075	2,9
Vitavax 200 FF, 2,5 L/t	400	1304	3,3	392	1222[1)]	3,1
MWF of EHF 1,8 kw/kg, 15 sec.	416	1380[1)]	3,2	410[1)]	1306[1)]	3,2
MWF of EHF 1,8 kw/kg,15 sec. + Mars EL	436[1)]	1439[1)]	3,3	420[1)]	1288[1)]	3,1
MWF of EHF 0,9kw/kg, 45 sec.	425[1)]	1420[1)]	3,4	416[1)]	1378[1)]	3,3
MWF of EHF 0,9kw/kg, 45 sec. + Mars EL	424[1)]	1400[1)]	3,3	401[1)]	1295[1)]	3,2
SSD $_{05}$	20,7	95,9	–	29,2	99,8	–

Note: [1)] – Significant difference

The significant fluctuations of the plant density indices in the autumn, which were observed during the years of the research regardless of the seed treatment method, are connected with different water content in the period of “germination – stopping of autumn vegetation” (Appendix D Table D.1). The maximum values of the tillering factor of 4,1 and 3,6 under the control and the number of stems of 1686 pieces/m^2 and 1400 pieces/m^2 under the control were observed in the most humid autumn period of 2010. The minimum values of the tillering factor of 2,4–2,6 and the number of stems 980–1028 pieces/m^2 were observed during the dry period of autumn tillering in 2011.

When recorded the plant density and number of stems in the spring it was found out that at a total decrease in the number of plants in all cases of the experiment after overwintering the regularities of these indices variability, depending on the case of the pre-sowing treatment in the whole have remained the same.

Thus, under different methods of applying MWF of EHF the plant density in the stalk shooting phase exceeded the control indices by 45, 55, 51 and 36 pieces/m^2 on the average for three years, and the number of stems was exceeded by 231, 213, 303 and 220 pieces/m^2 while under the control these indices were 365 and 1075 pieces/m^2 respectively. In this case, the tillering factor of winter wheat in the control case was 2,9, and when irradiated the seeds with MWF of EHF separately or with the additional treatment with Mars EL the tillering factor was 3,1–3,3. This index was maximum when using MWF of EHF in the mode of 0,9 kw/kg, 45 sec. (Appendix D Table D. 2).

It should be noted that the indices of plant density and a number of stems in the stalk shooting phase varied significantly over the years depending on the conditions of wintering and spring resumption of vegetation. Thus, the maximum values of the tillering factor and a number of stems were observed in 2012, and amounted to 3,7–4,2 and 1559–1709 pieces/ m^2 respectively (the control indices were 3,8 and 1559 pieces/ m^2), and the minimum ones were in 2013, when the tillering factor for different seed treatments was 1,9–2,2, and the number of stems was 756–909 pieces/m^2 (the control indices were 1,9 and 756 pieces/m^2).

The biometric records have established that the pre-sowing treatment of winter wheat seeds with MWF of EHF, depending on the mode and method of application, causes an increase in the height of winter wheat plants. It is noteworthy that when recorded at the beginning of the growing season of wheat – in the phase of autumn tillering – the height of plants in the experimental cases was almost indistinguishable from the control one and amounted to 23,3–24,3 cm at 23,1 cm under the control on the average for 2010–2012 (Table 4.9). However, in the spring, in the stalk shooting phase the height of plants in the cases of seed treatment with MWF of EHF, 1,8 kw/kg, 15 sec. + Mars EL; MWF of EHF, 0,9 kw/kg, 45 sec. and MWF of EHF, 0,9 kw/kg, 45 sec. + Mars EL significantly exceeded the control (53,2 cm) by 3,4; 2,2 and 2,7 cm.

In the phase of the full ripening the height of the plants under all methods of applying MWF of EHF, on the average for three years significantly exceeded the control (66,6 cm) by 4,0; 6,3; 6,3 and 7,9 cm respectively (Appendix D Table D. 3).

4.9. Height of winter wheat plants of Astet variety depending on pre-sowing seed treatment with MWF of EHF and plant growth regulator, cm

Cases of treatment	Plant development phase											
	autumn tillering				stalk shooting				full ripening			
	2010	2011	2012	average	2011	2012	2013	average	2011	2012	2013	average
Control, without treatment	16,3	21,7	31,3	23,1	45,0	51,5	63,1	53,2	61,2	71,4	67,2	66,6
Vitavax 200 FF, 2,5 L/t	17,3[1)]	22,2	30,9	23,5	46,1	51,1	64,7	54,0	63,3	75,6[1)]	69,4	69,4
MWF of EHF, 1,8 kw/kg, 15sec.	16,6	21,7	31,7	23,3	46,1	52,0	64,5	54,2	67,3[1)]	73,0	71,5	70,6[1)]
MWF of EHF, 1,8 kw/kg, 15 sec. + Mars EL	17,2[1)]	22,2	32,2[1)]	23,9[1)]	46,7	55,5[1)]	68,3[1)]	56,8[1)]	71,0[1)]	73,6	74,1[1)]	72,9[1)]
MWF of EHF, 0,9 kw/kg, 45 sec.	16,4	21,7	31,8	23,3	47,2	53,3	65,6[1)]	55,4[1)]	66,6[1)]	76,3[1)]	75,7[1)]	72,9[1)]
MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	17,8[1)]	22,6[1)]	32,4[1)]	24,3[1)]	48,2[1)]	53,6	66,0[1)]	55,9[1)]	68,7[1)]	76,7[1)]	78,1[1)]	74,5[1)]
SSD_{05}	0,7	0,6	0,7	0,63	3,0	2,7	2,4	1,52	3,1	3,4	5,3	3,9

Note: [1)] – Significant difference

Due to the researches carried out with spring barley it has been found out that the pre-sowing seed treatment with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec., and Radostim or Albit growth regulators, as well as their combination in most cases causes an increase in the field germination and stimulation of vegetative development of plants (Table 4.10, Appendix D Table D. 4).

4.10. Biometric indices of spring barley varieties in full ripening phase depending on pre-sowing seed treatment with MWF of EHF and plant growth regulators

№	Cases of treatment	Aspect, average for 2011–2013				Vyklyk, average for 2012–2013			
		number, pcs/m^2		tillering factor	plants height, cm	number, pcs/m^2		tillering factor	plants height, cm
		plants	stems			plants	stems		
1	Control, without treatment	293	564	1,9	51,9	328	665	2,0	43,9
2	Vitavax 200 FF, 2,5 L/t (standard)	307	570	1,9	54,5[1)]	333	678	2,0	45,9
3	Radostim, 0,25 L/t	301	587	1,9	57,4[1)]	336	697[1)]	2,1	47,4[1)]
4	Albit, 30 ml/t	321	607[1)]	1,9	58,0[1)]	326	663	2,1	48,6[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	318[1)]	634[1)]	2,0	58,6[1)]	347[1)]	701[1)]	2,0	47,9[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	313	593	1,9	58,0[1)]	325	684	2,2	47,3[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	307	590	1,9	58,0[1)]	350[1)]	718[1)]	2,1	48,0[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	320[1)]	597[1)]	1,9	59,9[1)]	346[1)]	717[1)]	2,1	47,6[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	311	586	1,9	58,3[1)]	329	713[1)]	2,2	49,2[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	322[1)]	617[1)]	1,9	56,3[1)]	343	673	2,0	51,1[1)]
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	318[1)]	596	1,9	56,6[1)]	343	710[1)]	2,1	48,7[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	318[1)]	613[1)]	1,9	56,7[1)]	331	691	2,1	48,6[1)]
	SSD $_{05}$	23	33		2,2	18	31		2,2

Note: [1)] – Significant difference

For example, in the cases of the pre-sowing seed treatment of spring barley of the Aspect variety with the Albit preparation, 30 ml/t; MWF of EHF, 0,9 kw/kg, 45 sec.; MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t; MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t; MWF of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t, on the average for three years the plant density exceeded the control indices by 25–29 pieces/m^2, and the number of stems exceeded the control indices by 33–70 pieces /m^2. The tillering factor of the Aspect spring barley variety did not change significantly and in most cases was 1,9 (Appendix D Table D. 5).

At the same time, the height of the Aspect barley plants variety in the phase of full ripening in the cases of MWF of EHF seed treatment and plant growth regulators exceeded the control index (51,9 cm) by 4,4–8,0 cm (Appendix E Table E 1).

The density of spring barley plants of the Vyklyk variety depending on the methods of the seed treatment varied less naturally. So, only in the cases of the pre-sowing seed treatment with MWF of EHF, 0,9 kw/kg, 45 sec.; MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t; MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t, on the average for two years the plant density significantly exceeded the control by 18–22 pieces/m^2, and in the rest of the cases the tendency to this index increasing has been noted. However, a characteristic varietal reaction of the Vyklyk variety to the application of MWF of EHF and plant growth regulators as a tendency to increase the factor of productive tillering to 2,1–2,2 has been identified in the course of the researches, whereas under the control and in the standard case with seed treatment with Vitavax 200 FF it was 2,0 (Appendix D Table D. 6, D. 7).

The height of plants of the Vyklyk spring barley variety during the full ripening phase in the cases of the seed treatment with MWF of EHF and plant growth regulators, on the average for 2012–2013 significantly exceeded the control index (43,9 cm) by 3,4–7,2 cm (Appendix E Table E. 1).

The leaf surface, which is connected with the height, plays an important role in increasing the crop yield capacity [221, 222].

E.A. Kalinina and E.A. Shevchenko believe that the use of phytoregulators – the synthetic analogues of natural phytohormones is one of the effective methods of controlling the physiological and biochemical processes in the plants. Thus, the triple treatment of the surface part of the plants during the ontogenesis leads to stems thickening by 15–20% and to an increase in the number of cells in the leaf 1,4 times, as a result, there is an increases in the leave surface and 1,6 times increase in the intensity of plants photosynthesis [169].

In the researches of the Plant Production Institute in 2006–2010 it was found out that an important consequence of the action of plant growth regulators (Endophyte L1, Biolan, Biosil, Reacom-CP-Zerno and Reastim-Zerno) under various ways of application is the increase in the leaf surface of spring wheat and barley by 12–23% on the average [170, 171].

According to the researches of A.A. Nychyporovych [221, 222] it is necessary that the leaf surface should enlarge rapidly and exceed 40 thousand m^2/ha in order to form the high-productive crops.

In our researches the determination of the leaf surface of winter wheat and spring barley was performed in the tillering, stalk shooting, and ear formation phases. A positive effect of the pre-sowing seed treatment with MWF of EHF on this index in comparison with the case without seed treatment as well as in the case of the traditional seed treatment with Vitavax 200 FF has been established.

Thus, as a result of the pre-sowing seed treatment with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. and 0,9 kw/kg, 45 sec. on the average for 2011–2013 the surface of winter wheat leaves has enlarged in the phases of tillering, stalk shooting and ear formation by 1,6 and 2,7 thousand m^2/ha, 1,9 and 3,5 thousand m^2/ha and 4,6 and 7,0 thousand m^2/ha respectively in comparison with the control, where it was 11,7, 29,4 and 37,8 thousand m^2/ha respectively (Table 4.11, Appendix F Table F. 1–3).

The additional treatment of the irradiated seeds with MWF of EHF and with the growth regulator Mars EL provided the further growth of the leaf surface only in the mode of 1,8 kw/kg, 15 sec. by 2,1, 3,8 and 5,0 thousand m^2/ha respectively on the average for three years.

The additional treatment of the irradiated seeds with MWF of EHF with the growth regulator Mars EL in the mode of 0,9 kw/kg, 45 sec. did not lead to the additional enlargement of the leaf surface in comparison with treatment only with MWF of EHF.

The photosynthetic sowing potential (PSP) and leaf surface were closely related. It was found out that the methods of the seed treatment influenced the value of the photosynthetic sowing potential, which characterises the duration of the leaf surface work. Thus, the highest PSP indices of 1,37 and 1,40 million m^2 days/ha have also been observed in the cases of the pre-sowing seed treatment with MWF of EHF in the mode of 1,8 kw/kg, 15 sec. with the additional treatment of the irradiated seeds with Mars EL growth regulator and MWF of EHF in the mode of 0,9 kw/kg, 45 sec. (Table 4.12).

4.11. Leaf surface of Astet winter wheat variety in tillering phase depending on method of pre-sowing seed treatment, thousand m^2/ha, 2011-2013

№	Seed treatment cases	Plant development phases		
		tillering	stalk shooting	ear formation
1	Control, without treatment	11,7	29,4	37,8
2	Vitavax 200 FF, 2,5 L/t	12,7	30,1	39,7
3	MWF of EHF 1,8 kw/kg,15 sec.	13,3[1)]	31,3	42,4[1)]
4	MWF of EHF 1,8 kw/kg,15 sec + Mars EL	13,8[1)]	33,2[1)]	42,8[1)]
5	MWF of EHF 0,9 kw/kg, 45 sec.	14,4[1)]	32,9[1)]	44,8[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	13,6[1)]	32,7[1)]	41,3[1)]
	$SSD_{0,5}$	1,1	1,9	2,1

Note: [1)] – Significant difference

4.12. Photosynthetic sowing potential (PSP) of Astet winter wheat variety depending on method of pre-sowing seed treatment, million m^2 days/ha

№	Seed treatment cases	Years			Average
		2011	2012	2013	
1	Control, without treatment	1,08	1,23	1,32	1,21
2	Vitavax 200 FF, 2,5 L/t	1,13	1,27	1,37	1,26
3	MWF of EHF 1,8 kw/kg, 15 sec.	1,17[1)]	1,36[1)]	1,43[1)]	1,32[1)]
4	MWF of EHF 1,8 kw/kg, 15 sec + Mars EL	1,24[1)]	1,33[1)]	1,55[1)]	1,37[1)]
5	MWF of EHF 0,9 kw/kg, 45 sec.	1,23[1)]	1,41[1)]	1,55[1)]	1,40[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	1,21[1)]	1,31[1)]	1,53[1)]	1,35[1)]
	$SSD_{0,5}$	0,07	0,08	0,10	0,06

The enlargement of the leaf surface depending on the method of MWF of EHF application has been noted in the researches with the spring barley varieties. Thus, the pre-sowing seed treatment with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. and 1,8 kw/kg, 20 sec. has caused an increase in the leaves surface of the Aspect spring barley variety in the phases of tillering, stalk shooting and ear formation by 1,0 and 1,4 thousand m^2/ha, 1,2 and 1,9 thousand m^2/ha and 1,6 and 2,1 thousand m^2/ha respectively on the average for 2011–2013, and when treating with the growth regulators Radostim and Albit the leaf surface was enlarged by 0,9 and 0,6 thousand m^2/ha, 2,20 and 3,50 thousand m^2/ha and 1,9 and 2,6 thousand m^2/ha respectively compared to the control where it was 9,9, 19,1 and 15,6 thousand m^2/ha respectively (Table 4.13, Appendix F Table F. 4–6). At the same time the leaf surface in the case of Vitavax 200 FF was 10,4, 19,5, and 16,0 thousand m^2/ha respectively.

The pre-sowing seed treatment with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. and 1,8 kw/kg, 20 sec., caused an enlargement of the leaves surface of the Vyklyk spring barley variety in the tillering, stalk shooting and ear formation phases by 1,3 and 2,1 thousand m^2/ha, 1,6 and 2,2 thousand m^2/ha, and 1,5 and 1,9 thousand m^2/ha respectively on the average for 2012–2013, and with the growth regulators Radostim and Albit – by 1,3 and 0,84 thousand m^2/ha, 2,6 and 4,2 thousand m^2/ha and 2,3 and 3,7 thousand m^2/ha, respectively compared to the control, where it was 9,9, 19,0 and 15,9 thousand m^2/ha, respectively. At the same time the leaf surface in the case with Vitavax 200 FF was 10,5, 19,6 and 16,4 thousand m^2/ha.

The results of the research given in Table 4.13 clearly show that when combined the pre-sowing irradiation with MWF of EHF of different modes with the additional seeds treatment with the plant growth regulators the leaf surface of barley varieties increases to a greater extent in comparison with other methods. For example, the leaf surface of the Aspect barley varieties in the cases with MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t and MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t in the phases of tillering, stalk shooting and ear formation amounted to 10,6 and 11,4 thousand m^2/ha, 21,3 and 23,0 thousand m^2/ha, and 17,5 and 19,0 thousand m^2/ha respectively on the average for three years while in the case with MWF of EHF, 0,9 kw/kg, 45 sec. it was 10,9, 20,3 and

4.13. Leaf surface of spring barley varieties in the ear formation phase depending on method of the pre-sowing seed treatment with MWF of EHF and plant growth regulators, thousand m^2/ha

№	Methods of pre-sowing seed treatment	Aspect			Vyklyk		
		plant development phases					
		tillering	stalk shooting	ear formation	tillering	stalk shooting	ear formation
1	Control, without treatment	9,86	19,1	15,6	9,89	19,0	15,9
2	Vitavax 200 FF, 2,5 L/t (standard)	10,4	19,5	16,0	10,5	19,6	16,4
3	Radostim, 0,25 L/t	10,7[1)]	21,3[1)]	17,5[1)]	11,2[1)]	21,6[1)]	18,2[1)]
4	Albit, 30 ml/t	10,5	22,6[1)]	18,2[1)]	10,7	23,2[1)]	19,6[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	10,9[1)]	20,3	17,2[1)]	11,2[1)]	20,6	17,4
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	11,0[1)]	20,7	17,2[1)]	11,6[1)]	22,3[1)]	18,7[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	10,6	21,3[1)]	17,5[1)]	11,4[1)]	22,9[1)]	19,3[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	11,4[1)]	23,0[1)]	19,0[1)]	11,7[1)]	22,1[1)]	18,7[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	11,3[1)]	21,0[1)]	17,7[1)]	12,0[1)]	21,2[1)]	17,8[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	10,5	20,3	17,0	11,9[1)]	20,7	17,4
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	10,9[1)]	21,5[1)]	18,0[1)]	11,7[1)]	23,1[1)]	19,6[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	11,5[1)]	24,9[1)]	20,6[1)]	13,2[1)]	25,9[1)]	21,8[1)]
	SSD_{05}	0,83	1,75	1,52	1,10	2,14	1,85

Note: [1)] – Significant difference

17,2 thousand m^2/ha. The leaf surface in the cases of MWF of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t in the phases of tillering, stalk shooting and ear formation amounted to 10,9 and 11,5 thousand m^2/ha, 21,5 and 24,9 thousand m^2/ha and 18,0 and 20,6 thousand m^2/ha, respectively on the average for three years, while in the cases with the growth regulators Radostim and Albit it was 10,7 and 10,5 thousand m^2/ha , 21,3 and 22,6 thousand m^2/ha, and 17,5 and 18,2 thousand m^2/ha respectively.

The similar tendencies as to the leaf surface variability have been also found out with the Vyklyk spring barley variety. On the average for 2012–2013 the maximum values of this index in the phases of tillering, stalk shooting and ear formation of 11,4 and 13,2 thousand m^2/ha, 22,9 and 25,9 thousand m^2/ha, and 19,3 and 21,8 thousand m^2/ha have been caused by the double pre-sowing seed treatment according to the following methods: treatment with MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t, while under the control and in the case with Vitavax 200 FF the leaf surface was respectively 9,9 and 10,5 thousand m^2/ha, 19,0 and 19,6 thousand m^2/ha and 15,9 and 16,4 thousand m^2/ha.

When calculating the photosynthetic sowing potential, it has been found out that quite high values of the sowing index have been formed in the cases with the largest leaf surface (Table 4.14).

Thus, as for the Aspect variety, the maximum index of PSP on the average for the years 2011–2013 of 0,75 and 0,80 million m^2 days/ha has resulted in the double pre-sowing seed treatment according to the following methods: MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t, while under the control and in the case with Vitavax 200 FF, PSP was 0,63 and 0,65 million m^2 days/ha respectively.

The highest index of PSP on the average for the years 2012–2013 as for the Vyklyk variety of 0,76 and 0,86 million m^2 days/ha was noted in the cases of the pre-sowing seed treatment according to the following methods: MWF of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t, while under the control and in the case with Vitavax 200 FF, PSP was 0,63 and 0,66 million m^2 days/ha respectively.

4.14. Photosynthetic sowing potential (PSP) of spring barley depending on method of pre-sowing seed treatment, million m^2 days/ha

№	Methods of pre-sowing seed treatment	Aspect				Vyklyk		
		2011	2012	2013	average	2012	2013	average
1	Control, without treatment	0,60	0,76	0,53	0,63	0,74	0,52	0,63
2	Vitavax 200 FF, 2,5 L/t (standard)	0,62	0,76	0,58	0,65	0,78	0,54	0,66
3	Radostim, 0,25 L/t	0,64	0,85[1)]	0,61[1)]	0,70[1)]	0,83[1)]	0,61[1)]	0,72[1)]
4	Albit, 30 ml/t	0,67[1)]	0,85[1)]	0,65[1)]	0,72[1)]	0,83[1)]	0,66[1)]	0,75[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	0,64	0,78	0,62[1)]	0,68[1)]	0,78	0,61[1)]	0,70[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	0,68[1)]	0,80	0,60[1)]	0,69[1)]	0,89[1)]	0,59	0,74[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	0,66[1)]	0,76	0,66[1)]	0,70[1)]	0,83[1)]	0,68[1)]	0,75[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	0,67[1)]	0,90[1)]	0,68[1)]	0,75[1)]	0,79	0,70[1)]	0,74[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	0,67[1)]	0,85[1)]	0,60[1)]	0,71[1)]	0,81[1)]	0,64[1)]	0,72[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	0,64	0,79	0,59[1)]	0,67	0,81[1)]	0,62[1)]	0,71[1)]
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	0,66[1)]	0,80	0,66[1)]	0,71[1)]	0,82[1)]	0,71[1)]	0,76[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	0,72[1)]	0,94[1)]	0,73[1)]	0,80[1)]	0,99[1)]	0,72[1)]	0,86[1)]
	SSD_{05}	0,05	0,06	0,06	0,05	0,06	0,08	0,06

Note: [1)] – Significant difference

4.5. Spreading and development of root rots on winter wheat and spring barley plants depending on pre-sowing seed treatment with MWF of EHF and plant growth regulators

According to FAO, the potential crop losses from the diseases, pests and weeds constitute 25–30 %, and during the years of epiphytoty they can reach 60 %. Therefore, the current cultivation technologies should be based on a comprehensive approach as to the pest control [223].

Cereal spike crops are infected by many diseases, such as root rot, ear blight, loose smut, covered smut and others. The yield shortage of these crops caused by a complex of the diseases is up to 20% on the average [224, 225].

It is known that about 60 % of all plant diseases are communicated through the seeds. Therefore, in many countries the pre-sowing seed treatment with the plant protection products is not only a necessary but also a legally obligatory way of protecting the basic agricultural crops from the harmful organisms [226, 227, 228, 229].

A constraining factor of increasing the yield capacity of the cereal crops are also the diseases caused by fungi, among which the root rots are especially harmful. The fungus *Cochliobolus sativus* Drechslera, ex Dastur (anamorph: *Drechslera, sorokiniana* Subram & Jain) is a pathogen of wheat common root rot [229].

A thin, delicate, fine-haired mycelium, which grows rapidly, appears on the caryopsis and radicles infected by the fusarial root rot; at first it is snow-white or bright crimson in colour with the veins. The radicles decay at the base, become brown or glassy-transparent. The tanning of coleptile and stem, the stem rolling, and the radicle deformation are observed [229, 230].

The infection by the fusarium root rot leads to the appearance of black bloom on the caryopses, tanning and decaying of the roots, which are covered with a black bloom from the base. The underdevelopments of radicles, tanning of stems and coleoptile, and deformation of seedlings are noted [229, 230].

The seeds with a bloom on the caryopsis also belong to the damaged ones; the infected shoots are those that have the signs of the root rot: the decayed radicles, spots, streak mosaic and stem tanning [229].

The linear dark strips and elongated brown spots appear on the radicles and leaves of wheat seedlings. The tanning and decaying of the coleoptile, yellowing and moulding of leaves are observed. The shortage of wheat yield caused by the common root rot can reach 5–10 % [231].

The pathogens of the barley root rot are fungi of the genera *Fusarium* Link and Drechslera, ito [229]. The disease is more intense in the dry years.

The world and domestic experience shows that when introducing into production the varieties resistant to the harmful organisms, the relationships in the pathogen-plant-feeder system do not always meet the expected results. This is especially true for the root rot pathogens, that belong to the necrotrophs according to the type of nutrition; their manifestation and development are highly dependent on many factors, including the environmental conditions, nutritional background, predecessor, tillage, timing and sowing methods, etc. [200, 232, 233, 234, 235].

The problem of plant protection from the root rot of the main grain crops due to the application of not only chemical but also biological preparations and plant growth regulators which have the fungicidal properties is also relevant from the point of view of the current environmental problems [97].

In the course of our researches the winter wheat and spring barley root rot have been recorded in the phases of tillering, stalk shooting, and full ripening of the plants.

At the same time it has been found out that the pre-sowing seed treatment with MWF of EHF in the proper modes of irradiation causes a decrease in the spreading and development of root rot on the crops of these agricultural plants.

Thus, when recorded the root rots in the tillering phase, their spreading on the plants of the Astet winter wheat variety in the cases of MWF of EHF was 0,2–0,4%, and the development was 0,1–0 ,2% on the average for 2010–2012, while under the control these values were 1,9 and 0,6% respectively. It is noteworthy that when treating the seeds with Vitavax 200 FF, 2,5 L/ha, the spreading and development of root rots were 0,7 and 0,2%, respectively (Table 4.15).

In general, the spreading and development of root rots on winter wheat plants in the stalk shooting phase have increased significantly. In the control case they were 16,7 and 8,0% respectively on the average for the years of 2011–2013, whereas in the case with different methods of applying MWF of EHF the indices were 7,9–12,1 and 3,8–6, 7% respectively, and when treating with Vitavax 200 FF the indices were 10,3 and 4,0%.

It should be noted that the pre-sowing seed irradiation only with MWF of EHF in the mode of 1,8 kw/kg, 15 sec. or in the combination with treatment with Mars EL preparation provided a lower level of root rot spreading in the stalk shooting phase than the treatment with Vitavax 200 FF – 0,6 and 2,4% respectively; whereas in the cases of treatment with MWF of EHF of 0,9 kw/kg, 45 sec. the level was higher by 1,8 and 1,7%, respectively. The development of root rots on winter wheat plants in the stalk shooting phase when applied only the mode of the irradiation with MWF of EHF or in combination with Mars EL preparation was also higher than in the standard case – by 2,7 and 2,6%, respectively.

4.15. Spreading and development of root rots of Astet winter wheat variety depending on method of pre-sowing seed treatment with MWF of EHF, %, 2010-2013

№	Methods of pre-sowing seed treatment	Tillering (autumn)		Stalk shooting (spring)		full ripening	
		spreading	development	spreading	development	spreading	development
1	Control, without treatment	1,9	0,6	16,7	8,0	9,7	4,0
2	Vitavax 200 FF, 2,5 L/t	0,7	0,2[1)]	10,3[1)]	4,0[1)]	6,1[1)]	2,4[1)]
3	MWF of EHF, 1,8 kw/kg, 15 sec.	0,3[1)]	0,1[1)]	9,7[1)]	4,3[1)]	4,9[1)]	2,1[1)]
4	MWF of EHF, 1,8 kw/kg, 15 sec. + Mars EL	0,4[1)]	0,1[1)]	7,9[1)]	3,8[1)]	4,9[1)]	2,1[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	0,2[1)]	0,1[1)]	12,1[1)]	6,7	5,4[1)]	2,0[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec + Mars EL	0,3[1)]	0,2[1)]	12,0[1)]	6,6	6,8[1)]	2,7[1)]
	SSD_{05}	1,4	0,2	4,44	2,36	2,37	1,18

Note: [1)] – Significant difference

The pre-sowing seed irradiation with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. and 0,9 kw/kg, 45 sec. both separately and additional treatment of seeds by the growth regulator Mars EL, provided a lower level of spreading and development of root rots on winter wheat plants compared to the case without treatment until the end of the growing season, i.e. in the phase of full ripening; these indices were 4,9–6,8 and 2,0–2,7 % respectively as compared to 9,7 and 4,0%.

In most cases of MWF of EHF application (except MWF of EHF, 0,9 kw/kg, 15 sec. + Mars EL), the spreading and development of root rots in the full ripening phase were lower than in the case with Vitavax 200 FF seed treatment – 4,9–5,4 and 2,0–2,1 % respectively compared to 6,1 and 2,4%.

It should be noted that the level of spreading and development of root rots of winter wheat varied significantly depending on the agro-meteorological conditions during the research year (Appendix G Table G.1–G.3).

For example, the spreading and development of root rots on winter wheat plants in the phase of autumn tillering in 2010 were insignificant and did not depend on the pre-sowing seed treatment with MWF of EHF either separately or with the subsequent treatment with Mars EL.

In 2011, in the phase of autumn tillering, the diseases of the winter wheat crops were absent, and as a result there was no difference found between the cases.

In the conditions of 2012, in the phase of autumn tillering, the decrease in the spreading and development of root rots on winter wheat plants was noted in the cases with the pre-sowing seed treatment in the mode of MWF of EHF of 0,9 kw/kg, 45 sec. both separately and with the subsequent Mars EL treatment – 0–0,3%, while the indices under the control were 5,1 and 1,5% respectively.

In the full ripening phase the highest level of spreading and development of the root rots on winter wheat plants was observed in 2011 in the cases of the pre-sowing treatment in the modes of EHF of 1,8 kw/kg, 15 sec. and EHF of 0,9 kw/kg, 45 sec. + Mars EL in the range of 9,9 and 4,5% and 8,8 and 4,3% according to the control of 18,7 and 9,4 % (Appendix G Table G. 3). This fact is connected with the character of weather conditions of this year; there were 46% of the precipitations (207 mm) of the annual amount and the average daily temperature was 20,6 °C during the interphase period of “ear formation – full ripening”.

In the conditions of 2012 in the full ripening phase a decrease in the spreading and development of root rots by 3,4 and 3,4% and 0,7 and 1,0%, respectively was noted in the cases with the pre-sowing seed treatment with MWF of EHF of 1,8 kw/kg, 15 sec., both separately and with the subsequent treatment with Mars EL, under the control these indices were 6,8% and 1,8 %. The treatment of seeds with Vitavax 200 FF at the full consumption rate (2,5 L/t) was less effective – 7,4 and 2,0 %, respectively.

In the full ripening phase, in the conditions of 2013, there was a decrease in the spreading and development of root rots in the cases with the pre-sowing seed treatment in the mode of EHF of 1,8 kw/kg, 15 sec., both separately and with the subsequent treatment with the plant growth regulators by 2,2 and 2 ,2% and 0,5 and 0,4% respectively at 3,8 and 0,9% under the control.

In the researches carried out with spring barley of the Aspect and Vyklyk varieties, the records of the spreading and development of root rots have been carried out in the stalk shooting and full ripening phases. The received results show that the pre-sowing seed treatment with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec., with the growth regulators Radostim and Albit, as well as their combination causes a decrease in the spreading and development of root rots during the whole vegetation period of barley varieties (Table 4.16, Appendix G Table G. 4, G. 5).

Thus, on the average for 2011–2013, the spreading and development of root rots in the cases of MWF of EHF and growth regulators application in the stalk shooting phase was 5,7–7,0 and 2,1–2,8%, respectively, while under the control the indices were 11,0 and 3,7% respectively, and in the standard case with Vitavax 200 FF they were 8,6 and 2, 3% respectively.
It is noteworthy that the application of MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. followed by a half-reduced rate of Vitavax 200 FF (1,25 L/ha) provided a lower degree of infection caused by the root rot to barley plants of the Aspect varieties in the stalk shooting phase than the application of the full rate of the treatment agent; the spreading was lower by 2,4 and 2,2% respectively, and the development – by 0,3 and 0,5%.

The combination of the pre-sowing irradiation of barley seeds with MWF of EHF with the growth regulators treatment in most cases led to a more significant reduction in plant infection by root rots than the microwave irradiation itself. For example, in the stalk shooting phase the

4.16. Spreading and development of root rots on spring barley in the stalk shooting phase depending on the variety, method of pre-sowing seed treatment and phase of plant development, %

№	Methods of pre-sowing seed treatment	Aspect (average for 2011-2013)				Vyklyk (average for 2012-2013)			
		stalk shooting		full ripening		stalk shooting		full ripening	
		spreading	development	spreading	development	spreading	development	spreading	development
1	Control, without treatment	11,0	3,7	3,8	1,5	8,9	2,6	3,0	1,1
2	Vitavax 200 FF, 2,5 L/t (standard)	8,6	2,3[1)]	2,1[1)]	0,9[1)]	3,2[1)]	1,2[1)]	2,7	1,1
3	Radostim, 0,25 L/t	5,7[1)]	2,3[1)]	1,8[1)]	0,7[1)]	6,2[1)]	2,3	1,4[1)]	0,7[1)]
4	Albit, 30 ml/t	6,1[1)]	2,4	2,8[1)]	1,0[1)]	5,0[1)]	1,4[1)]	1,5[1)]	0,7[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	7,0[1)]	2,8	3,1	1,2[1)]	3,1[1)]	1,0[1)]	1,6[1)]	0,6[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	6,2[1)]	2,0[1)]	3,2	1,2[1)]	7,5	2,2	3,0	1,0
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	6,3[1)]	2,3[1)]	2,8[1)]	0,9[1)]	4,9[1)]	1,7[1)]	1,7[1)]	0,6[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	5,8[1)]	1,9[1)]	2,7[1)]	1,0[1)]	3,5[1)]	1,2[1)]	0,9[1)]	0,4[1)]

9	MWF of EHF, 1,8 kw/kg, 20 sec.	6,8[1)]	2,1[1)]	2,4[1)]	1,0[1)]	5,7[1)]	2,3	2,0[1)]	0,7[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	6,4[1)]	1,8[1)]	2,5[1)]	0,9[1)]	6,3[1)]	2,1[1)]	1,8[1)]	0,9
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	5,4[1)]	1,9[1)]	2,4[1)]	1,0[1)]	5,5[1)]	1,7[1)]	2,2	0,8[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	9,0	3,4	2,6[1)]	1,1[1)]	3,6[1)]	1,3[1)]	1,2[1)]	0,4[1)]
	SSD_{05}	3,2	1,4	0,8	0,3	2,0	0,5	0,9	0,3

Note: [1)] – Significant difference

spreading and development of root rots in the cases of MWF of EHF of 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t and MWF of EHF of 0,9 kw/kg, 45 sec. + Albit, 30 ml/t were 6,3 and 2,3% and 5,8 and 1,9% respectively on the average for three years, while in the case of MWF of EHF of 0,9 kw/kg, 45 sec. the indices were 7,0 and 2,8% respectively.

While recorded during the phase of full ripening, it was found out that the positive influence of MWF of EHF on reducing the infection of plants caused by the root rots have remained the same until the end of the vegetation period of barley of both varieties, although there were some differences (Appendix G Table G. 6, G. 7).

Thus, as for the Aspect variety, in most cases of MWF of EHF application with the additional treatment with the plant growth regulators Radostim and Albit, with the treatment agent Vitavax 200 FF at a half-rate, the level of the spreading and development of root rots (respectively 2,4–3,2 and 0,9–1, 2%) was lower than under the control (3,8 and 1,5%), but higher than in the standard case with Vitavax 200 FF, 2,5 L/t (2,1 and 0,9%).

As for the Vyklyk variety, on the average for the years 2012–2013, while recorded during the stalk shooting phase in most cases of applying MWF of EHF (except MWF of EHF in the mode of 0,9 kw/kg, 45 sec.) and plant growth regulators, the spreading and development of root rots (3,5–6,2 and 1,3–2,3%, respectively) were lower than under the control (8,9 and 2,6%), but higher than in the standard case with Vitavax 200 FF (3, 2 and 1,2%).

In the phase of full ripening other tendencies have been identified. In most cases the application of MWF of EHF and growth regulators as well as their combination significantly lowered the level of spreading and development of the root rots of the Vyklyk variety, it was 1,2–2,2 and 0,4–0,9% respectively, whereas under the control the level was lower by 3,0 and 1,1% respectively and in the case with the full rate of Vitavax 200 FF it was 2,7 and 1,1%. The lowest level of spreading and development of root rots was established in the cases with the combination of MWF of EHF and the growth regulator Albit – 0,9–1,2% and 0,4% respectively.

It should be noted that when combined the pre-sowing seed treatment with MWF of EHF with the growth regulator Albit, 30 ml/t the indices of spreading and development of root rots on the plants of the Vyklyk spring barley variety in the phase of full ripening on the average for 2 years were lower than when using MWF of EHF and the Albit preparation separately and they were the lowest during the research. For example, in MWF of EHF case of 0,9 kw/kg, 45 sec. + Albit, 30 ml/t these indices were 0,9 and 0,4% respectively, which is 0,5 and 0,3% lower than in the case of Albit, 30 ml/t and by 0,7 and 0,2% lower than in the case of MWF of EHF, 0,9 kw/kg, 45 sec.

In the case of MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t these indices were 1,2 and 0,4% respectively, which is 0,3 and 0,3% lower than in the case of Albit, 30 ml/t and 0,4 and 0,2% lower than in MWF of EHF case of 1,8 kw/kg, 20 sec.

Such regularity has not been noticed with the Aspect barley variety.

Conclusions to Chapter 4

1. The pre-sowing irradiation of the Astet winter wheat seeds with MWF of EHF and Mars EL preparation does not significantly influence the laboratory indices of the sprouting energy and germinating power of seeds having the high sowing qualities (at the level of 95–96%), but increases these indices by 2–7% in the case of the low sowing qualities of seeds (80–81%).

2. The pre-sowing seed irradiation with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. and 0,9 kw/kg, 45 sec. causes an increase in the field germination of winter wheat on the average by 6,9 and 7,4% respectively, and with the additional treatment with Mars EL preparation – by 8,2 and 5,5%.

3. The pre-sowing seed irradiation with MWF of EHF with the subsequent treatment with Vitavax 200 FF and the growth regulators Radostim and Albit in most cases has a positive influence on the laboratory and field germination of the barley seeds of the Aspect and Vyklyk varieties. Besides, the influence of the method of the seed treatment depends on the variety.

4. The pre-sowing seed irradiation with MWF of EHF only or with the additional treatment by the plant growth regulators causes the stimulation of the vegetative development of winter wheat and spring barley plants, the peculiarities of which depend on the crop and the method of treatment.

5. The seed treatment with MWF of EHF only or in combination with the growth regulator Mars EL caused the increase in the height of winter wheat plants of the Astet variety, beginning from the spring vegetation resumption on the average by 4,0–7,9 cm at the height 66,6 cm under the control; the tillering factor increased by 0,2–0,4 while the index under the control was 2,9; the leaf surface in the phases of tillering, stalk shooting and ear formation enlarged by12–23, 6–13, and 9–19% respectively under the area of 11,7, 29,4, and 37,8 thousand m^2/ha under the control; PSP increased by 9–16% at 1,21 million m^2 days/ha. Over the years of the research the highest and most stable results of these indices have provided the application of MWF of EHF in the mode of 0,9 kw/kg, 45 sec. only or with additional treatment with Mars EL preparation.

6. The pre-sowing treatment of spring barley seeds of the Aspect and Vyklyk varieties only with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. or in combination with the growth regulators Radostim or Albit depending on the variety caused the average increase in the plant height by 3,4–8,0 cm; the increase in the plant density – by 5–10%, in the leaf surface in the phases of tillering, stalk shooting and ear formation – by 7–16, 6–30 and 10–32% of the Aspect variety and 13–33, 8–36 and 9–37% of the Vyklyk variety; PSP increased by 8–27% and 11–37%, according to the varieties, compared with the control, where they amounted to 51,9 and 43,9 cm, 293 and 328 pieces/m^2, 9,9, 19,1, 15,6 and 9,9, 19,0, 15,9 thousand m^2 /ha and 0,63 and 0,63 million m^2 days/ha respectively. At the same time in the standard case with Vitavax 200 FF these indices were 54,5 and 45,9 cm, 307 and 333 pieces/m^2, 10,4, 19,5, 16,0 and 10,5, 19,6, 16,4 respectively.

7. The seed treatment with MWF of EHF in the determined irradiation modes only or with the additional treatment with the growth regulators Mars EL (wheat) and Radostim or Albit (barley) causes a decrease in the spreading and development of root rots on the crops of these agricultural plants.

8. In the case of winter wheat the spreading and development of root rots in the full ripening phase when treating with MWF of EHF of 1,8 kw/kg, 15 sec., MWF of EHF of 0,9 kw/kg 45 sec. and MWF of EHF of 1,8 kw/kg 15 sec. + Mars EL made up 4,9 and 2,1%, 5,4 and 2,0%, 4,9 and 2,1% respectively, while under the control these indices were 9,7 and 4,0% respectively, and in the case with Vitavax 200 FF – 6,1 and 2,4%.

9. The pre-sowing seed treatment with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec., with the Radostim and Albit growth regulators, as well as in their combination causes a decrease in the spreading and development of root rots throughout the growing season of barley varieties.

10. The applying of MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. followed by the treatment at a half-reduced rate of Vitavax 200 FF (1,25 L/ha) provided a lower degree of root rots of plants of the Aspect barley varieties in the stalk shooting phase than the application of the full rate of the treatment agent when the spreading was lower by 2,4 and 2,2% respectively, and the development – by 0,3 and 0,5%.

CHAPTER 5. YIELD CAPACITY AND QUALITY OF WINTER WHEAT SEEDS AND GRAINS DEPENDING ON THE METHOD OF PRE-SOWING SEED TREATMENT WITH MWF OF EHF

5.1. Influence of pre-sowing seed treatment with MWF of EHF on the formation of structural elements of the yield and yield capacity of winter wheat depending on the method of application

As it is known, the level of the yield capacity consists of many interrelated factors; each of them has some influence on the plant growth and development. Increasing the yield capacity of grain crops is one of the main tasks of the agricultural science and production [1, 3, 181, 201, 236–239].

The study of the yield structure allows determining the peculiarities of the formation of the yield capacity and quality of the grain under the specific agro-meteorological conditions during the period of the field research depending on the influence of the developed elements of the crop growing technology.

Therefore, a part of our research was to study the influence of the pre-sowing seed treatment with MWF of EHF depending on the irradiation mode and the application of Mars EL growth regulator on the formation of the elements of the crop structure and the biological yield capacity of winter wheat grain of the Astet variety.

The formation of the structural elements of the winter wheat crop and its biological yield capacity was primarily influenced by the agro-meteorological conditions of the growing year. Thus, in 2011 the biological yield capacity of the Astet winter wheat variety according to the research made up 4,94 t/ha on the average, in 2012 it was 5,14 t/ha, and in 2013–6,91 t/ha (Table 5.1, Appendix H Table H. 1, H. 2, H. 3).

At the same time, the pre-sowing seed irradiation with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. or 0,9 kw/kg, 45 sec. only or with the additional seed treatment with the Mars EL growth regulator, 0,2 L/t, positively affecting the field germination, the processes of growth and plants development, and increasing the resistance of plants to the root rots, caused the formation of a larger number of elements of the yield structure and increase in the biological yield capacity of winter wheat.

5.1 Structure of winter wheat yield of Astet variety depending on the application of MWF of EHF and Mars EL plant growth regulator, on the average for 2011-2013.

№	Cases of pre-sowing seed treatment	Number, pcs/m²			Factor of productive tillering	Grain content in the ear, pcs	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems					
			total	including productive				
1	Control, without treatment	344	619	496	1,44	29,4	37,3	5,42
2	Vitavax 200 FF, 2,5 L/t	351	655	531[1)]	1,48	28,7	37,0	5,58
3	MWF of EHF 1,8 kw/kg, 15 sec.	369[1)]	715[1)]	552[1)]	1,45	28,9	36,6	5,74[1)]
4	MWF of EHF 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	345	680[1)]	542[1)]	1,55[1)]	29,0	37,8	5,80[1)]
5	MWF of EHF 0,9kw/kg, 45 sec.	380[1)]	675[1)]	535[1)]	1,44	29,8	36,6	5,76[1)]
6	MWF of EHF 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	359[1)]	654	536[1)]	1,51[1)]	29,4	37,2	5,77[1)]
correlation coefficient with yield capacity		0,51	0,75	0,91[1)]	0,50	0,01	-0,09	–
SSD_{05}		14,0	51,0	22,2	0,05	0,7	0,8	0,27

Note: [1)] – Significant difference

On the average for 2011–2013, according to the results of the yield capacity structural analysis, it has been established that, depending on the method of the pre-sowing seed treatment, the high plant density and the total number of stems including the productive ones remained until the harvesting period and amounted to 1–56, 37–96 and 35–56 pieces/m^2 respectively, while under the control these indices were 344, 619 and 496 pieces/m^2 respectively. The correlation coefficient of these indices with the biological productivity made up 0,51; 0,75 and 0,91 respectively.

Depending on the method of the pre-sowing seed treatment, the grain content in the ear and the weight of 1000 grains did not change significantly, and these indices practically did not influence the yield capacity level of winter wheat, the correlation coefficients made up 0,01 and 0,09.

On the average for 2011–2013 in the cases of the pre-sowing seed treatment with MWF of EHF, 1,8 kw/kg, 15 sec. and MWF of EHF, 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t, the biological yield capacity of winter wheat increased by 6% and 7% respectively; the yield capacity under the control was 5,42 t/ha.

In the similar cases of irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec., the biological yield capacity was almost the same and amounted to 5,76 and 5,77 t/ha respectively, which is on the average 6% higher than the control.

In the case with the traditional seed treatment with Vitavax 200 FF at the recommended consumption rate of 2,5 L/t the biological yield capacity made up 5,58 t/ha on the average for three years, which is 3% higher than the control.

In general, the harvesting and recording of the yield on the experimental plots confirmed the tendencies as to the variability of this index depending on the method of the pre-sowing seed treatment revealed under the structural analysis of the winter wheat yield capacity of the Astet variety.

According to the results of our researches, the pre-sowing seed irradiation with MWF of EHF in the mode of 1,8 kw/kg of seeds and exposure of 15 sec., as well as in the mode of 0,9 kw/kg of seeds and exposure of 45 sec. allows to increase the winter wheat yield capacity significantly, on the average for 2011 – 2013 it increased by 0,19 and 0,24 t/ha, or by 3,5 and 4,5% respectively, the yield under the control amounted to 5,39 t/ha (Table 5.2).

5.2. Yield capacity of Astet winter wheat variety depending on method of pre-sowing seed treatment, t/ha

№	Seed treatment methods	Years			Average	+/- Before control	
		2011	2012	2013		t/ha	%
1	Control, without treatment	4,44	5,09	6,63	5,39	–	–
2	Vitavax 200 FF, 2,5 L/t (standard)	4,66	5,09	6,72	5,49	0,10	1,9
3	MWF of EHF, 1,8 kw/kg, 15 sec.	4,73[1)]	5,21[1)]	6,79[1)]	5,58[1)]	0,19	3,5
4	MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	4,88[1)]	5,18	6,82[1)]	5,63[1)]	0,24	4,5
5	MWF of EHF, 0,9kw/kg, 45 sec.	4,99[1)]	5,26[1)]	6,65	5,63[1)]	0,24	4,5
6	MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	4,64	5,09	6,69	5,47	0,08	1,5
SSD $_{05}$		0,22	0,12	0,11	0,18	–	–

Note: [1)] – Significant difference

However, it should be noted that the efficiency of such seed treatment has varied significantly over the years. For example, in 2011, when the agro-meteorological conditions were the least favourable for the growth and development of winter wheat, which led to the lowest yield level on the whole during the research period, the positive effect from the application of MWF of EHF was the highest – the yield increase was the largest and amounted to 7 and 12% according to the irradiation mode, at the yield under the control of 4,44 t/ha.

When treating the seeds with Vitavax 200 FF at the recommended rate of 2,5 L/ha, the yield capacity of the Astet winter wheat variety was higher by 0,1 t/ha on the average for three years. And the largest significant effect of this method was also noted in 2011, the increase was 0,22 t/ha.

The efficiency of the additional pre-sowing treatment of the seeds irradiated with MWF of EHF and treated with Mars EL growth regulator at a consumption rate of 0,2 L/t depended on the irradiation mode and the conditions of the research year. Thus, on the average for 2011–2013, in the case of irradiation with MWF of EHF, 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t, the yield of winter wheat made up 5,63 t/ha, whereas in the case of MWF of EHF, 1,8 kw/kg, 15 sec. it was 5,58 t/ha.

At the same time, the efficiency of the pre-sowing seed treatment with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. as a result of the additional treatment with Mars EL has decreased. Thus, on the average for three years the yield capacity of winter wheat in this case was 5,47 t/ha, which is 0,16 t/ha less than in the cases with MWF of EHF, 0,9 kw/kg, 45 sec. Only in 2013 the yield capacity of winter wheat under double treatment was relatively higher and amounted to 6,65 and 6,69 t/ha respectively.

Thus, the most effective methods of the pre-sowing seed treatment which cause an increase in winter wheat yield capacity in comparison with Vitavax 200 FF seed treatment, 2,5 L/t are the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or the seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 15 sec. with the additional treatment with Mars EL growth regulator, 0,2 L/t.

5.2 Sowing qualities of winter wheat seeds depending on the method of pre-sowing treatment with MWF of EHF

According to the data of V.V. Malynovskyi, the MWF of EHF irradiation of winter wheat seeds of the Soiuz and Viktoriia varieties with low germinating power in the agricultural firm APF “Aleks” (Zaporizhzhia Oblast) increased the germinating power from 82 and 84% to 92 and 95% respectively [240].

In our researches a laboratory analysis of the sowing qualities of the seeds was performed after harvesting winter wheat of the Astet variety.

The germinating power of the harvested winter wheat seeds on the average for 2011–2013 was mainly high – within 96–97%, so we did not establish a significant difference between the cases of the researches (Table 5.3). This confirms the results of our laboratory researches carried out after the pre-sowing seed treatment with MWF of EHF and Mars EL growth regulator before sowing (see 4.2).

5.3. Sowing qualities of Astet winter wheat variety depending on MWF of EHF application (after harvesting in 2011-2013)

№	Seed treatment case	Sprouting energy, %			Average	Germinating power, %			Average
		2011	2012	2013		2011	2012	2013	
1	Control, without treatment	98	95	94	96,6	98	95	96	96,3
2	Vitavax 200 FF, 2,5 L/t	95[1)]	97	96[1)]	96,0	96	97	97	96,6
3	MWF of EHF, 1,8 kw/kg, 15 sec.	99	95	95	96,0	99	96	97	97,3
4	MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL	98	93	96[1)]	96,6	98	94	97	96,3
5	MWF of EHF, 0,9kw/kg, 45 sec.	97	95	95	96,0	98	95	96	96,3
6	MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL	98	95	95	96,6	99	96	96	97,0
	SSD_{05}	1,5	2,5	1,8	1,5	1,4	2,1	1,5	1,3

Note: [1)] – Significant difference

5.3. Quality indices of winter wheat grain depending on the method of pre-sowing seed treatment with MWF of EHF

Among the set of the techniques aimed at obtaining the high-quality wheat grain, the shortest possible terms of grain harvesting play an important role. A delay in the harvesting terms, as well as being in the swaths over a long period, increase the grain falling and decreases the grain glassiness. The yield losses in 20 days after full ripening are 0,25–0,64 t/ha depending on the variety. The protein content is reduced by 1,2–1,4% in comparison with the control and the gluten content is reduced by 2–3% [241, 242, 243].

The yield formation and quality of winter wheat grain are influenced by a number of factors, among which the genetic potential of the variety, agro-climatic conditions as well as the agro-technical measures or the elements of the crop growing technology are the main ones.

There is a feedback between the value of the yield and the protein content in the wheat grain. A high yield is forming under the optimum weather conditions, but the protein accumulation in the grain is decreasing [242, 251].

According to the data of M.H. Tsekhmeistruk, N.V. Kuzmenko, and A.E. Lytvinov, the sun pest bug as well as weather conditions have a great influence on the formation of the yield and quality of winter wheat grain. Thus, in 2011 the damage of winter wheat shoots caused by the sun pest at the end of the spring tillering phase was the largest and amounted to 5,5%, and the damage caused by the intra-stem pests was 20,0% [231]. During the winter wheat vegetation period the epidemiological threshold of harmfulness of the root rots was 5% as for the damaged plants; the seeds were damaged by 10–15%. At the same time 5% of spring barley plants and 12% of seeds were damaged during the arid years and 34% of seeds were damaged during the wet years.

In 2012 and 2013 the damage of the shoots caused by the sun pest bug was significantly lower – 2,2 and 0,4% respectively, though the damage caused by the intra-stem pests was on the contrary higher – 26,2 and 31,1%. In 2011 the damage to the winter wheat grain of the Astet variety caused by the sun pest bug was the highest and amounted to 4,5%; in 2012 the damage was 1,1%.

The quality of wheat grain depends not only on the quantity and quality of gluten, but also on the state of the hydrate and amylose complex of the grain, which is determined by the index of falling number, which can range from 60 to 600 sec. or more. The bread meets the standard when the falling number is not less than 150 sec. [189, 251, 252].

The results of the researches testify that the quality indices of the Astet winter wheat grain, namely the specific weight of protein, fluid gluten content and its quality, and falling number varied depending on the year conditions as well as on the pre-sowing seed treatment method. However, the changes were mostly insignificant. The grain quality under the control and in the standard case of treating the seeds with Vitavax 200 FF, as well as in the cases of MWF of EHF application corresponded to the third (III) class on the average for 2011–2013 (Table 5.4). However, in different years of the research some quality indices could be referred to higher classes.

Thus, the falling number ranged from 352 to 390 units, which corresponds to high grain quality indices.

The gluten quality in the grains of the Astet variety was from 43 units of the gluten deformation measurement (GDM) (corresponding to the second group) under the control up to 58 units of the gluten deformation measurement (corresponding to the first group) in the case of seed irradiation with MWF of EHF in the mode of 0,9 kw/kg of seeds, 45 sec.

In 2011 the fluid gluten and protein content in the grains of the Astet winter wheat variety under the seed irradiation with MWF of EHF in the mode of 1,8 kw/kg of seeds and exposure of 15 sec. reduced to 20,4–21,2% and 12,0–12,1 % respectively, under the control these indices were 22,4% and 12,3%. The irradiation of the seeds in the mode of 0,9 kw/kg and the exposure of 45 sec., on the contrary, contributed to the increase in the fluid gluten up to 22,8–24,8% (Table 5.4). That is, only the winter wheat grain irradiated with MWF of EHF in the mode of 0,9 kw/kg of EHF, 45 sec. can be referred to the 2nd class according to the content of fluid gluten in it, and the grains treated with other methods belong to the third class.

In our researches in 2011, the case with MWF of EHF of 45 sec. and 0,9 kw/kg should be noted by the gluten content (24,8%), i.e. it can be referred to the 2nd class, at 22,4% under the control.

5.4. Winter wheat grain quality indices depending on pre-sowing seed treatment with MWF of EHF and growth regulator Mars EL

№	Case	Years	Specific weight of protein, %	Fluid gluten		Falling number, sec.	Class
				Specific weight, %	GDM units /group		
1.	1 Control, without treatment	2011	12,3	22,4	55/I	376	III
		2012	11,5	21,2	45/I	396	III
		2013	12,9	20,0	30/II	399	III
		average	12,2	21,2	43/II	390	III
2.	Vitavax 200 FF, 2,5 L/t	2011	12,4	22,4	50/I	336	III
		2012	12,0	23,2	60/I	383	III
		2013	12,0	18,4	25/II	407	III
		average	12,1	21,3	45/I	375	III
3.	MWF of EHF, 1,8 kw/kg, 15 sec.	2011	12,1	20,4	40/II	336	III
		2012	11,9	22,8	65/I	336	III
		2013	12,0	19,2	40/II	385	III
		average	12,0	20,8	48/I	352	III
4.	MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL	2011	12,0	21,2	40/II	377	III
		2012	11,7	23,6	75/I	406	III
		2013	12,2	18,8	20/II	387	III
		average	12,0	21,0	45/I	390	III
5.	MWF of EHF, 0,9 kw/kg, 45 sec.	2011	12,4	24,8	60/I	306	III
		2012	12,1	24,4	85/II	409	III
		2013	12,4	18,4	30/II	389	III
		average	12,3	22,5	58/I	368	III
6.	MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL	2011	12,3	22,8	40/II	347	III
		2012	11,4	23,6	75/I	385	III
		2013	12,6	20,8	25/II	377	III
		average	12,1	22,4	47/I	370	III

In 2012, the best indices of the grain quality were also observed under the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg of seeds and exposure of 45 sec.; the fluid gluten content made up 24,4% and protein – 12,1%.

In the case with the irradiation with MWF of EHF in the mode of 1,8 kw/kg of the seeds and exposure of 15 sec. the content of the fluid gluten made up 22,8%, and protein – 11,9%, and in the case with the additional treatment with Mars EL growth regulator the content of the fluid gluten was 23,6% and 11,7% respectively, under the control these indices were 21,2% and 11,5%.

In 2013, the lowest grain quality was noted. The fluid gluten content was from 18,4 to 20,8%, and the content of protein was from 12,0 to 12,9%. At the same time the highest amount of the fluid gluten was observed under the irradiation with MWF of EHF in the mode of 0,9 kw/kg of seeds and exposure of 45 sec.; in the case with the additional application of the Mars EL growth regulator it was 20,8%, the protein content was 12,6%, while under the control they were 20,0% and 12,9%. The rest of the cases did not exceed the control according to grain quality indices.

On the average for 2011–2013 the content of the fluid gluten in the grain under the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg of seeds and exposure of 45 sec. increased to 22,4–22,5%, while under the control these indices were 21,2%. The protein content in the grain did not change significantly.

Considering the conditions of the elements formation of the winter wheat grain quality during the years of the researches it should be noted that at the early terms of spring vegetation resumption in 2013, 2011 (March 31 and April 2) the protein content in the grain made up 12,9 and 12,3%, and later in 2012 (April 18) it was 11,5%. The fluid gluten content was 20,0, 22,4 and 21,2% respectively.

Conclusions to Chapter 5

1. The formation of the elements of the winter wheat yield structure and its biological yield capacity were in the first turn influenced by the agro-meteorological conditions of the growing year.

2. The winter wheat yield capacity had a significant close positive correlation with the number of the productive stems ($r = 0,91$) and a close correlation with the total number of the stems ($r = 0,75$).

3. The most efficient methods of the pre-sowing seed treatment that cause an increase in the winter wheat yield capacity compared to the seed treatment with Vitavax 200 FF, 2,5 L/t are the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or the seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 15 sec. with the additional treatment with the Mars EL growth regulator, 0,2 L/t.

4. At high sowing quality indices of the harvested winter wheat grains of the Astet variety within 96–97% the naturally determined influence of MWF of EHF only or together with the Mars EL growth regulator on the indices of the sprouting energy and germinating power has not been established.

5. In general, the baking qualities of winter wheat grains of the Astet variety did not change significantly depending on the method of the pre-sowing seed treatment. According to the indices of the protein content and the quantity and quality of the fluid gluten, the winter wheat grain under the control and in the standard case with Vitavax 200 FF seed treatment as well as in the cases of applying MWF of EHF and the Mars EL growth regulator corresponded to the third (III) class on the average for 2011–2013

6. The highest content of the fluid gluten in the wheat grains was noted in the case of the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg of seeds and exposure of 45 sec.; it was 22,4−22,5%, while under the control it was 21,2%.

CHAPTER 6. YIELD CAPACITY AND QUALITY OF SEEDS AND GRAINS OF SPRING BARLEY DEPENDING ON THE METHODS OF PRE-SOWING SEED TREATMENT WITH MWF OF EHF

6.1. Influence of pre-sowing seed treatment with MWF of EHF on the formation of the yield structural elements and yield capacity of spring barley depending on the method of application

A part of our research with spring barley was to study the influence of the pre-sowing seed treatment with MWF oh EHF depending on the irradiation mode and growth regulators Radostim and Albit in comparison with Vitavax 200 FF seed treatment on the formation of structural elements of the crop and biological yield capacity of the Aspect and Vyklyk spring barley varieties.

It was found out that the agro-meteorological conditions of the cultivation year influenced the formation of the structural elements of the spring barley varieties and their biological yield capacity first of all. For example, in 2011 the biological yield capacity of the Aspect spring barley in the experiment averaged 3,1 t/ha, in 2012 it was 5,5 t/ha, and in 2013 it amounted to 2,9 t/ha. As for the Vyklyk variety, in 2012 and 2013 the biological yield capacity was 6,1 and 2,93 t/ha respectively (Tables 6.1, 6.2) (Appendix I Tables I. 1, I. 2).

However, the pre-sowing seed irradiation with MWF in the mode of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only or with the additional seed treatment with the growth regulators Radostim and Albit caused the formation of more elements of the yield structure, which had a positive influence on the biological yield capacity of both barley varieties under most ways of applications.

Thus, on the average for 2011–2013, according to the results of the structural analysis of the yield capacity of the Aspect barley varieties it has been found out that depending on the method of the pre-sowing seed treatment, the high plant density and the total number of stems, including the productive ones have preserved until the harvesting period, they were 14–29, 13–60 and 19–57 pieces/m^2 respectively, while under the control these indices were 293, 574 and 507 pieces/m^2 respectively (Table 6.1). The correlation coefficient of these indices with the biological yield capacity was 0,62, 0,64 and 0,82 respectively.

The grain content in the ear and the weight of 1000 grains did not change significantly depending on the method of the pre-sowing seed treatment, and these indices did not significantly influence the biological yield capacity of the Aspect variety – the correlation coefficients were 0,16 and 0,17.

It is characteristic that the pre-sowing irradiation of barley seeds of the Aspect variety with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. exceeded the standard case of the Vitavax 200 FF pre-sowing seed treatment regarding the number of plants, and total number of stems, including the productive ones (319, 634, 558 and 311, 586, 554 pieces/m^2 respectively); in the case with Vitavax 200 FF these indices were 307, 570 and 512 pieces/m^2 respectively.

When treating the seeds of the Aspect barley variety with the growth regulators Radostim and Albit only or in combination with the preceding treatment with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. the average number of plants and stems in 2011–2013 exceeded the control values (without treatment) and the values of the standard case, but they were lower than in the case with MWF of EHF only. This fact indicates the absence of the synergistic effect from the dual treatment of seeds when forming these elements of the yield structure.

However, in the cases of MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t, MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0.25 L/t and MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t, the average number of plants and stems for three years exceeded both the control and standard cases as well as the case of MWF of EHF 1,8 kw/kg, 20 sec.

According to the results of the yield structural analysis of the Vyklyk barley variety it is established that, depending on the method of the pre-sowing seed treatment, the number of the productive stems has increased by 16–58 pieces/m^2 on the average for 2012–2013, while under the control this index was 555 pieces/m^2 (Table 6.1)

The correlation coefficient of this index with the biological yield capacity was 0,74.

In most cases of the Vyklyk variety when applying MWF of EHF and plant growth regulators the total number of plants and stems, as well as the grain content in the ear and the weight of 1000 grains also exceeded the control indices, but differently influenced the formation of the biological yield capacity of barley – the correlation coefficients were 0,07; 0,38; 0,85 and 0,29 respectively.

6.1. Yield structure of spring barley varieties depending on the application of MWF of EHF and plant growth regulators

№	Cases of pre-sowing seed treatment	Aspect (on the average for 2011–2013)						Vyklyk (on the average for 2012–2013)					
		number, pcs/m²			grain content in the ear, pcs	weight of 1000 grains, g	biological yield capacity, t/ha	number, pcs/m²			grain content in the ear, pcs	weight of 1000 grains, g	biological yield capacity, t/ha
		plants	stems, total	including productive				plants	stems, total	including productive			
1	Control, without treatment	293	574	507	14,9	46,8	3,62	328	665	555	15,4	46,5	4,13
2	Vitavax 200 FF, 2,5 L/t	307	570	512	15,0	46,8	3,68	353[1)]	698[1)]	581	15,6	47,7[1)]	4,48
3	Radostim, 0,25 L/t	313	587	526	15,4[1)]	47,5[1)]	3,83[1)]	336	697[1)]	593[1)]	16,5[1)]	46,9	4,67[1)]
4	Albit, 30 ml/t	321[1)]	607[1)]	513	15,3	47,4[1)]	3,80	326	663	571	15,4	47,7[1)]	4,33
5	MWF of EHF 0,9 kw/kg, 45 sec.	319[1)]	634[1)]	558[1)]	14,9	47,1	3,99[1)]	347[1)]	701[1)]	601[1)]	15,5	46,8	4,52[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	313	593	537[1)]	15,5[1)]	46,7	3,99[1)]	325	684	582	15,8	47,5[1)]	4,53[1)]
7	MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	307	590	523	14,7	47,6[1)]	3,74	350[1)]	718[1)]	606[1)]	15,8	47,4[1)]	4,61[1)]
8	MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	320[1)]	597	534[1)]	15,2	47,4[1)]	3,93[1)]	346	717[1)]	602[1)]	15,4	46,6	4,41
9	MWF of EHF 1,8 kw/kg, 20 sec.	311	586	554[1)]	14,8	47,6[1)]	3,94[1)]	329	713[1)]	613[1)]	16,1[1)]	46,7	4,68[1)]

10	MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	$322^{1)}$	$610^{1)}$	518	$15,4^{1)}$	47,2	$3,84^{1)}$	343	663	$604^{1)}$	15,5	$47,2^{1)}$	$4,50^{1)}$
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	$318^{1)}$	596	$533^{1)}$	14,5	$47,6^{1)}$	3,74	343	$710^{1)}$	$599^{1)}$	15,3	46,9	4,42
12	MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	$318^{1)}$	$613^{1)}$	$564^{1)}$	14,5	$47,6^{1)}$	$3,97^{1)}$	331	691	$609^{1)}$	$16,6^{1)}$	$47,5^{1)}$	$4,97^{1)}$
correlation coefficient with yield capacity, r =		$0,62^{1)}$	$0,64^{1)}$	$0,82^{1)}$	0,16	0,17	–	0,07	0,38	0,74*	0,85*	0,29	–
SSD_{05}		22,7	32,8	25,0	0,5	0,5	0,19	18,6	31,0	32,6	0,4	0,6	0,35

Note: $^{1)}$ – Significant difference

It is noteworthy that, unlike the Aspect variety, the pre-sowing seed irradiation of the Vyklyk barley variety with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. exceeded the standard case of the pre-sowing seed treatment with Vitavax 200 FF only according to the index of the productive stems number (601 and 613 pieces/m^2 respectively); in the case with Vitavax 200 FF this index was 581 pieces/m^2.

In general, the level of the biological yield capacity of spring barley under each methods of the pre-sowing seed treatment was relatively higher in comparison with the case without treatment. At the same time, the mathematically reliable allowances for the Aspect variety have been determined in the cases of application of the growth regulator Radostim, 0,25 L/t; MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only, or in combination with Vitavax 200 FF, 1,25 L/t; as well as in the case of MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t.

Regarding the Vyklyk variety such cases were Radostim, 0,25 L/t; MWF of EHF, 1,8 kw/kg, 20 sec. and MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t.

Harvesting and record of the crops on the experimental plots in general confirmed the tendencies of variability of this index depending on the method of the pre-sowing seed treatment that have been revealed in the structural analysis of the spring barley varieties yield.

Thus, on the average for 2011–2013 the pre-sowing seed irradiation with MWF of EHF at the power of 0,9 kw/kg and exposure of 45 sec. or at the power of 1,8 kw/kg and exposure of 20 sec. provided a significant increase in the yield capacity of the Aspect barley variety by 0,17 (4,9%) and 0,18 (5,2%) t/ha respectively, while he yield capacity under the control was 3,45 t/ha (Table 6.2). In the case of Vitavax 200 FF, 2,5 L/t the increase in the yield averaged 0,11 t/ha or 3,2%.

The applying of MWF of EHF in combination with half a rate of Vitavax 200 FF (1,25 L/t) or with the growth regulator Albit, 30 ml/t was also effective; the increase in the yield capacity was 0,18–0,20 t/ha or 5,2–5,8%.

The similar effects were noted in the case of the Vyklyk spring barley variety. Thus, on the average for 2012–2013 the pre-sowing seed irradiation with MWF of EHF at the power of 0,9 kw/kg and exposure of 45 sec. or at the power of 1,8 kw/kg and exposure of 20 sec. provided a significant increase in the yield capacity of the Vyklyk barley variety by 0,14 (3,8%) and 0,21 (5,6%) t/ha with the yield capacity of 3,72 t/ha under the control (Table 6.2). In the case of treating the seeds with Vitavax 200 FF, 2,5 L/t the yield capacity exceeded the control by 0,06 t/ha or 1,6% on the average.

It should be noted that the application of MWF of EHF in the modes of 0,9 kw/ kg, 45 sec. or 1,8 kw/kg, 20 sec. in combination with treating the seeds at half a rate of Vitavax 200 FF (1,25 L/t) exceeded the efficiency of treatment with MWF of EHF only, as well as the treatment at the full rate of Vitavax 200 FF; the average increase in the yield for two years was 0,17 (4,6%) and 0,32 (8,6%) t/ha respectively. The application of MWF of EHF, 1,8 kw/kg, 20 sec. together with treating the seeds with the growth regulator Albit, 30 ml/t was also effective; the increase in the yield capacity amounted to 0,23 t/ha or 6,2%.

However, it should be noted that the efficiency of the examined methods of the pre-sowing treatment of spring barley seeds varied significantly over the years. In the years of less favourable agro-meteorological conditions for the growth and development of barley and of lower level of the yield capacity, the positive effect of MWF of EHF application was relatively higher.

For example, in 2012 the increase in the yield capacity of the Aspect barley variety due to the pre-sowing seed treatment with MWF of EHF, 1,8 kw/kg, 20 sec. was 3%, and in 2013 it was 7%, at the yield capacity under the control of 4,72 and 2,69 t/ha respectively.

In a similar case of the Vyklyk spring barley seed treatment with MWF of EHF the increase in the yield in 2012 amounted to 3% and in 2013 it was 12% while under the control the yield capacity was 4,83 and 2,60 t/ha.

Thus, the most effective methods of the pre-sowing seed treatment that increase the yield capacity of the Aspect spring barley variety in comparison with the treatment of seeds with Vitavax 200 FF, 2,5 L/t is the seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only or with the additional treatment with the Albit growth regulator, 30 ml/t.

The combination of the pre-sowing seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. and the subsequent seed treatment with the growth regulators Radostim, 0,25 L/t or Albit, 30 ml/t didn’t lead to the naturally determined additional increase

б.2. Yield capacity of spring barley varieties depending on the method of application of MWF of EHF and growth regulators, t/ha

№	Methods of seed treatment	Aspect						Vyklyk				
		2011	2012	2013	Average	+/- before the control		2012	2013	Average	+/- before the control	
						t/ha	%				t/ha	%
1	Control, without treatment	2,95	4,72	2,69	3,45	–	–	4,83	2,60	3,72	–	–
2	Vitavax 200 FF, 2,5 L/t (standard)	3,08[1)]	4,77	2,84[1)]	3,56	0,11	3,2	4,94	2,61	3,78	0,06	1,6
3	Radostim, 0,25 L/t	2,97	4,85[1)]	2,82	3,55	0,10	2,9	5,00[1)]	2,80	3,90[1)]	0,18	4,8
4	Albit, 30 ml/t	2,92	4,88[1)]	2,90[1)]	3,57[1)]	0,12	3,5	4,98[1)]	2,69	3,84	0,12	3,2
5	MWF of EHF 0,9 kw/kg, 45 sec.	3,11[1)]	4,82	2,93[1)]	3,62[1)]	0,17	4,9	5,01[1)]	2,71	3,86	0,14	3,8
6	MWF of EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	3,14[1)]	4,87[1)]	2,87[1)]	3,63[1)]	0,18	5,2	5,00[1)]	2,78	3,89[1)]	0,17	4,6
7	MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	2,99	4,83[1)]	2,80	3,54	0,09	2,6	4,83	2,98[1)]	3,91[1)]	0,19	5,1
8	MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	3,08[1)]	4,96[1)]	2,90[1)]	3,65[1)]	0,20	5,8	4,88	2,86[1)]	3,87	0,15	4,0

9	MWF of EHF 1,8 kw/kg, 20 sec.	3,14[1)]	4,87[1)]	2,88[1)]	3,63[1)]	0,18	5,2	4,96[1)]	2,90[1)]	3,93[1)]	0,21	5,6
10	MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	3,09[1)]	4,82	2,77	3,56	0,11	3,2	4,91	3,17[1)]	4,04[1)]	0,32	8,6
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	2,93	4,89[1)]	2,84[1)]	3,55	0,10	2,9	4,97[1)]	2,71	3,84	0,12	3,2
12	MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	3,11[1)]	4,89[1)]	2,90[1)]	3,63[1)]	0,18	5,2	5,02[1)]	2,87[1)]	3,95[1)]	0,23	6,2
	SSD_{05}	0,12	0,10	0,14	0,11	–	–	0,12	0,22	0,16	–	–

Note: [1)] – Significant difference

in the yield capacity of the Aspect and Vyklyk spring barley varieties in comparison with a single treatment with MWF of EHF.

The analysis of the yield capacity of barley varieties depending on the pre-sowing method of seed treatment with MWF of EHF and the plant growth regulators during the years of field researches, which varied significantly according to the agro-meteorological conditions (see Chapter 4.1), makes it possible to conclude that the factor “Seed treatment” has an influence at a level of 9%, the factor “Variety” has an influence of 1%, but the factor “Weather conditions of the year” was the determining one and amounted to 90% (Figure 6.1).

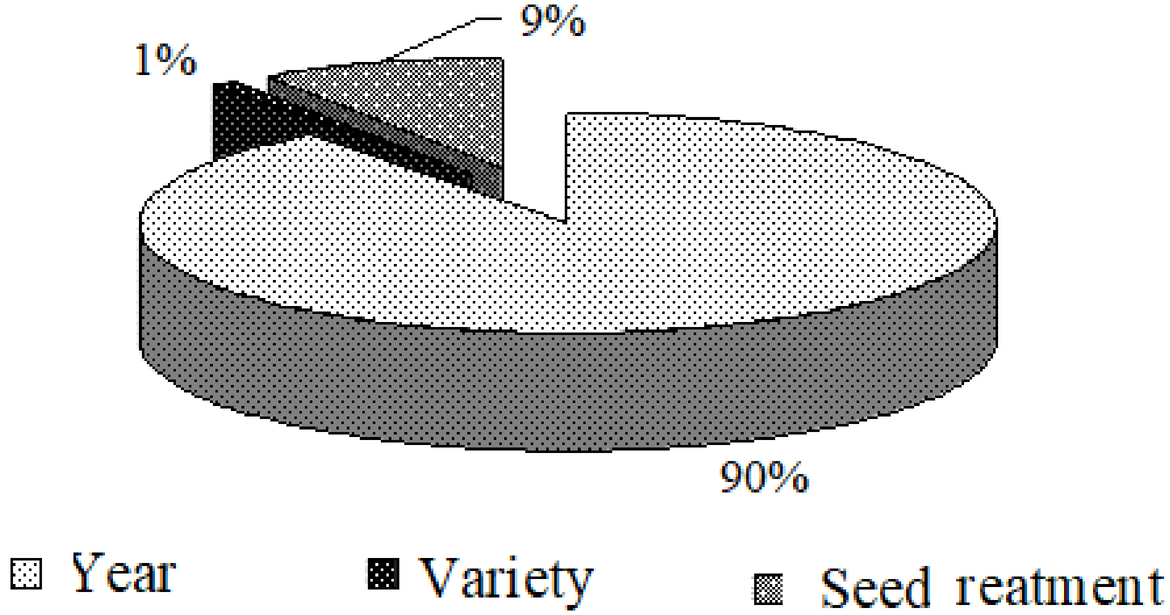


Figure 6.1 Influence of factors that determined the yield capacity of Aspect and Vyklyk spring barley varieties in 2012–2013

6.2 Sowing qualities of spring barley seeds depending on the method of pre-sowing seed treatment with MWF of EHF

An important aspect for the development of the new elements of crop cultivation technologies is a comprehensive study of their influence not only on the yield capacity, but also on the qualitative indices of the obtained products – seeds or grains.

During the period of the research the sowing qualities of spring barley seeds were determined annually after harvesting and refining the crops in each case of the experiment when studying the efficiency of different methods of the pre-sowing seed treatment with MWF of EHF and plant growth regulators.

6.3. Seed sowing qualities of spring barley varieties grown with the application of MWF of EHF and plant growth regulators, %

№	Case of treatment	Aspect								Vyklyk					
		sprouting energy				germinating power				sprouting energy			germinating power		
		years			average	years			average	years		average	years		average
		2011	2012	2013		2011	2012	2013		2012	2013		2012	2013	
1	Control, without treatment	90	94	93	92	95	99	97	97	96	92	94	97	97	97
2	Vitavax 200 FF, 2,5 L/t	94[1)]	97[1)]	92	94	97	99	97	97	97	93	95	98	98	98
3	Radostim, 0,25 L/t	94[1)]	97[1)]	93	95[1)]	98[1)]	99	96	97	94	92	93	96	98	97
4	Albit, 30 ml/t	93[1)]	97[1)]	93	93	96	99	95	97	96	94[1)]	95	99[1)]	99[1)]	99[1)]
5	MWF of EHF 0,9 kw/kg, 45 sec.	96[1)]	97[1)]	95	96[1)]	96	98	99	96	96	91	94	98	97	97
6	MWF of EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	97[1)]	98[1)]	93	96[1)]	98[1)]	99	97	98	99[1)]	94[1)]	96[1)]	100[1)]	98	99[1)]
7	MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	94[1)]	95	93	94	97	99	97	98	98[1)]	92	95	99[1)]	97	98

8	MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	92	96	94	94	98$^{1)}$	98	97	98	98$^{1)}$	92	95	99$^{1)}$	96	98
9	MWF of EHF 1,8 kw/kg, 20 sec.	94$^{1)}$	95	91	92	97	98	96	96	97	94$^{1)}$	96$^{1)}$	98	98	98
10	MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	94$^{1)}$	93	91	92	96	99	96	96	95	92	94	96	98	97
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	94$^{1)}$	95	90	92	97	100	95	97	97	94$^{1)}$	96$^{1)}$	97	98	98
12	MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	93$^{1)}$	97$^{1)}$	93	94	97	98	96	97	96	94$^{1)}$	95	97	97	97
	SSD_{05}	2,11	2,07	1,89	2,17	2,02	2,01	1,78	1,55	1,55	1,63	1,29	1,45	1,32	1,33

Note: $^{1)}$ – Significant difference

It should be noted that, in general, the agro-meteorological conditions of 2011–2013 contributed to the formation of high sowing qualities of the seeds of both barley varieties. Thus, in the control case (without treatment) the sprouting energy and germinating power of seeds of the Aspect variety were respectively 92 and 97% on the average in 2011–2013, and those of the Vyklyk variety were 94 and 97% respectively on the average for 2012–2013 (Table 6.3). Obviously for this reason, according to the results of our researches no significant regularities in the variability of sowing qualities of spring barley seeds depending on the method of the pre-sowing seed treatment with MWF of EHF and growth regulators have been established.

Thus, the average sprouting energy of the Vyklyk barley variety seeds in the case of the Vitavax 200 FF treatment was 95% in 2012–2013, and the germinating power was 98%; in the case of MWF of EHF, 0,9 kw/kg, 45 sec. these indices were 94 and 97% respectively; in the case of MWF of EHF, 1,8 kw/kg, 20 sec they were 96 and 98% respectively, and when combined the application of MWF of EHF with the growth regulators the indices were 95–96 and 97–98% respectively. That is, the disparity between the methods of MWF of EHF and the growth regulators application and the control and standard cases did not exceed 1–2%. The highest indices (99%) were observed in the case of the pre-sowing seed treatment with Albit, 30 ml/t and MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t.

The germinating power of spring barley seeds of the Aspect variety varied in the same manner. In the standard case (Vitavax 200 FF, 2,5 L/t) this index was 97% and in the cases of MWF of EHF it was 96–98 %.

However, the seed sprouting energy when applying 0,9 kw/kg MWF of EHF, 45 sec. and 0,9 kw/kg MWF of EHF, 45 sec. + Vitavax 200 FF, 1,25 L/t exceeded the control by 4%, and the standard – by 2% on the average for three years.

It is noteworthy that in 2011 the sprouting energy of the Aspect barley variety seeds under all methods of the pre-sowing seed treatment exceeded the control index (90%) by 3–7%, and in the cases of applying MWF of EHF, 0,9 kw/kg, 45 sec. and MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t it exceeded the standard by 2 and 3% respectively.

6.3 Spring barley grain quality indices depending on the method of pre-sowing seed treatment with MWF of EHF

The quality of spring barley grain is significantly influenced by the agro-meteorological conditions of the cultivation year. The abundant rains during the vegetation period of plants contribute to the production of brewing barley, and the low amount of precipitation against the background of high air temperature contributes to the production of feed barley [253–259]. Weather factors often cause the conversion of brewing barley into the feed one and vice versa [260–268]. As the conditions of spring barley cultivation during the period of our research were mainly arid, then in general, they contributed to the formation of the commercial grain regardless the method of the pre-sowing seed treatment.

An interesting consequence of the Aspect barley variety seed irradiation is an evident decrease in the protein content of the obtained grain crops. Thus, in 2011 in the cases of applying MWF of EHF with the subsequent seed treatment with the growth regulator Albit, the protein content in the grain was 12,8–13,0%, while under the control it was 14,2%.

The similar tendency was also noted in 2012. The protein content in the seeds of the Aspect barley variety in the cases of the pre-sowing seed treatment with MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF and MWF of EHF, 1,8 kw/kg, 20 sec. + Albit was 11,8%, and under the control it was 13,0%; and in the cases of the Vyklyk barley variety when treating the seeds with Vitavax 200 FF or Albit preparations the protein content was 11,9 and 11,2% respectively, and under the control it was 12,7% (Table 6.3.).

In 2013 in the cases of the pre-sowing seed treatment of the Aspect variety with the Vitavax 200 FF treating agent, the growth regulator Albit or MWF of EHF in the mode of 1,8 kw/kg of seeds, 20 sec., the protein content in the grain was 11,9, 11,7 and 11,9% respectively, under the control it was 12,6%. Under other ways of the pre-sowing seed treatment of the Aspect barley variety as well as in general in the experiment with the Vyklyk variety the protein content did not change significantly.

On the average, in the course of the researches for 2011–2013 the lowest level of the protein content in the grains of the Aspect barley variety (12,4%) was noted in the cases of the pre-sowing seed treatment with MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF or MWF of EHF 1,8 kw/kg, 20 sec. + Albit, under the control it was 13,3%; and in the grains of the Vyklyk barley variety the lowest level of the protein content

6.4. Grain quality indices of spring barley varieties grown with application of MWF of EHF and plant growth regulators, %

№	Case of seed treatment	Aspect								Vyklyk					
		protein content				starch content				protein content			starch content		
		2011	2012	2013	average	2011	2012	2013	average	2012	2013	average	2012	2013	average
1	Control, without treatment	14,2	13,0	12,6	13,3	59,8	62,1	61,2	61,0	12,7	12,5	12,6	61,3	61,1	61,2
2	Vitavax 200 FF, 2,5 L/t (standard)	13,5	12,8	11,9[1)]	12,7[1)]	58,9	62,4	62,2	61,2	11,9[1)]	12,2	12,1	62,7[1)]	61,5	62,1[1)]
3	Radostim, 0,25 L/t	13,4[1)]	12,1[1)]	12,2	12,6[1)]	59,9	62,8	61,6	61,4	12,1	12,0	12,1	62,5[1)]	61,5	62,0[1)]
4	Albit, 30 ml/t	13,8	12,0[1)]	11,7[1)]	12,5[1)]	60,0	61,7	62,1	61,3	11,2[1)]	12,3	11,8[1)]	61,8	61,8	61,8
5	MWF of EHF 0,9 kw/kg, 45 sec.	13,3[1)]	12,5	12,1	12,6[1)]	60,5	61,6	61,8	61,3	12,3	12,0	12,2	62,3[1)]	62,7[1)]	62,5[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	13,2[1)]	11,8[1)]	12,1	12,4[1)]	60,3	61,3	61,4	61,0	12,1	12,3	12,2	62,3[1)]	61,9[1)]	62,1[1)]
7	MWF of EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	13,6	12,6	12,5	12,9	59,9	60,8	60,6	60,4	13,0	12,2	12,6	62,1	61,9[1)]	62,0[1)]
8	MWF of EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	13,0[1)]	12,9	12,5	12,8[1)]	60,0	61,8	61,4	61,1	13,8[1)]	12,5	13,2	62,6[1)]	60,7	61,7
9	MWF of EHF 1,8 kw/kg, 20 sec.	13,9	12,3[1)]	11,9[1)]	12,7[1)]	60,2	61,1	62,1	61,1	13,4	12,6	13,0	62,9[1)]	61,3	62,1[1)]
10	MWF of EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	13,4[1)]	13,1	12,3	12,9	60,1	61,2	60,7	60,7	12,9	12,3	12,6	61,4	61,6	61,5
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	13,5	12,5	12,1	12,7[1)]	59,4	62,1	61,3	60,9	12,9	12,8	12,9	61,5	61,0	61,3
12	MWF of EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	12,8[1)]	11,8[1)]	12,5	12,4[1)]	59,1	62,0	61,5	59,9	12,4	12,7	12,6	60,9	61,1	61,0
	SSD_{05}	0,75	0,67	0,58	0,41	1,12	1,37	1,14	0,87	0,71	0,65	0,54	0,98	0,79	0,63

was in the case of the pre-sowing seed treatment with the preparation Albit and it amounted to 11,8%, under the control this index was 12,6%.

On the average in 2011–2013 the starch content in the grain of the Aspect spring barley variety depending on the method of the pre-sowing seed treatment did not change significantly (Table 6.4).

The starch content in the grains of the Vyklyk variety in the cases of the pre-sowing seed treatment with Vitavax 200 FF treating agent, the growth regulator Radostim and irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. both in their combination and separately, as well as in the case of irradiation with MWF of EHF, 1,8 kw/kg, 20 sec. was 62,0–62,5%; under the control it was 61,2%.

Conclusions to Chapter 6

1. The agro-meteorological conditions of the cultivation year influenced the formation of the yield structural elements of the spring barley varieties and their biological yield capacity first of all.

2. The density of plants, and the total number of stems, including the productive ones became the structural elements that caused the increase in the biological and actual yield capacity of the Aspect barley variety depending on the method of the pre-sowing seed treatment; the correlation coefficients were 0,62; 0,64 and 0,82 respectively; as for the Vyklyk variety the correlation coefficient of the productive stems number was 0,74.

3. The most effective methods of the pre-sowing seed treatment that cause the increase in the yield capacity of the Aspect barley variety in comparison with the Vitavax 200 FF 2,5 L/t treatment is the seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only or with the additional treatment with the growth regulator Albit, 30 ml/t.

4. The most effective methods of the pre-sowing seed treatment that cause the increase in the yield capacity of the Vyklyk spring barley variety in comparison with the Vitavax 200 FF 2,5 L/t treatment is the seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only or with the additional treatment with Vitavax 200 FF at half a rate of 1,25 L/t or treatment with the growth regulator Albit, 30 ml/t.

5. The combination of the pre-sowing seed irradiation with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. and seed treatment with the growth regulators Radostim, 0,25 L/t or Albit, 30 ml/t didn’t lead to the naturally determined increase in the yield capacity of the

Aspect and Vyklyk spring barley varieties in comparison with a single treatment with MWF of EHF.

6. Under favourable agro-meteorological conditions that lead to high basic level of the sprouting energy (92–93%) and germinating power (97%) the significant regularities in the variability of the sowing qualities of spring barley seeds depending on the pre-sowing seed treatment with MWF of EHF and growth regulators have not been found out.

7. Under the influence of barley seeds irradiation with MWF of EHF the protein content in the obtained grain yield has a tendency to decrease. A significantly lower protein level in the grain of the Aspect barley variety (12,4%) was noted in the cases of the pre-sowing seed treatment with MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF or MWF of EHF 1,8 kw/kg, 20 sec. + Albit, under the control it was 13,3%; as for the Vyklyk barley grains, the protein content was 11,8% in the case of the pre-sowing seed treatment with the preparation Albit, while under the control it was 12,6%.

8. The starch content in the grains of the Aspect spring barley did not change significantly depending on the method of the pre-sowing seed treatment.

The starch content in the grains of the Vyklyk spring barley in the cases of the pre-sowing seed treatment with the Vitavax 200 FF treating agent, the growth regulator Radostim and irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. both separately and in their combination, as well as in the case of irradiation with MWF of EHF, 1,8 kw/kg, 20 sec. was significantly higher and amounted to 62,0–62,5%, while under the control it was 61,2%.

CHAPTER 7. ECONOMIC EFFICIENCY OF METHODS FOR PRE-SOWING SEEDS OF CEREAL SPIKE CROPS TREATMENT WITH MWF OF EHF AND PLANT GROWTH REGULATORS

Each of the measures aimed at increasing the yield capacity is practically applicable only when it has an economic effect. The expediency of the measure can be discussed if the additional costs connected with its implementation at the agricultural enterprise provide the additional products that exceed the costs.

Along with the measures that contribute to improving the economic situation of the agricultural enterprises, the introduction of not only new high-yielding varieties but also certain technological methods of their cultivation which contribute to the fuller realization of their productive potential confirmed by the economic efficiency are of great importance.

The economic evaluation of the studied elements of the cultivation technology, namely the methods of the pre-sowing seed treatment, was carried out according to the modern methodical recommendations [269, 270].

The production costs for the pre-sowing treatment of one ton of seeds included:

– the cost of the treating agent or plant growth regulator, which, according to the seeding rate, was distributed over 4 ha of the crops;

– the cost of electricity when treating the seeds with MWF of EHF or using the seed treater of “PS-10” brand;

– labour payment;

– allowance for depreciation, current repairs, etc. [191].

The cost of the yield was calculated according to the current prices of the regional grain exchange in February 2018.

The economic efficiency of cereal spike crops cultivation, depending on the method of the pre-sowing seed treatment, in general was determined by its application costs and the level of the obtained increase in the yield capacity.

7.1. Economic efficiency of methods for winter wheat seeds pre-sowing treatment with MWF of EHF and plant growth regulator Mars EL

The calculations of the economic efficiency indicate that the highest costs spent for the seed treatment were in the case of treatment with the Vitavax 200 FF; they amounted to 178 UAH/ha with the lowest increase in the yield capacity of 0,1 t/ha (Table 7.1). In the cases of the seed irradiation with MWF of EHF, both separately and in combination with the plant growth regulator, the costs did not exceed 31–45 UAH/ha, and the increase ranged from 0,08 to 0,24 t/ha.

7.1. Economic efficiency of pre-sowing methods for treatment of Astet winter wheat variety seeds, 2011-2013

Pre-sowing seed treatment methods	Yield capacity, t/ha	Increase, t/ha	Costs of seed treatment, UAH/ha	Yield value, UAH/ha	Extra profit, UAH/ha
Control, without treatment	5,39	–	–	24794	–
Vitavax 200 FF, 2,5 L/t (standard)	5,49	0,10	178	25254	282
MWF of EHF, 1,8 kw/kg, 15 sec.	5,58	0,19	31	25668	843
MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	5,63	0,24	45	25898	1059
MWF of EHF, 0,9kw/kg, 45 sec.	5,63	0,24	31	25898	1073
MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	5,47	0,08	45	25162	323

Besides, it was found out that the most cost effective and profitable methods of the pre-sowing seed treatment of the Astet winter wheat variety was the pre-sowing seed irradiation with MWF of EHF at the power of 1,8 kw/kg with the exposure of 15 sec. with the additional treatment with the Mars EL growth regulator, as well as the pre-sowing irradiation with MWF of EHF at the power of 0,9 kw/kg at the exposure of 45 sec. The extra profit in these cases made up 1059 and 1073 UAH/ha respectively.

It is noteworthy that the pre-sowing seed treatment only with the Vitavax 200 FF treatment agent provided an extra profit of 282 UAH/ha.

This fact indicates that the pre-sowing irradiation of winter wheat seeds with MWF of EHF, both separately and in combination with the Mars EL growth regulator, is a more cost-effective method than the traditional seed treatment with the Vitavax 200 FF at the recommended rate of 2,5 L/t.

7.2 Economic efficiency of methods for pre-sowing seed treatment of spring barley varieties with MWF of EHF and plant growth regulators

When growing spring barley the costs in the case of the Vitavax 200 FF seed treatment at the full consumption rate (2,5 L/t) made up 178 UAH/ha, and in the cases of the pre-sowing seed irradiation with MWF of EHF in combination with the Vitavax 200 FF treatment (1,25 L/t)) the costs amounted to 120 UAH/ha (Tables 7.2, 7.3).

The costs of the Radostim growth regulator application (96 UAH /ha) and its combination with MWF of EHF (127 UAH/ha) were relatively high. The least expensive was the seed irradiation with MWF of EHF, which amounted to 31 UAH/ha and application of the Albit growth regulator, the costs were 22 UAH/ha.

At the same time the highest extra profit regarding the Aspect barley variety was provided by the pre-sowing seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. with the additional seed treatment by the Albit growth regulator, 30 ml/t; MWF of EHF in the mode of 1,8 kw/kg, 20 sec. only or with the additional seed treatment with the Albit growth regulator, 30 ml/t; the extra profit was 857, 788 and 766 UAH/ha respectively (Table 7.2).

7.2. Economic efficiency of methods for pre-sowing seed treatment of Aspect spring barley variety, 2011–2013

Pre-sowing seed treatment methods	Yield capacity, t/ha	Increase, t/ha	Costs of seed treatment, UAH/ha	Yield value, UAH/ha	Extra profit, UAH/ha
Control, without treatment	3,45	–	–	15698	–
Vitavax 200 FF, 2,5 L/t (standard)	3,56	0,11	178	16198	323
Radostim, 0,25 L/t	3,55	0,10	96	16153	359
Albit, 30 ml/t	3,57	0,12	22	16244	524
MWF of EHF, 0,9 kw/kg, 45 sec.	3,62	0,17	31	16471	743
MWF of EHF, 0,9 kw/kg, 45 sec.+ Vitavax 200 FF, 1,25 L/t	3,63	0,18	120	16517	699
MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0, 25 L/t	3,54	0,09	127	16107	283
MWF of EHF, 0,9 kw/kg, 45 sec.+ Albit, 30 ml/t	3,65	0,20	53	16608	857
MWF of EHF, 1,8 kw/kg, 20 sec.	3,63	0,18	31	16517	788
MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	3,56	0,11	120	16198	381
MWF of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	3,55	0,10	127	16153	328
MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	3,63	0,18	53	16517	766

7.3. Economic efficiency of pre-sowing seed treatment of Vyklyk spring barley variety, 2012-2013

Pre-sowing seed treatment methods	Yield capacity, t/ha	Increase, t/ha	Costs of seed treatment, UAH/ha	Yield value, UAH/ha	Extra profit, UAH/ha
Control, without treatment	3,72	–	–	16926	
Vitavax 200 FF, 2,5 L/t (standard)	3,78	0,06	178	17199	95
Radostim, 0,25 L/t	3,90	0,18	96	17745	723
Albit, 30 ml/t	3,84	0,12	22	17472	524
MWF of EHF, 0,9 kw/kg, 45 sec.	3,86	0,14	31	17563	606
MWF of EHF, 0,9 kw/kg, 45 sec.+ Vitavax 200 FF, 1,25 L/t	3,89	0,17	120	17700	654
MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0, 25 L/t	3,91	0,19	127	17791	738
MWF of EHF, 0,9 kw/kg, 45 sec.+ Albit, 30 ml/t	3,87	0,15	53	17609	630
MWF of EHF, 1,8 kw/kg, 20 sec.	3,93	0,21	31	17882	925
MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	4,04	0,32	120	18382	1336
MWF of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	3,84	0,12	127	17472	419
MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	3,95	0,23	53	17973	994

The pre-sowing seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. only or with the additional seed treatment with the Vitavax 200 FF treatment agent at a consumption rate of 1,25 L/t was also economically efficient – the extra profit was 743 and 699 UAH/ha, respectively.

It should be noted that these indices significantly exceeded the economic efficiency of the traditional seed treatment of the Aspect variety with Vitavax 200 FF, where the extra profit made up 323 UAH/ha.

In the case of the Vyklyk spring barley variety the highest extra profit was provided by the pre-sowing seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 20 sec. both only and with the additional treatment with the Vitavax 200 FF treatment agent at a consumption rate of 1,25 L/t or with the Albit growth regulator, 30 ml/t; the extra profit was 925, 1336 and 994 UAH/ha respectively.

The economic efficiency of other methods of pre-sowing seed treatment of the Vyklyk barley varieties was lower and ranged within 419–738 UAH/ha, but when treating the seeds with the Vitavax 200 FF, the extra profit made up only 96 UAH/ha.

7.3. Production test, implementation and economic efficiency of pre-sowing seeds of winter wheat and spring barley treatment

The efficiency of seed irradiation with MWF of EHF using the installation of a microwave design of the "UMVK-1" brand developed by the Kharkiv National Technical University of Radio Electronics and modern growth regulators was confirmed by a production test on the farms of different forms of ownership in the area of 331 hectares; 83,9 tons of quality seeds or grain were additionally obtained. An increase in the winter wheat yield capacity was 0,22–0,36 t/ha or 5–8%, in the case of spring barley it was 0,12–0,20 t/ha or 6%, which provided the total extra profit of 284,880 thousand UAH. The results of the production test and the implementation into the cultivation of cereal spike crops in 2011–2016 are shown in Table 7.4.

Therefore, the use of the plant growth regulators is quite efficient and should become an important element of modern technologies for cultivation of high-quality seeds of cereal spike crops.

7.4. Results of productive test and implementation of methods of pre-sowing seed treatment, 2011-2016

Crop, variety, acreage	Case	Yield capacity, t/ha	Difference in yield capacity		Extra costs, UAH/ha	Yield value, UAH/ha	Extra profit, UAH/ha
			t/ha	%			
Agricultural Firm “Pischanska”, Krasnohrad Region, Kharkiv Oblast, 2011							
Winter wheat Antonovka, 50 ha	Control	4,61	–	–	–	12447	–
	Seed irradiation with MWF of EHF 0,9kw, 45 sec.	4,93	0,32	7	31	13311	833
Agricultural Firm “Pischanska”, Krasnohrad Region, Kharkiv Oblast, 2012							
Spring barley Helius, 45 ha	Control	2,84	–	–	–	8804	–
	Seed irradiation with MWF of EHF 1,8kw, 20 sec. + Albit, 30 ml/t	3,02	0,18	6	41	9362	517
Winter wheat Bohdana, 40 ha	Control	4,42	–	–	–	12376	–
	Seed irradiation with MWF of EHF 1,8kw, 15sec. + Mars EL, 0,2 L/t	4,78	0,36	8	37	13384	971
“Semagro” LLC on the territory of Valky Region of Kharkiv Oblast, 2014							
Winter wheat Yesaul, 20 ha	Control	4,12	–	–	–	15656	–
	Seed irradiation with MWF of EHF 1,8 kw,15sec. + Mars EL, 0,2 L/t	4,34	0,22	5	37	16492	799

	Mars EL, 0,2 L/t						
Spring barley Zdobutok 20 ha	Control	3,03	–	–	–	11363	–
	Seed irradiation with MWF of EHF 1,8 kw, 20 sec. + Albit, 30 ml/t	3,15	0,12	4	41	11813	409
"Semagro" LLC on the territory of Valky Region of Kharkiv Oblast, 2016							
Winter wheat Doskonala, 24 ha	Control	4,61	–	–	–	25355	–
	Seed irradiation with MWF of EHF 1,8kw,15sec. + Mars EL, 0,2 L/t	4,93	0,32	7	45	27115	1715
Spring barley Aspect, 27 ha	Control	3,2	–		–	18260	–
	Seed irradiation with MWF of EHF 1,8 kw, 20 sec. + Albit, 30 ml/t	3,52	0,20	6	53	19360	1047
"Novoaleksandrivske" LLC on the territory of Vovchansk Region of Kharkiv Oblast, 2016							
Spring barley Dzherelo, 65 ha	Control	3,03	–	–	–	11060	–
	Seed irradiation with MWF of EHF + Albit, 30 ml/t	3,22	0,19	6	71	11753	622
Winter wheat Alians, 40 ha	Control	5,21	–	–	–	20059	–
	Seed irradiation with MWF of EHF + Albit, 30 ml/t	5,54	0,33	6	67	21329	1203

Conclusions to Chapter 7

1. The pre-sowing irradiation with MWF of EHF at the power of 1,8 kw/kg and exposure of 15 sec. with the additional treatment with the Mars EL growth regulator as well as the pre-sowing irradiation with MWF of EHF at the power of 0,9 kw/kg and exposure of 45 sec. are the most economically efficient pre-sowing methods of the Astet winter wheat variety seeds treatment, which provides an extra profit of 1059 and 1073 UAH/ha respectively, that is 777 and 791 UAH/ha more than in the case of treating the seeds with the Vitavax 200 FF, 2,5 L/ha.

2. The highest extra profit was provided by the irradiation of barley seeds of the Aspect variety with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. with the additional treatment of seeds by the growth regulator Albit, 30 ml/t, the irradiation with MWF of EHF in the mode of 1,8 kw/kg, 20 sec., as well as the irradiation with MWF of EHF in the mode of 1,8 kw/kg, 20 sec. with the additional seed treatment with the growth regulator Albit, 30 ml/t. The extra profit was 857, 788 and 766 UAH/ha respectively, which is 531, 465 and 443 UAH/ha more than in the case of treating the seeds with the Vitavax 200 FF.

3. The highest extra profit regarding the Vyklyk spring barley variety was provided by the pre-sowing seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 20 sec. only as well as with the additional seed treatment with the Vitavax 200 FF at a consumption rate of 1,25 L/t or with the plant growth regulator Albit, 30 ml/t. The extra profit amounted to 925, 1336 and 994 UAH/ha respectively, which is 830, 1241 and 899 UAH/ha more than in the case of treating seeds with the Vitavax 200 FF.

4. 83,9 tons of quality seeds or grains with a total value of 284,880 thousands UAH have been obtained additionally from the area of 331 ha due to the application of the seed irradiation with MWF of EHF and modern plant growth regulators in the production.

CONCLUSIONS

The theoretical generalization and new solution of an important scientific problem regarding the development of the ecologically friendly technologies for increasing the yield capacity of winter wheat and spring barley in the conditions of the Eastern part of the Forest–Steppe Zone of Ukraine by the pre-sowing irradiation of the cereal spike crops with the microwave field of extra high frequencies and the subsequent treatment with the plant growth regulators and Vitavax 200 FF seed treating agent, by establishing the regularities and identifying the mechanism of action and interaction of physical, biological and chemical factors, resulting in the determination of the optimum modes of pre-sowing seed treatment, including the subsequent treatment at the reduced rates of the agent or plant growth regulators have been done in the work. As a result, the efficient and economically justified elements of the resource-saving cultivation technology have been developed. It makes possible to reduce the consumption of pesticides or completely replaced them by the ecologically friendly factors that increase the seed sowing qualities and yield capacity, which is essential for the agricultural production.

1. Treatment of spring barley and winter wheat seeds irradiated with MWF of EHF or treating them with the plant growth regulators contribute to the additional increase in the seeds sowing qualities depending on the preparation and its consumption rate.

2. The pre-sowing seed irradiation with MWF of EHF in the modes of 1,8 kw/kg, 15 sec. and 0,9 kw/kg, 45 sec. causes an increase in the field germination of winter wheat on the average by 6,9 and 7,4 % respectively; when additionally treated the seeds with the Mars EL preparation, the increase was 8,2 and 5,5 %.

3. The field germination of the Aspect spring barley variety was the best one (81%) in the case of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t; in the case of EHF, 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t it amounted to 80% and in the case when treated the seeds with the plant growth regulators Albit the field germination was 76% and in the case of Radostim it was 74%; in the control case it was 69%.

4. Seed treatment with MWF of EHF only or in combination with the growth regulator Mars EL caused an increase in the height of the winter wheat plants of the Astet variety beginning from the spring resumption of

vegetation on the average by 4,0–7,9 cm at 66,6 cm under the control; the tillering factor increased by 0,2–0,4 at the index of 2,9 under the control; the leaf surface in the phases of tillering, stalk shooting and ear formation also increased by 12–23, 6–13, and 9–19% respectively while under the control the leaf surface was 11,7, 29,4, and 37,8 thousand m^2/ha; PSP increased by 9–16% while under the control it was 1,21 million m^2 days/ha. Over the years of the research, according to these indices, the highest and most stable results were provided by the application of MWF of EHF in the mode of 0,9 kw/kg, 45 sec. only or with the additional treatment with the Mars EL preparation.

5. The pre-sowing seed treatment of the Aspect and Vyklyk spring barley varieties with MWF of EHF in the modes of 0,9 kw/kg, 45 sec. or 1,8 kw/kg, 20 sec. only or in combination with the growth regulators Radostim or Albit, depending on the variety, caused an increase in the height of plants on the average by 3,4–8,0 cm; the plant density increased by 5–10%, the leaf surface in the phases of tillering, stalk shooting and ear formation increased by 7–16, 6–30 and 10–32% as for the Aspect variety and in the case of the Vyklyk variety these indices were 13–33, 8–36 and 9–37%; PSP increased by 8–27% and 11–37% according to the varieties, under the control these indices were 51,9 and 43,9 cm; 293 and 328 pcs/m^2; 9,9, 19,1, 15,6 and 9,9, 19,0, and 15,9 thousand m^2/ha and 0,63 and 0,63 million m^2 days/ha respectively.

6. The seed treatment with MWF of EHF in certain irradiation modes only or with the additional treatment with the growth regulators Mars EL (wheat) and Radostim or Albit (barley) causes a decrease in the level of spreading and development of the root rots on the crops of these plants.

7. The yield capacity of winter wheat had a significant close positive correlation with the number of the productive stems ($r = 0,91$), as well as a close correlation with the total number of stems ($r = 0,75$).

8. In comparison with treating the seeds with Vitavax 200 FF, 2,5 L/t, the most effective methods of the pre-sowing seed treatment that cause an increase in the winter wheat yield capacity are the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. and the seed irradiation with MWF of EHF in the mode of 1,8 kw/kg, 15 sec. with the additional processing by the Mars EL growth regulator, 0,2 L/t.

9. The highest content of the fluid gluten in the wheat grains was observed in the case of seeds irradiation with MWF of EHF in the mode of

0,9 kw/kg of seeds and the exposure of 45 sec. It was 22,4–22,5% at 21,2% under the control.

10. The structural elements that caused an increase in the biological and actual yield capacity of barley, depending on the method of pre-sowing seed treatment regarding the Aspect variety were the density of plants, and the total number of stems, including the productive ones; the correlation coefficients were 0,62, 0,64 and 0,82 respectively; and in the case of the Vyklyk variety the number of the productive stems had a correlation coefficient of 0,74.

11. The most effective methods of the pre-sowing seed treatment that increase the yield capacity of the Aspect spring barley variety in comparison with the seed treatment with Vitavax 200 FF, 2,5 L/t are the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or in the mode of 1,8 kw/kg, 20 sec. only or with the additional treatment with the growth regulator Albit, 30 ml/t; in the case of the Vyklyk spring barley variety the best results were obtained when irradiated the seeds with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. or in the mode of 1,8 kw/kg, 20 sec. only or with the additional treatment with Vitavax 200 FF at half a rate of 1,25 L/t or with the Albit growth regulator, 30 ml/t.

12. Under the influence of the barley seeds irradiation with MWF of EHF the protein content in the obtained grain yield has a tendency to decrease. The significantly lower protein level in the Aspect barley grains (12,4%) was noted in the pre-sowing cases of seed treatment with MWF of EHF in the mode of 0,9 kw/kg, 45 sec. + Vitavax 200 FF or MWF of EHF in the mode of 1,8 kw/kg, 20 sec. + Albit , at 13,3% under the control. In the grains of the Vyklyk barley variety the protein content was at the level of 11,8 % when treated with the Albit preparation, while under the control it was 12,6%.

13. The highest extra profit when cultivated the Aspect barley variety was obtained in the cases of the seed irradiation with MWF of EHF in the mode of 0,9 kw/kg at an exposure of 45 sec. with the subsequent treatment with Vitavax 200 FF, 1,25 L/t, or with the growth regulator Albit, 30 ml/t, as well as in the case of seed irradiation with MWF of EHF in the mode of 1,8 kw/kg at an exposure of 20 sec, both separately and with the subsequent seed treatment with the growth regulator Albit, 30 ml/t; the extra profit amounted to 699–857 UAH/ha. In the case of the Vyklyk variety the highest extra profit was obtained when irradiated the seeds with

MWF of EHF in the mode of 1,8 kw/kg at an exposure of 20 sec., both separately and with the subsequent seed treatment with Vitavax FF 200 at a rate of 1,25 L/t or with the Albit growth regulator, 30 ml/t; the extra profit was 925–1336 UAH/ha.

14. By applying the irradiation of seeds with MWF of EHF and modern growth regulators at the agricultural enterprises of the Kharkiv region, where the production test of the advanced technologies was carried out on an area of 331 hectares, the additional 83,9 tons of quality seeds or grains of winter wheat and spring barley at a total value of 284,880 thousand UAH were obtained.

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APPENDICES

Appendix A

Table A. 1

Sprouting energy and germinating power of winter wheat seeds of Astet variety with MWF of EHF irradiation at different power and exposure modes

Irradiation exposure, sec.	Temperature of seed heating, °C						Sprouting energy, %						Germinating power, %					
	Irradiation power, kw/kg of seeds																	
	0,9			1,8			0,9			1,8			0,9			1,8		
	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average
0	19	21	20	19	21	20	86	90	88	86	90	88	87	91	89	87	91	89
5	20	22	21	24	26	25	86	90	88	88	92	90	87	91	89	89[1)]	93[1)]	91[1)]
10	21	23	22	29	31	30	86	90	88	89[1)]	93[1)]	91[1)]	87	91	89	90[1)]	94[1)]	92[1)]
15	23	25	24	34	36	35	87	91	89	91[1)]	95[1)]	93[1)]	87	91	89	91[1)]	95[1)]	93[1)]
20	25	27	26	41	43	42	87	91	89	85	89	87	88	92	90	86	90	88
25	26	28	27	46	48	47	87	91	89	84	88	86	88	92	90	85[1)]	89	87[1)]
30	28	30	29	50	52	51	87	91	89	83[1)]	87[1)]	85[1)]	88	92	90	84[1)]	88	86[1)]
35	30	32	31	–	–	–	88[1)]	92	90	–	–	–	88	92	90	–	–	–
40	31	33	32	–	–	–	88[1)]	92	90	–	–	–	88	92	90	–	–	–
45	33	35	34	–	–	–	89[1)]	93[1)]	91[1)]	–	–	–	89[1)]	93[1)]	91[1)]	–	–	–
50	35	37	36	–	–	–	84[1)]	88	86	–	–	–	86	90	88	–	–	–
55	37	39	38	–	–	–	84[1)]	88	86	–	–	–	85[1)]	89[1)]	87[1)]	–	–	–
60	39	41	40	–	–	–	84[1)]	88	86	–	–	–	85[1)]	89[1)]	87[1)]	–	–	–
65	41	43	42	–	–	–	84[1)]	88	86	–	–	–	85[1)]	89[1)]	87[1)]	–	–	–
70	43	45	44	–	–	–	83[1)]	87[1)]	85[1)]	–	–	–	85[1)]	89[1)]	87[1)]	–	–	–
75	45	47	46	–	–	–	83[1)]	87[1)]	85[1)]	–	–	–	84[1)]	88[1)]	86[1)]	–	–	–
80	47	49	48	–	–	–	83[1)]	87[1)]	85[1)]	–	–	–	84[1)]	88[1)]	86[1)]	–	–	–
SSD_{05}							1,7	2,7	2,3	2,6	2,8	2,3	1,8	1,7	1,5	1,4	1,5	1,4

Note: [1)] – Significant difference

Table A. 2

Sprouting energy and germinating power of spring barley seeds of Aspect variety with MWF of EHF irradiation at different power and exposure modes

Irradiation exposure, sec.	Temperature of seed heating, °C						Sprouting energy, %						Germinating power, %					
	Irradiation power, kw/kg of seeds																	
	0,9			1,8			0,9			1,8			0,9			1,8		
	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average	2009	2010	average
0	19	17	18	19	17	18	90	89	90	90	89	90	90	91	91	90	91	91
5	21	19	20	25	24	25	89	90	90	88	90	89	90	91	91	92[1)]	91	92
10	22	23	23	29	31	30	86[1)]	90	88	87[1)]	91	89	88	91	90	91	91	91
15	25	24	25	45	39	42	87[1)]	91	89	87[1)]	91	89	88	91	90	91	92	92
20	27	26	27	49	46	48	85[1)]	90	88	91	90	91	88	91	90	92[1)]	91	92
25	29	29	29	52	54	53	86[1)]	90	88	85[1)]	90	88	90	91	91	86[1)]	91	89
30	32	31	32	59	59	59	92[1)]	91	92	86[1)]	90	88	93[1)]	92	93[1)]	88[1)]	92	90
35	36	33	35	62	64	63	89	92[1)]	91	66[1)]	88	77[1)]	90	92	91	82[1)]	91	87[1)]
40	34	34	34	78	70	74	87[1)]	91	89	57[1)]	79[1)]	68[1)]	90	92	91	67[1)]	86[1)]	77[1)]
45	36	35	36	84	76	80	94[1)]	92[1)]	93[1)]	54[1)]	68[1)]	61[1)]	94[1)]	92	93[1)]	60[1)]	83[1)]	72[1)]
50	38	40	39	92	82	87	93[1)]	91	92	42[1)]	48[1)]	45[1)]	94[1)]	92	93[1)]	43[1)]	66[1)]	55[1)]
55	41	41	41	–	–	–	89	90	90	–	–	–	91	90	91	–	–	–
60	45	42	44	–	–	–	89	89	89	–	–	–	90	90	90	–	–	–
65	51	44	48	–	–	–	89	92[1)]	91	–	–	–	90	92	91	–	–	–
70	47	45	46	–	–	–	86[1)]	90	88	–	–	–	87[1)]	92	90	–	–	–
75	57	48	53	–	–	–	89	91	90	–	–	–	92	92	92	–	–	–
80	56	49	53	–	–	–	85[1)]	91	88	–	–	–	88	91	90	–	–	–
85	64	54	59	–	–	–	86[1)]	87	87[1)]	–	–	–	89	90	90	–	–	–
90	66	55	61	–	–	–	84[1)]	88	86[1)]	–	–	–	88	91	90	–	–	–
95	68	56	62	–	–	–	84[1)]	85[1)]	85[1)]	–	–	–	89	89	89	–	–	–
SSD $_{05}$							1,9	2,9	2,5	2,8	3,6	3,7	2,0	1,9	1,6	1,5	2,5	3,7

Note: [1)] – Significant difference

Appendix B

Table B. 1

Sowing qualities of spring barley seeds of Aspect variety depending on MWF of EHF and growth regulators application (before sowing)

№	Case of seed treatment	Sprouting energy, %				Germinating power, %			
		2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	88	92	86	89	89	93	90	91
2	Vitavax 200 FF, 2,5 L/t	89	89[1)]	57[1)]	76[1)]	91	91[1)]	88	90
3	Radostim, 0,25 L/t	91	90	89	90	91	92	92	91
4	Albit, 30 ml/t	90	91	85	89	93[1)]	92	89	91
5	MWF of EHF 0,9kw/kg, 45 sec.	89	92	88	88	91	93	92	91
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	89	91	85	86[1)]	92	93	94[1)]	92
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	91	91	90[1)]	90	92	92	93[1)]	92
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	89	92	88	89	91	92	91	92
9	MWF of EHF 1,8 kw/kg, 20 sec.	89	91	91[1)]	90	91	92	92	92
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	91	90	95[1)]	92[1)]	92	91[1)]	97[1)]	94[1)]
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	92[1)]	93	89	90	93[1)]	94	92	92
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	88	92	91[1)]	91	93[1)]	93	94[1)]	93[1)]
	SSD $_{05}$	4,42	1,79	3,6	2,6	3,9	1,6	3,0	2,1

Note: [1)] – Significant difference

Table B. 2

Sowing qualities of spring barley seeds of Vyklyk variety depending on MWF of EHF and growth regulators application (before sowing)

№	Cases of seed treatment	Sprouting energy, %		Average	Laboratory germinating power, %		Average
		2012	2013		2012	2013	
1	Control, without treatment	88	94	91	90	97	93
2	Vitavax 200 FF, 2,5 L/t	85	86[1)]	86[1)]	86[1)]	93	90[1)]
3	Radostim, 0,25 L/t	90	93	92	92[1)]	96	94
4	Albit, 30 ml/t	92	94	93	94[1)]	98	96[1)]
5	MWF of EHF 0,9kw/kg, 45 sec.	87	94	91	89	97	93
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	90	97[1)]	94[1)]	93[1)]	97	93
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	91	97[1)]	94[1)]	93[1)]	98	96[1)]
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	88	93	91	90	98	94
9	MWF of EHF 1,8 kw/kg, 20 sec.	91	94	93	93[1)]	95	94
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	88	94	91	92[1)]	95	94
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	92[1)]	94	93	93[1)]	97	95
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	93[1)]	95	94[1)]	94[1)]	97	96[1)]
	SSD_{05}	3,3	2,67	2,8	1,6	2,64	2,3

Note: [1)] – Significant difference

Appendix C

Table C. 1

Field germination of Aspect spring barley variety depending on MWF of EHF and growth regulators application, pcs/m^2, 2011 – 2013

№	Cases of seed treatment	Number of plants, pcs/m^2				Field germination, %			
		years				years			
		2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	300	320	313	311	67	71	69	69
2	Vitavax 200 FF, 2,5 L/t	341$^{1)}$	344	328	337$^{1)}$	76$^{1)}$	76	72	74
3	Radostim, 0,25 L/t	332	328	340	333	74$^{1)}$	73	76	74
4	Albit, 30 ml/t	322	366$^{1)}$	353$^{1)}$	347$^{1)}$	71	81$^{1)}$	78$^{1)}$	76$^{1)}$
5	MWF of EHF 0,9kw/kg, 45 sec.	352$^{1)}$	317	368$^{1)}$	345$^{1)}$	78$^{1)}$	70	81$^{1)}$	76$^{1)}$
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	314	360$^{1)}$	391$^{1)}$	355$^{1)}$	70	80	86$^{1)}$	78$^{1)}$
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	300	349	347	332	67	78	77$^{1)}$	74
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	282	351	384$^{1)}$	339$^{1)}$	63	78	85$^{1)}$	75$^{1)}$
9	MWF of EHF 1,8 kw/kg, 20 sec.	333	368$^{1)}$	332	344$^{1)}$	74$^{1)}$	81$^{1)}$	74	76$^{1)}$
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	338	373$^{1)}$	382$^{1)}$	364$^{1)}$	75$^{1)}$	83$^{1)}$	84$^{1)}$	81$^{1)}$
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	401$^{1)}$	356	325	360$^{1)}$	89$^{1)}$	79$^{1)}$	72	80$^{1)}$
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	306	335	399$^{1)}$	346$^{1)}$	68	74	88$^{1)}$	77$^{1)}$
	SSD$_{05}$	38,3	36,7	37,9	25,0	7,5	7,2	7,4	4,9

Note: $^{1)}$ – Significant difference

Table C. 2

Field germination of Vyklyk spring barley variety depending on MWF of EHF and growth regulators application, 1 m^2, 2012–2013

№	Cases of seed treatment	Number of plants, pcs/m^2		Average	Field germination, %		Average
		2012	2013		2012	2013	
1	Control, without treatment	340	369	354	75	81	78
2	Vitavax 200 FF, 2,5 L/t	342	375	358	75	83	79
3	Radostim, 0,25 L/t	340	383	362	75	84	80
4	Albit, 30 ml/t	368	356	362	81	78	80
5	MWF of EHF 0,9kw/kg, 45 sec.	339	378	359	75	83	79
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	367	376	372	81	83	82
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	355	394	375[1)]	78	87[1)]	83[1)]
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	350	399[1)]	375[1)]	77	88[1)]	83[1)]
9	MWF of EHF 1,8 kw/kg, 20 sec.	353	373	363	82[1)]	82	82
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	358	382	370	79	84	82
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	359	378	366	81	83	82
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	366	372	369	81	82	81
	SSD_{05}	31,7	26,6	20,7	6,9	5,8	4,7

Note: [1)] – Significant difference

Appendix D

Table D. 1

Plant density of Astet winter wheat variety depending on MWF of EHF and plant growth regulators application, 2010–2012 (autumn tillering)

№	Cases of seed treatment	Number of plants, pcs/m^2				Number of stems, pcs/m^2				Tillering factor			
		2010	2011	2012	average	2010	2011	2012	average	2010	2011	2012	average
1	Control, without treatment	390	412	391	398	1400	980	1393	1258	3,6	2,4	3,6	3,2
2	Vitavax 200 FF, 2,5 L/t (standard)	388	395	418	400	1512[1)]	1028	1373	1304	3,9[1)]	2,6[1)]	3,3	3,3
3	MWF of EHF, 1,8 kw/kg, 15 sec.	421[1)]	430	429[1)]	416	1571[1)]	990	1580[1)]	1380[1)]	3,7	2,3	3,7	3,2
4	MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	430[1)]	437[1)]	440[1)]	436[1)]	1638[1)]	992	1687[1)]	1439[1)]	3,8[1)]	2,3	3,8[1)]	3,3
5	MWF of EHF, 0,9kw/kg, 45 sec.	413	428	433[1)]	425[1)]	1686[1)]	990	1584[1)]	1420[1)]	4,1[1)]	2,3	3,7	3,4[1)]
6	MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	427[1)]	413	431[1)]	424[1)]	1554[1)]	1005	1640[1)]	1400[1)]	3,6	2,4	3,8[1)]	3,3
	SSD $_{05}$	23,2	24,6	29,6	20,7	89,1	78,4	93,8	95,9	0,20	0,18	0,19	0,15

Note: [1)] – Significant difference

Table D. 2

Plant density of Astet winter wheat variety depending on MWF of EHF and plant growth regulators application, 2011–2013 (stalk shooting phase)

№	Cases of treatment	Number of plants, pcs/m^2				Number of stems, pcs/m^2				Tillering factor			
		2011	2012	2013	average	2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	293	412	390	365	910	1559	756	1075	3,1	3,8	1,9	2,9
2	Vitavax 200 FF, 2,5 L/t (standard)	377[1)]	395	404[1)]	392	1373[1)]	1653	893[1)]	1306[1)]	3,6[1)]	4,2[1)]	2,2[1)]	3,3[1)]
3	MWF of EHF, 1,8 kw/kg, 15 sec.	420[1)]	420	421[1)]	420[1)]	1290[1)]	1548	827	1222[1)]	3,1	3,7	2,0	2,9
4	MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	403[1)]	430	427[1)]	420[1)]	1280[1)]	1709[1)]	876[1)]	1288[1)]	3,2	4,0	2,1[1)]	3,1[1)]
5	MWF of EHF, 0,9kw/kg, 45 sec.	420[1)]	425	433[1)]	426[1)]	1180[1)]	1702[1)]	893[1)]	1258[1)]	2,8[1)]	4,0	2,1[1)]	3,0
6	MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	337[1)]	412	423[1)]	391	1043[1)]	1663[1)]	909[1)]	1205[1)]	3,1	4,0	2,1[1)]	3,1[1)]
	SSD $_{05}$	47,4	26,2	30,7	29,2	129,2	97,2	96,4	99,8	0,19	0,21	0,18	0,17

Note: [1)] – Significant difference

Table D. 3

Plant density of Astet winter wheat variety depending on MWF of EHF and plant growth regulators application, 2011–2013, full ripening phase

Cases of treatment	Number of plants, pcs/m^2				Number of stems, pcs/m^2				Tillering factor			
	2011	2012	2013	average	2011	2012	2013	average	2011	2012	2013	average
Control, without treatment	292	388	353	344	545	709	604	619	1,9	1,8	1,7	1,8
Vitavax 200 FF, 2,5 L/t (standard)	314	380	358	351	701[1)]	734	613	683[1)]	2,2[1)]	1,9	1,7	2,0[1)]
MWF of EHF, 1,8 kw/kg, 15 sec.	313	415[1)]	379[1)]	369[1)]	578[1)]	864[1)]	638	693[1)]	1,8	2,1[1)]	1,7	1,9
MWF of EHF, 1,8 kw/kg,15 sec. + Mars EL, 0,2 L/t	296	394	344	345	543	752	593	629	1,8	1,9	1,7	1,8
MWF of EHF, 0,9kw/kg, 45 sec.	335[1)]	430[1)]	376	380[1)]	663[1)]	756	637	685[1)]	2,0	1,8	1,7	1,8
MWF of EHF, 0,9kw/kg, 45 sec.+ Mars EL, 0,2 L/t	314	393	371	359[1)]	616[1)]	735	664[1)]	672[1)]	2,0	1,9	1,8	1,9
SSD $_{05}$	25,2	25,9	24,2	14,0	52,1	75,02	45,4	51,0	0,14	0,13	0,12	0,11

Note: [1)] – Significant difference

Table D. 4

Plant density of Aspect spring barley variety depending on MWF of EHF and plant growth regulators application, 2011–2013 (tillering phase)

№	Cases of treatment	Number of plants, pcs/m^2				Number of stems, pcs/m^2				Tillering factor			
		2011	2012	2013	average	2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	284	296	356	312	296	764	452	504	1,8	2,6	1,1	1,8
2	Vitavax 200 FF, 2,5 L/t (standard)	196[1)]	284	404[1)]	294	392[1)]	664[1)]	520[1)]	523	2,3[1)]	2,6	1,4[1)]	2,1[1)]
3	Radostim, 0,25 L/t	303[1)]	268	372	314	480[1)]	696[1)]	540[1)]	572[1)]	1,6[1)]	2,7	1,5[1)]	1,9
4	Albit, 30 ml/t	328[1)]	300	428[1)]	323	524[1)]	620[1)]	552[1)]	565[1)]	1,6[1)]	3,5[1)]	1,3[1)]	1,9
5	MWF of EHF 0,9kw/kg, 45 sec.	280	240	420[1)]	313	436[1)]	628[1)]	536[1)]	533	1,6[1)]	2,6	1,3[1)]	1,8
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	224	390[1)]	436[1)]	363[1)]	492[1)]	664[1)]	564[1)]	573[1)]	2,2[1)]	3,4[1)]	1,3[1)]	2,2[1)]
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	256	296	404[1)]	319	412[1)]	692[1)]	484	529	1,6[1)]	2,6	1,2	1,8
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	348[1)]	260	430[1)]	356[1)]	568[1)]	600[1)]	516[1)]	561[1)]	1,6[1)]	2,9[1)]	1,2	1,9

9	MWF of EHF 1,8 kw/kg, 20 sec.	240	276	356	291	360[1)]	720[1)]	472	517	1,6[1)]	2,9[1)]	1,3[1)]	1,9
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	248	304	432[1)]	335[1)]	388[1)]	844[1)]	512[1)]	581[1)]	1,6[1)]	2,8[1)]	1,2	1,8
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	312[1)]	244	384	313	556[1)]	654[1)]	520[1)]	576[1)]	1,8	2,7	1,4[1)]	2,0[1)]
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	244	272	416[1)]	311	576[1)]	744	460	593[1)]	1,9	2,8[1)]	1,1	1,9
	SSD $_{05}$	21,0	24,0	39,6	21,1	25,1	40,0	39,8	33,2	0,13	0,14	0,12	0,11

Note: [1)] – Significant difference

Table D. 5

Plant density of Aspect spring barley variety depending on MWF of EHF and plant growth regulators application, 2011–2013, full ripening phase

№	Cases of treatment	Number of plants, pcs/m²				Number of stems, pcs/m²				Tillering factor			
		2011	2012	2013	average	2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	279	300	300	293	541	687	493	574	1,9	2,3	1,6	2,0
2	Vitavax 200 FF, 2,5 L/t (standard)	294	307	319	307	558	677	476	570	1,9	2,2	1,5	1,9
3	Radostim, 0,25 L/t	298	323	281	301	547	753[1)]	461	587	1,8	2,3	1,6	1,9
4	Albit, 30 ml/t	281	332[1)]	350[1)]	321[1)]	541	775[1)]	506	607[1)]	1,9	2,3	1,4[1)]	1,9
5	MWF of EHF 0,9kw/kg, 45 sec.	287	312	356[1)]	318[1)]	561	791[1)]	549[1)]	634[1)]	2,0[1)]	2,5[1)]	1,5	2,0
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	281	299	360[1)]	313	536	740[1)]	503	593	1,9	2,5[1)]	1,4[1)]	1,9
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	282	308	330	307	567[1)]	708	495	590	2,0[1)]	2,3	1,5	1,9
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	276	305	378[1)]	320[1)]	551	690	550[1)]	597	2,0[1)]	2,3	1,5	1,9

9	MWF of EHF 1,8 kw/kg, 20 sec.	312[1)]	329[1)]	292	311	579[1)]	713	466	586	1,9	2,2	1,6	1,9
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	284	314	367[1)]	322[1)]	563	705	582[1)]	617[1)]	2,0[1)]	2,2	1,6	1,9
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	309[1)]	331[1)]	315	318[1)]	583[1)]	732[1)]	473	596	1,9	2,2	1,5	1,9
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	287	315	351[1)]	318[1)]	572[1)]	725	542[1)]	613[1)]	2,0[1)]	2,3	1,5	1,9
	SSD_{05}	20,7	23,9	39,1	22,7	24,7	39,7	38,9	32,8	0,14	0,14	0,12	0,11

Note: [1)] – Significant difference

Table D. 6
Plant density of Vyklyk spring barley variety depending on MWF of EHF and plant growth regulators application, 2012–2013 (tillering phase)

№	Cases of treatment	Number of plants, pcs/m²			Number of stems, pcs/m²			Tillering factor		
		2012	2013	average	2012	2013	average	2012	2013	average
1	Control, without treatment	248	372	310	708	640	674	2,9	1,7	2,3
2	Vitavax 200 FF, 2,5 L/t (standard)	216	476[1)]	346[1)]	672	612	642	3,2[1)]	1,3[1)]	2,2
3	Radostim, 0,25 L/t	260	388	324	644[1)]	672	658	2,7	1,7	2,2
4	Albit, 30 ml/t	220	548[1)]	384[1)]	552[1)]	780[1)]	666	2,9	1,4[1)]	2,2
5	MWF of EHF 0,9kw/kg, 45 sec.	288[1)]	528[1)]	408[1)]	684	724	648	2,8	1,4[1)]	2,1[1)]
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	188[1)]	428[1)]	308	660	636	648	3,5[1)]	1,5[1)]	2,5[1)]
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	212	520[1)]	366[1)]	660	652	656	3,1[1)]	1,3[1)]	2,2
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	260	452[1)]	356[1)]	644	724	684	2,4	1,6	2,0[1)]

9	MWF of EHF 1,8 kw/kg, 20 sec.	260	456[1)]	320	728	660	694	2,8	1,4[1)]	2,1[1)]
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	260	380	320	692	688	690	2,7[1)]	1,8	2,3
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	280[1)]	468[1)]	374[1)]	676	632	654	2,5[1)]	1,4[1)]	2,0[1)]
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	208	460[1)]	334[1)]	628	664	646	3,0	1,4[1)]	2,2
	SSD_{05}	25,6	27,0	18,9	38,6	33,9	31,7	0,16	0,15	0,15

Note: [1)] – Significant difference

Table D. 7

Plant density of Vyklyk spring barley variety depending on MWF of EHF and plant growth regulators application, 2012–2013, full ripening phase

№	Cases of treatment	Number of plants, pcs/m^2			Number of stems, pcs/m^2			Tillering factor		
		2012	2013	average	2012	2013	average	2012	2013	average
1	Control, without treatment	324	332	328	826	503	665	2,5	1,5	2,0
2	Vitavax 200 FF, 2,5 L/t (standard)	335	371[1)]	353	849	547[1)]	698[1)]	2,5	1,5	2,0
3	Radostim, 0,25 L/t	330	341	336	849	544[1)]	697[1)]	2,6	1,6	2,1
4	Albit, 30 ml/t	300	352	326	827	499	663	2,8[1)]	1,4	2,1
5	EHF 0,9kw/kg, 45 sec.	333	360[1)]	347[1)]	892[1)]	509	701[1)]	2,7[1)]	1,4	2,0
6	EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	300	350	325	848	520	684	2,8[1)]	1,5	2,2[1)]
7	EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	322	378[1)]	350[1)]	837	599[1)]	718[1)]	2,6	1,6	2,1
8	MWF of EHF 0,9kw/kg, 45 sec. + Albit, 30 ml/t	304	388[1)]	346	826	607[1)]	717[1)]	2,7[1)]	1,6	2,1
9	EHF 1,8 kw/kg, 20 sec.	309	348	329	831	595[1)]	713[1)]	2,7[1)]	1,7	2,2[1)]

10	EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	335	351	343	830	496	663	2,5	1,4	1,9
11	EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	316	370[1)]	343	899[1)]	520	710[1)]	2,8[1)]	1,4	2,1
12	EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	315	347	331	852	530	691	2,7[1)]	1,5	2,1
	SSD_{05}	25,1	26,7	18,6	38,1	33,6	31,0	0,16	0,14	0,14

Note: [1)] – Significant difference

Appendix E

Table E. 1

Height of plants of spring barley varieties depending on pre-sowing seed treatment with MWF of EHF and plant growth regulators, cm

№	Cases of treatment	Aspect								Vyklyk					
		stalk shooting				full ripening				stalk shooting			full ripening		
		2011	2012	2013	average	2011	2012	2013	average	2012	2013	average	2012	2013	average
1	Control, without treatment	46,6	43,7	27,4	39,2	62,7	46,5	50,3	53,2	37,6	28,3	33,0	45,2	44,7	45,0
2	Vitavax 200 FF, 2,5 L/t	46,4	41,8	31,5$^{1)}$	39,9	64,2	47,0	57,4$^{1)}$	56,2$^{1)}$	39,4	27,3	33,4	45,5	44,9	45,2
3	Radostim, 0,25 L/t	53,6$^{1)}$	44,3	30,6$^{1)}$	42,8$^{1)}$	66,2$^{1)}$	48,2	57,7$^{1)}$	57,4$^{1)}$	38,9	30,5	34,7$^{1)}$	46,5	46,7	46,6
4	Albit, 30 ml/t	48,1	46,8$^{1)}$	33,3$^{1)}$	42,7$^{1)}$	66,1$^{1)}$	51,4$^{1)}$	56,5$^{1)}$	58,0$^{1)}$	38,4	31,9$^{1)}$	35,2$^{1)}$	48,3$^{1)}$	45,6	47,0
5	MWF of EHF 0,9kw/kg, 45 sec.	46,8	44,7	30,9$^{1)}$	40,8	69,2$^{1)}$	49,2	59,2$^{1)}$	59,2$^{1)}$	38,1	27,0	32,6	47,8	46,9	47,4$^{1)}$
6	MWF of EHF 0,9kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	47,6	43,7	33,4$^{1)}$	41,6$^{1)}$	67,7$^{1)}$	48,2	56,7$^{1)}$	57,5$^{1)}$	41,4$^{1)}$	28,1	34,8$^{1)}$	46,9	45,7	46,3
7	MWF of EHF 0,9kw/kg, 45 sec. + Radostim, 0,25 L/t	47,4	44,7	32,4$^{1)}$	41,5$^{1)}$	69,5$^{1)}$	49,7	58,5$^{1)}$	59,2$^{1)}$	39,3	25,4	32,4	48,5$^{1)}$	48,4$^{1)}$	48,5
8	MWF of EHF	50,1	43,6	33,0$^{1)}$	42,2$^{1)}$	65,5	49,2	57,8$^{1)}$	58,0$^{1)}$	39,5	29,2	34,4	47,1	48,4$^{1)}$	47,8$^{1)}$

9	MWF of EHF 1,8 kw/kg, 20 sec.	46,9	43,7	30,6[1)]	40,4	65,4	51,8[1)]	57,2[1)]	58,1[1)]	38,9	28,8	33,9	47,2	48,2[1)]	47,[1)]7
10	MWF of EHF 1,8 kw/kg, 20 sec.+ Vitavax 200 FF, 1,25 L/t	51,7[1)]	43,7	28,0	41,1	65,5	51,3[1)]	50,6	55,8[1)]	38,7	28,0	33,4	48,7[1)]	53,3[1)]	51,0[1)]
11	MWF of EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	50,3	43,8	29,9	41,3[1)]	63,7	51,0[1)]	53,9	56,2[1)]	39,4	28,4	33,9	47,8[1)]	46,0	46,9
12	MWF of EHF 1,8 kw/kg, 20 sec.+ Albit, 30 ml/t	52,7[1)]	45,8	32,5[1)]	43,7[1)]	62,8	51,7[1)]	56,3[1)]	56,9[1)]	40,2[1)]	30,2	35,2[1)]	47,4	53,4[1)]	50,4[1)]
	SSD_{05}	3,9	3,0	2,7	2,0	3,1	3,3	4,5	2,2	2,4	3,4	1,7	2,6	3,0	2,2

Note: [1)] – Significant difference

Appendix F

Table F. 1

Leaf surface of Astet winter wheat variety in tillering phase depending on the method of pre-sowing seed treatment, thousand m²/ha

№	Cases of seed treatment	Years			Average
		2011	2012	2013	
1	Control, without treatment	9,7	12,3	13,2	11,7
2	Vitavax 200 FF, 2,5 L/t	10,5	12,7	14,8	12,7
3	MWF of EHF 1,8 kw/kg,15 sec.	11,0	13,7	15,1[1)]	13,3[1)]
4	MWF of EHF 1,8 kw/kg,15 sec.+ Mars EL	11,8[1)]	13,2	16,3[1)]	13,8[1)]
5	MWF of EHF 0,9kw/kg, 45 sec.	11,9[1)]	14,6[1)]	16,6[1)]	14,4[1)]
6	MWF of EHF 0,9kw/kg, 45 sec. + Mars EL	11,5[1)]	12,6	16,7[1)]	13,6[1)]
	$SSD_{0,5}$	1,3	1,5	1,6	1,1

Note: [1)] – Significant difference

Table F. 2

Leaf surface of Astet winter wheat variety in tillering phase depending on the method of pre-sowing seed treatment, thousand m^2/ha

№	Cases of seed treatment	Years			Average
		2011	2012	2013	
1	Control, without treatment	28,0	29,1	31,2	29,4
2	Vitavax 200 FF, 2,5 L/t	28,8	30,0	31,4	30,1
3	MWF of EHF 1,8 kw/kg,15 sec.	29,5	31,9 1)	32,4	31,3
4	MWF of EHF 1,8 kw/kg,15 sec.+ Mars EL	30,9 1)	31,8	36,9 1)	33,2 1)
5	MWF of EHF 0,9kw/kg, 45 sec.	30,3 1)	32,3 1)	36,2 1)	32,9 1)
6	MWF of EHF 0,9kw/kg, 45 sec. + Mars EL	30,1	32,0 1)	36,1 1)	32,7 1)
	$SSD_{0,5}$	2,1	2,7	2,8	1,9

Note: 1) – Significant difference

Table F. 3

Leaf surface of Astet winter wheat variety in ear-formation phase depending on the method of pre-sowing seed treatment, thousand m^2/h

№	Cases of seed treatment	Years			Average
		2011	2012	2013	
1	Control, without treatment	31,2	39,6	42,5	37,8
2	Vitavax 200 FF, 2,5 L/t	33,8[1)]	40,9	44,4	39,7
3	MWF of EHF 1,8 kw/kg,15 sec.	35,5[1)]	44,2[1)]	47,6[1)]	42,4[1)]
4	MWF of EHF 1,8 kw/kg,15 sec. + Mars EL	37,9[1)]	42,5[1)]	48,0[1)]	42,8[1)]
5	MWF of EHF 0,9kw/kg, 45 sec.	38,3[1)]	46,9[1)]	49,3[1)]	44,8[1)]
6	MWF of EHF 0,9kw/kg, 45 sec. + Mars EL	37,1[1)]	40,7[1)]	46,1[1)]	41,3[1)]
	$SSD_{0,5}$	2,5	2,9	3,1	2,1

Note: [1)] – Significant difference

Table F. 4

Leaf surface of spring barley varieties in the tillering phase depending on the method of pre-sowing seed treatment with MWF of EHF and plant growth regulators, thousand m^2/ha

№	Methods of pre-sowing seed treatment	Aspect				Vyklyk		
		2011	2012	2013	average	2012.	2013	average
1	Control, without treatment	9,18	12,95	7,45	9,86	12,55	7,24	9,89
2	Vitavax 200 FF, 2,5 L/t (standard)	9,69	12,85	8,67[1)]	10,40	13,46	7,45	10,46
3	Radostim, 0,25 L/t	9,37	14,69[1)]	8,06	10,71[1)]	14,37[1)]	8,03	11,20[1)]
4	Albit, 30 ml/t	9,27	14,21[1)]	8,03	10,50	13,95[1)]	7,52	10,73
5	MWF of EHF, 0,9 kw/kg, 45 sec.	9,99	13,85	8,76[1)]	10,87[1)]	14,18[1)]	8,24	11,21[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	10,51[1)]	13,98	8,45[1)]	10,98[1)]	15,12[1)]	8,03	11,58[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	9,57	13,93	8,32[1)]	10,61	14,08[1)]	8,74[1)]	11,41[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	10,09	15,81[1)]	8,42[1)]	11,44[1)]	14,95[1)]	8,53[1)]	11,74[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	10,50[1)]	15,10[1)]	8,22	11,27[1)]	15,32[1)]	8,63[1)]	11,98[1)]

10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	9,88	13,87	7,80	10,52	14,79[1)]	9,03[1)]	11,91[1)]
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	9,77	14,48[1)]	8,30[1)]	10,85[1)]	15,20[1)]	8,19	11,69[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	10,40[1)]	14,89[1)]	9,14[1)]	11,47[1)]	17,78[1)]	8,61[1)]	13,20[1)]
	SSD_{05}	1,0	1,2	0,9	0,83	1,4	1,2	1,10

Note: [1)] – Significant difference

Table F. 5

Leaf surface of spring barley varieties in the stalk shooting phase depending on the method of pre-sowing seed treatment with MWF of EHF and plant growth regulators, thousand m^2/ha

№	Methods of pre-sowing seed treatment	Aspect				Vyklyk		
		2011	2012.	2013	average	2012	2013	average
1	Control, without treatment	18,40	22,44	16,6	19,1	21,89	16,1	19,0
2	Vitavax 200 FF, 2,5 L/t (standard)	18,86	22,22	17,5	19,5	22,55	16,7	19,6
3	Radostim, 0,25 L/t	19,78	24,53[1)]	19,6[1)]	21,3[1)]	23,87[1)]	19,4[1)]	21,6[1)]
4	Albit, 30 ml/t	21,74[1)]	24,97[1)]	21,2[1)]	22,6[1)]	24,42[1)]	22,0[1)]	23,2[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	18,98	22,55	19,5[1)]	20,3	22,00	19,2[1)]	20,6
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	20,24[1)]	22,88	18,9	20,7	26,29[1)]	18,4[1)]	22,3[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	20,70[1)]	21,56	21,6[1)]	21,3[1)]	24,20[1)]	21,6[1)]	22,9[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	20,59[1)]	26,07[1)]	22,3[1)]	23,0[1)]	21,67	22,6[1)]	22,1[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	19,55	24,42[1)]	19,1[1)]	21,0[1)]	22,44	19,9[1)]	21,2[1)]

10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	19,21	22,88	18,7	20,3	22,66	18,8[1)]	20,7
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	20,24[1)]	22,77	21,6[1)]	21,5[1)]	22,77	23,4[1)]	23,1[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	22,43[1)]	28,60[1)]	23,8[1)]	24,9[1)]	28,38[1)]	23,5[1)]	25,9[1)]
	SSD_{05}	1,7	1,9	2,3	1,75	1,8	2,2	2,14

Note: [1)] – Significant difference

Table F. 6

Leaf surface of spring barley varieties in the ear formation phase depending on the method of pre-sowing seed treatment with MWF of EHF and plant growth regulators, thousand m^2/ha

№	Methods of pre-sowing seed treatment	Aspect				Vyklyk		
		2011	2012	2013	average	2012	2013	average
1	Control, without treatment	15,0	17,7	14,1	15,6	17,3	14,5	15,9
2	Vitavax 200 FF, 2,5 L/t (standard)	15,6	17,6	14,9	16,0	17,8	15,0	16,4
3	Radostim, 0,25 L/t	16,4	19,4	16,7[1)]	17,5[1)]	18,9	17,5[1)]	18,2[1)]
4	Albit, 30 ml/t	16,9[1)]	19,7	18,0[1)]	18,2[1)]	19,3	19,8[1)]	19,6[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	17,2[1)]	17,8	16,6[1)]	17,2[1)]	17,4	17,3[1)]	17,4
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	17,5[1)]	18,1	16,1[1)]	17,2[1)]	20,8[1)]	16,6	18,7[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	17,1[1)]	17,0	18,4[1)]	17,5[1)]	19,1	19,4[1)]	19,3[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	17,5[1)]	20,6[1)]	19,0[1)]	19,0[1)]	17,1	20,3[1)]	18,7[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	17,6[1)]	19,3	16,2[1)]	17,7[1)]	17,7	17,9[1)]	17,8[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	16,9[1)]	18,1	15,9	17,0	17,9	16,9	17,4

11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	17,6[1)]	18,0	18,4[1)]	18,0[1)]	18,0	21,1[1)]	19,6[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	19,1[1)]	22,6[1)]	20,2[1)]	20,6[1)]	22,4[1)]	21,2[1)]	21,8[1)]
	SSD_{05}	1,6	2,1	2,0	1,52	2,2	2,8	1,85

Note: [1)] – Significant difference

Appendix G

Table G. 1

Spreading and development of root rots on Astet winter wheat variety plants in the phase of autumn tillering depending on the method of pre-sowing seed treatment, %, 2010–2012

№	Methods of pre-sowing seed treatment	Spreading				Development			
		2010	2011	2012	average	2010	2011	2012	average
1	Control, without treatment	0,7	0	5,1	1,9	0,2	0	1,5	0,4
2	Vitavax 200 FF, 2,5 L/t	1,1$^{1)}$	0	1,1$^{1)}$	0,7	0,4	0	0,3$^{1)}$	0,3
3	MWF of EHF 1,8 kw/kg, 15 sec.	0,4	0	0,4$^{1)}$	0,3$^{1)}$	0,1	0	0,1$^{1)}$	0,2
4	MWF of EHF 1,8 kw/kg, 15 sec + Mars EL	0$^{1)}$	0	1,3$^{1)}$	0,4$^{1)}$	0	0	0,3$^{1)}$	0,2
5	MWF of EHF 0,9 kw/kg, 45 sec.	0,7	0	0,0$^{1)}$	0,2$^{1)}$	0,2	0	0,0$^{1)}$	0,3
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	0,7	0	0,3$^{1)}$	0,3$^{1)}$	0,5$^{1)}$	0	0,1$^{1)}$	0,4
	SSD_{05}	0,6	0	1,2	1,4	0,2	0	0,4	0,2

Note: $^{1)}$ – Significant difference

Table G. 2

Spreading and development of root rots on Astet winter wheat variety plants in the phase of stalk shooting depending on the method of pre-sowing seed treatment, %, 2011-2013

№	Methods of pre-sowing seed treatment	Spreading				Development			
		2011	2012	2013.	average	2011	2012	2013	average
1	Control, without treatment	13,7	20,6	15,8	16,7	8,3	10,5	5,1	8,0
2	Vitavax 200 FF, 2,5 L/t	11,4	5,6[1)]	14,0	10,3[1)]	5,6	2,4[1)]	4,1	4,0[1)]
3	MWF of EHF 1,8 kw/kg, 15 sec.	13,5	8,2[1)]	7,4[1)]	9,7[1)]	6,6	4,2[1)]	2,0[1)]	4,3[1)]
4	MWF of EHF 1,8 kw/kg, 15 sec + Mars EL	6,4[1)]	4,9[1)]	12,5[1)]	7,9[1)]	5,0[1)]	2,7[1)]	3,6[1)]	3,8[1)]
5	MWF of EHF 0,9 kw/kg, 45 sec.	17,7	11,8[1)]	16,1	15,2	11,5[1)]	5,8[1)]	5,6	7,6
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	19,1	4,5[1)]	12,5[1)]	12,0	12,3[1)]	2,7[1)]	4,9	6,6
	SSD_{05}	5,9	3,8	2,8	5,1	3,0	2,0	1,2	2,7

Note: [1)] – Significant difference

Table G. 3

Spreading and development of root rots on Astet winter wheat variety plants in the phase of full ripening depending on the method of pre-sowing seed treatment, %, 2011–2013

№	Cases of pre-sowing seed treatment	Spreading, %				Development, %			
		2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	18,7	6,8	3,8	9,8	9,4	1,8	0,9	4,0
2	Vitavax 200 FF, 2,5 L/t	9,7[1)]	7,4	1,4[1)]	6,2[1)]	4,9[1)]	2,0	0,4[1)]	2,4[1)]
3	MWF of EHF 1,8 kw/kg, 15 sec.	9,9[1)]	3,4[1)]	1,6[1)]	5,0[1)]	4,9[1)]	1,1[1)]	0,4[1)]	2,1[1)]
4	MWF of EHF 1,8 kw/kg, 15 sec + Mars EL	9,7[1)]	3,4[1)]	1,6[1)]	4,9[1)]	5,1[1)]	0,8[1)]	0,5[1)]	2,1[1)]
5	MWF of EHF 0,9 kw/kg, 45 sec.	10,6[1)]	2,5[1)]	3,2	5,4[1)]	4,9[1)]	0,7[1)]	0,6[1)]	2,1[1)]
6	MWF of EHF 0,9 kw/kg, 45 sec. + Mars EL	12,5[1)]	4,8	3,1	6,8[1)]	6,3	1,2[1)]	0,7	2,7
	SSD_{05}	5,8	2,2	0,8	2,4	3,1	0,6	0,2	1,2

Note: [1)] – Significant difference

Table G. 4

Spreading and development of root rots on Aspect spring barley variety plants in the phase of stalk shooting depending on the method of pre-sowing seed treatment, %, 2011–2013

№	Methods of pre-sowing seed treatment	Spreading				Development			
		2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	14,4	7,5	11,2	11,0	5,6	2,6	3,1	3,8
2	Vitavax 200 FF, 2,5 L/t	9,7[1)]	5,8	10,3	8,6	4,0	2,2	2,9	3,0
3	Radostim, 0,25 L/t	8,1[1)]	2,7[1)]	6,3[1)]	5,7[1)]	4,0	1,1[1)]	1,9[1)]	2,3[1)]
4	Albit, 30 ml/t	6,6[1)]	6,2	5,6[1)]	6,1[1)]	2,6[1)]	2,7	1,9[1)]	2,4
5	MWF of EHF, 0,9 kw/kg, 45 sec.	4,2[1)]	4,6[1)]	12,2	7,0[1)]	3,0[1)]	1,9	3,6	2,8
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	4,6[1)]	3,3[1)]	10,7	6,2[1)]	2,1[1)]	1,0[1)]	2,9	2,0[1)]
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	3,6[1)]	5,6	9,7	6,3[1)]	1,5[1)]	2,6	3,0	2,4
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	1,9[1)]	5,8	9,7	5,8[1)]	1,1[1)]	2,2	2,4	1,9[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	3,2[1)]	6,9	10,4	6,8[1)]	1,4[1)]	2,3	2,6	2,1[1)]

10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	2,7[1)]	5,4	11,1	6,4[1)]	1,0[1)]	1,8	2,6	1,8[1)]
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	2,1[1)]	2,7[1)]	11,4	5,4[1)]	1,2[1)]	1,1[1)]	3,5	1,9[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	10,3[1)]	3,5[1)]	13,2	9,0	5,4	1,2[1)]	3,5	3,4
	SSD $_{05}$	3,0	2,8	3,4	3,2	1,7	1,1	1,1	1,4

Note: [1)] – Significant difference

Table G. 5

Spreading and development of root rots on Aspect spring barley variety plants in the phase of full ripening depending on the method of pre-sowing seed treatment, %, 2011–2013

№	Methods of pre-sowing seed treatment	Spreading				Development			
		2011	2012	2013	average	2011	2012	2013	average
1	Control, without treatment	4,8	5,6	1,1	3,8	2,3	1,9	0,4	1,5
2	Vitavax 200 FF, 2,5 L/t	2,9[1)]	3,0[1)]	0,3[1)]	2,1[1)]	1,5[1)]	1,2	0,1[1)]	0,9[1)]
3	Radostim, 0,25 L/t	4,0	1,4[1)]	0,0[1)]	1,8[1)]	1,5[1)]	0,6[1)]	0,0[1)]	0,7[1)]
4	Albit, 30 ml/t	4,1	3,0[1)]	0,9	2,7[1)]	1,8	0,9	0,4	1,0[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	4,0	4,1	1,2	3,1	1,7	1,4	0,5	1,2
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	4,4	4,1	1,0	3,2	2,0	1,4	0,3	1,2
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	3,8	4,2	0,3[1)]	2,8[1)]	1,2[1)]	1,3	0,1[1)]	0,9[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	3,7[1)]	3,1[1)]	1,2	2,7[1)]	1,7	1,1	0,3	1,0[1)]

9	MWF of EHF, 1,8 kw/kg, 20 sec.	3,7[1)]	2,5[1)]	1,5	2,6[1)]	1,7	0,9	0,4	1,0[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	4,4	2,3[1)]	0,9	2,5[1)]	1,6[1)]	0,8[1)]	0,3	0,9[1)]
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	4,0	3,2[1)]	0,0[1)]	2,4[1)]	1,8	1,3	0,0[1)]	1,0[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	4,4	2,8[1)]	0,6	2,6[1)]	1,9	1,2	0,2	1,1[1)]
	SSD $_{05}$	1,0	2,1	0,7	0,8	0,6	1,0	0,2	0,3

Note: [1)] – Significant difference

Table G. 6

Spreading and development of root rots on Vyklyk spring barley variety plants in the phase of stalk shooting depending on the method of pre-sowing seed treatment, %, 2012-2013

№	Methods of pre-sowing seed treatment	Spreading			Development		
		2012	2013	average	2012	2013	average
1	Control, without treatment	7,7	10,0	8,9	2,4	2,7	2,6
2	Vitavax 200 FF, 2,5 L/t (standard)	4,3	2,1 1)	3,2 1)	1,7	0,6 1)	1,2 1)
3	Radostim, 0,25 L/t	3,5 1)	8,8	6,2 1)	2,3	2,2	2,3
4	Albit, 30 ml/t	4,5	5,4 1)	5,0 1)	2,0	0,8 1)	1,4 1)
5	MWF of EHF, 0,9 kw/kg, 45 sec.	2,9 1)	3,3 1)	3,1 1)	1,0 1)	0,9 1)	1,0 1)
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	7,9	7,0	7,5	2,5	1,8	2,2
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	6,3	3,5 1)	4,9 1)	2,2	1,2 1)	1,7 1)
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	4,5	2,4 1)	3,5 1)	1,8	0,6 1)	1,2 1)
9	MWF of EHF, 1,8 kw/kg, 20 sec.	5,3	6,1	5,7 1)	2,0	2,5	2,3
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	5,8	6,7	6,3 1)	2,1	2,0	2,1
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	5,7	5,2 1)	5,5 1)	2,0	1,4 1)	1,7 1)
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	2,1 1)	5,0 1)	3,6 1)	1,2	1,4 1)	1,3 1)
	SSD_{05}	3,5	4,1	2,0	1,2	1,1	0,5

Note: 1) – Significant difference

Table G. 7

Spreading and development of root rots on Vyklyk spring barley variety plants in the phase of full ripening depending on the method of pre-sowing seed treatment, %, 2012–2013

№	Methods of pre-sowing seed treatment	Spreading			Development		
		2012	2013	average	2012	2013	average
1	Control, without treatment	5,3	0,6	3,0	1,9	0,2	1,1
2	Vitavax 200 FF, 2,5 L/t (standard)	4,6	0,8	2,7	1,8	0,3	1,1
3	Radostim, 0,25 L/t	2,5	0,3[1)]	1,4[1)]	1,2	0,2	0,7[1)]
4	Albit, 30 ml/t	2,6	0,4	1,5[1)]	1,1	0,2	0,7[1)]
5	MWF of EHF, 0,9 kw/kg, 45 sec.	2,5	0,7	1,6[1)]	0,9[1)]	0,2	0,6[1)]
6	MWF of EHF, 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	5,2	0,7	3,0	1,8	0,1[1)]	1,0
7	MWF of EHF, 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	3,0	0,4	1,7[1)]	1,0[1)]	0,1[1)]	0,6[1)]
8	MWF of EHF, 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	1,6[1)]	0,2[1)]	0,9[1)]	0,6[1)]	0,1[1)]	0,4[1)]
9	MWF of EHF, 1,8 kw/kg, 20 sec.	3,7	0,3[1)]	2,0[1)]	1,3	0,1[1)]	0,7[1)]
10	MWF of EHF, 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	3,2	0,3[1)]	1,8[1)]	1,6	0,1[1)]	0,9
11	MWF of EHF,1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	3,8	0,6	2,2	1,4	0,2	0,8[1)]
12	MWF of EHF, 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	2,2[1)]	0,2[1)]	1,2[1)]	0,7[1)]	0,1[1)]	0,4[1)]
	SSD_{05}	3,0	0,3	0,9	0,9	0,1	0,3

Note: [1)] – Significant difference

Appendix H

Table H. 1

Yield structure of Astet winter wheat variety depending on application of MWF of EHF and plant growth regulator Mars EL, 2011

№	Cases of pre-sowing seed treatment	Number, pcs/m^2			Factor of productive tillering	Grain content in the ear, pcs/ear	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems in total	productive stems				
1	Control, without treatment	292	545	407	1,39	34,8	31,4	4,45
2	Vitavax 200 FF, 2,5 L/t	314	617[1)]	468[1)]	1,54[1)]	32,3	31,9	4,82[1)]
3	EHF 1,8 kw/kg, 15 sec.	313	643[1)]	467[1)]	1,49[1)]	33,1	31,7	4,90[1)]
4	EHF 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t	296	596	456	1,55[1)]	34,2	32,6[1)]	5,08[1)]
5	EHF 0,9 kw/kg, 45 sec.	335[1)]	663[1)]	471[1)]	1,43[1)]	34,7	31,7	5,18[1)]
6	EHF 0,9 kw/kg, 45 sec.+ Mars EL, 0,2 L/t	314	600[1)]	464[1)]	1,48[1)]	34,4	32,8[1)]	5,24[1)]
correlation coefficient with yield capacity		0,60	0,63	0,80	0,38	0,12	0,70	–
SSD_{05}		25,2	52,1	50,8	0,12	0,8	0,9	0,35

Note: [1)] – Significant difference

Table H. 2

Yield structure of Astet winter wheat variety depending on application of MWF of EHF and plant growth regulator Mars EL, 2012

№	Cases of pre-sowing seed treatment	Number, pcs/m²			Factor of productive tillering	Grain content in the ear, pcs/ear	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems in total	productive stems				
1	Control, without treatment	388	709	571	1,47	22,7	38,7	5,02
2	Vitavax 200 FF, 2,5 L/t	380	734	598	1,45	22,5	37,3	5,02
3	EHF 1,8 kw/kg, 15 sec.	415[1)]	864[1)]	643[1)]	1,41	22,2	36,8	5,25[1)]
4	EHF 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t	394	752	626[1)]	1,58	22,0	38,3	5,27[1)]
5	EHF 0,9 kw/kg, 45 sec.	430[1)]	756	603[1)]	1,40	23,7[1)]	36,7	5,24[1)]
6	EHF 0,9 kw/kg, 45 sec.+ Mars EL, 0,2 L/t	393	735	603[1)]	1,54	23,1	36,3	5,06
correlation coefficient with yield capacity		0,73	0,64	0,78	-0,06	0,14	-0,13	–
SSD $_{05}$		25,9	75,2	31,1	0,11	0,8	2,5	0,21

Note: [1)] – Significant difference

Table H. 3

Yield structure of Astet winter wheat variety depending on application of MWF of EHF and plant growth regulator Mars EL, 2013

№	Cases of pre-sowing seed treatment	Number, pcs/m^2			Factor of productive tillering	Grain content in the ear, pcs/ear	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems in total	productive stems				
1	Control, without treatment	353	604	511	1,45	30,6	41,7	6,52
2	Vitavax 200 FF, 2,5 L/t	358	613	527	1,46	31,3$^{1)}$	41,9	6,91$^{1)}$
3	EHF 1,8 kw/kg, 15 sec.	379$^{1)}$	638	546$^{1)}$	1,45	31,4$^{1)}$	41,3	7,08$^{1)}$
4	EHF 1,8 kw/kg, 15 sec. + Mars EL, 0,2 L/t	344	593	544$^{1)}$	1,53	30,6	42,5	7,07$^{1)}$
5	EHF 0,9 kw/kg, 45 sec.	376	607	532	1,50	31,1	41,5	6,87$^{1)}$
6	EHF 0,9 kw/kg, 45 sec.+ Mars EL, 0,2 L/t	371	626	540$^{1)}$	1,52	30,6	42,5	7,02$^{1)}$
correlation coefficient with yield capacity		0,27	0,37	0,97$^{1)}$	0,48	0,28	0,29	–
SSD $_{05}$		24,2	45,4	23,2	0,10	0,6	1,2	0,31

Note: $^{1)}$ – Significant difference

Appendix I

Table I. 1

Yield structure of Aspect spring barley variety depending on application of MWF of EHF and various preparations, 2011–2013

№	Cases of pre-sowing seed treatment	Number, pcs/m^2			Factor of productive tillering	Grain content in the ear, pcs/ear	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems in total	incl.productive stems				
1	Control, without treatment	293	574	507	1,7	14,9	46,8	3,62
2	Vitavax 200 FF, 2,5 L/t	307	570	512	1,7	15,0	46,8	3,68
3	Radostim, 0,25 L/t	313	587	526	1,7	15,4[1)]	47,5[1)]	3,83[1)]
4	Albit, 30 ml/t	321[1)]	607[1)]	513	1,6	15,3	47,4[1)]	3,80
5	EHF 0,9 kw/kg, 45 sec.	319[1)]	634[1)]	558[1)]	1,8	14,9	47,1	3,99[1)]
6	EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	313	593	537[1)]	1,7	15,5[1)]	46,7	3,99[1)]
7	EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	307	590	523	1,7	14,7	47,6[1)]	3,74
8	EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	320[1)]	597	534[1)]	1,7	15,2	47,4[1)]	3,93[1)]
9	EHF 1,8 kw/kg, 20 sec.	311	586	554[1)]	1,8	14,8	47,6[1)]	3,94[1)]
10	EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	322[1)]	610[1)]	518	1,7	15,4[1)]	47,2	3,84[1)]
11	EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	318[1)]	596	533[1)]	1,7	14,5	47,6[1)]	3,74
12	EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	318[1)]	613[1)]	564[1)]	1,8	14,5	47,6[1)]	3,97[1)]
correlation coefficient with yield capacity, r =		0,62[1)]	0,64[1)]	0,82[1)]	0,53	0,16	0,17	–
SSD $_{05}$		22,7	32,8	25,0	0,08	0,5	0,5	0,19

Note: [1)] – Significant difference

Table I. 2

Yield structure of Vyklyk spring barley variety depending on application of MWF of EHF and various preparations, 2012-2013

№	Cases of pre-sowing seed treatment	Number, pcs/m^2			Factor of productive tillering	Grain content in the ear, pcs/ear	Weight of 1000 grains, g	Biological yield capacity, t/ha
		plants	stems in total	Incl. productive stems				
1	Control, without treatment	328	665	555	1,7	15,4	46,5	4,13
2	Vitavax 200 FF, 2,5 L/t	353[1)]	698[1)]	581	1,7	15,6	47,7[1)]	4,48[1)]
3	Radostim, 0,25 L/t	336	697[1)]	593[1)]	1,8[1)]	16,5[1)]	46,9	4,67[1)]
4	Albit, 30 ml/t	326	663	571	1,8[1)]	15,4	47,7[1)]	4,33
5	EHF 0,9 kw/kg, 45 sec.	347[1)]	701[1)]	601[1)]	1,8[1)]	15,5	46,8	4,52[1)]
6	EHF 0,9 kw/kg, 45 sec. + Vitavax 200 FF, 1,25 L/t	325	684	582	1,9[1)]	15,8[1)]	47,5[1)]	4,53[1)]
7	EHF 0,9 kw/kg, 45 sec. + Radostim, 0,25 L/t	350	718[1)]	606[1)]	1,8[1)]	15,8[1)]	47,4[1)]	4,61[1)]
8	EHF 0,9 kw/kg, 45 sec. + Albit, 30 ml/t	346	717[1)]	602[1)]	1,8[1)]	15,4	46,6	4,41
9	EHF 1,8 kw/kg, 20 sec.	329	713[1)]	613[1)]	1,9[1)]	16,1[1)]	46,7	4,68[1)]
10	EHF 1,8 kw/kg, 20 sec. + Vitavax 200 FF, 1,25 L/t	343	663	604[1)]	1,8[1)]	15,5	47,2[1)]	4,50[1)]
11	EHF 1,8 kw/kg, 20 sec. + Radostim, 0,25 L/t	343	710[1)]	599[1)]	1,8[1)]	15,3	46,9	4,42
12	EHF 1,8 kw/kg, 20 sec. + Albit, 30 ml/t	331	691	609[1)]	1,9[1)]	16,6[1)]	47,5[1)]	4,97[1)]
correlation coefficient with yield capacity		0,07	0,38	0,74[1)]	0,69[1)]	0,85[1)]	0,29	–
SSD_{05}		18,6	31,0	32,6	0,09	0,4	0,6	0,35

Note: [1)] – Significant difference

У роботі здійснено теоретичне узагальнення і нове практичне вирішення важливого наукового завдання з удосконалення та підвищення екологічної безпечності технологій вирощування пшениці озимої та ячменю ярого в зоні східної частини Лісостепу України за допомогою застосування передпосівного мікрохвильового опромінення насіння замість протруєння хімічними препаратами. На основі проведених досліджень установлено оптимальні режими опромінення насіння мікрохвильовим полем надзвичайно високої частоти (МХП НВЧ) в діапазоні 2,4-3,4 ГГц, при витраті енергії 0,9 кВт на 1 кг насіння з експозицією 45 с. або 1,8 кВт на 1 кг насіння з експозицією 15–20 с. залежно від культури, на установці УМВК-1, розробленій Харківським національним технічним університетом радіоелектроніки, які зумовлюють підвищення енергії проростання, схожості насіння та врожайності. Розроблено екологічно безпечні способи комплексної передпосівної обробки насіння МХП НВЧ в поєднанні з регуляторами росту рослин та зниженими нормами протруйника.

Призначено для викладачів та здобувачів вищої освіти ВНЗ аграрного спрямуванн, сільгоспвиробників та всіх, кого цікавить екологізований захист пшениці та ячменю від хвороб.

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СПОСОБИ ПІДВИЩЕННЯ ВРОЖАЙНОСТІ ПШЕНИЦІ ОЗИМОЇ ТА ЯЧМЕНЮ ЯРОГО НА ОСНОВІ ЗАСТОСУВАННЯ ПЕРЕДПОСІВНОГО ОПРОМІНЕННЯ НАСІННЯ МІКРОХВИЛЬОВИМ ПОЛЕМ НАДЗВИЧАЙНО ВИСОКИХ ЧАСТОТ В УМОВАХ СХІДНОЇ ЧАСТИНИ ЛІСОСТЕПУ УКРАЇНИ

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