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THE ROLE OF THE FLAG LEAF IN THE FORMATION OF THE YIELD OF WINTER WHEAT PLANTS (*TRITICUM AESTIVUM* L.) GROWN FROM SEEDS TREATED WITH THE BIOSTIMULANT REGLALG

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The effect of treating seeds of hexaploid wheat Moldova 5, Missia and Kuyalnik with the biostimulator (BS) *Reglagl* on the activity of the flag leaf photosystem II (PS-2) and the yield during the period of formation and ripening of grain in the ear was studied. The experiments were conducted during 2015 -2018 at the Experimental Field of the Institute of Genetics, Physiology and Plant Protection, MSU. The duration of the grain formation and maturation phases in Moldova 5 plants was 26 days, and in Missia and Kuialnik plants - 33 days. The application of BS *Reglagl* contributed to extending the duration of grain formation and maturation by 1-3 days. In the control variants, the harvest was 3.76 - 4.20 t/h, and in the experimental ones - 3.81 - 4.73 t/h. The efficiency of seed treatment with BS *Reglagl* varied depending on the variety and the climatic conditions of the year.
Keywords: *Triticum aestivum L., varieties, seeds, BS Reglalg, harvest, activity PS-2, flag leaf.*

ROLUL FRUNZEI STEAG ÎN FORMAREA PRODUCTIVITĂȚII PLANTELOR DE GRÂU DE TOAMNĂ (*TRITICUM AESTIVUM* L.), CULTIVATE DIN SEMINȚE TRATATE CU BIOSTIMULATORUL REGLALG

În această lucrare a fost redat efectul tratării semințelor de grâu hexaploid Moldova 5, Missia și Kuialnik cu biostimulatorul (BS) *Reglalg* asupra activității fotosistemei II a frunzei steag, a recoltei în perioada de formare și maturare a boabelor în spic. Experiențele au fost efectuate între anii 2015-2018 pe Câmpul Experimental al Institutului de Genetică, Fiziologie și Protecție a Plantelor, USM. Durata totală a fazelor de formare și maturare a boabelor în spic la plantele soiului Moldova 5 a constituit 26 de zile, iar la plantele soiurilor Missia și Kuialnik – 33 de zile. Aplicarea BS *Reglalg* a contribuit la extinderea duratei de formare și maturare a boabelor în spic cu 1-3 zile. În variantele martor recolta a fost de 3,76-4,20 t/h, iar în cele experimentale –3,81-4,73 t/h. Eficiența tratamentului semințelor cu BS *Reglalg* a variat în funcție de soi și de condițiile climatice ale anului.
Cuvinte-cheie: *grâu hexaploid, soiuri, semințe, BS Reglalg, recoltă, activitatea FS-2, frunzei steag.*

Introduction

Wheat is one of the most important plant species [1]. Around the world, about 2.1 x 10^8 hectares are sown with this crop, resulting in approximately 6 x 10^8 tons per head [2]. Although over the past 40 years, the size of the area sown has not changed by more than 10%, thanks to the introduction of modern agricultural technology and improved varieties, wheat yields have tripled. Despite this, the demand for wheat consumption is constantly growing. That suggests that prices for wheat grain have doubled over the past decade [3]. At the same time, adverse climate change is occurring, with average temperatures rising and water availability decreasing in many wheat-growing areas. This situation is especially typical for the Republic of Moldova, located in a zone of risky agriculture [4]. Thus, the rational use of existing varieties and the selection of new wheat genotypes, resistant to extreme temperatures and drought is an urgent task.

The growth, development, and productivity of plants are complexly dependent on the intensity of photosynthesis [5, 6]. The complexity of this dependence is especially pronounced in higher plants, in which leaves of different ages and locations have specific effects on growth, flowering, seed formation, and the accumulation of reserve substances. In general, the plants' harmonious growth and development depend on the specific integration of the effects of photosynthetic activity of different ages of leaves and the level of their formation on the plant [7]. For evaluating these features, it is convenient to use wheat plants. They form the new leaves in a strictly acropetally direction. In wheat, leaf formation ceases after initiation of heading, accompanied by flowering, seed formation and ripening, plant senescence, and death. Integrally, the occurrence of these processes depends on the photosynthetic activity of all leaves. The relative role of different levels of leaves on the efficiency of each of these processes is specific. We must note that the outside leaf in wheat plants' assimilation organs are the leaf sheaths, the stem, and the ear [8, 9, 10]. As with leaves of different levels (ages), the importance of photosynthesis processes in each of these organs in determining the yield depends on the stage of plant development [11].

Harvest level and the biomass of the plant aerial part are the principal indicators of the productivity of wheat genotypes [12]. Over the years, thanks to advances in breeding, the yield of wheat varieties increased, and its share of the total biomass of the above-ground part of the plant. In modern wheat varieties, it reaches 0.55 [13]. According to the results of researchers [14, 15], up to 90 - 95% of the dry biomass of grain is created due to the process of photosynthesis, which takes place in all leaves of plants, and only 5 - 10% of their biomass depends on the photosynthesis in the stem, ear, leaf sheath, and awns. It is for this reason that, as a rule, the size of the assimilating surface of plants is often characterized only by the leaf surface area. Research dedicated to the study of the influence of leaf surface on yield, productivity, and its elements of the wheat plants [16, 4] highlighted the mentioned data. In this research, we established a relationship between the leaf surface area and the yield level of wheat plants. Considering the above, experts recommend creating such crops and agricultural technology conditions for winter wheat plants where the leaf surface index reaches 40 - 60 thousand m2/ha [17, 18]. At the same time, there is information (S.F. Lyfenko) [19] that due to water evaporation through the stomata, a large leaf area can lead to a decrease in drought and heat resistance of plants. In addition, according to (V.V. Maimistov) [20], during the period of grain-filling, drought-resistant wheat genotypes have increased, but not the highest, foliage indicators [21]. During grain-filling, only the upper leaves have high assimilating activity, the size of which closely correlates with the productivity of the ear. The correlation coefficient between leaf area and such indicators as grain weight in an ear, number of grains in an ear, and weight of 1000 grains are +0.65 - 0.97, +0.48 - 0.97, and +0.22 - 0.96. respectively [22, 23]. In this regard, the author concluded about the necessity to select wheat varieties with a long period of maintaining the viability of this particular leave. According to the works of (V.I. Lukyanyuk) [24], daily increases in dry matter after the initiation of the heading phase are determined by the productivity of photosynthesis per unit of the leaf surface. At the same time, according to [25 – 27], an increase in leaf area does not always influence positively the yield of cereals. According to their data, the photosynthesis of cereal leaves plays a leading role in determining plant productivity only in the first half of the growing season, while starting from the heading phase, photosynthesis in organs such as the ear and stem becomes increasingly important [28, 29]. According to some researchers, the share of ear photosynthesis in the supply of grains with plastic substances is 10 - 40% [30], 50 - 60% [31], or even 90% [32].

The above data indicate that there is still no consensus on the role of various organs in determining the productivity of cereal crops. At the same time, there is no doubt that leaf photosynthesis plays an essential role in providing wheat plants with plastic substances at different stages of grain formation and maturation in the ear. From a practical point of view, it is of particular interest to identify the specific role of photosynthesis activity in the flag leaf of wheat, which appears last and remains highly active during grain formation and filling in the ear phases.

The presented data show that to increase the efficiency of growing plants, essential improved technologies of selection and cultivation that correspond to specific conditions in each region are necessary. For improving agricultural technologies, the use of biostimulators was proposed [33]. Treatment of seeds with biostimulants before sowing and plants during the growing season [34, 35] has a beneficial effect on resistance to extreme temperatures and plant productivity. Unlike synthetic crop protection products, they do not harm the environment. Therefore, they meet the requirements of organic agriculture [36]. Since plant resistance to stress factors is genetically determined, it can be improved by treating plants with biostimulators [35]. In the Republic of Moldova, BS *Reglalg*, isolated from aqueous acid of the Spirogyra type, is certified for industrial use [37]. Different methods of treating the wheat genotype seeds with a solution of BS *Reglalg* before sowing were studied for their seed germination and plants' resistance to shock caused by positive or negative temperatures [38, 39].

This article presents the results of a study of the influence of the pre-sowing treatment of wheat seeds with a solution of BS *Reglalg*, as well as the results of appreciation of the effects of pre-sowing seeds` sprinkling with the BS *Reglalg* solution, as well as the activity of photosynthesis in the flag leaf of plants on the yield of three varieties of winter wheat, depending on the specific conditions of the year.

Materials and methods

We carried out research over three consecutive years (from 2015 to 2018) of the cultivation of three varieties of wheat at the experimental site of the Institute of Genetics, Physiology, and Plant Protection, Moldova State Universety of the Republic of Moldova. As the objects of research, we used the winter wheat variety of the local selection Moldova 5 and two varieties of the Ukrainian amelioration, Missia, and Kuyalnik. The agricultural technology for cultivating winter wheat met generally accepted requirements for this climatic zone [4]. The predecessor was black steam. The seeding rate was 5.5 million seeds per hectare.

At the end of the heading stage, when the leaf growth stopped, the flag leaf area of the central stem of ten plants, in each of three replications, was determined by the weight method [40]. During the entire growing season, we determined the chlorophyll index of the crops with the FieldScout CM – 1000 chlorophyll meter from the company Spectrum Brands Holdings, Inc, (USA). The intensity of photosynthesis of the flag leaf at various stages of grain formation and ripening (flowering, grain growth, milky ripeness, and milky-waxy ripeness) was assessed based on the activity of photosystem two (PS-2) using a PAM-2100 fluorimeter (WALZ, Germany), the Yield index of the flag leaf was determined in ten central (main) shoots, in triplicate.

We carried out the mathematical processing of the data using the Microsoft Excel 2016 program according to statistical methods [41], calculating the average indicators, dispersion, and the minimal significant difference (MSD) between the averages of different options.

Results and discussion

We carried out the studies with winter wheat plants of the Moldova 5, Missia, and Kuyalnik varieties. In Table 1, we present. The numerical values of the morphological parameters of the flag leaf of plants of the indicated wheat varieties grown in 2016, 2017, and 2018.

To characterize the photosynthetic activity of the flag leaf of plants of the studied wheat varieties, which are at different stages of seed maturation in the ear, the dynamics of changes in the quantum yield (Yield) of photosystem II were determined based on the fluorescence of leaf chlorophyll, measured using a PAM 2100 fluorimeter (Germany). We have checked the fluorescence throughout the entire photoperiod at different daylight intensities. This method makes it possible to appreciate the indicators of the daily dynamics of the flag leaf photosynthetic activity for plants at different grain formation and ripening stages. This method ensures the determination of photosynthetic activity without damaging the leaves. Thanks to this, we can measure the photosynthetic activity of the flag leaf of the same selected plants at different stages of grain formation and maturation in the ear. The obtained data is shown in Figure 1. The figure shows that with increasing illumination in the morning, the values of the Yield indicator consistently fell from the maximum level detected at 8 a.m., PAR 860 μmol*m^{-2}*s^{-1}, until reaching PAR values 1100 μmol*m^{-2}*s^{-1}, at noon. Then, as the PAR level increased to 1400 μmol*m^{-2}*s^{-1}, at 13:00, the Yield values dropped sharply to 100 and below, remaining at a low level until 15:00, after which the Yield value increased with a drop in the PAR level below 1000 μmol*m^{-2}*s^{-1}. It is important to note that as the grain matured in the ear, the maximum value of the Yield index consistently decreased from 0.420, for the flag leaf in the heading initiation phase, to 210, for the flag leaf of plants that were in the milky-wax ripeness phase. In the evening, regardless of the wheat variety, with a decrease in PAR levels, the yield increased as the leaf aged slowed down. As noted above, the flag leaf aging and grain ripening in the ear were accompanied by a gradual decrease in Yield values determined at 8 a.m.

Table 1. The values of the flag leaf morphological parameters of the wheat plant varieties Moldova 5, Missia, and Kuyalnik cultivated in 2015 -2018

Varieties	2015 – 2016			2016 – 2017			2017 – 2018		
	Leaf area, cm^2	Leaf length, cm	Leaf width, cm	Leaf area, cm^2	Leaf length, cm	Leaf width, cm	Leaf area, cm^2	Leaf length, cm	Leaf width, cm
Control									
Moldova 5	18,9*	21,8*	*1,14**	20,2*	28,3*	*1,18**	*21,8**	29,0*	1,21*
Missia	15,8*	18,4	1,16*	19,3*	23,3*	1,27*	19,5*	24,3*	1,15*
Kuyalnik	14,7*	17,2*	1,12*	18,9*	20,0*	1,14*	*19,1**	20,5*	1,17*
MSD (0,05)	1,82	0,64	0,017	0,38	1,26	0,02	1,14	0,98	0,032
Experiment									
Moldova 5	20,1*	22,8*	1,20*	22,4*	29,9*	*1,31**	22,9*	30,5*	1,29*
Missia	*16,8**	*19,3**	1,22*	20,9	25,5*	1,37*	21,3*	27,4*	*1,25**
Kuyalnik	*15,4**	*18,8**	1,16*	19,6*	20,8	*1,29**	19,7*	21,1*	*1,26**
MSD (0,05)	1,21	0,51	0,012	0,32	1,32	0,031	1,02	1,12	0,028

Notes: *1. - * marked reliable at the 95% level differences between options; 2. –if the differences are not reliable at the 95% level, the options with an asterisk are written in Italic font.*

As the grain ripened, regardless of the wheat variety, the difference between the maximum *Yield* value of the flag leaf achieved at 7:00 p.m. and that which was detected at 8:00 in the morning consistently changed from positive, in the flowering and grain growth phases, to negative, in the dairy and milky - waxy ripeness phase. These data indicate that the dynamics of photochemical restoration of inhibited centers decrease faster than the dynamics of their inhibition in the morning as the flag leaf ages, as a result, the difference between the *Yield* level of the flag leaf at 7:00 p.m. and 8:00 in the morning gradually changed from positive to negative values as the grain ripened.

Quantitatively, in the studied wheat varieties, the daily dynamics of changes in *Yield* values as the grain ripened in the ear differed significantly. In the morning, the fall in the *Yield* indicator of the flag leaf of plants of the Moldova 5 variety, which were in the flowering phase, passed faster, and, in the evening, it recovered more slowly than in the flag leaf of the other two wheat varieties. These differences persisted after 12 hours only in plants that were in the phase of grain growth and milk ripeness. They practically disappeared in plants that entered the stage of milky-wax ripeness. In general, the data presented in Figure 1 indicate that in the morning, with increasing illumination, in plants of the Moldova 5 variety, the inhibition of photosynthetic activity of the flag leaf was more intense compared to that which was characteristic of the flag leaf of plants of the Missia and Kuyalnik. In the afternoon, as PAR values decreased, the following trend was revealed in the *Yield* dynamics: the rate and level of restoration of photosynthetic activity of the flag leaf decreased as the grain ripened in the ear.

It should be noted that the dynamics of changes in the *Yield* level of the flag leaf of plants of the Missia and Kuyalnik varieties were similar. In plants of the Missia variety, there was a tendency to exceed the levels of this indicator compared to that characteristic for plants of the Kuyalnik variety in all phases of grain ripening. It is important to note that the level of *Yield* values detected at 8 a.m. at the flag leaf in the studied wheat varieties, which were at different phases of grain ripening, was practically the same. The mentioned indicates that during the night, the efficiency of restoring inhibition of photosynthetic centers in the studied wheat varieties was the same. It is important to note that the *Yield* values of the plant's flag, being in the phases of flowering, grain growth, milky ripeness, and milky-wax ripeness, gradually decreased, reaching 430, 350, 310, and 210, respectively. These decreases in the *Yield* values were due to the consistent aging of the flag, leaf, and the whole plant.

Comparing the data shown in Figures 1A and 1B, it is easy to notice that in plants obtained from seeds treated with BS *Reglalg*, regardless of the variety and phase of grain ripening, the daily dynamics of the intensity of photosynthesis in the flag leaf during the day has the same patterns as those described above for the control option. It should be noted, however, that under the influence of BS *Reglalg* during the day, all three varieties exhibit a clear tendency to increase the *Yield* values of flag leaf photosynthesis. This implies a higher expected total biomass accumulated in the experimental plants.

The above-mentioned specific changes in the *Yield* indicator during aging of the flag leaf were also observed in plants obtained from seeds treated before sowing with a solution of BS *Reglalg*, figure 1B. At the same time, we have to note that for all phases of seed ripening in the ear, throughout the daylight hours, the *Yield* values of the flag leaf of the experimental plants tended to be higher than those that were characteristic of the flag leaf of the control plants. Thus, the expected ear biomass accumulation in plants obtained from seeds treated with BS *Reglalg* is also higher. When assessing the biological characteristics of wheat varieties, it should be borne in mind that plant productivity may depend not only on the rate of the flag leaf aging but also on the duration of the phases of grain formation and ripening in the ear.

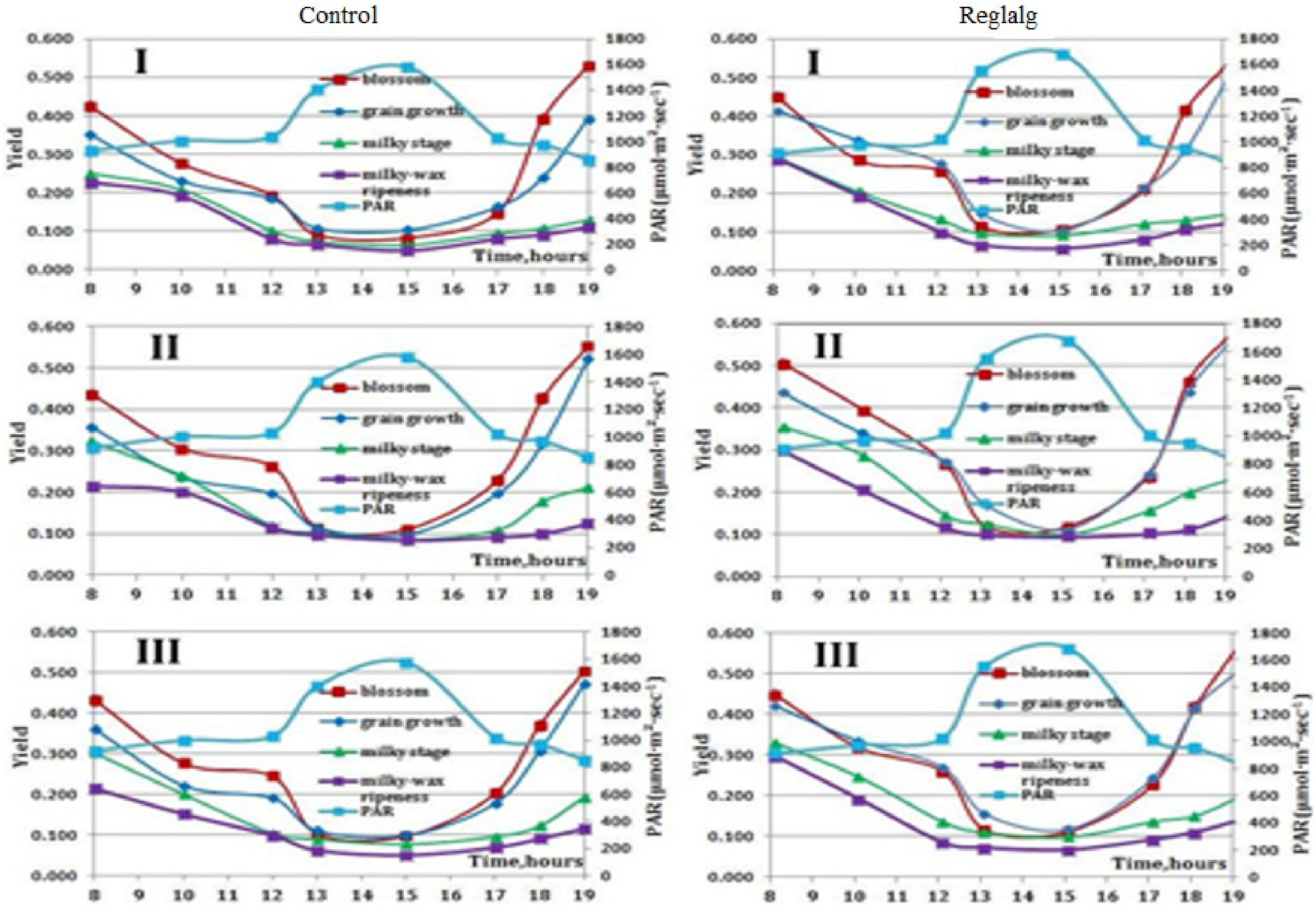

Figure 1. The activity of PS - 2 of the flag leaf of winter wheat varieties I - Moldova 5 , II - Missia, III - Kuyalnik. A - control variants , B - experimental variants at various phases of seed maturation

According to our data, the length of the flowering, grain growth, and milky and milky-wax ripeness phases in plants of the Missia and Kuyalnik varieties cultivated in 2018 were the same and equal to 7, 12, 8, and 6 days, respectively. For the Moldova 5 variety, they were 6, 10, 6, and 4 days, respectively. These data indicate that in plants of the Moldova 5 variety, compared with the plants of the Missia and Kuyalnik varieties, a more rapid aging of the flag leaf was observed, accompanied by the acceleration of the grain formation and ripening in the ear phases. In plants of Moldova 5 variety, the total duration of these phases was 26 days, and in the other two varieties - 33 days. Thus, if we take into account that in these varieties, a degree of tillering of wheat plants obtained after sowing 5.5 million seeds per hectare was almost the same (it was equal to 1.15) and we assume that the photosynthetic activity of the flag leaf is essential for the formation of plant-yield wheat, then the expected yield of the Missia and Kuyalnik varieties may exceed the plants of the Moldova 5 variety. Accordingly, in plants of experimental variants obtained from seeds treated with BS *Reglalg* solution, compared with plants of the control variant, at all phases of grain ripening in the spikelet, not only more high intensity of photosynthesis but also an extension of the period of ripening of ears by 2 - 5 days, depending on the variety and year conditions.

When assessing the biological characteristics of wheat varieties, it should be borne in mind that plant productivity may depend not only on the aging of the flag leaf rate but also on the duration of the grain formation and ripening in the ear phases. According to our data, the length of the flowering, grain growth, and milky and milky-wax ripeness phases in plants of the Missia and Kuyalnik varieties cultivated in 2018 were identical and equaled 7, 12, 8, and 6 days respectively, while in the Moldova 5 variety, they were equal to 6, 10, 6 and 4 days, respectively. These data indicate that compared with plants of the Missia and Kuyalnik varieties, in plants of the Moldova 5 variety, more rapid flag leaf aging, more rapid passage of the grain formation and ripening phases in the ear were observed. The total duration of these phases in the Moldova 5 variety plants was 26 days, and in the other two varieties - 33 days. Thus, if we take into account that in these varieties' the degree of tillering of wheat plants obtained after sowing 5.5 million seeds per hectare was almost the same (it was equal to 1.15) and we assume that the photosynthetic activity of the flag leaf plays a significant role in the formation of plant yield wheat, then the expected yield of the Missia and Kuyalnik varieties may exceed the plants of the Moldova 5 variety. Accordingly, in plants of experimental variants obtained from seeds treated with BS *Reglalg* solution, compared with plants of the control variant, at all phases of grain ripening in the spikelet, not only more high intensity of photosynthesis but also an extension of the period of ripening of ears by 2 - 5 days, depending on the variety and year conditions.

Data on the integral content of chlorophyll in the experimental and control plants of wheat variety Moldova 5 and Missia, shown in Figure 2, indirectly confirm the above patterns. From the analysis of the data included in this figure, it follows that during this period, the plants of the Missia variety were characterized by a higher vegetation period and a higher chlorophyll content in the leaves compared to those of the Moldova 5 variety. Regardless of the het variety specificity, the treatment of seeds with a solution of BS *Reglalg* led to higher chlorophyll content in the leaves during the entire growing season of the plants obtained from them. This indicates a positive effect of the biostimulant on the viability of both varieties of wheat plants.

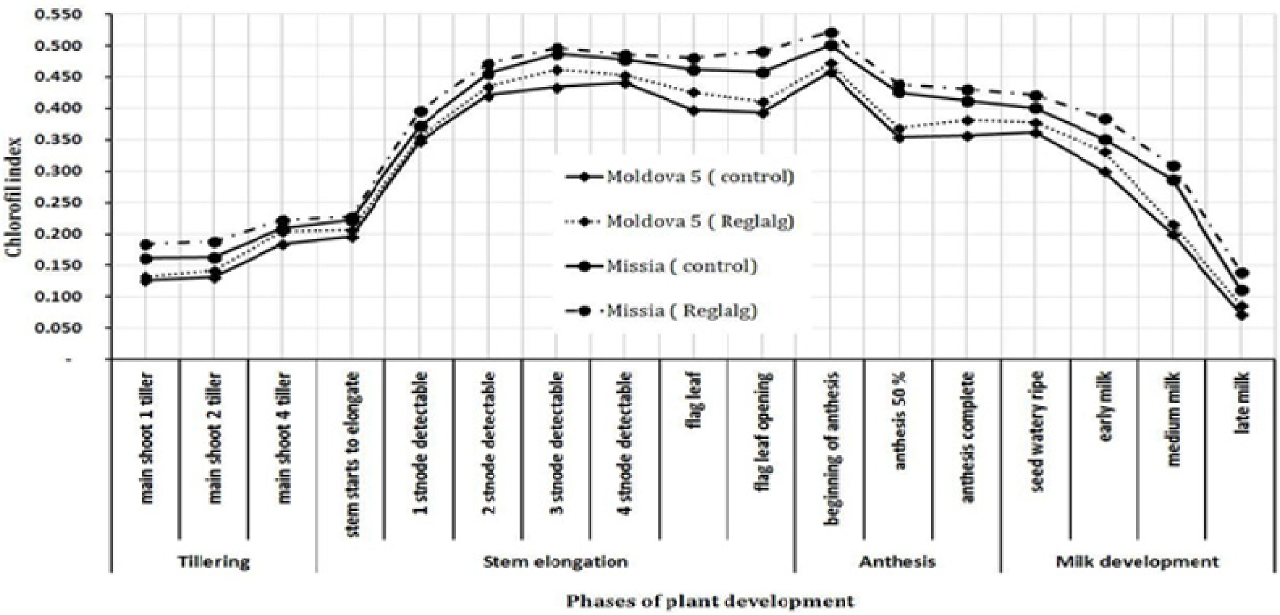

Figure 2. Dynamics of the chlorophyll index of plants of hexaploid wheat varieties Moldova 5 an Missia during yhe growing season, grow in 2018

Data on the structure and yield level of the wheat varieties Moldova 5, Missia, and Kuyalnik are shown in Table 2. They indicate that the variety Moldova 5, despite the large size of the flag leaf, has all productivity indicators, including estimated productivity per one hectare, showed a general tendency to be lower compared to the corresponding parameters in plants of the Missia and Kuyalnik varieties. The attention is drawn to the fact that in different years of cultivation, the number of plants per square meter for the Moldova 5 variety was lower than the corresponding value for the other two varieties, despite the same sowing density. It follows that seed germination, or plant survival of this variety was lower, regardless of the year of cultivation. Additionally, the productivity of plants of this variety was negatively affected by the comparatively lower number of grains produced in the central ear. Several factors harmed the productivity of the variety of Moldova 5 plants. Among these, we mention the relatively short period of vegetative growth, the low chlorophyll content in leaves, Figure 2, as well as the low values of PS II efficiency throughout the day, Figure 2. Overall, the specificity of the development of the ontogenesis of the plants of the Moldova 5 variety led to the relative reduction of the beneficial effects of treating the seeds before sowing with BS *Reglalg*. The yield of the plants of this variety, estimated per hectare, was 40-100 kilograms lower compared with plants of the Missia and Kuyalnik varieties.

The data presented in Table 2 indicate that the treatment of seeds of the studied wheat varieties with BS *Reglalg* solution, as a rule, led to a decrease in the number of ears per square meter. Despite this, due to the increase in the number of plants with large ears, the average number of grains per ear, and the weight of 1000 grains, the estimated grain yield per hectare for the experimental plant variants was always significantly higher compared to that which was typical for the control variants. Depending on the variety and year of cultivation, seed treatment before sowing led to an increase in the estimated wheat grain yield from 40 to 510 kilograms per hectare.

The data presented in Table 2 differ from the results of studies by other authors [4, 39], who showed that with an increase in the width of the flag leaf of wheat plants, the size of the central spike, the total number of productive spikelets, the grain content and productivity of the spike increase, the height of plants and the number of unproductive spikelets decreases. In our new studies, we have shown that in the wheat varieties, the relative width of the flag leaf varies, and an increase in its value is not accompanied by a corresponding increase in the relative productivity of plants. For example, in 2018, the Moldova 5 variety plants had the largest flag leaf width (Table 1) and the lowest productivity (Table 2). The unpredictable and different direction of variation in the relative width of the flag leaf from year to year in different wheat genotypes gives reason to believe that its width cannot serve as a reliable indicator for the breeding of highly productive wheat varieties.

Table 2. Effect of treatment before sowing winter wheat seeds with water (control) or the biostimulant *Reglalg* diluted with water in a ratio of 1:200 (experiment) on parameters characterizing the yield structure of plants of the Moldova 5, Missia, and Kuyalnik varieties grown in 2015 - 2018

Parameters	2015 – 2016			2016 – 2017			2017 – 2018		
	Moldova 5	Missia	Kuyalnik	Moldova 5	Missia	Kuyalnik	Moldova 5	Missia	Kuyalnik
Control									
Harvest, t/ha	3,76	3,82	3,80	3,93	3,99	3,96	4,20	4,30	4,25
Number of ears per m²	585	535	531	554	528	528	514	520	512
Ears length (>7 cm) per m²	115	118	116	136	140	142	124	132	133
Ears length (<7 cm) per m²	470	417	415	418	388	386	390	388	379
Grains per ear with length (>7 cm)	25,4	28,6	28,8	26,1	28,4	27,9	29,3	29,9	30,1
Grains per ear with length (<7 cm)	18,2	18,6	18,7	19	18,9	18,8	19,7	19,5	19,6
Weight of 1000 grains, g	32,2	34,4	34,2	34,2	35,3	35,6	36,7	37,4	37,2

Experiment									
Harvest, t/ha	3,81*	3,93*	3,92*	4,35*	4,48*	4,39*	4,73*	4,80*	4,76*
MSD (0,05) between the harvest of experience and control	0,04	0,09	0,09	0,12	0,16	0,15	0,21	0,22	0,26
Number of ears per m^2	534	522	488	569	564	579	481	520	534
Ears length (>7 cm) per m^2	121	124	122	144	144	143	172	184	186
Ears length (>7 cm) per m^2	413	398	366	425	420	436	309	336	348
Grains per ear with length (>7 cm)	28,1	29,6	29,8	29,4	29,9	28,1	40,5	30,3	30,3
Grains per ear with length (<7 cm)	19,1	19,1	19,4	19,4	19,2	19,6	19,6	21,1	20,6
Weight of 1000 grains, g	1,16	1,24	1,22	1,24	1,26	1,25	1,26	1,29	1,26
Number of ears per m^2	33,8	34,9	34,7	34,9	36,2	35,2	36,3	38,1	37,2

Notes: *- * marked reliable at the 95% level differences between options.*

According to our data, the duration of the phases of flowering, grain growth, and milky and milky-wax ripeness in plants of the Missia and Kuyalnik varieties cultivated in 2018 was respectively equaled 7, 12, 8, and 6 days, while in the Moldova 5 variety, they were respectively equaled 6, 10, 6 and 4 days. These data indicate that in the plants of the Moldova 5 variety, compared to the plants of the Missia and Kuyalnik varieties, the faster aging of the flag leaf and the faster passage of the phases of formation and ripening of the grains in the ear are manifested. The total duration of these phases in the Moldova 5 plants was 26 days, and 33 days in the plants of the other two varieties. The importance of the length of these periods in determining the yield level is also evidenced by the fact that in plants obtained from seeds treated with BS *Reglalg* solution, an increase in the period of grain formation and ripening in the ear is accompanied by an increase in yield, Table 1, Figure 2.

The yield of wheat plants depends significantly on weather conditions during the period of heading and grain ripening. During this period in the ear processes determining the number of grains and the number of cells in the endosperm of the grain take place. The total dry matter content in grain depends on the number of cells in the endosperm and the level of accumulation of reserve substances in each cell [4]. Intensive formation of cells in the endosperm occurs during the flowering and grain growth phase. Then, the cells were filled with reserve substances in the milky and milky-waxy ripeness phases [35]. Thus, the yield of wheat plants depends on the process's characteristics of all four-grain formation phases. Our data confirm these conclusions. The total period from grain formation to its ripening for the Moldova 5 wheat variety was 26 days and for the Missia and Kuyalnik varieties - 33 days. As a result, the accounting grain yield per hectare for wheat plants of the Moldova 5 variety was 3.76 t for plants of the other two varieties – 3.8 t per hectare (Table 2). It should be taken into account that the differences regarding the yield of the Moldova 5 wheat variety compared with that of the Missia and Kuyalnik varieties may also depend on the specific dynamics of changes in the intensity of photosynthesis during the day. In wheat variety Moldova 5, the photosynthesis intensity in grain formation and ripening phases tended to be lower than in the other two wheat varieties, see Figure 2. It is also important to emphasize that the quantity and quality of the wheat harvest significantly depend on the specific processes taking place during all phases of grain formation and ripening in the ear. The influence of high temperatures and drought on endosperm cell formation and division has been studied less fully than their influence on the processes occurring in the phases of reserve substance accumulation and grain ripening [41]. It has been shown that under conditions of heat and drought, such processes as grain ripening in the ear, inhibition of starch biosynthesis, cell apoptosis in endosperm tissues, and achievement of physiological grain maturity are accelerated [42]. Under the influence of high temperatures during the grain-filling period, the expression of gluten biosynthesis genes accelerated in the wheat ear. As a result of these changes, an acceleration of grain ripening was observed, which led to a decrease in the period from the beginning of heading to the grains ripening in the ear [43]. These phenomena, probably, occur because drought and heat accelerate the processes taking place in the embryo and endosperm, due to which grain ripening is accelerated. These data are confirmed by the results given in Table 2 and Figure 1. An increase in the period of formation and grain ripening in the ear, as well as an increase in the photosynthetic activity of the flag leaf during daylight hours in plants obtained from seeds treated before sowing with a solution of BS *Reglalg*, leads to a significant increase in yield wheat plants.

In light of the above results, we cannot exclude the possibility that the lower estimated productivity of plants of the Moldova 5 variety that we identified compared with that which is typical for the other two wheat varieties, Table 2, is associated not only with the lower potential productivity of the wheat variety. Plant productivity is influenced by environmental conditions, which in 2016 turned out to be more critical for the Moldova 5 variety than for the Missia and Kuyalnik varieties. Indirectly, these considerations are supported by the fact that in 2016, in plants obtained from seeds treated with BS *Reglalg,* the increase in yield of the studied varieties was the smallest (fluctuating between 40 and 120 kg per hectare), being minimal in plants of the Moldova 5 variety (40 kg per hectare). That is why the conclusion about the stability and productivity of wheat varieties can be made only after analyzing the results of cultivating the variety in different climatic zones [43].

Conclusions

1. Wheat plants, which have a higher daily activity of photosynthesis of the flag leaf during the passage of various phases of grain formation and ripening in the ear, tend to be characterized by a higher period of each phase passage, starting from the initiation of heading and ending with the grain ripening phase.
2. Based on the daily dynamic's specificity of PS2 activity in the flag leaf of plants, being in the same phase of grain development in the ear, we can distribute wheat genotypes according to their productivity under given environmental conditions.
3. Since the duration of the grain formation and ripening phases in a wheat ear varies depending on environmental conditions (mainly temperature and humidity), to correctly determine the potential productivity of a genotype, tests should be carried out in different climatic zones.
4. The beneficial effect of BS *Reglalg* on winter wheat plants mainly depends on increasing the viability of the plants and the efficiency of their adaptation to the action of extreme temperatures and drought, which ultimately ensures the increase of plant productivity.

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