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Effect of Foliar Products on Yield and Grain Quality in Common Wheat Sorts

REFERAT

FOR AWARDING THE "DOCTOR" EDUCATIONAL AND SCIENTIFIC DEGREE IN CROP PRODUCTION

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The research has been done throughout the period 2016-2019 at the trial base of the Agricultural University, Plovdiv.

The thesis is 155 pages long and contains 48 tables and 1 graph. The number of used sources is 79.

The thesis has been discussed and approved for defense by the department council of the Crop Production Department with the Agronomy Faculty of the Agricultural University, Plovdiv.

The official defense of the thesis will be held on ……………… at …………….. at the convention of the Specialized Scientific Jury at the Agricultural University, Plovdiv, whose members are as follows:

Internal members

Prof. Dr. Ivan Yanchev

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The materials are available on the website of the Agricultural University, Plovdiv: www.au-plovdiv.bg.

I. INTRODUCTION

Over the last years foliar products have become widely used in the technology of wheat production. They are used to control growth, plant development and productivity, to the same extent as macro- and micro fertilizers, herbicides, insecticides, and fungicides. Most of the foliar products known and used in practice can be mixed with crop protection products, are easily applicable, efficient, and ecologically safe. In some years there are problems, caused by low or high temperatures, draught, excessive wet and other abiotic stress factors.

This calls for the need to research the new foliar products on the market and establishing the appropriate products for common wheat production.

II. GOAL AND TASKS OF THE RESEARCH

Establishing the effect of Plantafol and Bombandier foliar products on the yield and grain quality in Enola, Anapurna, Ginra and Bilyana common wheat sorts.

Tasks

- Establishing the effect of the foliar products on the growth and development of common wheat sorts;
- Establishing the effect of the tested foliar products on the structural elements of common wheat yield;
- Establishing the effect of the tested foliar products on common wheat sort productivity;
- Establishing the changes in the chemical attributes of the grain (physical and chemical) of common wheat sorts Enola, Anapurna, Ginra and Bilyana following the application of Plantafol and Bombandier foliar products.

Material and methods

Three annual field trials have been conducted in the period 2016-2019 to achieve the goal and the tasks of the thesis.

The trials were conducted at the trial base of the Crop Production Faculty following the method of the fractional plots in 4 repetitions, with each plot the size of 15 m^2.

Tested factors and levels

Factor A - sort

A_1 – Enola (standard)

A_2 – Annapurna

A_3 – Ginra

A_4 - Bilyana

Factor B – foliar products

B_0 – control plot (without crop protection products, without fertilizers)

B_1 – control plot (without crop protection products, with fertilizers)

B_2 - Plantafol – 250 g/da

B_3 – Bombandier – 400 ml/da

B_4 – Plantafol (250 g/da) + Bombandier (400 ml/da)

The tested foliar products Plantafol and Bombandier were applied both independently and in combination in phase end of tillering – beginning of stem elongation (29-31 according to Zadoks scale).

Phenological observations

The main phenological phases are marked according to Zadoks scale (emergance (Z10), tillering (Z22), elongation (Z31), heading (Z57), ripening (Z94).

Morphological observations – done in ¼ m^2 in 4 repetitions:

- tillering in autumn – number of plants on m^2.
- beginning of stem elongation – number of plants and tillers per m^2.
- heading - number of ears per m^2.
- ripening – plant high (from 10 plants), number of ears per m^2.

The effect of the products is analyzed separately vs the non-treated control plot and vs the non-fertilized control plot.

Structural elements of the yield

- ear length , cm
- number of spikes, nr
- number of grains, nr
- grain mass per ear, g

Grain yield, kg/da (recalculated with standard grain moisture of 13%).

Physical indicators of the grain

- volume per 1000 grains, (g) – weighing two samples 500 grains each;
- hectoliter volume, (kg) – weighing scales.

Biochemical analysis of the grain

- Protein content in the grain - % according to Keldal;
- Wet and dry gluten content in the grain - % ;
- Starch content - %
- Fat content - %.

Physiological analyses

- Leaf gas exchange
- Chlorophyll fluorescence
- Photosynthetic pigments (according to Lichthentaler, 1987)

Mathematical processing of the data

Three-year field trials were conducted in order to research and assess the effect of the foliar products Plantafol and Bombandier over the structural elements of the yield and productivity of common wheat sorts.

Samples of 10 plants were collected for biometrical analysis at the end of the vegetation and the following indications were observed: ear length, брой класчета в клас, брой зърна в клас, маса на зърното от клас, маса на 1000 зърна. The hectoliter volume of each tested variant and grain yield in kg/da were reported.

The data was processed using the ANOVA method to assess the effect of foliar treatment on the researched elements.

The mathematical processing of the data from the conducted experiments was done using SPSS-16. A statistical assessment using dispersion analysis was done to evaluate the presence or absence of proven differences in the tested indications both for each sort and for all possible combinations between the tested indications. The Dunkan multi-rank test was used to establish the differences between the tested variants with the least significant difference (LSD) – 0,05 (5%).

III. SOIL-CLIMATIC CONDITIONS

Soil Conditions

Soil characteristics in the region of the trial.

Nutrient content before the trial at 0-20 cm depth is shown in Table 1.

Table 1

Agrochemical soil analysis before trial

Year	pH	Mineral nitrogen in mg/kg soil			In mg/100 g soil	
		NH4	NO3	Total	P2O5	K2O
2016	7,81	7,5	10,8	18,3	8,14	53,21
2017	7,85	7,5	8,7	16,2	9,12	48,37
2018	7,82	7,5	17,4	24,9	8,22	42,6

The soil was scarcely loaded with nitrogen, with average loads of phosphorus and very well loaded with potassium.

In all three years of testing, the pH analysis showed low alkalescence 7,81 (2016) 7,85 (2017) и 7,66 (2018), which is characteristic of this type of soil.

In year one of the trial the load of the soil, after harvesting the preceding crop, is the following: nitrogen: 18,3 mg/kg soil; phosphorus P_2O_5: 8,14 mg/100 g soil; potassium K2O : 53,21 mg/100 g soil.

In year two of the trial the load of the soil with nitrogen is 2,1 mg/kg lower. K2O level is also lower, while P_2O_5 has 0,98 mg/100g higher levels.

In year three of the trial the soil is loaded with mineral nitrogen of 24,9 mg/kg, which is 8,7 mg/kg higher vs the previous year. P2O5 load is 0,9 mg/ 100 g lower vs the previous year, K2O load decreased by 5,77 mg/100g compared to 2017.

Meteorological Conditions

Meteorological conditions during wheat vegetation throughout the study years.

Unlike the climatically dry 2016 - 278 mm, the second and third of trial were characterized by wetter climate and higher average temperatures. There was also a smoother rise and fall in temperatures during the second and third years of the trial.

The years 2017/20 as well as 2018/2019 can be considered the most favourable because of the good development of the crop in autumn and the provision of soil moisture during that period, as well as the rains in April - May contributing to the favourable development of wheat in spring.

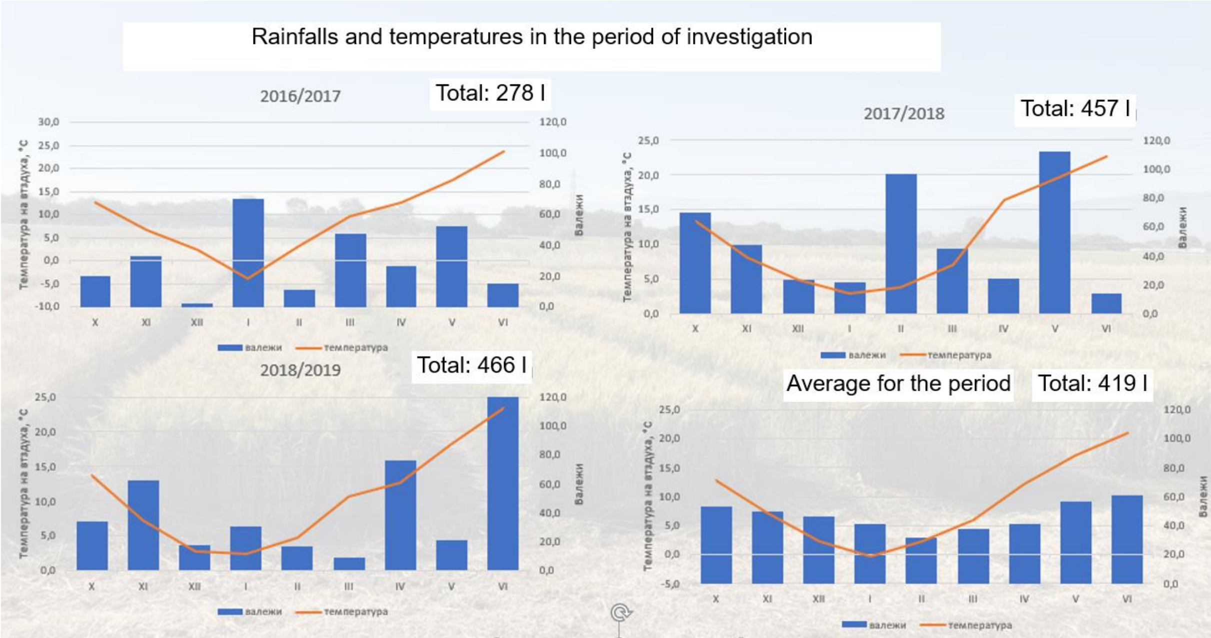

Figure 1. Climategate

IV. RESULTS AND DISCUSSION

1. Effect of the treatment with mineral foliar fertilizers enriched with trace elements and foliar biostimulators on the structural elements of wheat yield

1.1. Phenological observations

Sowing was carried out in the optimal agrotechnical period in all three trial years. The differences in development after the third leaf phase are mainly due to the dynamics of precipitation and temperature regime in different years.

Taking into account the data on precipitation and temperature regime over the years, it can be concluded that they are crucial for the course of the various phenophases. Higher temperatures in the second and third years cause a reduction in the time of the phenological phases of the crop development.

Due to the higher average temperatures in October, as well as the significantly more abundant rainfall in the second and third trial years, the germination period takes place in a shorter period of time compared to the first trial year.

In the second and third trial years, the crop reaches the tillering phase in December, which is the fastest of the trial period (an average of 15 days), while in the first year this phase was reached in March (90 days). Here again, the main limiting factor is the lack of moisture in this period.

In 2016/2017 no differences were observed in the periods of onset of the phenophases to stem elongation in the various tested cultivars. The possible reason for that is the delay in the cultivar development and the presence of a limiting moisture factor. During the other phenophases differences are observed in in the onset of the phenophases and the cultivar Enola starts its stem elongation first (6.4.2017), followed by Ginra (7.4.2017), Bilyana and Anapurna (8.4.2017). Regarding the heading and flowering phases, first is the Enola cultivar, followed by Bilyana, Ginra and Anapurna.

From the tillering phase to the grain filling phase different duration of the interphase period has been recorded in the various cultivars. In 2017/2018 and in 2018/2019 the accumulation of active temperature and moisture favours the timely occurrence of the phases and Enola cultivar enters the stem elongation phase the first, followed by Ginra, Bilyana and Anapurna. These differences contribute to explaining the biological requirements of cultivars and their interaction with the environment.

All cultivars ripen at a similar duration and do not differ much. The reason about it is that all four cultivars are moderately early as ripening is concerned and under the same climatic conditions they ripen identically. Yet it can be reported that Anapurna cultivar ripens latest due to the slower passing through the previous phases.

Table № 3

Date of phenological phases

Year	Phenological phases	Variety			
		Enola	Annapurna	Ginra	Bilyana
2016/2017	Sowing	11.10.2016	11.10.2016	11.10.2016	11.10.2016
	Emerging	5.11.2016	5.11.2016	5.11.2016	5.11.2016
	Tirth leaf	15.12.2016	15.12.2016	15.12.2016	15.12.2016
	Tillering	15.3.2017	13.3.2017	13.3.2017	15.3.2017
	Elongation	6.4.2017	8.4.2017	7.4.2017	8.4.2017
	Heading	5.5.2017	13.5.2017	11.5.2017	8.5.2017
	Flowering	10.5.2017	18.5.2017	15.5.2017	12.5.2017
	Full maturity	21.6.2017	23.6.2017	26.6.2017	21.6.2017
2017/2018	Sowing	12.10.2017	12.10.2017	12.10.2017	12.10.2017
	Emerging	20.10.2017	24.10.2017	23.10.2017	23.10.2017
	Tirth leaf	6.11.2017	8.11.2017	6.11.2017	6.11.2017
	Tillering	18.12.2017	21.12.2017	19.12.2017	19.12.2017
	Elongation	16.4.2018	20.4.2018	18.4.2018	19.4.2018
	Heading	7.5.2018	11.5.2018	9.5.2018	10.5.2018
	Flowering	12.5.2018	15.5.2018	13.5.2018	16.5.2018
	Full maturity	20.6.2018	25.6.2018	21.6.2018	22.6.2018
2018/2019	Sowing	26.10.2018	26.10.2018	26.10.2018	26.10.2018
	Emerging	6.11.2018	13.11.2018	7.11.2018	8.11.2018
	Tirth leaf	24.11.2018	30.11.2018	25.11.2018	25.11.2018
	Tillering	12.12.2018	15.12.2018	12.12.2018	13.12.2018
	Elongation	9.4.2019	14.4.2019	10.4.2019	11.4.2019
	Heading	8.5.2019	15.5.2019	9.5.2019	10.5.2019
	Flowering	13.5.2019	18.5.2019	15.5.2019	15.5.2019
	Full maturity	25.6.2019	1.7.2019	23.6.2019	27.6.2019

Morphological observations

1.2.3. Tiller number, spike number, tiller production, plant height

Morphological observations are the so-called yield components.

Crop productivity comprises the following components: tiller number; spike number; tiller production and plant height.

The spike components are: spike length, spikelet number, grain number and grain weight per spike.

To a great extent tillering determines yield formation. It depends both on the cultivar characteristics, but also on the climatic conditions, agrotechnology and available nutrients.

In the studied cultivars Anapurna has the greatest total tillering – an average of 616 tillers/m^2 for the three study years, followed by Enola - 550 tillers/m^2, Ginra - 509 tillers/m^2 and Bilyana - 500 tillers/m^2 (Table 6).

At the time of tillering cultivars were not treated with factor B foliar application products and the difference in tillering is accounted for mainly by the cultivar differences. However, pre-seeding fertilization also has an effect on wheat tillering. Due to that reason less tillers have been observed in the non-fertilized and non-treated variants.

Spike number is an indicator effecting yield, hence it is of great importance for the crop tiller production. Ginra cultivar has the greatest tiller production with 441 spikes/m^2, followed by Enola - 434 spikes/m^2, Anapurna - 431 spikes/m^2 and Bilyana - 419 spikes/m^2.

For the entire trial period variation in the tillering of cultivars has been observed, which implies that tillering is a genotypic characteristic, but it can be provoked by the environmental factors.

The results obtained lead to the conclusion that the difference in spike length among cultivars is not significant due to the elimination of non-productive tillers in the more heavily tillering cultivars.

Table № 6

Number of tillers, number of ears, productive tillers

(average for three years of investigation)

№	Variety	Products	tillers/m ^{2}	Number of plants with ears/ m ^{2}	Productive tillering, %
1.	A_1 - Enola	B_0 Control – non fertile	544,8	424,4	78
		B_1 Control-fertile	548,2	452,1	82
		B_2 Plantafol	553,1	452,3	82
		B_3 Bombandier	556	448,2	81
		B_4 Plantafol + Bombandier	548,5	442,1	81
2.	A_2 - Anapurn a	B_0 Control – non fertile	607,4	423,1	70
		B_1 Control-fertile	620,7	431,4	70
		B_2 Plantafol	622,6	424,2	68
		B_3 Bombandier	620,3	429,3	69
		B_4 Plantafol + Bombandier	615,7	435,5	71
3.	A_3- Ginra	B_0 Control – non fertile	492,9	414,2	84
		B_1 Control-fertile	494,1	416,1	84
		B_2 Plantafol	499,4	439,8	88
		B_3 Bombandier	505,2	433,3	86
		B_4 Plantafol + Bombandier	540,7	476,8	88
4.	A_3 - Bilyana	B_0 Control – non fertile	501,2	429,9	86
		B_1 Control-fertile	505,5	433,6	86
		B_2 Plantafol	507,5	396,8	78
		B_3 Bombandier	498,7	418,4	84
		B_4 Plantafol + Bombandier	494,4	432,6	88

Structural elements of yield

2.1. Spike length

Spike length is a genotypic trait, which is constant. Nevertheless, the study throughout the years revealed that depending on the treated variants, differences in that trait were found. Meteorological conditions during the year and the formation of plants during the autumn-winter period are of considerable importance.

Spike length average for the study period

The summarized three-year results by cultivars and traits adhere to the same tendency that had been established in the analysis of each of the experimental years.

Table 12 presents the data revealing the results about reliability of differences by cultivars compared to the controls B_0 and B_1 in relation to the spike length trait.

For the Enola cultivar (A_1) is has been found the greatest spike length is typical of the variants treated with Bombardier, Plantafol and the combination thereof.

Compared to the two controls, the difference is statistically reliable at levels P 0.1% and P 1%.

In the Anapurna cultivar (A_2) most differences are insignificant, which shows that this cultivar has a relatively stable manifestation of the trait and is not significantly influenced by the treatments applied.

This is probably due to the fact that spike length is a cultivar trait.

For Ginra cultivar (A_3) differences with regard to the trait with both controls B_0 and B_1 are insignificant.

For Bilyana cultivar (A_4) the greatest, yet proven, length has been reported in the combined application of both products.

The values of the other variants are close to the controls.

Table № 12

Provement on differences by varieties compared to the controls B_0 and B_1 according to the ear length(sm) average for the period

Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A_1B_3	10.50	1.9 ++	1.8 ++	A_2B_1	9,40	1,0 +	
A_1B_2	10.36	1,8 ++	1.7 +	A_2B_3	8,62	0,22 ns	-0,78 ns
A_1B_4	10.13	1,5 +	1.4 ns	A_2B_0	8,40		-1,0 (-)
A_1B_1	8.70	0,1 ns		A_2B_4	8,34	-0,06 ns	-1,06 (-)
A_1B_0	8.60		-0.1 ns	A_2B_2	8,28	-0,17 ns	-1,12 (-)
GDP5%= 1,45 GDP1%= 1,77 GDP0,1%= 2,05 GDP5%=0,98 GDP1%=1,45 GDP0,1%= 1,84							
Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A_3B_2	9,60	1,77 ns	0,54 ns	A_4B_4	10.53	0.73+	0.77+
A_3B_3	9,13	1,30 ns	0,07 ns	A_4B_3	9.90	0.1 ns	0.14 ns
A_3B_1	9,06	1,23 ns		A_4B_0	9.80		0.04 ns
A_3B_4	8,90	1,07 ns	-0,16 ns	A_4B_1	9.76	-0.04 ns	
A_3B_0	7,83		-1,23 ns	A_4B_2	9.73	-0.07 ns	-0.03 ns
GDP5%=1,85 GDP1%= 2,05 GDP0,1%=2,96 GDP5%=0,68 GDP1%=1,11 GDP0,1%=1,45							

Spikelet number per spike average for the study period

Concerning spikelet number per spike, the data about the cultivars have been presented in Table 17.

This trait is important because spike density depends on it.

In Enola cultivar (A_1), a proven higher spikelet number has been reported in the variants treated with Plantafol and the combination Plantafol+Bombardier.

The lowest value has been reported in the untreated and unfertilized control (B_0).

The highest value of the trait was obtained when the two products were applied together in the Anapurna cultivar (A_2) as well, although the differences here were insignificant in all comparisons made.

For the Ginra cultivar (A_3) it has been found that in the untreated control (B_1) a proven higher manifestation of the trait has been reported.

All differences compared to B_0 and B_1 in the Bilyana cultivar (A_4) are unproven, which shows that there is no significant difference in the manifestation of the trait due to the studied foliar treatment products.

On the one hand, this trait depends on the cultivar and spike type, and on the other hand, on the moment of spikelet setting in the spike, which takes place at the time of treatment with the foliar fertilization products.

Table № 17

Provement on differences by varieties compared to the controls B_0 and B_1 according to the number of the spikelet(nr) average for the period

Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1	Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1
A_1B_2	21,03	1,43 ++	1,26 +	A_2B_4	18,63	0,28 ns	0,30 ns
A_1B_4	20,53	0,96 +	0,76 ns	A_2B_0	18,35		0,02 ns
A_1B_3	19,77	0,20 ns	0 ns	A_2B_1	18,33	-0,02 ns	
A_1B_1	19,77	0,20 ns		A_2B_2	18,23	-0,12 ns	-0,10 ns
A_1B_0	19,57		-0,2 ns	A_2B_3	17,80	-0,55 ns	-0,53 ns
GDP5%=0,95 GDP1%=1,35 GDP0,1%=2,15				GDP5%=0,85 GDP1%=1,15 GDP0,1%=1,95			
Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1	Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1
A_3B_1	18,60	1,50 +		A_4B_1	19,53	0,83 ns	
A_3B_2	18,33	1,23 ns	-0,27 ns	A_4B_2	19,37	0,67 ns	-0,16 ns
A_3B_3	17,97	0,87 ns	-0,63 ns	A_4B_3	18,97	0,27 ns	-0,56 ns
A_3B_4	17,93	0,83 ns	-0,67 ns	A_4B_4	18,93	0,23 ns	-0,60 ns
A_3B_0	17,10		-1,50 (- -)	A_4B_0	18,70		-0,83 ns
GDP5%=1,35 GDP1%=1,95 GDP0,1%=2,45				GDP5%=0,95 GDP1%= 1,45 GDP0,1%=1,85			

Grain number per spike average for the period

One of the traits directly related to the crop grain yield is the grain number per spike trait.

The data presented in Table 23 show that in the Enola cultivar (A_1) grain number has been proven to be the highest in the single and combined application of the two products.

In the case of Anapurna cultivar (A_2), only in the combined application of the products and the independent effect of the product Bombardier, a proven higher value of the trait has been reported compared to the one established in the untreated and non-fertilized control. All other differences are insignificant.

The difference between the single application of Bombardier compared to B_0 has been proven for the Ginra variety (A_3) as well.

The differences with regard to the second control B_1 are insignificant.

In the case of the Bilyana (A_4) cultivar, no significant difference has been found in the manifestation of the trait, due to which they are of the same level.

The importance of the cultivar for this trait can definitely be taken into account, with the greatest grain number per spike being found in the Anapurna cultivar. However, all varieties treated with products for foliar application are influenced in a positive way and show better results.

Table № 23

Provement on differences by varieties compared to the controls B_0 and B_1 according to the number of grains in spike(nr) average for the period

Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A1B2	54,07	8,27 ++	9,27 ++	A2B4	59,87	7,02+	4,84 ns
A1B3	53,80	7,27 +	9,00 ++	A2B3	58,57	5,72 +	3,54 ns
A1B4	53,17	6,64+	8,37++	A2B2	57,07	4,22 ns	2,04 ns
A1B0	46,53		1,73 ns	A2B1	55,03	2,18 ns	
A1B1	44,80	-1,73 ns		A2B0	52,85		-2,18
GDP5%/=5,82 GDP1%=7,43 GDP0,1%=10,25				GDP5%=5,20 GDP1%=7,45 GDP0,1%=9,20			
Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A3B3	50,30	7,20 +	4,17 ns	A4B3	57,53	0,56 ns	1,66 ns
A3B2	49,80	6,70 ns	3,67 ns	A4B0	56,97		1,10 ns
A3B4	49,50	6,40 ns	3,37 ns	A4B1	55,87	-1,10 ns	
A3B1	46,13	3,03 ns		A4B4	55,07	-1,90 ns	-0,80 ns
A3B0	43,10		-3,03 ns	A4B2	54,27	-2,70 ns	-1,60 ns
GDP5%=6,80 GDP1%=8,55 GDP0,1%=11,8				GDP5%=5,49 GDP1%= 7,55 GDP0,1%=9,45			

Grain weight per spike average for the period

The grain weight per spike trait plays a decisive role in yield formation. The data about the effect of the tested products in the studied cultivars are presented in Table 29.

The findings about the Enola cultivar (A_1) show that the independent and combined effect of factor B has led to proven higher values of manifestation of the trait compared to the two controls - B_0 and B_1.

The same effect has been observed for the Anapurna cultivar (A_2). Proven higher values of the trait have been reported in the single and combined effect of factor B.

The Ginra cultivar (A_3) also reacted positively to the combined effect of the two products, although the differences from the accepted controls were insignificant.

In the Bilyana cultivar (A_4) a proven higher grain weight per spike has been reported in the untreated control B_1 and in the variant treated with Bombardier B_3 compared to B_0. The difference between the two controls was shown to be negative in favour of B_1.

The data presented in Table 30 comprise mathematical analysis of the studied trait. The most significant effect has been reported for the variants of the Anapurna cultivar treated with a combination of the two products A_2B_4 and the variant treated with Plantafol A_2B_2, respectively X 3.09 and X 2.94.

Table № 29

Provement on differences by varieties compared to the controls B_0 and B_1 according to the wight per spike(g) average for the period

Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A1B4	2,37	0,30 +	0,34 ++	A2B4	3,09	0,59 ++	0,49 +
A1B2	2,36	0,29 ns	0,33 ++	A2B2	2,94	0,44 +	0,34 ns
A1B3	2,28	0,21 ns	0,25 ns	A2B3	2,85	0,35 +	0,25 ns
A1B0	2,07		0,04 ns	A2B1	2,60	0,10 ns	
A1B1	2,03	-0,04 ns		A2B0	2,50		-0,10 ns
GDP5%=0,29 GDP1%=0,32 GDP0,1%= 0,48				GDP5%=0,35 GDP1%= 0,54 GDP0,1%=0,81			
Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A3B4	2,47	0,37 ns	0,07 ns	A4B1	2.97	0.48 ++	
A3B3	2,44	0,34 ns	0,04 ns	A4B3	2.90	0.41 ++	-0,07 ns
A3B1	2,40	0,30 ns		A4B4	2.81	0.32 ns	-0,16 ns
A3B2	2,38	0,28 ns	-0,02 ns	A4B2	2.68	0.19 ns	-0,29 ns
A3B0	2,10		-0,30 (-)	A4B0	2.49		-0,48 (- -)
GDP5%=0,38 GDP1%=0,49 GDP0,1%= 0,61				GDP5%=0,33 GDP1%= 0,41 GDP0,1%= 0,53			

Grain yield average for the period

The results about the reported grain yield (kg/da) by cultivars depending on the applied treatments are presented in Table 35. They are similar to the ones reported about the traits analyzed.

For the Enola cultivar (A1) the highest yields were found in the combined and independent application of foliar treatment products. The differences between the two controls are statistically significant.

The same grading of the variants has been found for the Anapurna variety (A_2). The highest yield has been reported for the combination Plantafol+Bombardier, followed by the variants treated separately with the preparations Plantafol and Bombardier.

In the other two cultivars Ginra (A_3) and Bilyana (A_4) the lowest are the values of the variants accepted as controls B_0 and B_1.

For the Ginra cultivar (A_3) it has been found out that the variants with combined and independent treatment have higher yield than the one reported for the two controls, but the differences are statistically insignificant.

The yield data reported for the Bilyana (A_4) variety show that this cultivar is slightly affected by the influence of the studied factors. Nevertheless, the variant with the combined effect of the two foliar treatment products is characterized by higher yield here as well, followed by their independent application.

Table 35 presents the results from the analysis of variance among all possible combinations (variants) between the degrees of the studied factors in relation to the reported average yield.

The results make it possible to assess which cultivars in what combination with the relevant fertilizing products have resulted in a proven higher yield.

It is noteworthy that Anapurna cultivar (A_2) during the study period has achieved the highest average yield, both in the combined application of the products and in their independent impact.

The yield gradation is followed by the variants treated with the products Bombardier and Plantafol.

The Enola cultivar (A1) in the combination Plantafol+Bombardier (B_4) also showed a proven higher yield.

The studied variants (cultivar in combination with foliar fertilizing) according to the level of evidence of the differences between them can be conditionally divided into two large groups.

The first eight of the variants graded in descending order are proven to have higher yield. The second group includes mainly the Ginra cultivar (A_3) in all of its combinations with or without foliar fertilization, as well as the cultivars that have not been treated or nourished.

The data presented in Table 36 show a mathematical analysis with respect to the tested trait. The highest results have been reported for the Anapurna cultivar treated in combination of the two products A_2B_4 - X 593.7

The lowest results have been are reported for Ginra cultivar A_3B_1 116.4+++ and A_3B_0 116+++, which have not been treated with foliar application products.

Table № 35

Provement on differences by varieties compared to the controls B_0 and B_1 according to the yield average for the period

Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1	Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1
A1B4	567,3	70,00 ++	76,30 ++	A2B4	593,7	24,70 +	84,00 +++
A1B3	548,0	50,70 +	57,00 +	A2B3	591,0	22,00 ns	81,30 +++
A1B2	529,3	32,00 +	38,30 +	A2B2	584,7	15,70 ns	75,00 ++
A1B0	497,3		6,30 ns	A2B0	569,0		59,30 ++
A1B1	491,0	-6,30 ns		A2B1	509,7	-59,30(- -)	
GDP5%=31,98 GDP1%=58,16 GDP0,1%=87,24				GDP5%=23,55 GDP1%=49,40 GDP0,1%=75,70			
Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1	Variants	$\dot{X}$	Provement of D compared to B_0	Provement of D compared to B_1
A3B4	523,0	45,30 ns	45,70 ns	A4B4	560,7	46,40 ns	50,40 +
A3B2	511,7	34,00 ns	34,40 ns	A4B3	556,7	42,40 ns	46,40 ns
A3B3	504,0	26,30 ns	26,70 ns	A4B2	535,7	21,40 ns	25,40 ns
A3B0	477,7		0,40 ns	A4B0	514,3		4,00 ns
A3B1	477,3	-0,40 ns		A4B1	510,3	-4,00 ns	
GDP5%=47,02 GDP1%=55,40 GDP0,1%=67,80				GDP5%=46,50 GDP1%=51,60 GDP0,1%=64,90			

Table № 36

Provement on differences between the varieties by yield average for the period

Variant	X	Diff with:																			
		A2B4	A2B3	A2B2	A2B0	A1B4	A4B4	A4B3	A1B3	A4B2	A1B2	A3B4	A4B0	A3B2	A4B1	A2B1	A3B3	A1B0	A1B1	A3B0	A3B1
A2B4	593,7	-	2.7	9.0	24.7	26.4	33	37	46.7	58	64.4+	70,7+	79,4++	82++	83,4++	84++	89,7++	96,4++	102,7++	116+++	116,4+++
A2B3	591,0		-	7	22	23,7	30,3	34,3	43	55,3	61,7+	68+	77++	79,3++	80,7++	81,3++	87++	93,7++	100++	113,3+++	113,7+++
A2B2	584,7			-	15,7	17,4	24	28	36,7	48,3	55,4	61,7+	70,4+	73+	74,4++	75++	80,7++	87,4++	93,7++	107+++	107,4+++
A2B0	569,0				-	1,7	8,3	12,3	21	33,3	39,7	46	54,7	57,3	58,7	59,3	65+	71,7+	78++	91,3++	91,7++
A1B4	567,3					-	6,6	10,6	19,3	31,6	38	44,3	53	55,6	57	57,6	63,3+	70+	76,3++	89,6++	90++
A4B4	560,7						-	3,3	12,7	25	31,4	37,7	46,4	48,3	50,4	51	56,7	63,4+	69,7+	83++	83,4++
A4B3	556,7							-	8,7	21	27,4	33,7	42,4	45	46,4	47	52,7	59,4	65,7+	79++	79,4++
A1B3	548,0								-	12,3	18,7	25	33,7	36,3	37,7	38,3	44	50,7	57	70,3+	70,7+
A4B2	535,7									-	6,4	12,7	21,4	24	25,4	26	31,7	38,4	44,7	58	58,4
A1B2	539,3										-	6,3	15	17,6	19	19,6	25,3	32	38,3	51,6	52
A3B4	523,0											-	8,7	11,3	12,7	13,3	19	25,7	32	45,3	45,7
A4B0	514,3												-	2,6	4	4,6	10,3	17	23,3	36,6	37
A3B2	511,7													-	1,4	2	7,7	14,4	20,7	34	34,4
A4B1	510,3														-	0,6	6,3	13	19,3	32,6	33
A2B1	509,7															-	5,7	12,4	18,7	32	32,4
A3B3	504,0																-	6,7	13	26,3	26,7
A1B0	497,3																	-	6,3	19,6	20
A1B1	491,0																		-	13,3	13,7
A3B0	477,7																			-	0,4
A3B1	477,3																				
GDP5%= 59,8 GDP1%= 73,2 GDP0,1%= 105,4																					

1000 grain weight average for the period

One of the main components of productivity is the 1000 grains weight. The phenotypic diversity of this trait, combined with its ambiguous effect on total productivity makes it important for the study.

The 1000 grain weight is a trait that reflects the size and fullness of the grain.

The results of the study on the effect of foliar treatment products on the 1000 grain weight trait are presented in Table 41.

Proven higher values for the Enola cultivar (A_1) for the trait have been reported during treatment with Bombardier and the combination between the two products.

The other differences between the two controls were statistically insignificant.

The influence of the studied factors is similar in the Annapurna cultivar (A_2). The arrangement of the variants by manifestation of the trait is in favour of the applied single and combined effect of the studied treatment products.

In the Ginra cultivar (A_3), a proven greater 1000 grain weight has also been observed in treatment with Bombardier and the combination of Plantafol and Bombardier compared to the control B_0.

With regard to B_1, differences are statistically insignificant.

For the Bilyana cultivar it has been found that the differences in terms of the trait were statistically significant for the variants treated with the Bombardier product alone, as well as their combined effect Plantafol+Bombardier.

Table № 41

Provement on differences by varieties compared to the controls B_0 and B_1 according to the mass per 1000 grains average for the period

Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A1B3	44,33	5,00 ++	3,73 +	A2B4	46,00	3,33 +	3,00 +
A1B4	42,33	3,00 +	1,73 ns	A2B3	45,33	2,66 +	2,33 ns
A1B1	40,6	1,27 ns		A2B2	44,67	2,00 ns	1,67 ns
A1B2	40,00	0,67 ns	-0,60 ns	A2B1	43,00	0,33 ns	
A1B0	39,33		-1,27 ns	A2B0	42,67		-0,33 ns
GDP5%=3,00 GDP1%=4,29 GDP0,1%=6,35					GDP5%= 2,55 GDP1%=3,75 GDP0,1%=5,45		
Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A3B4	47,30	3,30 +	2,00 ns	A4B3	44,67	2,37 +	2,67 +
A3B3	47,30	3,30 +	2,00 ns	A4B4	44,30	2,00 +	2,30+
A3B2	45,60	1,60 ns	0,30 ns	A4B2	44,00	1,70 ns	2,00 ns
A3B1	45,30	1,30 ns		A4B0	42,30		0,30 ns
A3B0	44,00		-1,30 ns	A4B1	42,00	-0,30 ns	
GDP5%=3,15 GDP1%=4,24 GDP0,1%=5,63					GDP5%= 1,95 GDP1%=2,45 GDP0,1%=4,01		

Hectolitre weight average for the period

One of the important physical indicators for determining grain quality is the hectolitre weight.

The applied foliar fertilization products for the Enola cultivar (A_1) have had a proven positive effect in the independent effect of Bombardier (Table 47).

In the Anapurna cultivar (A_2), it has been found that the combined application of the products has had a significant effect on the manifestation of the hectolitre weight trait. The effect of the Plantafol product (B_2) has also been proven.

Higher values in the Ginra cultivar (A_3) have been reported in the single and combined application of foliar treatment products.

The effect of Plantafol on the control B_0 has been proven.

For the Bilyana cultivar (A_4) only the difference between the combined influence of the studied factors compared to the two controls has been proved at a significance level P 5%.

Table № 47

Provement on differences by varieties compared to the controls B_0 and B_1 according to the hectoliter mass average for the period

Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A1B3	79,67	2,00 +	2,67 ++	A2B4	80,33	4,16 +	5,53 ++
A1B2	79,00	1,33 ns	2,00 +	A2B2	79,67	3,50 +	4,87 ++
A1B0	77,67		0,67 ns	A2B3	77,33	1,16 ns	2,53 +
A1B1	77,00	-0,67 ns		A2B0	76,17		1,37 ns
A1B4	76,50	-1,17 ns	-0,50 ns	A2B1	74,8	-1,37 ns	
GDP5%=1,78 GDP1%=2,64 GDP0,1%=3,45				GDP5%= 2,14 GDP1%=4,56 GDP0,1%=6,85			
Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1	Variants	Ẋ	Provement of D compared to B_0	Provement of D compared to B_1
A3B2	80,67	3,17 +	1,96 ns	A4B4	78,00	2,17 +	2,17 +
A3B4	80,50	3,00 ns	1,80 ns	A4B3	77,00	1,17 ns	1,17 ns
A3B3	79,50	2,00 ns	0,80 ns	A4B2	77,00	1,17 ns	1,17 ns
A3B1	78,70	1,20 ns		A4B1	75,83	0,00 ns	
A3B0	77,50		-1,20 ns	A4B0	75,83		0,00 ns
GDP5%=3,07 GDP1%=4,15 GDP0,1%=5,85				GDP5%= 2,05 GDP1%=3,15 GDP0,1%=4,55			

4.1.3. Biochemical indicators of grain

For the purpose of the analysis, average grain samples of 500 grams from each variant have been taken and analyzed for nitrogen, protein, fat, gluten and nitrogen-free extracts content during all three years of study.

The analyses were performed in the Accredited Laboratory at the Agricultural University - Plovdiv. The methods used are as follows: total nitrogen BDS 13490:1976, protein calculated by formula N x 5.83 according to BDS 13490:1976; fats BDS 11374:1986, item 4.4, gluten BDS EN ISO 21415-1:2007; Nitrogen-free extracts by internal laboratory method.

All values are averages of four measurements and are presented in percentages.

Table 48 presents the results for the biochemical indicators of grain quality.

In the cultivar Enola there is an increase in the nitrogen, protein and gluten content compared to the control, in treatment with Plantafol, as well as in the combination Plantafol + Bombardier (Table 48).

In the columns of each indicator for a specific cultivar, the numbers followed by the same letters (a, b, c) are not statistically significant.

In the Anapurna cultivar, a positive effect on the content of the same indicators has been observed when treated with Bombardier alone and in combination with Plantafol.

In the Ginra cultivar, the application of Plantafol and Bombardier alone and in combination increases the nitrogen, protein and gluten content.

In the Bilyana cultivar, the application of Plantafol alone and in combination with Bombardier increases the nitrogen, protein and gluten content. The observed cultivar difference in the reaction to the products in terms of protein content is in line with studies by other authors (Abedi et al., 2010).

Nitrogen-free extracts are usually inversely related to protein content. In the described study, this trait has little effect (Table 48).

The fat content in the grain is highly variable and changes significantly under the effect of the products.

The highest values for fat content have been reported in the Ginra cultivar variant Plantafol+Bombardier (5.85%) and Plantafol alone (3.63%).

For the Anapurna cultivar the highest values (3.73%) were reported for Bombardier alone, and for the Enola cultivar, the combination of the two products gave the highest values about fat (2.23%).

The application of Plantafol and Bombardier preparations in wheat has a positive effect on the biochemical quality of the grain. This may be due to improved nutrition, since both products provide albeit different important nutrients.

On the one hand, Plantafol provides the necessary mineral elements such as nitrogen, phosphorus and potassium needed to build amino acids, proteins and lipids, and on the other hand, it provides various trace elements that are an essential part in biochemical reactions, regulate enzyme activity, regulate metabolic processes.

The other product - Bombardier, provides various amino acids that can be directly or after transformations involved in protein synthesis, fulvic acids, which maintain optimal nutritional status of plants, helps cell formation in vegetative growth, thanks to the presence of polysaccharides - 7.9% (such as starch or cellulose).

The use of foliar fertilization products is widespread, as it helps to overcome adverse conditions and improves the growth and development of crops, as well as the quality of the resulting products.

Various authors have presented data on increasing yields and quality in wheat as a result of the use of foliar products containing trace elements alone or in combination (Asad and Rafique, 2002; Zeidanet al., 2010; Khan et al., 2010; Gomaa et al., 2015, 2019; Rawashdeh and Sala, 2015).

Таблица № 48

Qualitative parameters for wheat treated by Plantafol and Bombandier. Total N, protein, fatty, gluten, Nitrogen-free extractives – NFE All values are in %.

	Variants	N %	Protein %	Fatty %	Gluten %	NFE %
Enola	B_0 Control – non fertile	2,18b	12,44b	1,87b	18,63c	75,79b
	B_1 Control-fertile	2,14b	12,2b	1,94b	22,5b	82,46a
	B_2 Plantafol	2,33a	13,26a	1,64c	26,88a	82,5a
	B_3 Bombandier	2,18b	12,41b	1,52c	19,3c	83,87a
	B_4 Plantafol + Bombandier	2,37a	13,51a	2,23a	26,67a	82,46a
Anapurna	B_0 Control – non fertile	1,91b	10,9b	2,27b	18,57c	84,23a
	B_1 Control-fertile	1,99a	11,33a	1,15c	21,25a	83,82a
	B_2 Plantafol	1,88b	10,73b	1,55c	20,24b	84,02a
	B_3 Bombandier	2,03a	11,59a	3,73a	20,55b	81,28b
	B_4 Plantafol + Bombandier	2,1a	12,01a	1,98b	22,1a	82,45b
Ginra	B_0 Control – non fertile	1,89b	10,79b	1,68c	18,54c	80,34c
	B_1 Control-fertile	1,87b	10,68b	1,09c	19,7b	85,93a
	B_2 Plantafol	1,98a	11,27a	3,63b	20,95a	81,2c
	B_3 Bombandier	1,9a	10,85a	1,26b	19,84b	86,7a
	B_4 Plantafol + Bombandier	2a	11,41a	5,85a	19,78b	84,93b

Bilyana	B_0 Control – non fertile	1,84a	10,48a	1,87b	18,22b	84,15b
	B_1 Control-fertile	1,77b	10,11b	3,6a	19,94a	83,99b
	B_2 Plantafol	1,87a	10,65a	1,99b	20,63a	84,96a
	B_3 Bombandier	1,82a	10,36b	1,71b	19,68a	84,63a
	B_4 Plantafol + Bombandier	1,86a	10,62a	1,62b	19,96a	85,06a

4.1.4. Physiological analyses of leaves (photosynthesis rate, transpiration intensity, intercellular CO_2 concentration)

During vegetation physiological analyses were performed - leaf gas exchange (photosynthesis rate, transpiration intensity, intercellular CO_2 concentration) with a portable gas analyzer LCpro+ (Anallytical Development Company Ltd., Hoddesdon, England).

Photosynthesis is only a prerequisite for obtaining high yields, while the quality of the obtained produce is strongly influenced by nutrition and the environment.

The main indicator about the condition of plants, which depends on environmental conditions and can be monitored non-destructively, is photosynthesis. This integrated process is essential for biomass accumulation and yield determination.

In the present study, the leaf gas exchange of the flag leaf of ten plants from each variant was measured over the three study years. The values in Table 49 are average for the period.

The results presented in Table 49 show an increase in photosynthesis in Enola and Anapurna cultivars treated with Plantafol and Bombardier, with the highest values compared to the control being obtained from a combination of the products for the Anapurna cultivar (131.4%).

In the Ginra cultivar the application of Plantafol only increased the photosynthetic activity (105.3%), while in the Bilyana cultivar the highest values compared to the control were obtained in the application of Bombardier only (132.4%), and in combination with Plantafol there is a positive effect on this indicator as well (120%).

Comparing the effect of the products used, varietal sensitivity has been noted, but in general the photosynthesis rate increases. This may be due both to the improved plant nutrition and the specific action of some of the components in the products. Increased photosynthetic activity will also contribute to the accumulation of more biomass, respectively will increase yields.

These results are in line with research by other authors working with wheat and foliar products (fertilizers or biostimulants) (Yang et al., 2013; Gomaa et al., 2020; Wang et al., 2020).

The role of transpiration is also important for plants. On the one hand, it is associated with mass flow, the uptake of nutrients by the roots, their transfer to the aboveground parts, but on the other hand, it is associated with water loss.

Table 49 shows an increase in transpiration in the Enola and Anapurna cultivars as a result of the products used, while in the Ginra cultivar a decrease in transpiration has been noted in the variants treated with Plantafol, Bombardier or combined, in the Bilyana cultivar the transpiration decreases only in the variants Bombardier and Plantafol+Bombardier.

In the columns of each indicator for a specific cultivar, the numbers followed by the same letters (a, b, c) are not statistically significant.

The data on intercellular CO_2 concentration show slight change under the effect of the products, and in most cases, there is a decrease in the values of this indicator in the variants in which higher intensity of photosynthesis had been noted (Table 49). Intercellular CO_2 concentration is an indicator related to the capacity of Rubisco (the main carboxylating enzyme in dark reactions) and it depends both on the environment and the concentration of gases in it, and on the overall condition of plants.

At reduced transpiration rate, when the stomata are is closed, the values of this indicator can be lower due to the Rubisco effect and/or the reduced gas exchange with the environment.

Conversely, with elevated ci values a decrease in Rubisco regeneration capacity is assumed, or a decrease in electronic transport rate, which is ultimately associated with inhibition of dark photosynthesis reactions (Ehleringer and Cerling, 1995; Flexas et al. 2016 Paunov et al., 2018).

Plantafol and Bombardier products used for foliar treatment of wheat improve physiological processes (in particular photosynthesis) and grain quality in four wheat cultivars Enola, Anapurna, Ginra and Bilyana. There are also cultivar differences in the studied indicators as a result of the product action.

Таблица № 49

Leaf gas exchange in treated wheat treated by Plantafol and Bombandier. Speed of photosynthesis – A (□mol CO_2 m^{-2} s^{-1}, intensity of transpiration - E (mmol H_2O m^{-2} s^{-1}), intercellular concentration to CO_2 - ci (vpm)

Variety	Variants	A	E	ci
Enola	B_0 Control – non fertile	8,46b	0,43b	739,55a
	B_1 Control-fertile	8,43b	0,43b	739,68a
	B_2 Plantafol	8,50a	0,89a	645,18b
	B_3 Bombandier	8,51a	0,92a	634,49b
	B_4 Plantafol + Bombandier	8,52a	0,96a	629,83b
Anapurna	B_0 Control – non fertile	7,01c	0,94c	614,43a
	B_1 Control-fertile	8,45b	1,01c	609,78b
	B_2 Plantafol	9,02b	1,25bc	604,89b
	B_3 Bombandier	9,18a	1,32b	605,26b
	B_4 Plantafol + Bombandier	9,21a	1,41a	602,00b
Ginra	B_0 Control – non fertile	8,62b	1,31a	600,58b
	B_1 Control-fertile	8,95a	1,45a	614,18a
	B_2 Plantafol	9,08a	0,68c	619,70a
	B_3 Bombandier	8,49b	1,12b	611,72a
	B_4 Plantafol + Bombandier	8,22c	1,22b	602,95b
B il y a n a	B_0 Control – non fertile	6,35c	1,15b	557,58c

	B_1 Control-fertile	7,14c	1,21a	581,33c
	B_2 Plantafol	7,38b	1,22a	546,26c
	B_3 Bombandier	8,41a	0,80c	708,50a
	B_4 Plantafol + Bombandier	7,62b	0,94b	645,47b

V. CONCLUSIONS

Based on the experimental work and the results obtained on the role and importance of foliar treatment products Plantafol and Bombardier on grain yield and quality in common wheat cultivars Enola (A_1), Anapurna (A_2), Ginra (A_3) and Bilyana (A_4) , the following conclusions can be drawn:

1. With regard to phenological development, the studied common wheat cultivar do not differ significantly in length of the vegetation season. The reason for this is that all four cultivars are medium early in regard to ripening and under the same climatic conditions ripen almost at the same time. The interphase stem elongation-heading period is the longest for the Anapurna cultivar (30 days), followed by the Ginra and Bilyana cultivars (29 days) and Enola cultivar (27 days).

2. Ginra cultivar has the highest tillering production with 441 tillers/m^2, followed by the cultivars Enola 434 tillers/m^2, Anapurna 431 tillers/m^2 and Bilyana with 419 tillers/m^2. The applied foliar fertilizing products have a positive effect, both individually and in combination on the structural elements of yield.

3. The better development of the studied common wheat cultivars treated with the tested foliar treatment products (alone and in combination) compared to the accepted controls B_0 and B_1 is proven by statistically significant differences in terms of structural elements of yield: spike length, spikelet number per spike, grain number per spike, grain weight per spike, which determine the economic productivity of the cultivar.

4. Proven differences have been found between grain yields in the studied common wheat cultivars, reported on average over the study period in the variants treated alone and in combination compared to controls B_0 and B_1.

5. In the complex assessment of the impact of the cultivar and foliar fertilizing factors, it has been established that the cultivar best influenced by the applied foliar treatment products is Anapurna cultivar (A_2). For the other cultivars, the variants to which Bombardier product (B_3) was applied alone and in combination (B_4) also showed a proven higher yield. Significantly lower yields, regardless of the foliar products used, were reported for common wheat cultivar Ginra (A_3).

6. The highest 1000 grain weight in all four studied common wheat cultivars has been reported in the combined application of the foliar products Plantafol and Bombardier (B_4). Second and third in the hierarchy are the variants treated with Bombardier (B_3) and Plantafol (B_2).

7. In Enola cultivar (A_1), the positive effect of the independent action of Bombardier on the hectoliter weight has been demonstrated. In the Anapurna cultivar (A_2) it has been found that the combined application of the products has had a significant effect on the manifestation of the hectolitre weight trait. Higher values of hectolitre weight in the Ginra cultivar (A_3) have been reported in the single and combined application of foliar treatment products. For Bilyana cultivar (A_4) only the difference between the combined effect of the studied factors compared to the two controls has been proven at a significance level P 5%.

8. Photosynthesis rate increased in the common wheat cultivars Enola and Anapurna, with the highest values compared to the control are obtained in the combination of Plantafol and Bombardier products in the Anapurna cultivar (31.4%). In Ginra cultivar the application of Plantafol alone increased photosynthetic activity (5.3%), while in Bilyana cultivar the highest values compared to the control were obtained with application of Bombardier alone (32.4%), as well as in combination with Plantafol (20 %).

9. Transpiration has been found to increase in the Enola and Anapurna cultivars as a result of the tested preparations, while in the Ginra cultivar a decrease in transpiration has been observed in the variants treated with Plantafol, Bombardier or combined. In Bilyana cultivar transpiration is reduced only in the variants Bombardier and Plantafol+Bombardier.

10. In Enola cultivar, an increase in the nitrogen, proteins and gluten content has been noted compared to the control, in treatment with Plantafol, as well as in combination Plantafol+Bombandier. In Anapurna cultivar, a positive effect on the content of the same indicators has been noted in treatment with Bombardier alone and in combination with Plantafol. In Ginra cultivar, the application of Plantafol and Bombardier alone and in combination also leads to an increase in the nitrogen, protein and gluten content. In Bilyana cultivar, the application of Plantafol alone and in combination with Bombardier also results in an increase in the nitrogen, protein and gluten content.

VI. CONTRIBUTIONS

Scientific and theoretical contributions:

1. The effect of foliar treatment products Plantafol and Bombardier on the growth and development of the common wheat cultivars Enola, Anapurna, Ginra and Bilyana has been established.
2. The effect of the studied foliar treatment products Plantafol and Bombardier on the structural elements of yield of common wheat cultivars Enola, Anapurna, Ginra and Bilyana has been established.
3. The effect of the studied foliar treatment products Plantafol and Bombardier on the productivity of common wheat cultivars Enola, Anapurna, Ginra and Bilyana has been established.
4. Changes in the quality indicators of grain (physical and chemical) of common wheat cultivars Enola, Anapurna, Ginra and Bilyana under the effect of the studied foliar treatment products Plantafol and Bombardier have been established.

Scientific and applied contributions:

1. The effect of foliar treatment products Plantafol and Bombardier in the studied doses in common wheat cultivars: Enola, Anapurna, Ginra and Bilyana has been established.
2. The productivity of common wheat cultivars: Enola, Anapurna, Ginra and Bilyana under the independent and combined application of the studied foliar treatment products Plantafol and Bombardier has been established.
3. The positive effect of foliar treatment products Plantafol and Bombardier has been proven, both in independent and combined treatment on the studied indicators, the values of which are higher compared to untreated controls.
4. The optimal combinations between the studied common wheat cultivar and the applied foliar treatment products Plantafol and Bombardier depending on its biological characteristics and meteorological conditions during the vegetation period have been determined.
5. Under this cultivation mode, wheat cannot realize its genetic potential for production of more gluten, which changes the direction of production.

6. The results of the conducted study make it possible to apply the foliar treatment products Plantafol and Bombardier in the technology for growing the tested common wheat cultivars: Enola, Anapurna, Ginra and Bilyana.

Publications by Radko Petrov Hristov related to the dissertation paper

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2. Hristov, R. 2019. Effect of foliar treatment products on the yield of common wheat Bilyana cultivar. /Христов, Р. 2019. Влияние на продукти за листно третиране върху добива на обикновена пшеница сорт Биляна./ Journal of Mountain Agriculture on the Balkans, 22 (1). 170-178.

3. Hristov, R. 2019. Changes in the grain quality of common wheat Ginra cultivar under the effect of foliar treatment products. /Христов, Р. 2019. Промени в качеството на зърното при обикновена пшеница сорт Гинра под влияние на продукти за листно третиране./ Journal of Mountain Agriculture on the Balkans, 22 (2). 102-110.

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