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INFLUENCE OF SOWING PERIOD AND TREATMENT WITH VARIOUS FOLIAR FERTILIZERS ON THE PRODUCTIVITY OF RAPESEED

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Abstract

The experiment is conducted in the Experimental Base of the Department of Plant Growing at Agricultural University of Plovdiv in the period 2012-2015. The experiment is set in block mode, in 4 repetitions, with cultivated plot size of 20 m^2, with winter rapeseed – the Visby hybrid. The aim of the experiment is to establish rapeseed yield treated with the following leaf fertilizers: Lactofol B - 4000 ml/ha, Litovit® - 2000 g/ha, and Fertiactyl Starter - 3000 ml/ha, and one untreated control. Rapeseed is sown during the following sowing dates - 1-10.IX, 1-10.X, 10-20.X, 20-30.X. The leaf fertilization is carried out in the 2-4 leaf stages for the first two sowing periods and in 1-2 leaf stages for the second two sowing periods. The studied leaf fertilizers have positively influenced the yield of rapeseed. The highest grain yield was recorded in 2014, and the lowest in 2013. Both during the three-years period and averagely for the study period, the highest grain yield for the different sowing periods was obtained from variants treated with Fertiactyl Starter - 3000 ml/ha.

Key words*: rapeseed, sowing period, leaf fertilization, yield.*

INTRODUCTION

The problem of shortage of moisture during sowing – germination period of rapeseed in Bulgaria in recent years has been steadily increasing. The small amount of precipitation in this period leads to the later germination of the crop and its inability to enter the optimum phase necessary for wintering. One way to stimulate plant growth and overcome unfavourable weather conditions is to use leaf fertilizers. The direct treatment of the leaves leads to a faster and more efficient supply of the plants with the necessary nutrients and minerals.

Experiments with leaf fertilizers have been carried out in many countries around the world and in our country on various agricultural crops (Sekar S. et al., 2010; Soare M. et al., 2010; Stoyanova A. et al., 2010; Toader C., 2010; Sanmueang A. et al., 2011), however those concerning rapeseed are scarce.

That is why we set ourselves the objective to find out the effect of some foliar fertilizers on the productivity of the oil producing rapeseed.

MATERIALS AND METHODS

The experiment was carried out within the period of the years 2012-2015, on the land of the Training, experimental and implementation base of the Department of Plant growing of the Agricultural University of Plovdiv. The experiment was carried out according to the block method, with 4 reiterations, with the experimental plot having the size of 20 m^2, using Visby hybrid that originates from Germany.

Experimental variants:

Factor A - Sowing dates

Factor B - Foliar fertilizers

Factor C - Development phases

I. Date of sowing 1-10.IX

- Untreated variant
- Spraying with Lactofol B - 4000 ml/ha - phenophase - 2-4th leaf
- Spraying with Litovit® - 2000 g/ha - phenophase - 2-4th leaf
- Spraying with Fertiactyl Starter - 3000 ml/ha - 2-4th leaf

II. Date of sowing 1-10.X

- Untreated variant
- Spraying with Lactofol B - 4000 ml/ha - phenophase - 2-4th leaf
- Spraying with Litovit® - 2000 g/ha - phenophase - 2-4th leaf
- Spraying with Fertiactyl Starter - 3000 ml/ha - 2-4th leaf.

III. Date of sowing 10 – 20.X

- Untreated variant

- Spraying with Lactofol B - 4000 ml/ha - phenophase - 2-4th leaf
- Spraying with Litovit® - 2000 g/ha - phenophase - 2-4th leaf
- Spraying with Fertiactyl Starter - 3000 ml/ha - 2-4th leaf.

IV. Date of sowing 20-30. X

- Untreated variant
- Spraying with Lactofol B - 4000 ml/ha - phenophase - 2-4th leaf
- Spraying with Litovit® - 2000 g/ha - phenophase - 2-4th leaf
- Spraying with Fertiactyl Starter - 3000 ml/ha - 2-4th leaf.

Rapeseed is planted after wheat being the precursor. After its harvesting, the land was ploughed at a depth of 18-20 cm, and then cultivated twice by cross-disking and rolling before sowing. With the main soil cultivation 100 kg/ha phosphorus and 80 kg/ha potassium were inserted. From a total of 170 kg/ha nitrogen - 30 kg/ha have been imported in the autumn in the course of pre-sowing treatment, and the rest of the quantity - as early as early spring.

Sowing was carried out by means of a seed drill, at a 12-15 cm distance between the rows, with a sowing rate of 6 kg/ha, which delivers a density of 60 plants/m^2. The depth of sowing is 2-3 cm. After sowing, the land is rolled.

In the course of the experiment the productive capacity of rapeseed is observed and studied, the one resulting from different sowing dates and treated with different foliar fertilizers.

The main meteorological factors that have influenced crop productivity over the years are air temperature and quantity of rainfall during the periods that are of critical importance for the development of rapeseed. (Figures 1, 2, 3).

The study of these factors shows specifics with regard to the average monthly temperatures and especially with respect to moisture (quantity and distribution of rainfall during vegetation), which is one of the risk factors for obtaining high yields of rapeseed.

Significant deviations from the values of the average day and night temperature during the three years of the experiment carried out on the lands of the Training, experimental and implementation base versus the multi-year period were not observed.

More unevenly distributed during vegetation, however the highest quantity of rain in the course of the three experimental years was reported in 2014-2015 (856.4 mm).

Less, but better distributed are rainfalls reported in 2013-2014 (574.7 mm), while in the period 2012-2013 (541.0 mm) the reported rainfall is the least.

The coldest months during the winter period are December and January, with minimum temperatures being recorded in January 2014-2015 (-14.2°C), December 2012-2013 and 2013-2014 (-9.8°C; -10.4°C) (Figure 2).

RESULTS AND DISCUSSIONS

The indicators related to seed yield are given in Tables 1, 2 and 3. The data shows that, depending on the sowing dates, weather conditions, and foliar fertilization, these indicators change during the years of the experiment.

All structural elements with the exception of fruit length and pods weight of a plant have the highest values in 2012-2013, and the lowest in 2014-2015.

During the three years of sowing, all structural elements, averagely in the course of the experimental period, have higher values in the variants sown in the period 20-30.X and 1-10. IX, followed by those sown from 1 to 10.X and from 10 to 20.X.

Plant height from all sowing dates, and averagely for the studied period had the highest values for the plants treated with Fertiactyl Starter (from 159.9 to 166.5 cm), followed by Lactofol B treated (from 159.1 to 164.4 cm), Litovit® (from 158.7 to 163.7 cm), while and the lowest height is registered for the control plants (from 158.0 to 163.5 cm).

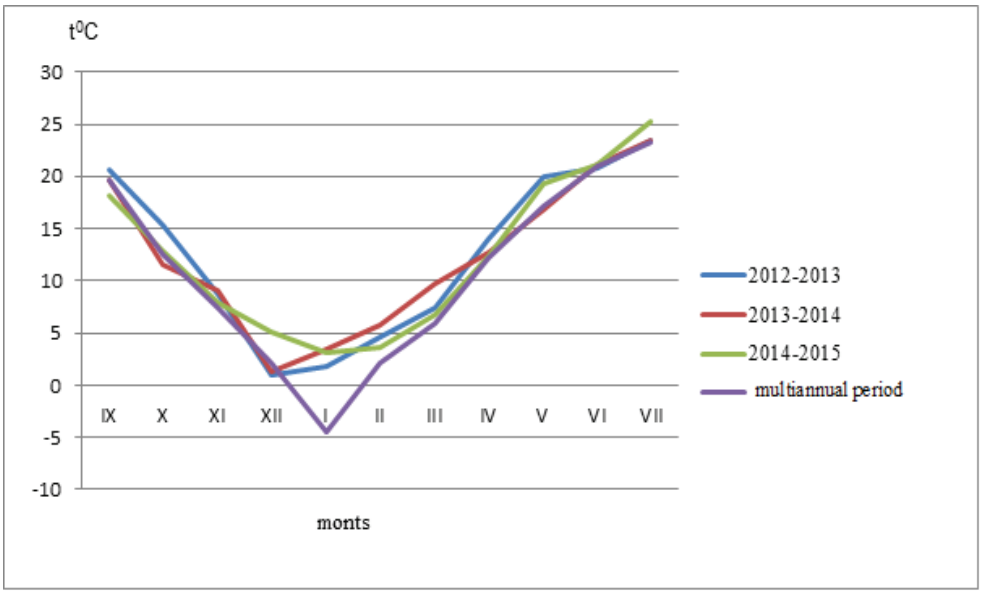

Figure 1. Average monthly temperatures in the region of the Training, experimental and implementation base

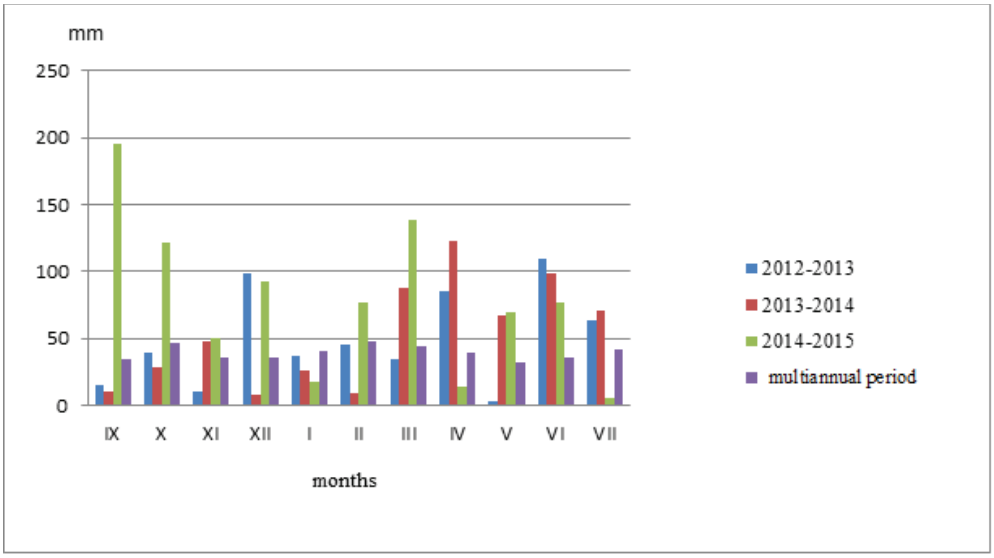

Figure 2. Quantity of rainfall during the years of survey in the region of the Training, experimental and implementation base

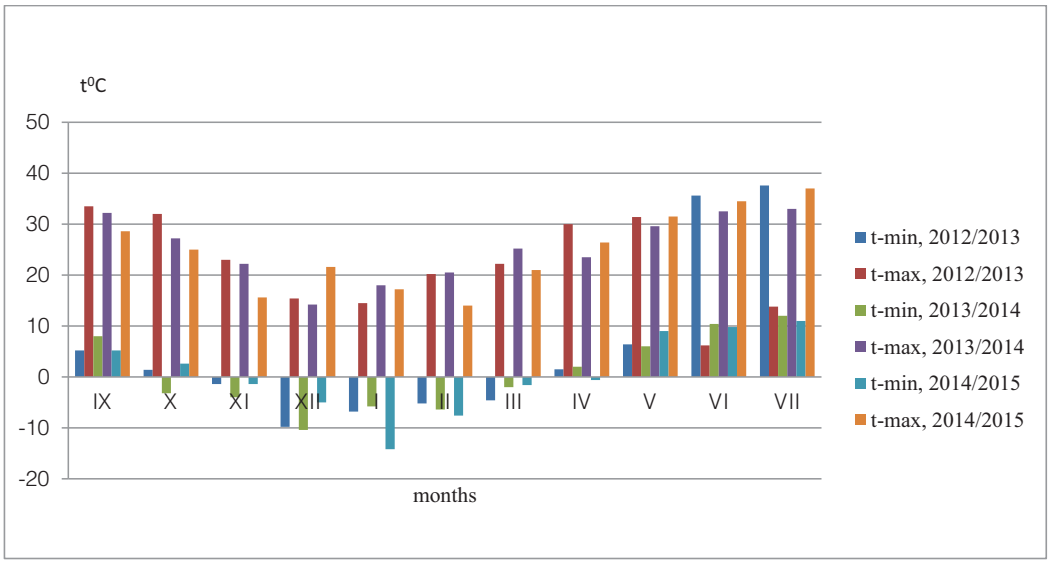

Figure 3. Absolute minimum and maximum temperatures by months 2012/2015

Averagely for the experimental period, Fertiactyl treated variants again have the highest values with regards to the number of branches (from 7.9 to 9.5 pieces), followed by the variants treated with Lactofol B (from 7.9 to 9.3 pieces), Litovit® (from 7.8 to 9.2 pieces), and finally the control group of plants (from 7.8 to 9.2 pieces).

In terms of the number of fruits of a plant, higher values during the three years and averagely for the study period were reported for the leaf fertilizer treated variants versus the control group.

Of the foliar fertilized variants, averagely for the experimental period, the number of fruits was greatest (from 203.7 to 218.0) in Fertiactyl Starter treated plants, followed by those treated with Lactofol B (202.2 to 215.6) and Litovit® (from 200.7 to 213.7 pieces). The smallest number of fruits was reported in the control variants (from 199.8 to 212.4 pieces).

The length of the fruits from the different sowing dates and between the control
and leaf treated variants varies within a small range.

With regards to the number of seeds in a single fruit, the highest number of seeds averagely for the period was reported for Fertiactyl Starter treated variants (27.0 to 28.2 pieces).

The number of seeds averagely for the experimental period for the remaining variants ranged from 26.8 to 27.7 for Lactofol B, 26.6 to 27.5 for Litovit® and from 26.6 to 27.3 for the control plants.

The main structural elements that have the greatest impact on seed yield are the weight of the fruits and seeds of a single plant.

Highest values of these structural elements in leaf-fertilized variants were reported for Fertiactyl Starter, while the lowest - for Litovit®.

On average during the experimental period, the values of these indicators in leaf-fertilized variants ranged from 25.1 to 26.2 g for Fertiactyl Starter treated plants, followed by Lactofol B treated plants (from 24.8 to 25.7 g), Litovit® (from 24.7 to 25.6 g), and the lowest in the control plants (24.6 to 25.5 g) in terms of fruit weight, and within 14.1 to 15.0 g for Fertiactyl Starter treated plants, followed by Lactofol B treated variants (13.9 to 14.8 g), Litovit® (from 13.8 to 14.7 g), and the lowest for the control plants (from 13.7 to 14.6 g) in terms of the weight of the seeds of a plant.

Both at all sowing dates, and for all variants, the values of these two indices are the lowest in the control.

Table 1. Plant height and structural elements of the seed yield

	Plant height (cm)				Number of branches in a single plant (pcs)				Number of fruits in a single plant (pcs)			
	1-10.IX											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	165.4	163.1	162,0	163.5	9.6	9.0	8,9	9.2	218.3	211.6	207,3	212.4
Fertiactyl Starter	167.3	165.1	163,5	165.3	9.8	9.3	9,1	9.4	225.7	217.2	212,0	218.3
Litovit®	165.7	163.3	162,1	163.7	9.6	9.1	9,0	9.2	219.5	213.0	208.5	213.7
Lactofol B	166.3	164.2	162,8	164.4	9.7	9.2	9,1	9.3	221.4	215.2	210.2	215.6
	1-10.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	162.2	161.1	160.3	161.2	8.4	8.3	8.2	8.3	210.7	205.9	203.0	206.5
Fertiactyl Starter	164.4	163.2	161.7	163.1	8.7	8.6	8.4	8.6	216.8	211.9	207.3	212.0
Litovit®	162.8	161.5	160.6	161.6	8.5	8.4	8.3	8.4	212.4	207.4	204.1	208.0
Lactofol B	163.7	162.3	161.1	162.4	8.6	8.5	8.3	8.5	214.3	209.3	206.5	210.0
	10-20.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	160.1	157.2	156.8	158.0	8.0	7.8	7.7	7.8	203.7	198.7	197.1	199.8
Fertiactyl Starter	162.2	159.4	158.1	159.9	8.1	7.9	7.8	7.9	207.5	203.2	200.5	203.7
Litovit®	160.9	157.9	157.2	158.7	8.0	7.8	7.7	7.8	204.7	199.6	197.7	200.7
Lactofol B	161.9	158.3	157.2	159.1	8.0	7.8	7.8	7.9	206.5	201.1	199.0	202.2
	20-30.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	-	163.3	162.2	-	-	9.1	9.0	-	-	213.5	209.9	-
Fertiactyl Starter	168.5	166.2	164.7	166.5	9.7	9.5	9.4	9.5	221.3	218.4	214.3	218.0
Litovit®	-	164.1	163.0	-	-	9.3	9.3	-	-	215.9	212.1	-
Lactofol B	-	165.5	164.2	-	-	9.4	9.3	-	-	217.1	213.2	-

Table 2. Structural elements of the seed yield

	Fruit length (cm)				Number of seeds in one fruit (pcs)				Weight of the fruit in a single plant (g)			
	1-10.IX											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	7.7	7.6	7.6	7.6	27.6	27.2	27.0	27.3	26.0	25.6	24.8	25.5
Fertiactyl Starter	7.8	7.8	7.7	7.8	28.3	28.0	27.8	28.0	26.5	26.1	25.2	25.9
Litovit®	7.7	7.7	7.8	7.7	27.8	27.4	27.3	27.5	26.1	25.7	24.9	25.6
Lactofol B	7.8	7.7	7.7	7.7	28.1	27.6	27.4	27.7	26.3	25.8	25.0	25.7
	1-10.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	7.6	7.5	7.5	7.5	27.0	26.9	26.8	26.9	25.0	24.9	24.7	24.9
Fertiactyl Starter	7.7	7.6	7.6	7.6	27.8	27.5	27.3	27.5	26.0	25.7	25.4	25.7
Litovit®	7.6	7.6	7.6	7.6	27.1	27.0	26.9	27.0	25.2	25.1	24.9	25.1
Lactofol B	7.6	7.6	7.5	7.6	27.3	27.1	27.0	27,1	25.7	25.4	25.2	25.4
	10-20.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	7.6	7.5	7.5	7.5	26.8	26.5	26.4	26.6	24.8	24.5	24.4	24.6
Fertiactyl Starter	7.7	7.7	7.6	7.7	27.3	27.0	26.7	27.0	25.3	25.1	24.9	25.1
Litovit®	7.6	7.6	7.5	7.6	26.9	26.6	26.4	26.6	24.9	24.6	24.5	24.7
Lactofol B	7.7	7.6	7.5	7.6	27.0	26.8	26.6	26.8	25.1	24.8	24.6	24.8
	20-30.X											
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	-	7.6	7.5	-	-	27.4	27.2	-	-	25.7	25.1	-
Fertiactyl Starter	7.8	7.7	7.6	7.7	28.4	28.2	27.9	28.2	26.6	26.4	25.5	26.2
Litovit®	-	7.6	7.6	-	-	27.6	27.5	-	-	25.8	25.2	-
Lactofol B	-	7.7	7.6	-	-	27.8	27.6	-	-	26.0	25.3	-

Table 3. Structural elements of the seed yield

	Weight of the seeds in a single plant (g)				Weight of pods in a single plant (g)			
	1-10.IX							
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	15.0	14.6	14.1	14.6	11.0	11.0	10.7	10.9
Fertiactyl Starter	15.3	15.0	14.4	14.9	11.2	11.1	10.8	11.0
Litovit®	15.1	14.7	14.2	14.7	11.0	11.0	10.7	10.9
Lactofol B	15.2	14.8	14.3	14.8	11.1	11.0	10.7	10.9
	1-10.X							
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	14.0	14.0	13.9	14.0	11.0	10.9	10.8	10.9
Fertiactyl Starter	14.9	14.6	14.4	14.6	11.1	11.1	11.0	11.1
Litovit®	14.2	14.1	14.0	14.1	11.0	11.0	10.9	11.0
Lactofol B	14.7	14.4	14.2	14.4	11.0	11.0	11.0	11.0
	10-20.X							
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	13.9	13.7	13.6	13.7	10.9	10.8	10.8	10.8
Fertiactyl Starter	14.2	14.1	14.0	14.1	11.1	11.0	10.9	11.0
Litovit®	14.0	13.8	13.7	13.8	10.9	10.8	10.8	10.8
Lactofol B	14.1	13.9	13.8	13.9	11.0	10.9	10.8	10.9
	20-30.X							
	2012/ 2013	2013/ 2014	2014/ 2015	Average	2012/ 2013	2013/ 2014	2014/ 2015	Average
Control	-	14.6	14.2	-	-	11.1	10.9	-
Fertiactyl Starter	15.3	15.1	14.5	15.0	11.3	11.3	11.0	11.2
Litovit®	-	14.7	14.3	-	-	11.1	10.9	-
Lactofol B	-	14.9	14.4	-	-	11.1	10.9	-

The weight of the pods for the different variants and dates of sowing do not differ significantly.
Averagely for the experimental period, the highest values for pod weight were reported in the Fertiactyl Starter treated variant (from 11.0 to 11.2 g).
All structural elements at different sowing dates and experimental variants have the highest values in the case of treatment with Fertiactyl Starter foliar fertilizer, while the lowest - for the control variant.

Seed yield

Data on the seed yield from the experimental variants and sowing dates are presented in Table 4.
The results obtained show that, depending on the year, the meteorological conditions, the sowing date and the treatment with foliar fertilizers, the seed yield varies.
The more favourable combination and distribution of meteorological factors in 2013-2014 create a prerequisite for obtaining higher yields during the years and cultivation variants followed by the yields of 2014-2015. The lowest yield was obtained in 2012-2013.
In the second or third year of the experiment, the highest seed yields were obtained during the first sowing date, whereas in the following dates yields gradually decreased.
The optimal combination of moisture and temperature at the second and third sowing dates in 2012-2013 (from 1 to 10.X and 10 to 20.X) are a prerequisite for obtaining higher yields in all cultivation variants compared to the first sowing date.
Lower temperatures during the sowing period from 20 to 30.X create a prerequisite for the inability of the plants to reach the phase that is optimal for wintering during the three experimental years.
Therefore the yields of seeds are the lowest at this sowing date, and in 2013, yields are only reported for the variants treated with Fertiactyl Starter.
Averagely for the experimental period, the highest seed yield was obtained by Fertiactyl Starter treated variants at all sowing dates (1 to 10.IX - 3.774 t/ha; 1 to 10.X - 3.946 t/ha; 10 to 20.X - 3.703 t/ha; 20 to 30.X - 0.981 t/ha), followed by Lactofol B (from 1 to 10.IX - 3.713 t/ha; from 1 to 10.X - 3.823 t/ha , from 10 to 20.X - 3.604 t/ha), Litovit® (from 1 to 10.IX - 3.617 t/ha; from 1 to 10.X -3.706 t/ha; from 10 to 20.X - 3.496 t/ha), and the control (from 1 to 10.IX - 3.527 t/ha; from 1 to 10.X - 3.598 t/ha; from 10 to 20.X - 3.335 t/ha).
Foliar fertilizer treatment compared to the control plants is of greatest importance for sowing period from 10 to 20.X, followed by sowing period 1-10.X and 1-10.IX.
Fertiactyl Starter-treated variants have the highest percentage increase in yield compared to the control plants (from 7.0 to 11.0%), followed by Lactofol B treated plants (from 5.3 to 8.1%) and Litovit® treated plants (from 2.4 to 4.8%).
On the basis of the mathematical processing, during the three experimental years, at all sowing dates, statistical proof in terms of seed yield data, at LSD 5%, was established between the leaf-fertilized variants and the control.

CONCLUSIONS

Foliar fertilization has a beneficial effect on structural elements and seed yield for all variants and dates of sowing.
Compared to the control plants, the structural elements producing the seed yield have higher values for the leaf-fertilizer treated variants.
The highest values of all structural elements forming the seed yield were reported in the variant treated with Fertiactyl Starter.
For leaf-treated variants, seed yield is from 2.4 to 11.0% higher than the control.
Averagely during the experimental years, the highest seed yield was obtained from Fertiactyl Starter treated variant (0.981-3.946 t/ha), which exceeds the control with 7.0 to 11%.

Table 4. Seed yield t/ha

Variants / Sowing dates	Seed yield t/ha				
			1-10.IX		
	2012/ 2013	2013/ 2014	2014/ 2015	Average	%
Control	3.058[a]	3.908[a]	3.614[a]	3.527	100.0
Fertiactyl Starter	3.236[c]	4.148[c]	3.939[d]	3.774	107.0
Litovit®	3.132[b]	4.007[b]	3.712[b]	3.617	102.4
Lactofol B	3.202 [bc]	4.102[bc]	3.836[c]	3.713	105.3
LSD 5%	0.0701	0.0988	0.0890	-	-
			1-10.X		
	2012/ 2013	2013/ 2014	2014/ 2015	Average	%
Control	3.553[a]	3.662[a]	3.579[a]	3.598	100.0
Fertiactyl Starter	3.903[d]	4.023[d]	3.911[d]	3.946	109.7
Litovit®	3.659[b]	3.784[b]	3.674[b]	3.706	103.0
Lactofol B	3.784[c]	3.902[c]	3.799[c]	3.828	106.4
LSD 5%	0.079	0.080	0.079	-	-
			10-20.X		
	2012/ 2013	2013/ 2014	2014/ 2015	Average	%
Control	3.285[a]	3.383[a]	3.337[a]	3.335	100.0
Fertiactyl Starter	3.647[d]	3.752[d]	3.709[d]	3.703	111.0
Litovit®	3.437[b]	3.546[b]	3.505[b]	3.496	104.8
Lactofol B	3.544[c]	3.655[c]	3.613[c]	3.604	108.1
LSD 5%	0.073	0.075	0.074	-	-
			20-30.X		
	2012/ 2013	2013/ 2014	2014/ 2015	Average	%
Control	-	1.000[a]	0.754[a]	-	-
Fertiactyl Starter	0.889	1.154 [d]	0.901[d]	0.981	-
Litovit®	-	1.047[b]	0.817[b]	-	-
Lactofol B	-	1.101[c]	0.863[c]	-	-
LSD 5%	-	0.030	0.028	-	

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