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INFLUENCE OF FOLIAR FERTILIZATION ON THE PHENOLOGICAL DEVELOPMENT OF RAPESEED

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Abstract

The experiment is conducted in 2012-2015 in the Training and Experimental Base of the Department of Plant Growing at Agricultural University of Plovdiv. The experiment is set in block mode with four repetitions, with size of the cultivated plot of 20 m^2, with winter rapeseed type - the Visby hybrid. The following leaf fertilizers were tested: Lactofol B - 4000 ml/ha, Litovit® - 2000 g/ha and Fertiactyl Starter - 3000 ml/ha, and untreated control variant. The rapeseed sowing was done 1-10. IX, 1-10. X, 10-20. X, 20-30. X. The leaf fertilization was performed in the 2-4 leaf stages for the first two sowing periods and in 1-2 leaf stages for the second two sowing periods. As a result of the experiment, leaf fertilization has been found to affect the development of the phenophases. The strongest stimulation effect during the three years of the experiment at the different sowing periods is obtained in the variant treated with Fertiactyl Starter - 3000 ml/ha.

Key words*: rapeseed, leaf fertilization, development phases.*

INTRODUCTION

Foliar fertilization is not opposed to soil one but is considered a necessary additional activity in the overall system of optimal mineral nutrition of plants.

While nutrient elements in the soil may have synergistic and antagonistic relationships between them, an important advantage of leaf fertilization is that the problem of elemental antagonism is eliminated. Another advantage of their use is the conservation of the natural ecological parameters of the environment.

The small amount of rainfall during the preparation of the soil and the sowing of rapeseed leads to its later germination and the inability of the plants to enter the optimum phase for wintering. By using foliar fertilizers at different stages of rapeseed development, we can accelerate its development to reach a phase more suitable for wintering.

There are lots of such studies for other agricultural crops, both in the world and in Bulgaria (Coelho H. et al., 2011; Delchev G., 2010; Sanmueang A. et al., 2011; Kolev T. et al., 2012; Kolev T. et al., 2013), but for rapeseed they are insufficient or completely absent.

It is precisely for this purpose that we study the influence of some foliar fertilizers and application phases on the development and productivity of oilseed rape.

In this article we look at one part of the experiment, i.e. the influence of certain foliar fertilizers and application phases on the phenological development of rapeseed.

MATERIALS AND METHODS

The study was conducted in the period 2012-2015 in the area of Training, experimental and implementation base of the Department of Plant Growing at Agricultural University - Plovdiv.

The experiment is based on the block method, repeated 4 times, with a trial plot of 20 m^2, with a Visby hybrid originating in Germany.

Experiment 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 - 2-4 leaf.

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

II. Date of sowing 1-10.X

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

III. Date of sowing 10-20.X

- Untreated variant
- Spraying with Lactofol B - 4000 ml/ha - phenophase-1-2 leaf.
- Spraying with Lithovit® - 2000 g/ha - phenophase-1-2 leaf.
- Spraying with Fertiactyl Starter - 3000 ml/ha-1-2 leaf.

IV. Date of sowing 20-30.X

- Untreated variant
- Spraying with Lactofol B - 4000 ml/ha - phenophase-1-2 leaf.
- Spraying with Lithovit® - 2000 g/ha - phenophase-1-2 leaf.
- Spraying with Fertiactyl Starter -3000 ml/ha-1-2 leaf.

The experiment was carried out after a precursor of wheat. Immediately after its harvesting, ploughing was carried out at a depth of 18-20 cm, followed by a two-fold cross-disking and pre-sowing rolling. 100 kg/ha Phosphorus, 80 kg/ha Potassium are inserted into the soil with the main processing of the soil, as well as 170 kg/ha Nitrogen, of which 30 kg/ha in autumn with the pre-sowing cultivation, and the remainder at the earliest opportunity in spring.

Sowing is at 12-15 cm distance between rows and at a sowing rate of 6 kg/ha, providing a density of 60 plants/m^2. Seeds are sown at a depth of 2-3 cm with a seed drill. After sowing, the land is rolled. The phenological development of rapeseed has been monitored in the sown variants.

Regarding the agro-climatic characteristics during the experiment period, the meteorological factors (air temperature and rainfall), their combination and distribution through vegetation, which determine the growth and development of the crop during the years of cultivation, have a major influence.

The data characterizing these factors over the three experimental years in the study area are shown in Figure 1. It can be seen that during the three years of the study, significant deviations from the average monthly temperatures in the experiment area compared to the multiannual period are not observed.

Greater differences are seen in terms of moisture. Over the three years of the experiment, the highest amount of rainfall in the cultivated area during September - July period was reported in 2014-2015 (856.4 mm). They exceed with 422.9 mm those of the multiannual period (433.5 mm).

All three years of study are characterized by sufficient amount of moisture in the critical phases of the development of the crop, with the exception of the sowing-germination period during the first two years.

The absolute minimum temperature during the three years of the study was reported in December -9.8°C in 2012-2013, -10.4°C in 2013-2014, while in 2014-2015 - in January -14.2°C (Figure 2).

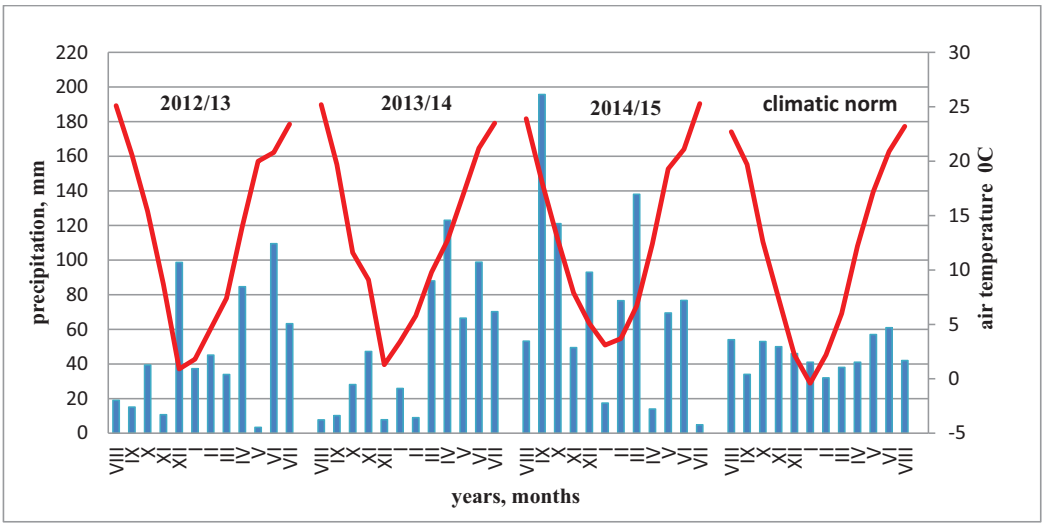

Figure 1. Average monthly temperatures and sum of precipitation during the years of study in the area of the Training, experimental and implementation base

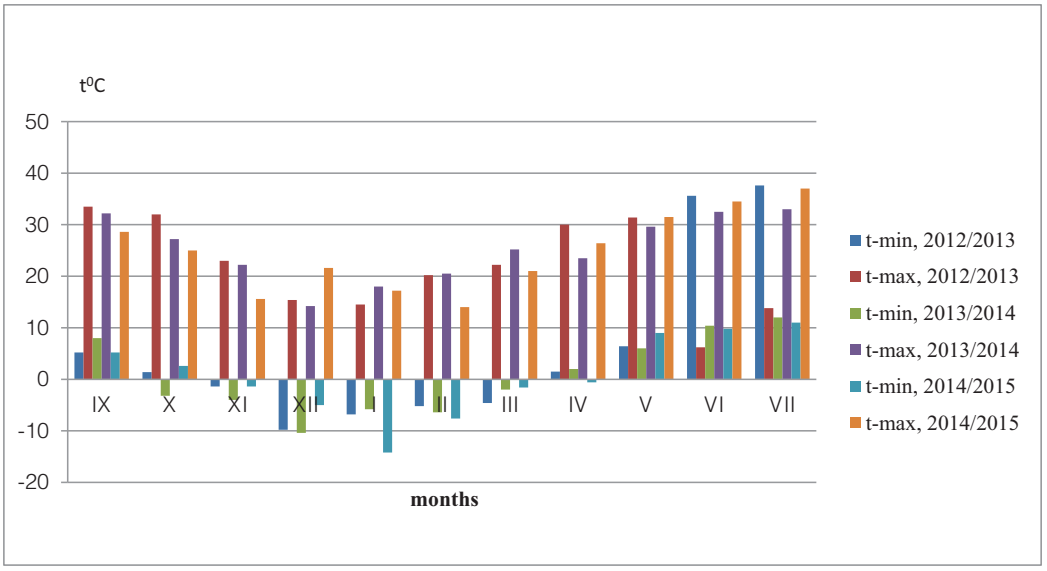

Figure 2. Absolute minimum and maximum temperatures by months 2012/2015

RESULTS AND DISCUSSIONS

Depending on the year, the date of sowing, weather conditions, and used foliar fertilizers phases of development in the area of Training, experimental and implementation base occur at different times (Tables 1, 2, 3 and 4).

The results in the tables show that during the three years of the study, the plants germinate at the earliest at the first sowing date of 1-10.IX, followed by those sown in the periods 1-10.X; 10-20.X and 20-30.X.

Higher temperatures during the germination period at the earliest date of sowing create conditions for the plants to germinate for 21 days in 2012. More balanced distribution of precipitation in 2014 and in 2013 led to the germination of the plants for 16 and 18 days at

the first date of sowing, while in the sowing from 10 to 20.X, during the three years of study plants germinate for 18 to 20 days.

During the three years of study, for the remaining sowing dates, the plants germinate for 25 and 18 days at sowing from 01 to 10.X. and for 16, 18 and 14 days at sowing period from 20 to 30.X.

At the first two sowing dates, all tested variants in the three years of study entered the 6-8 leaf stage, about one month after germination.

At sowing in the period of 10 to 20.X, only the Fertiactyl Starter-treated plants in the first year and those treated with Fertiactyl Starter and Lactofol B in the second and third years reached the 6-8 leaf phase.

Late sowing of rapeseed at the end of October (from 20 to 30.X) is the reason for ending the vegetation of plants in all variants at 2-4 leaf phase, with the exception of Fertiactyl Starter-treated variants that reach 4-6 leaf phase in 2013 and 2014.

Phase 6-8 leaf in all sowing dates and over the three years of the experiment were reported for Fertiactyl Starter treated variants with 3 to 6 days earlier than the control variant.

Falling temperatures in December 2012 to minus 9.8°C, and the failure of rapeseed to reach the optimum wintering phase at the last sowing date resulted in plant deaths in Lactofol B, Litovit® treated variants and of the control variants.

The development phases in 2012-2013 were only reported for the Fertiactyl Starter variant.

Temperatures in December 2014 reached minus 5°C, while in 2013 - minus 10.4°C but due to the snow cover and higher average day and night temperatures during this period led to the successful wintering of part of the plants during the two years of study being sown on the last sowing date.

The rise in temperatures at the end of February 2013 to 10.3°C and the 45.1 mm precipitations that had fallen resulted in the earliest resumption of vegetation at all dates and variants of sowing (26.02).

Fallen 76.6 mm precipitation in February of 2015 and a gradual increase in temperatures lead to a later resumption of vegetation (4.03).

The alternation of lower and higher temperatures in February 2014 and less rainfall of 9 mm are a prerequisite for the latest resuming of vegetation (9.03).

Once the vegetation has resumed, the development phases during the three years of the study occur at the earliest at sowing from 1 to 10.IX, followed by sowing in the period 1-10. X, 10-20. X, and 20-30.X.

The rainfall in February in 2013 (45.1 mm) creates a prerequisite for the stem formation phase for all variants and sowing dates to occur at the earliest, i.e. from 14.03 to 6.04.

Later onset of vegetation in 2014 and less rainfall in February (9.0 mm) this year lead to a delay in the stem formation phase. For all tested variants and sowing dates, this phase runs the latest - from 21.03 to 12.04.

The gradual rise in temperature and 76.6 mm precipitation in February 2015 led to a stem formation phase from 17.03 to 9.04.

The earliest phase of stem formation during the three years of study was reported in the Fertiactyl Starter variants (14.03-6.04 in 2013, 21.03-09.04 in 2014, 17.03-6.04 in 2015) followed by the Lactofol B variants (15.03-27.03 in 2013, 22.03-10.04 in 2014, 17.03-7.04 in 2015), Litovit® (15.03-28.03 in 2013, 22.03-11.04 in 2014, 18.03-8.04 in 2015), and control (16.03-29.03 in 2013, 23.03-12.04 in 2014, 19.03-9.04 in 2015).

Plants of all tested variants, during the three years of the experiment, entered budding phase in April.

Of all the variants studied, the earliest budding phase was recorded in Fertiactyl Starter-treated variants followed by Lactofol B, Litovit® treated variants and the control.

Budding phase over the three years of the study occurred from 1 to 4 days earlier in the Fertiactyl Starter treated versus the other variants and the control.

The mass blossoming phase was first reported in Fertiactyl Starter treated plants (15.04 to 4.05 in 2013, 20.04 to 7.05 in 2014, and 16.04 to 5.05 in 2015) followed by those treated with Lactofol B (16.04-27.04 in 2013, 21.04 - 9.05 in 2014, and 17.04 to 6.05 in 2015), Litovit® (17.04-28.04 in 2013, 22.04-9.05 in 2014 and from 18.04 to 07.05 in 2015) and the control variant (17.04-29.04 in 2013, 22.04-10.05 in 2014 and from 19.04 to 8.05 in 2015).

Table 1. Phenological development of rapeseed sown in the period of 1 to 10. IX

Development phases	Sowing			Germination			1-2 leaf			2-4 leaf		
Sowing date	1-10. IX											
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Control	07.09	06.09	10.09	28.09	24.09	26.09	05.10	02.10	04.10	14.10	11.10	12.10
Fertiactyl Starter	07.09	06.09	10.09	28.09	24.09	26.09	05.10	02.10	04.10	14.10	11.10	12.10
Litovit®	07.09	06.09	10.09	28.09	24.09	26.09	05.10	02.10	04.10	14.10	11.10	12.10
Lactofol B	07.09	06.09	10.09	28.09	24.09	26.09	05.10	02.10	04.10	14.10	11.10	12.10

Development phases	4-6 leaf			6-8 leaf			Vegetation termination			Vegetation resuming		
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2013	2014	2015
Control	24.10	23.10	24.10	02.11	01.11	01.11	13.12	14.12	17.12	26.02	09.03	04.03
Fertiactyl Starter	22.10	20.10	20.10	29.10	27.10	26.10	13.12	14.12	17.12	26.02	09.03	04.03
Litovit®	23.10	22.10	23.10	30.10	29.10	29.10	13.12	14.12	17.12	26.02	09.03	04.03
Lactofol B	23.10	21.10	21.10	30.10	28.10	27.10	13.12	14.12	17.12	26.02	09.03	04.03

Development phases	Stem formation			Budding			Start of blossoming – 10%			Mass blossoming – 75%		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	16.03	23.03	19.03	04.04	08.04	05.04	09.04	14.04	11.04	17.04	22.04	19.04
Fertiactyl Starter	14.03	21.03	17.03	02.04	06.04	02.04	07.04	12.04	08.04	15.04	20.04	16.04
Litovit®	15.03	22.03	18.03	03.04	07.04	04.04	09.04	14.04	10.04	17.04	22.04	18.04
Lactofol B	15.03	22.03	17.03	03.04	07.04	03.04	08.04	13.04	09.04	16.04	21.04	17.04

Development phases	Waxy maturity			Full maturity			Vegetation period		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	04.06	09.06	07.06	18.06	24.06	22.06	263	273	269
Fertiactyl Starter	02.06	07.06	04.06	16.06	22.06	20.06	261	271	267
Litovit®	04.06	09.06	06.06	18.06	24.06	22.06	263	273	269
Lactofol B	03.06	08.06	05.06	17.06	23.06	21.06	262	272	268

Table 2. Phenological development of rapeseed sown in the period of 1 to 10. X

Development phases	Sowing			Germination			1-2 leaf			2-4 leaf		
Sowing date							1-10. X					
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Control	05.10	07.10	06.10	30.10	25.10	24.10	07.11	02.11	01.11	17.11	13.11	12.11
Fertiactyl Starter	05.10	07.10	06.10	30.10	25.10	24.10	07.11	02.11	01.11	17.11	13.11	12.11
Litovit®	05.10	07.10	06.10	30.10	25.10	24.10	07.11	02.11	01.11	17.11	13.11	12.11
Lactofol B	05.10	07.10	06.10	30.10	25.10	24.10	07.11	02.11	01.11	17.11	13.11	12.11

Development phases	4-6 leaf			6-8 leaf			Vegetation termination			Vegetation resuming		
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2013	2014	2015
Control	27.11	24.11	23.11	05.12	03.12	03.12	13.12	14.12	17.12	26.02	09.03	04.03
Fertiactyl Starter	23.11	20.11	19.11	02.12	30.11	29.11	13.12	14.12	17.12	26.02	09.03	04.03
Litovit®	26.11	23.11	22.11	04.12	02.12	02.12	13.12	14.12	17.12	26.02	09.03	04.03
Lactofol B	25.11	22.11	21.11	03.12	01.12	01.12	13.12	14.12	17.12	26.02	09.03	04.03

Development phases	Stem formation			Budding			Start of blossoming – 10%			Mass blossoming – 75%		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	23.03	30.03	26.03	10.04	16.04	12.04	16.04	22.04	18.04	24.04	30.04	26.04
Fertiactyl Starter	20.03	27.03	23.03	07.04	13.04	09.04	13.04	19.04	15.04	21.04	25.04	21.04
Litovit®	22.03	29.03	25.03	09.04	15.04	11.04	14.04	21.04	17.04	23.04	29.04	25.04
Lactofol B	21.03	29.03	24.03	08.04	14.04	10.04	14.04	20.04	16.04	22.04	26.04	22.04

Development phases	Waxy maturity			Full maturity			Vegetation period		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	14.06	19.06	17.06	28.06	04.07	02.07	241	252	250
Fertiactyl Starter	11.06	16.06	14.06	25.06	01.07	29.06	238	249	247
Litovit®	13.06	18.06	16.06	27.06	03.07	01.07	240	251	249
Lactofol B	12.06	17.06	15.06	26.06	02.07	30.06	239	250	248

Table 3. Phenological development of rapeseed sown in the period of 10 to 20. X

Development phases	Sowing			Germination			1-2 leaf			2-4 leaf		
Sowing date	10-20. X											
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Control	15.10	15.10	14.10	04.11	02.11	01.11	14.11	12.11	11.11	25.11	24.11	24.11
Fertiactyl Starter	15.10	15.10	14.10	04.11	02.11	01.11	14.11	12.11	11.11	22.11	21.11	20.11
Litovit®	15.10	15.10	14.10	04.11	02.11	01.11	14.11	12.11	11.11	24.11	23.11	23.11
Lactofol B	15.10	15.10	14.10	04.11	02.11	01.11	14.11	12.11	11.11	23.11	22.11	21.11

Development phases	4-6 leaf			6-8 leaf			Vegetation termination			Vegetation resuming		
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2013	2014	2015
Control	05.12	04.12	04.12	-	-	-	13.12	14.12	17.12	26.02	09.03	04.03
Fertiactyl Starter	30.11	29.11	28.11	09.12	08.12	07.12	13.12	14.12	17.12	26.02	09.03	04.03
Litovit®	04.12	03.12	03.12	-	-	-	13.12	14.12	17.12	26.02	09.03	04.03
Lactofol B	03.12	02.12	01.12	-	10.12	09.12	13.12	14.12	17.12	26.02	09.03	04.03

Development phases	Stem formation			Budding			Start of blossoming – 10%			Mass blossoming – 75%		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	29.03	04.04	01.04	15.04	20.04	17.04	21.04	26.04	23.04	29.04	04.05	01.05
Fertiactyl Starter	25.03	01.04	29.03	11.04	16.04	13.04	16.04	21.04	18.04	24.04	29.04	26.04
Litovit®	28.03	03.04	31.03	14.04	18.04	15.04	20.04	24.04	21.04	28.04	02.05	29.04
Lactofol B	27.03	02.04	30.03	13.04	17.04	14.04	19.04	22.04	19.04	27.04	01.05	28.04

Development phases	Waxy maturity			Full maturity			Vegetation period		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	20.06	24.06	23.06	05.07	09.07	08.07	243	249	249
Fertiactyl Starter	15.06	20.06	19.06	01.07	05.07	04.07	239	245	245
Litovit®	19.06	22.06	21.06	04.07	08.07	07.07	242	248	248
Lactofol B	18.06	21.06	20.06	03.07	07.07	06.07	241	247	247

Table 4. Phenological development of rapeseed sown in the period of 20 to 30. X

Development phases	Sowing			Germination			1-2 leaf			2-4 leaf		
Sowing date							20-30. X					
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Control	25.10	25.10	22.10	10.11	12.11	08.11	21.11	23.11	20.11	07.12	08.12	07.12
Fertiactyl Starter	25.10	25.10	22.10	10.11	12.11	08.11	21.11	23.11	20.11	04.12	05.12	03.12
Litovit®	25.10	25.10	22.10	10.11	12.11	08.11	21.11	23.11	20.11	06.12	07.12	06.12
Lactofol B	25.10	25.10	22.10	10.11	12.11	08.11	21.11	23.11	20.11	05.12	06.12	04.12

Development phases	4-6 leaf			6-8 leaf			Vegetation termination			Vegetation resuming		
Years and variants	2012	2013	2014	2012	2013	2014	2012	2013	2014	2013	2014	2015
Control	-	-		-	-	-	13.12	14.12	17.12	-	09.03	04.03
Fertiactyl Starter	-	14.12	13.12	-	-	-	13.12	14.12	17.12	26.02	09.03	04.03
Litovit®	-	-		-	-	-	13.12	14.12	17.12	-	09.03	04.03
Lactofol B	-	-		-	-	-	13.12	14.12	17.12	-	09.03	04.03

Development phases	Stem formation			Budding			Start of blossoming – 10%			Mass blossoming – 75%		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	-	12.04	09.04	-	28.04	26.04	-	04.05	02.05	-	10.05	08.05
Fertiactyl Starter	06.04	9.04	06.04	22.04	25.04	23.04	28.04	01.05	29.04	04.05	07.05	05.05
Litovit®	-	11.04	08.04	-	26.04	25.04	-	02.05	01.05	-	09.05	07.05
Lactofol B	-	10.04	07.04	-	26.04	24.04	-	02.05	30.04	-	09.05	06.05

Development phases	Waxy maturity			Full maturity			Vegetation period		
Years and variants	2013	2014	2015	2013	2014	2015	2013	2014	2015
Control	-	01.07	30.06	-	17.07	16.07	-	247	250
Fertiactyl Starter	27.06	28.06	27.06	12.07	15.07	14.07	244	245	248
Litovit®	-	01.07	29.06	-	17.07	16.07	-	247	250
Lactofol B	-	29.06	28.06	-	16.07	15.07	-	246	249

The uneven distribution of rainfall in May and June (3.4; 109.5 mm) in 2013 led to a reduction in the phases of mass blossoming, waxy and full maturity in all tested variants, and they passed through them the fastest and the earliest. Higher rainfall in May and June (66.5, 98.8 mm) in 2014 and (69.5, 76.7 mm) in 2015 in all tested variants lead to the later occurrence of these phases.

During the three years of study and at the different sowing dates, Fertiactyl Starter (3000 ml/ha) treated variants entered these developmental stages 2-3 days earlier than control, whereas Lactofol B-4000 ml/ha and Litovit® 2000 g/ha treated variants reach these phases one day earlier or simultaneously with the control. Comparing the entering into the phase of blossoming, waxy and full maturity by the Lactofol B variant (4000 ml/ha) and Litovit® variant (2000 g/ha), this occurred 1 day earlier in favour of Lactofol B (4000 ml/ha).

The vegetation period for all variants of the experiment at sowing from 1 to 10. X is the longest (from 261 to 263 days, in 2013, from 267 to 269 days, in 2015 and from 271 to 273 days in 2014) for the rest of the sowing dates, it is almost the same from 238 to 244 days in 2013; from 245 to 250 days in 2015 and from 245 to 252 days in 2014.

CONCLUSIONS

On the basis of the experimental work and the results obtained, the following conclusions can be drawn:

1. The phenological observations made during the three years of the experiment show that, at all sowing dates, foliar fertilization contributes to faster developmental phases than the control.
2. The strongest developmental stimulant effect during the three years and at different sowing dates was observed in the Fertiactyl Starter (3000 ml/ha) treated variant followed by Lactofol B (4000 ml/ha) sprayed variant, and Litovit® (2000 g/ha).
3. Phases of development in 2012-2013 at the last sowing date were only reported for the Fertiactyl Starter variant, while the remaining Lactofol B, Litovit® variant and the control plants perished.
4. The vegetation period is the longest in 2015 (248 to 250 days), and the shortest in 2013 (244 days).

Of all foliar fertilizer treated variants with the shortest vegetation period (238 to 271 days) are those treated with Fertiactyl Starter.

REFERENCES

Coelho, H., Grassi Filho, H., Barbosa, R., Romeiro, J. (2011). Pompermayer, G. V.; Lobo, T. Agronomic efficiency of leaf application of nutrients in the soybean crop. *Revista Agrarian*, *4*(11), 73–78.

Delchev, G. (2010). Stability valuation of some mixtures between foliar fertilizers and antibroadleaved herbicides for the grain yield of durum wheat. *Pochvoznanie, Agrokhimiya i Ekologiya*, *44*(2), 41–46.

Kolev, T., Todorov, Zh., Koleva, L. (2012). Influence of the complex foliar fertilizer "Crystallon Special" on the productivity of the hard wheat (*Tr. durum* Desf.). Научные исследования и разработки. Международной научно-практической конференции молодых ученых (19-20 апреля 2012г.), Иркутск, 81–85.

Kolev, T., Todorov, Zh., Koleva, L. (2013). Effect of the liquid fertilizers for leaves on the growth and productivity of durum wheat. Международной научно-практической конференции. Климат, экология, сельское хозяйство евразии (28-30 мая 2013г.), Иркутск, 154-158.

Sanmueang, A., Detpiratmongkol, S., Yoosukyingsataporn, S., Ubolkerd, T. (2011). Influence of foliar application of potassium fertilizers on growth and yield of sweet sorghum. *Proceedings of the 49th Kasetsart University Annual Conference, Kasetsart University, Thailand, 1-4 February. Subject: Plants*, *I*, 458–464.