Development and Productivity of the Serbian Oat Cultivars under Agrometeorological conditions in Bulgaria

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Abstract:
Within the period 2006 – 2008 in the experimental field of the Plant growing Department at the Agricultural University – Plovdiv, Republic of Bulgaria a comparative test was carried out with three cultivars of Serbian oats (Slavuj, Lovken, Rajac) compared to the Bulgarian standard for spring cultivars – "Obraztsov Chiflik 4". Block method was repeated three times. The cultivars were sown in March; sowing rate – 600 germinating seeds per m2. Phenological observations were carried out. The level of tillering as well as other basic elements of productivity formed under the specific agrometeorological conditions of 2006, 2007 and 2008 were found out. The elements of panicle and its productiveness were analyzed. The yield of the tested Serbian cultivars as per 1 da under the weather conditions in Central Southern Bulgaria was also evaluated. The Serbian cultivars were considered highly adaptive. The Lovken cultivar proved best yield results.

Key words: oat, cultivar, yield

Introduction
In Bulgaria oats growing (*Avena sativa* L.) is mainly associated with its use as concentrated fodder for animals. The precious qualities of oats make them irreplaceable food both for people and growing up animals. The percentage of area occupied in the past and now is associated with the specifications of the culture to agrometeorological conditions and the necessity to implement sorts of high productivity. In order to grow, the crop demands average temperature conditions and relatively high level of humidity of air and soil. Due to agricultural and technological advances and the purpose to find the most appropriate sorts of oats, suitable for the agrometeorological conditions in our country, winter sorts of oats have been created and tested in Bulgaria (1, 2, 3, 6). The increased yield is a result of better utilization of soil humidity in the period of autumn and winter (5, 6). However, the spring sorts are still considered worthy in the traditions and practice of Bulgarian farmers. Spring oats are used to compensate for scarce yield from the autumn sowing as well as to take part in the process of crop rotation after a late precursor. In regard to this, the creation of new Bulgarian sorts and the introduction of foreign ones appropriate for the respective climate area is an important factor for gaining stable yield when the climate conditions are constantly changing (8, 9).
The great fluctuations of crop yield for the last few years are due to a greater amount to the climate changes taking place in the world, and particularly in Bulgaria. The harvested crop area is getting less than the sowed one, and the average amount of yield is decreasing (7). In such conditions it is of great importance these sort to be relatively adaptable, drought-resistant, particularly adaptable to high temperatures and extreme conditions during the years.
In the region of Plovidv the yearly average temperature tends to increase, and the summer period extends decreasing the winter one. This inevitably changes the optimal period of planting and the duration of growth phases. These frequent temperature changes require better selection of sorts which could be most appropriate for a specific area (4).
The introduction of foreign sorts may become a good alternative to the Bulgarian sorts, which was the reason to start our research, namely: development and productivity of three Serbian spring cultivars of oats in the agrometeorological conditions of Central Southern Bulgaria.

Materials and methods
In the period between 2006 and 2008 in the experimental field of Plant Growing Department at the Agricultural University – Plovdiv was carried out a comparative test following the block method with three repetitions and field size of 10.5 m².
Subject to the test were three spring sorts - Slavuj, Lovken and Rajac while the Bulgarian sort Obraztsov Chiflik 4 was considered for standard (the standard for spring sorts in Bulgaria). In the first year of the survey the Serbian sorts were selected and compared, and in the second and the third one the Bulgarian standard was included.
In the early spring (in March), as soon as it was possible, disinfected seeds were planted preceded by sunflower. The planting rate was 600 germinating seeds per m^2.

The field was fertilized as the fertilization rates were N_6, P_8, K_8; the entire quantity of nitrogen fertilizers had been introduced before planting the crop, early in spring, and the phosphorus and potassium fertilizers before the basic processing in autumn.
During vegetation the crops were preserved from weeds, diseases and pests. At the same time phenological observations and measurements were carried out.

1. Phenological development – observation about the commencement of phenol-phases – as per dates;
2. Tillering (general and productive) – the number of tillers registered as per 1 plant after a biometrical analysis of a sample sheaf.
3. Plant height – measured in cm.
4. Elements of the panicle – length (cm), the number of spikelets of the panicle, the number of grains in the panicle, weight of grains – out of 20 plants as per each repetition.
5. Physico-mechanical properties of grains – the mass of 1000 grains in g, husk content (lemma+palea) – from a sample of g, stated in %;
6. Yield kg/da – the grain yielded from the yield field is weighed.

The data from the yield are processed with the use of a computer program for Single Factor Analysis of Variance with the comparative analysis as per the method of Dunkan (Dunkan D.V. 1995; SAS Institute, 1986).

Agrometeorological characteristics

The development of meteorological factors through the testing years is shown in tables 1, 2, 3, 4.
The year 2006 is characterized with higher temperatures during the vegetation period (March – June) as opposed to the long-term average value. The amount of rainfall also differs significantly from the average for the long-term period. Heavy rainfall accompanied by strong winds in the end of June caused flooding and lodging of 20% of the crops that at this point are in their wax ripeness. Despite this fact, the year can be described as relatively favorable for the development of oats.
Temperatures during March and April 2007 are also favorable for the future development of the early spring cultures, including oats. However the amount of rainfall throughout April and up to the third third of May was very limited and this inevitably influences the formation of the productive elements of the panicle. Heavy to flooding rains fell only in the end of May and the beginning of June and caused lodging of the crops and difficulties in harvesting.
2008 is most favorable for the development of the culture. March, April and May have temperatures that are a little above the norm but the rainfalls, especially in April, May and June, are favorably distributed and grant optimal conditions for high yield.

Table 1. Average monthly temperature (t˚C) for the years 2006, 2007 and 2008

Months	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
2006												
Average monthly temperature (t˚C)	-0.7	2.1	7.5	12.4	17.6	21.3	23.1	24.6	19.2	14.0	7.7	2.7
2007												
Average monthly temperature (t˚C)	6.5	4.5	8.2	12.9	18.8	23.7	26.2	28.1	17.1	13.2	5.6	1.1
2008												
Average monthly temperature (t˚C)	-1.9	4.6	9.8	12.9	17.5	22.0	23.4	25.1	17.9	13.3	8.0	4,3
Average monthly temperature for the period 1916-1970	-0.4	2.2	6.0	12.2	17.2	20.9	23.2	22.7	18.3	12.6	7.4	2.2

Table 2. Sum of the rainfall distributed in 10-day intervals and months in mm/m2 for the year 2006

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1st third of the month	29.7	19.7	19.9	35.3	0.5	17.0	93.9	3.5	0.1	54.3	2.0	0.0
2nd third of the month	0.0	2.2	46.7	30.6	7.6	9.3	0.8	1.1	1.7	1.3	6.0	19.0
3rd third of the month	2.2	26.1	0.3	3.4	0.8	23.2	2.6	18.0	47.9	3.9	7.7	14.9
Monthly rainfall sum (mm/m2)	31.9	48.0	66.9	69.3	8.9	49.5	97.3	22.6	49.7	59.5	15.7	33.9
Average for the period 1916-1970	40	48	44	39	32	36	42	54	65	47	35	36

Table 3. Sum of the rainfall distributed in 10-day intervals and months in mm/m2 for the year 2007

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1st third of the month	10.5	0.0	0.1	13.2	10.3	129.3	0.7	156.8	32.9	22.2	0.8	30.3
2nd third of the month	5.1	14.0	0.6	0.9	5.6	3.5	0.0	0.1	0.0	10.2	116.3	48.2
3rd third of the month	18.7	3.0	36.8	1.2	124.0	0.0	0.0	0.0	0.0	46.8	0.3	0.0
Monthly rainfall sum (mm/m2)	34.3	17.0	37.5	15.3	139.9	132.8	0.7	156.9	32.9	79.2	39.1	26.1
Average for the period 1916-1970	40	48	44	39	32	36	42	54	65	47	35	36

Table 4. Sum of the rainfall distributed in 10-day intervals and months in mm/m2 for the year 2008

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1st third of the month	26.7	2.0	2.5	18.8	25.2	29.6	0.3	2.5	0.0	13.9	4.2	13.3
2nd third of the month	7.6	0.5	5.0	12.7	0.0	37.9	0.2	0.9	20.2	0.0	36.7	78.5
3rd third of the month	8.1	0.0	4.7	4.3	29.6	1.4	19.5	0.0	63.7	0.0	5.1	2.7
Monthly rainfall sum (mm/m2)	42.4	2.5	12.2	35.8	54.8	68.9	20.0	3.4	83.9	13.9	46.0	94.5
Average for the period 1916-1970	40	48	44	39	32	36	42	54	65	47	35	37

Results and discussions

1. Phenological development

The development and productivity of oats is greatly influenced by the meteorological conditions during its vegetation. Oats is a crop that shows its full potential in moist and cool climates. The big decrease of yield is often the result of the high daytime temperatures during the panicle formation - milk ripeness period, combined with the lack of rainfall.

2006 was characterized by heavy rain in March that prevented timely sowing of oats and it was not performed until 05.04 (Table 5). The conditions after sowing were favorable and the plants grew relatively quickly - for 8 days (13.04.). No cultivar specifics were observed in relation to growth. The tillering, stem alongation, panicle emergence and ripening phases developed in periods shorter than usual – a result from the limited amounts of rain during all of May and up to the third third of June (Table 2).

The sowing of oats for 2007 was performed under temperatures that were normal for the period and with low soil humidity, on 14.03. The later rainfall (in the third third of March) secured the relatively timely germination – up till the end of the month of March. The tillering and stem elongation phases developed under

Table 5. Phenophases of oats development

Cultivar	Year	Sowing	Germination	3-rd leaf	Tillering	Stem elongation	Panicle emergence	Milk ripeness	Wax ripeness	Full ripeness
Obraztsov chiflik 4	2007	14.03.	26.03.	16.04.	13.04.	01.05.	20.05.	04.06.	25.06.	06.07.
	2008	05.03.	17.03.	31.03.	06.04.	30.04.	24.05.	10.06	26.06.	04.07.
Slavuj	2006	05.04.	13.04.	26.04.	03.05.	23.05.	05.06.	19.06.	28.06.	14.07.
	2007	14.03.	26.03.	06.04.	13.04.	01.05.	20.05.	05.06.	24.06.	04.07.
	2008	05.03.	17.03.	31.03.	06.04.	02.05.	28.05.	10.06.	26.06.	04.07.
Lovken	2006	05.04.	13.04.	26.04.	03.05.	23.05.	05.06.	19.06.	28.06.	14.07.
	2007	14.03.	26.03.	06.04.	13.04.	01.05.	20.05.	05.06.	24.06.	04.07.
	2008	05.03.	17.03.	31.03.	06.04.	02.05.	28.05.	10.06.	26.06.	04.07.
Rajac	2006	05.04.	13.04.	26.04.	03.05.	23.05.	05.06.	19.06.	28.06.	14.07.
	2007	14.03.	26.03.	06.04.	13.04.	01.05.	20.05.	05.06.	24.06.	04.07.
	2008	05.03.	17.03.	31.03.	06.04.	02.05.	28.05.	10.06.	26.06.	04.07.

temperatures below the average for the long-term period and rainfall that was of no importance to agriculture (Table 4). The heavy rainfall in the end of May and the beginning of June - 270 mm/m² that represented 83% of all rainfall during the vegetation period, contributed to an extent for the compensation of yield formation. This year, once again, there were no differences in the phases among the cultivars.
In 2008 the conditions for soil preparation and sowing were most favorable. Due to that, sowing was performed at the earliest point (05.03.) and was of the highest quality. Germination of the seeds took 12 days (17.03). No observable differences between the cultivars. The stem elongation, panicle emergence and ripening phases developed under temperatures close to the average and optimally distributed rainfall.

2. Tillering
The great adaptive reaction of oats, due to which the plants possess the ability to overcome the unfavorable influence of climatic factors and give relatively good yields, is due above all to their ability to tiller. This is an important biological phenomenon with almost all grains.
The results for overall and productive tillering are presented in table 6. The 2007 cultivars have the highest overall tillering with plants forming up to 2,9 tillers – average for the four cultivars. Among them Obraztsov chiflik 4 formed the most tillers – 3,6 per plant. The Lovken cultivar showed the weakest tillering. In 2007 the same trend is preserved with productive tillering – 2,0 for Obraztsov chiflik 4 against 1,3 for Lovken. The reduction of a large part of the tillers is typical for the spring cultivars. This phenomenon is particularly well underlined in cases of late sowing and draughts.
On average for the period, among the Serbian cultivars, Slavuj displayed the largest number of productive tillers.

Table 6. Overall and productive tillering (number of tillers/ plant)

Overall tillering				
Cultivar	**2006**	**2007**	**2008**	**Average**
Obraztsov chiflik 4		3.6	2.3	3.0
Slavuj	2.7	3.0	2.5	2.7
Lovken	2.2	2.3	2.5	2.7
Rajac	2.7	2.7	2.7	2.3
Average for the years	2.5	2.9	2.5	
Productive tillering				
Sample farm 4		2.0	1.3	1.7
Slavuj	1.4	1.6	1.2	1.4
Lovken	1.4	1.3	1.1	1.3
Rajac	1.3	1.4	1.2	1.3
Average for the years	1.3	1.6	1.2	

3. Height

The data for plant height and the basic elements of the panicle are presented in tables 7, 8 and 9. Plants developed best in 2008, which turned out to be most favorable for the getting high grain yields. The crops of Obraztsov chiflik 4 grew tallest in all three years and reached 144 cm in 2008. Big height is not always desired as it determines a greater tendency for lodging, especially in years with heavy rainfall. In this sense Lovken and Rajac from the tested Serbian cultivars proved more stable because of their lower height. The differences in standard over the years is from 25 to 50 cm.

4. Panicle elements

4.1 Panicle length

The results recorded over the three years show that the values for this index vary from 13.7 cm and 23.6 cm and are influenced above all by meteorological conditions. Values were lowest in 2007 and highest in 2008. There is no established dependency in the differences between cultivars.

4.2 Number of spikelets per panicle

The number of spikelets per panicle is of great importance to the productivity of oats.

The cultivars gave best results in this index during the last year - 2008. Lovken has the highest values for 2008 - 55,9 spikelets. The other cultivars also formed a large number of spikelets per panicle – from 43 spikelets for Obraztsov chiflik 4 to 50 for Slavuj. The Lovken cultivar has the largest number of spikelets per panicle for the previous two years.

4.3. Number of grains per panicle

During the three-year period the cultivars formed from 23 to 100 grains in their panicle. This index, together with grain weight, has a direct impact on the productivity of the panicle. Values were lowest in 2007. Rajac formed only 23 grains, Lovken – 53 and Slavuj- 33, against 20 grains for the standard – the Bulgarian cultivar.

2008 had the best values of this index. All cultivars formed at least 69 grains in their panicles, the Lovken cultivar having the most (100 grains).

The better indices of the panicle elements formed in 2008 are a result from the even distribution of rainfall over the period (stem elongation phase)

Table 7. Plant height (cm) and panicle elements for 2006

Cultivar	Height (cm)	Panicle length (cm)	Spikelets per panicle (number)	Grains per panicle (number)	Grains per spikelet (number)	Grain weight per panicle, (g)	Grain weight per plant (g)
Slavuj	93.1	18.8	46.5	79.6	1.6	2.0	2.8
Lovken	84.3	16.3	27.3	48.3	1.7	1.3	2.5
Rajac	92.9	19.7	49.3	81.0	1.7	2.0	2.4

Table 8. Plant height (cm) and panicle elements for 2007

Cultivar	Height (cm)	Panicle length (cm)	Spikelets per panicle (number)	Grains per panicle (number)	Grains per spikelet (number)	Grain weight per panicle (g)	Grain weight per plant (g)
Obraztsov chiflik 4	94.4	17.8	17,0	20.3	1.2	0.5	1,0
Slavuj	90.9	15.5	22,0	33.1	1.4	0.8	1.3
Lovken	88,0	20.3	39.8	53.7	1.7	2.6	2.4
Rajac	79.2	13.7	16.4	23.4	1.2	0.9	1.7

Table 9. Plant height (cm) and panicle elements for 2008

Cultivar	Height (cm)	Panicle length (cm)	Spikelets per panicle (number)	Grains per panicle (number)	Grains per spikelet (number)	Grain weight per panicle (g)	Grain weight per plant (g)
Obraztsov chiflik 4	143.6	29.6	43.2	68.7	1.6	2.2	2.5
Slavuj	113.9	22.3	49.7	88.6	1.8	2.5	3.0
Lovken	96.1	22.1	55.9	100.4	1.8	3.1	3.7
Rajac	108.9	23.6	45.7	77.3	1.7	2.3	2.9

4.4. Grain weight per plant.

The heaviest grain per plant in two of the testing years (2007 and 2008) belongs to the Lovken cultivar – 2,4 g in 2007 and 3,7 g in 2008. The heavier grain per panicle has a direct influence on the productivity. In this index the Obraztsov chiflik 4 cultivar yielded less than the Serbian cultivars in both years.

5. Physical and mechanical properties of grain

5.1. Mass per 1000 grains

This index describes the size and the nourishment of the grain and is a factor that is influenced by the agro-ecological conditions and the cultivation technology. Mass is a factor that describes well the potential possibilities for high yield of the cultivars.

The data is presented in table 10.

Over the three years the mass per 1000 grains for the Serbian cultivars varies from 24.6 g to 32.1 g. It is highest in 2008 – all cultivars accumulated mass of over 32 g. The Lovken cultivar displayed grain that is a little heavier. The Obraztsov chiflik 4 cultivar outmatches all Serbian cultivars with its larger grain and respectively – its greater mass per 1000 grains.

Table 10. Mass per 1000 grains (g)

Cultivar	2006	2007	2008	Average	%
Obraztsov chiflik 4		28,1	34,7	31,4	100,0
Slavuj	24,6	26,6	32,0	27,7	88,2
Lovken	27,1	26,4	32,1	28,5	90,8
Rajac	25,4	26,2	32,0	27,9	88,7

5.2.Husk content (lemma+palea)

It is known (5) that the nutritional qualities of grain husk are too low. It contains very little protein, little fats and lots of cellulose, because of which oats selection is geared towards lowering its husk content. This is particularly important for cultivars that are processed for use in diet foods, nuts, etc. For this purpose the husked cultivars must be cleared of the husk. In this sense it is better if the husk is in a smaller percentile proportion.

With the tested cultivars the husk content percentage varies: 27- 35 (Table 11).

The Bulgarian cultivar has the thinnest husk. The percentile ratio of grain to husk is 73% : 27%. With Serbian cultivars the highest grain percentage belongs to Lovken. It comes closest to the Bulgarian standard and is best suited for processing among the cultivars introduced as regards the percentile ratio of grain to husk. Slavuj and Rajac follow after it in this index.

Table 11. Husk content of grain (%)

Cultivar	Mass per 20 grains (g)	Husk mass (g)	Mass of naked grain (g)	% ratio	
				Husk	Naked grain
Obraztsov chiflik 4	0.59	0.16	0.43	27.12	72.88
Lovken	0.62	0.18	0.44	29.04	70.96
Slavuj	0.61	0.20	0.41	32.79	67.21
Rajac	0.60	0.21	0.39	35,00	65,00

6. Grain yield

The average grain yields are presented in table 12.

In the first year of the testing only the Serbian cultivars were planted to determine their adaptive capabilities and perspectives for use. On average for the testing period (2006-2008) the 2006 yields were lowest. We can explain this with the late sowing and the shifting of the vegetation period towards the hot months of summer. From the three Serbian cultivars Lovken had the highest yield, followed by Rajac and Slavuj.

In 2007 the plants developed in more favorable conditions. The Lovken cultivar once again surpassed the others in productivity. Its yield was 290 kg/da, which exceeds the yield of the Bulgarian cultivar Obraztsov chiflik 4 by two and a half times. The differences have been calculated with an accuracy of 95%. Even if by a smaller gap, Slavuj and Rajac also exceed the yield of the standard, respectively with 11 and 20%.

2008 was the testing year that was most favorable for the development of oats. All three Serbian cultivars were proven to exceed the standard and the differences vary from 35 to 48%, respectively for Rajak and Lovken.
We can summarize that all three tested Serbian cultivars exceed the productivity of the Bulgarian standard Obraztsov chiflik 4. Among them Lovken realized its productivity best, followed by Rajac and Slavuj. With this data, as well as with the results obtained for the elements of the panicle, we largely confirm other similar tests of these cultivars carried out in the Republic of Macedonia (8).

Table 12. Grain yield, кg/da

Cultivar	2006		2007		2008	
	kg/da	%	kg/da	%	kg/da	%
Obraztsov chiflik 4			115,4 **a**	100,0	316,8 **a**	100,0
Slavuj	92,6 **a**	100,0	127,6 **a**	110,6	430,8 **b**	136,0
Lovken	109,8 **a**	118,6	289,8 **b**	251,1	469,8 **b**	148,3
Rajac	100,1 **a**	108,1	137,9 **a**	119,5	427,3 **b**	134,9

Conclusions

1. The tested Serbian spring oats cultivars Slavuj, Lovken and Rajac do not differ among themselves regarding the entering and passing of the basic phonological phases.
2. The spring Serbian cultivars form up to 3 tillers per plant (Slavuj, 2007), out of which from 1,1 (Lovken, 2008) to 1,6 (Slavuj, 2007) develop into productive ones. The Bulgarian cultivar Obraztsov chiflik 4 outmatches the Serbian cultivars in both general and productive tillering.
3. The Lovken cultivar forms and develops the best panicle parameters – number of spikelets (56, 2008), number of grains (100, 2008) and grain weight per plant (3,7g, 2008). The standard Obraztsov chiflik 4 fails to match the parameters of all tested Serbian cultivars.
4. The Obraztsov chiflik 4 cultivar exceeds the Serbian cultivars in the parameters of mass per 1000 grains and husk content. It forms the largest grain with the lowest percentage of husk content for 2007 and 2008. This makes it better suited for processing into oat foods.
5. The tested Serbian cultivars exceed the grain productivity of the Bulgarian standard Obraztsov chiflik 4. The highest yield in the period of the study was received from the Lovken cultivar, followed by Rajak and Slavuj.

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