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DURATION OF CERTAIN PHENOLOGICAL PHASES OF DIFFERENT CORN HYBRIDS DEPENDING ON THE SOWING DATE

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Abstract

The trial was set up in 2014 in the area of Leskovac, on alluvial soil. During the research period, the duration of individual phenological phases and the entire vegetation period of individual maize hybrids was monitored. As plant material, 6 maize hybrids were used, three FAO ripening groups (400-600). The goal of the research was to determine the duration of certain phenological phases, as well as the entire vegetation of certain hybrid maize, based on the number of days, the sum of the total, and the sum of the effective temperatures. During the investigated period, in all three sowing dates, the difference in vegetation length between the hybrid with the longest and the hybrid with the shortest vegetation period was 32 days, while the difference was determined in SUT 591.3 ºC and SET 200 ºC. The hybrid ZP 434 (FAO 400) had the shortest average vegetation period in all three sowing dates in 2014, and the hybrid NS 6030 (FAO 600) had the longest vegetation period. Observed by hybrids and sowing dates, all hybrids had the shortest vegetation period on the first sowing date, and the longest on the third sowing date. As the most reliable method for determining the length of vegetation of individual maize hybrids, the method of the sum of effective temperatures stood out, and the least accurate method is based on the number of days.

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Key words: *Total air temperatures, effective air temperatures, maize, length of vegetation, sowing date.*

Introduction

Due to their numerous properties, cereals form the basis of human nutrition (Nedeljković, 2018). In Serbia, maize is one of the most common agricultural plants (Mandić et al., 2024), however, there has been stagnation in the area and yield of corn for many years (Živanović et al., 2019). According to RZS data, in 2024, 2.3% of the area was sown less than in previous years. Maize is an arable crop characterized by great diversity in the length of the vegetation. Maize sowing time and vegetation length are greatly influenced by high summer and low spring temperatures (Tang et al., 2024). The optimal time for sowing maize may vary depending on the production area due to differences in soil and climatic elements (Paraschivu et al., 2015). Later sowing dates affect numerous traits, such as silking time, photosynthesis intensity, physiological maturity and dry matter production (Shrestha et al., 2018).

Different hybrids react differently to different sowing dates. Sowing dates in maize cause a series of morpho-anatomical, physiological and biochemical changes in plants, which are reflected in plant growth and development, and such changes can lead to drastic variations in vegetation length and yield (Shrestha et al., 2018). Of all external factors, temperature has the greatest influence on the length of vegetation. Sangoi et al., (1998) state that if there is a period with lower temperatures during the period of intensive growth and development in maize, slower growth and development of plants occurs due to problems with the formation of fewer leaves and smaller leaf area.

The amount and distribution of precipitation directly affect the period of active growth and development of the corn crop (Huzsvai and Nađ, 2005; Lobell and Burke, 2008). In order to achieve stable maize yields in different production conditions, a large number of researchers studied the vegetation length of different corn hybrids in different localities. The duration of individual phenological phases in corn depends on the climatic conditions of the year, type of soil, choice of hybrids, sowing time, and applied agricultural techniques during production (Biberdžić et al., 2000).

Several different methods for determining the length of the maize vegetation are known in the world. Determining the length of vegetation based on the duration of individual phases in the number of days is considered the least reliable method (Jovanović et al., 2013), while determining the length of vegetation based on the sum of total and sum of effective temperatures are considered more accurate methods.

Material and methods

The trial was set up in 2014 in the area of Leskovac, on alluvium-type land at 225 m above sea level. The pre-crop was winter wheat. Six maize hybrids of three FAO ripening groups were sown, namely: H1 - ZP 434, H2 - NS 4023, (FAO

400); H3 - ZP 555, H4 - NS 5051 (FAO 500); H5 - ZP 666, H6 - NS 6030 (FAO 600). Standard agricultural techniques were applied in the production of maize, characteristic of the examined area. Sowing was done during April in three sowing periods: I – beginning of April; II - mid-April and III - end of April. The trial was set up in three repetitions, and 4 rows of each hybrid were sown. Sowing was done at an inter-row spacing of 70 cm x 20 cm (FAO group 400), 70 cm x 25 cm (FAO group 500) and 70 cm x 30 cm (FAO group 600).

Of the meteorological conditions during the research, the air temperature and the amount of precipitation were monitored (Table 1). The meteorological station in Leskovac, which is located in the immediate vicinity of the trial plot, served us to obtain data on the mean, minimum and maximum daily air temperatures and the amount and distribution of precipitation. The following phenological phases were monitored on all hybrids from both sowing periods: from sowing to sprouting; from sprouting to the 10th leaf stage; from the 10th leaf stage to silking; from silkiness to the appearance of a black layer; from the appearance of the black layer to full maturity and from sowing to full maturity-harvest.

To determine the phenological phases, a visual assessment was used when 70% of the plants entered the phenological phase. For each phenological phase, the duration is determined based on the number of days, the sum of effective air temperatures (SET) and the sum of total air temperatures (SUT). The accuracy of individual methods is determined based on the Standard Deviation (Sd) and the Coefficient of Variation (Cv).

Results and discussion

Based on the data from Table 1, we note that during the two-year research and the ten-year average temperature and precipitation, differences were observed in terms of the total amount of precipitation and in terms of the distribution of precipitation by month.

Table 1. Average monthly air temperatures (°C) and precipitation (mm) in Leskovac during 2014

	April	**May**	**June**	**July**	**Avg.**	**Sept.**	**A./S.**
Average monthly temperatures and precipitation during 2014							
mm	214	117	64.3	86	47.1	121.2	649.6
°C	11.40	15.55	19.59	21.60	21.50	17.00	17.77
Mean monthly temperatures and precipitation during the ten-year average							
mm	50	60.8	61.2	38.7	32.7	64.8	308.2
°C	12.30	16.20	20.3	22.8	22.2	17.4	18.53

The total amount of precipitation during the vegetation period in 2014 was 649.6 mm, with an average temperature of 17.77 °C. Looking at the data on the amount of precipitation and average temperatures, we conclude that this year was favorable for maize production. This is supported by the fact that 155.9 mm more precipitation fell in 2014 compared to the ten-year average.In the first sowing period (Table 2), the sowing-sprouting phase in all hybrids lasted nine days (SUT-

111.9 °C while SET-52 °C was achieved). The sprouting phase – 10th leaves in the first sowing period in all hybrids lasted 42 days with SUT 712.9 °C and SET 321.2 °C. The phase of the 10th leaf to silking in the first sowing period lasted from 20-24 days depending on the hybrid (SUT 389 °C-489.5 °C and SET 189.8-249.5 °C).

The phase of silking to appearance of the black layer lasted 43-50 days depending on the hybrid, with SUT 861.4-1003.8 °C, while SET was measured 395.3-468.1 °C). The phenological phase of the appearance of the black layer to full maturity in the first sowing period lasted 25-35 days, depending on the hybrid (SUT 456 °C-609 °C, and SET 245.1 °C -308.1 °C). The total vegetation period in the first sowing period lasted 139-159 days (SUT 2,420-2,902.8 °C, and the measured SET was 1,203-1,384.6 °C). On average, for all hybrids, in the first period of sowing, the vegetation lasted 150 days (SUT 2713.2 °C and SET 1.310.8 °C). The hybrid ZP 434 had the shortest vegetation period in the first sowing period (139 days, SUT 2,420 °C, SET 1,203 °C). In the same sowing time, hybrid NS 6030 had the longest vegetation period of 159 days (SUT 2,902.8 °C, SET 1,384.6 °C)

Table 2. Duration of individual phases in maize hybrids in the1st sowing date

Pheno phase	**Sowing - Sprouting**			**Sprouting – 10th leaf**			**10th leaf – Silking**		
Hyb maize	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**
HK 1	9	111.9	52	42	712.9	321.2	20	389.8	189.8
HK 2	9	111.9	52	42	712.9	321.2	20	389.8	189.8
HK 3	9	111.9	52	42	712.9	321.2	22	439.0	219.0
HK 4	9	111.9	52	42	712.9	321.2	24	489.5	249.5
HK 5	9	111.9	52	42	712.9	321.2	23	465.2	235.2
HK 6	9	111.9	52	42	712.9	321.2	23	465.2	235.2
Av	9	111.9	52	42	712.9	321.2	22	439.8	219.8
Sd	0.00	0.00	0.00	0.00	0.00	0.00	1.67	41.86	25.13
Cv	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.11
I sowing date - 2014.									
Pheno phase	**Silking-Apperance of a black layer**			**Apperance of a black layer – Full maturity**			**Sowing - Full maturity – Harvest**		
Hyb maize	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**
HK 1	43	861.4	395.3	25	456.0	245.1	139	2420.0	1203.0
HK 2	44	887.0	410.7	26	474.1	253.2	141	2582.9	1226.0
HK 3	46	932.1	432.3	29	503.4	272.5	148	2599.1	1296.5
HK 4	48	969.9	452.2	34	607.7	306.8	157	2891.9	1380.9
HK 5	49	986.0	460.3	33	606.7	305.8	156	2882.7	1374.0
HK 6	50	1003.8	468.1	35	609.0	308.1	159	2902.8	1384.6
Av	46	940.0	436.5	30.3	542.8	281.9	150	2713.2	1310.8
Sd	2.80	56.80	28.96	4.20	72.70	28.70	8.63	206.10	81.70
Cv	0.06	0.06	0.06	0.14	0.13	0.10	0.06	0.08	0.06

Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, Sd - Standard deviation, Cv – Coefficient of variation*

Table 3. Duration of certain phases in certain hybrids of maize in the second sowing date

Pheno phase	Sowing - Sprouting			Sprouting – 10th leaf			10th leaf - Silking		
Hyb maize	ND	SUT (°C)	SET (°C)	ND	SUT (°C)	SET (°C)	ND	SUT (°C)	SET (°C)
HK 1	12	125.8	55.3	42	788.0	317.2	20	378.9	198.8
HK 2	12	125.8	55.3	42	788.0	317.2	20	378.9	198.8
HK 3	12	125.8	55.3	42	788.0	317.2	22	426.3	219.1
HK 4	12	125.8	55.3	42	788.0	317.2	25	462.5	250.9
HK 5	12	125.8	55.3	42	788.0	317.2	24	443.5	239.7
HK 6	12	125.8	55.3	42	788.0	317.2	24	443.5	239.7
Av	12	125.8	55.3	42	788.0	317.2	22.5	422.27	224.5
Sd	0.00	0.00	0.00	0.00	0.00	0.00	2.17	35.49	22.40
Cv	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.10
II sowing date- 2014.									
Pheno phase	**Silking-Apperance of a black layer**			**Apperance of a black layer – Full maturity**			**Sowing – Full maturity**		
Hyb maize	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**
HK 1	41	801.4	396.8	27	524.7	247.3	142	2618.8	1215.1
HK 2	43	814.7	417.0	27	530.5	255.1	144	2637.9	1218.1
HK 3	44	855.9	429.8	30	581.2	283.8	150	2777.2	1305.2
HK 4	47	916.1	461.4	37	646.2	311.6	163	2938.6	1396.4
HK 5	47	889.2	457.0	38	659	315.4	163	2905.5	1384
HK 6	48	908.9	467.6	38	662.1	317.2	164	2927.4	1397
Av	45	864.4	438.3	32.8	600.6	288.4	154.3	2800.9	1319.3
Sd	2.52	48.54	28.25	5.42	63.75	31.36	10.21	145.7	86.56
Cv	0.06	0.06	0.06	0.17	0.11	0.11	0.07	0.05	0.07

Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, Sd - Standard deviation, Cv – Coefficient of variation*

In the second sowing period (Table 3), the sowing-sprouting phase lasted 12 days with the achieved SUT 125.87 °C and SET 55.3 °C. In the second sowing period, the emergence-10th leaf phase lasted 42 days (SUT-788.0 °C, SET-317.2 °C). The 10th leaf-silking phase in the second sowing period lasted from 20-25 days (SUT 378 °C- 462 °C and SET 198.8-250.9 °C).

In the second sowing period, the silking-appearance of the black layer phase lasted 41-48 days depending on the hybrid, with SUT 801.4-908.9 °C, while SET was measured 396.8-467.6 °C.

In the second sowing time, the black layer appearance-full maturity phase lasted 27-38 days (SUT 524.7-662.1 °C, with measured SET 247.3-317.2 °C). Hybrid ZP 434 had the shortest vegetation period (142 days, SUT 2,618.8 °C, and SET 1,215.1 °C). The longest vegetation period in the second sowing period was hybrid NS 6030, (164 days with achieved SUT 2,927.4 °C and SET 1.397 °C.

The sowing-emergence phase in the third sowing period (table 4) lasted 8 days (SUT-113.5 °C, SET-50.3 °C), and the emergence-10th leaves phase in the third

sowing period lasted 37 days with the achieved SUT 866.2 °C and SET 327.4 °C. Depending on the sowing dates, a different number of days were required for the phase, while the SET was approximately the same.

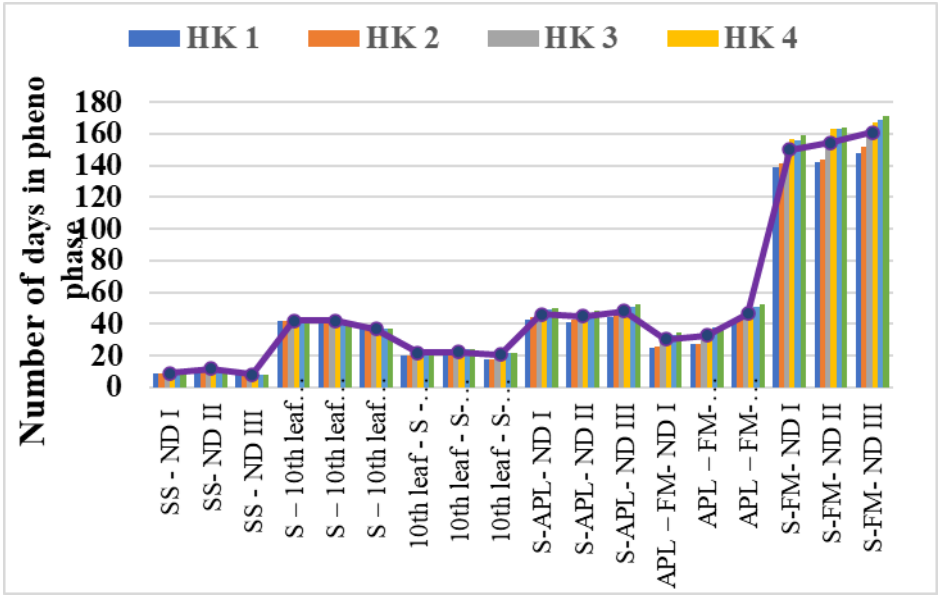
In the third sowing period (Table 4) the phase of the 10th leaf until silking lasted 18-23 days (SUT 364 °C-447 °C and SET 194-246.3 °C). In the third period of sowing, the silking-appearance of the black layer phase lasted 44-52 days, with the achieved SUT 820.5-913.3 °C, and SET 404.7-474.9 °C. In the third sowing period, the phase of appearance of the black layer-full maturity lasted 41-52 days (with achieved SUT 515.2-673 °C, and SET 251.9-319.8 °C).

Table 4. Duration of certain phases in certain hybrids of maize in the 3rd sowing period

Pheno phase	**Sowing - Sprouting**			**Sprouting – 10th leaf**			**10th leaf - Silking**		
Hyb maize	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**
HK 1	8	113.5	50.3	37	866.2	327.4	18	364	194
HK 2	8	113.5	50.3	37	866.2	327.4	18	364	194
HK 3	8	113.5	50.3	37	866.2	327.4	20	404.5	214.5
HK 4	8	113.5	50.3	37	866.2	327.4	23	447.3	246.3
HK 5	8	113.5	50.3	37	866.2	327.4	22	445.3	235.3
HK 6	8	113.5	50.3	37	866.2	327.4	22	445.3	235.3
Av	8	113.5	50.3	37	866.2	327.4	20.5	411.7	219.9
Sd	0.00	0.00	0.00	0.00	0.00	0.00	2.17	40.32	22.55
Cv	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10	0.10
III sowing date - 2014.									
Phenoph ase	**Silking-Apperance of a black layer**			**Apperance of a black layer – Full maturity**			**Sowing – Full maturity**		
Hyb maize	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**	**ND**	**SUT (°C)**	**SET (°C)**
HK 1	44	820.5	404.7	41	515.2	251.9	148	2679.4	1223.3
HK 2	46	847.5	427.9	43	544.7	265.8	152	2735.9	1228.8
HK 3	48	867.8	440.3	45	559.2	291.6	158	2820.9	1293.5
HK 4	51	909.4	470.0	48	602.8	307.2	167	2939.2	1401.1
HK 5	51	897.3	466.3	51	653.6	315.1	169	2975.9	1394.4
HK 6	52	913.3	474.9	52	673	319.8	171	3011.3	1403.0
Av	48.0	876.0	447.4	46.7	591.4	291.9	160.8	2860.4	1324.0
Sd	3.20	37.20	27.85	4.41	62.74	27.68	9.58	135.75	86.34
Cv	0.07	0.04	0.06	0.09	0.11	0.09	0.06	0.05	0.07

Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, Sd - Standard deviation, Cv – Coefficient of variation*

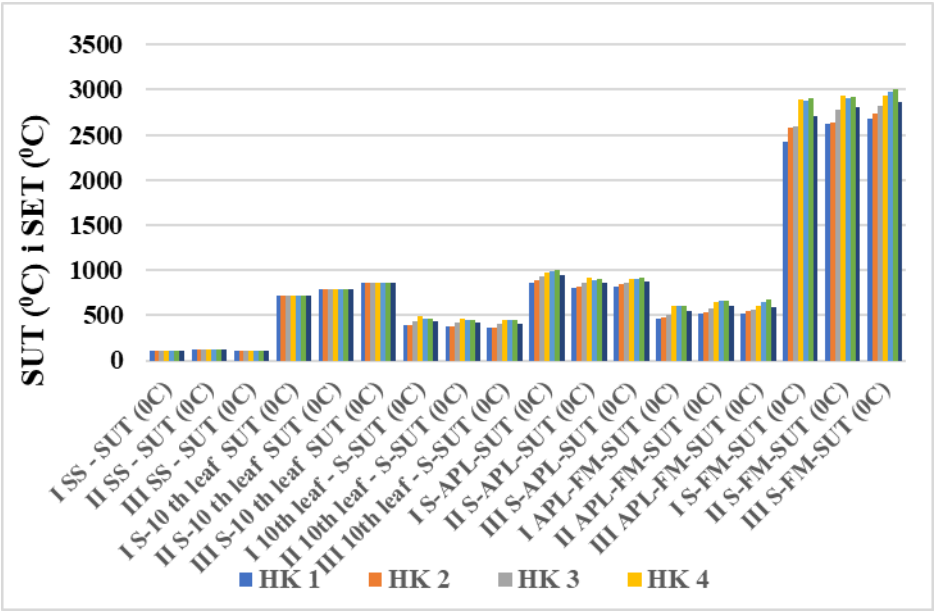
The total vegetation period in the third sowing period lasted from 148-171 days (with achieved SUT 2,679.4-3,011.3 °C, i.e. SET 1,223.3-1,403 °C). The shortest vegetation period in the third sowing period was recorded in hybrid ZP 434 vegetation lasted 148 days, (SUT 2,679.4 °C, and SET 1223.3 °C).



Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, SS - Sowing – Sprouting, S-10 th leaf - Sprouting – 10 th leaf, 10 th leaf -S -10th leaf – Silking, S-APL- Silking-Apperance of a black layer, APL-FM- Apperance of a black layer – Full maturity, S-FM- Sowing – Full maturity*

Graph 1. Length of individual phenological phases in days

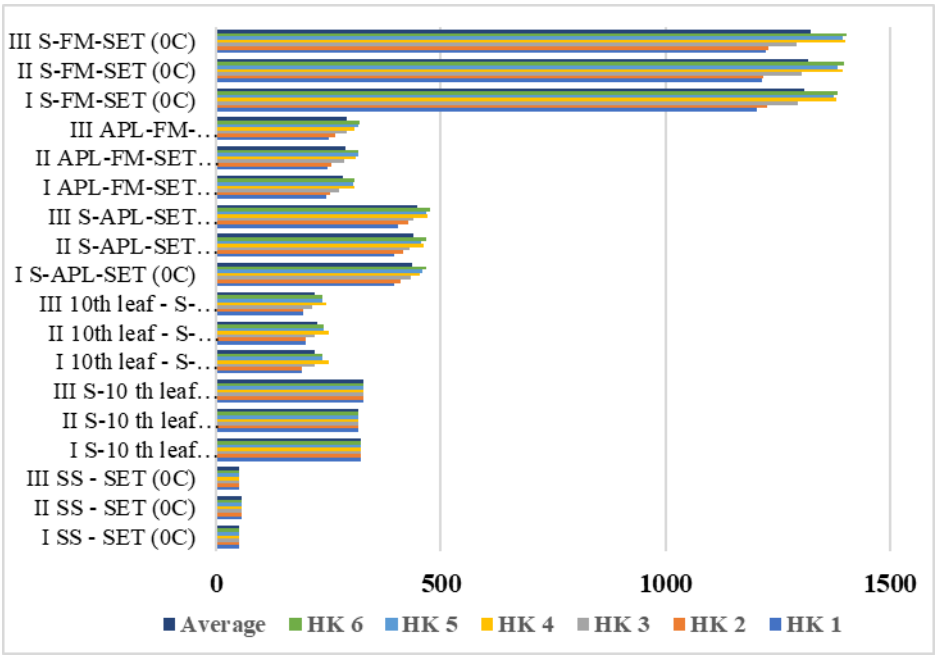
During 2014, observing the different sowing dates, we note that the duration of individual phenological phases as well as the total vegetation period in days differed from each other (Graph 1). In the first sowing date, the total vegetation period lasted 139-159 days, depending on the hybrid, while in the second sowing date the total vegetation period lasted 142-160, and in the third 148-171 days. The research is in agreement with other researchers who found that measuring the length of vegetation in days is the least reliable method. The outdated classification of the duration of individual phenological phases and the total vegetation of corn according to the required number of days from sprouting to ripening proved to be insufficiently reliable because it is correlated with average temperatures and precipitation during the growing season (Jovanović et al., 2002). The greatest variations in the length of vegetation in the number of days between deadlines were determined in the periods when the greatest temperature oscillations were observed.



Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, SS - Sowing – Sprouting, S-10 th leaf - Sprouting – 10 th leaf, 10 th leaf -S -10th leaf – Silking, S-APL- Silking-Apperance of a black layer, APL-FM- Apperance of a black layer – Full maturity, S-FM- Sowing – Full maturity*

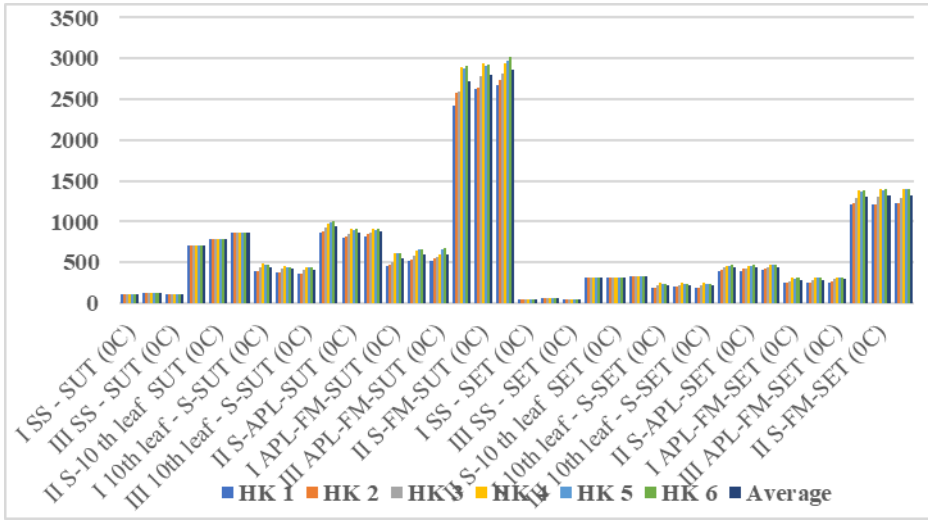
Graph 2. SUT (°C) and SET (°C)

Graph 2 shows data on the duration of individual phenological phases during the examined period in SUT/SET. In the first sowing date, SUT ranged from 2420.04-2902.8 °C, and SET 1203.0-1380.9 °C, depending on the hybrid, while in the second sowing date, SUT was measured 2618.8-2927.4 °C and SET 1215.1-1397 °C. In the third sowing date of 2014 (Graph 3), the measured SUT ranged from 2679.4 to 3011.3 °C, and SET 1223.3-1403.0 °C observed by hybrids (Graph 4). The research is in line with the research results of Biberdžić et al., (2000) who state that the most accurate method of determining the length of the maize vegetation period is the method of the sum of effective temperatures.



Legend: *HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, SS - Sowing – Sprouting, S-10 th leaf - Sprouting – 10 th leaf, 10 th leaf -S -10th leaf – Silking, S-APL- Silking-Apperance of a black layer, APL-FM- Apperance of a black layer – Full maturity, S-FM- Sowing – Full maturity*

Graph 3. Number of days phenological phases



Legend: HK1 - ZP 434, HK2 - NS 4023, HK3 - ZP 555, HK4 - NS 5051, HK5 - ZP 666, HK6 - NS 6030, ND-number of days, SS - Sowing – Sprouting, S-10 th leaf - Sprouting – 10 th leaf, 10 th leaf -S -10th leaf – Silking, S-APL- Silking-Apperance of a black layer, APL-FM- Apperance of a black layer – Full maturity, S-FM- Sowing – Full maturity

Graph 4. Phenological phases in research period

Conclusion

Observed by sowing dates, during 2014 the vegetation period lasted differently, depending on the hybrid and the sowing date. Depending on the time of sowing, the difference in the length of vegetation between the hybrid with the shortest and the hybrid with the longest vegetation period was 32 days, while the difference in SUT 591.3 °C and SET 200 °C was determined.

The ZP 434 (FAO 400) hybrid had the shortest average vegetation period in all three sowing dates in 2014, and the NS 6030 (FAO 600) hybrid had the longest vegetation period. The shortest vegetation period for all hybrids was recorded in the first sowing date, and the longest vegetation period in the third sowing date.

When choosing a maize hybrid for sowing, it should be borne in mind that different maize hybrids have different lengths of vegetation, and the sowing plan and selection of corn hybrids should be adapted to the production conditions.

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DUŽINA TRAJANJA POJEDINIH FENOLOŠKIH FAZA RAZLIČITIH HIBRIDA KUKURUZA U ZAVISNOSTI OD ROKA SETVE

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Apstrakt

Ogled je sproveden tokom 2014. godine na području Leskovca, na zemljištu tipa aluvijum. U periodu istraživanja praćena je dužina trajanja pojedinih fenoloških faza i celog perioda vegetacije pojedinih hibrida kukuruza. Kao biljni materijal korišćeno je 6 hibrida kukuruza, tri FAO grupe zrenja (400-600). Cilj istraživanja je bio da se na osnovu broja dana, sume ukupnih, i sume efektivnih temperatura utvrdi dužina trajanja pojedinih fenoloških faza, kao i cele vegetacije pojedinih hubrida kukuruza. Tokom ispitivanog perioda, u sva tri roka setve razlika u dužini vegetacije između hibrida sa najdužim i hibrida sa najkraćim vegetacionim periodom bila je 32 dana, dok je utvrđena razlika u SUT 591.3 0C, a SET 200 0C. Prosečno najkraći period vegetacije u sva tri setvena roka tokom 2014. godine imao je hibrid ZP 434 (FAO 400), a najduži period vegetacije imao je hibrid NS 6030 (FAO 600). Posmatrano po hibridima i rokovima setve, svi hibridi su imali najkraći period vegetacije u prvom setvenom roku, a najduži u trećem setvenom roku. Kao najpouzdaniji metod za određivanje dužine vegetacije pojedinih hibrida kukuruza istakao se metod sume efektivnih temperatura, a najmanje precizan metod na osnovu broja dana.

Ključne reči: *Ukupne temperature vazduha, efektivne temperature vazduha, kukuruz, dužina vegetacije, rok setve.*

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