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PHENOLOGICAL DEVELOPMENT OF SUNFLOWER HYBRIDS GROWN UNDER CONTRASTING AGROECOLOGICAL CONDITIONS

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Abstract. *The experiment was set up using a block method in 4 replications after a wheat predecessor in the fields of two different ecological regions – Thrace (Plovdiv region) and Dobrudja (Dobrich region), Bulgaria. Six sunflower hybrids were studied – P64LP170, breeded in Corteva, USA as a standart, and Bulgarian hybrids Dalena, Deveda, Enigma, Krasela and Sunny, breeded at the Dobruja Agricultural Institute - General Toshevo. For the purpose of the study, the occurrence of the main phenological phases have been recorded: sowing (V0), germination (VE), second pair of leaves (V2), the fourth pair of leaves (V4), budding (R1),beginning of flowering (R5), end of flowering (R6) and ripening(R9). Depending on the dates of the phenological phases, the duration of the interphase periods is calculated. Each of the phenological phases occurs to a different extent earlier in the Plovdiv region than in the Dobrich region, which is completely explainable, because of the later warming in Northern Bulgaria than in Southern Bulgaria. Of primary importance for the development of sunflower is the duration of the interphase periods, which is a consequence of the meteorological conditions of the year and the region and of the genotypic differences between individual sunflower hybrids. The interphase period sowing-germination has a very different duration in the two regions in the first year. The reason for the long germination period in Southern Bulgaria is the low temperatures in March. The remaining interphase periods do not differ significantly between the two regions, nor between the hybrids. In the second year of the study, the interphase periods did not differ significantly, both between the two regions and between the hybrids until the moment of the latter.*

Keywords*: sunflower, phenology, agroecology,*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an annual plant. Its botanical name *Helianthus* comes from the Greek words helios (sun) and anthos (flower). It is a diploid species (2n = 34) that belongs to the suborder *Helianthineae*, section *Helianthea*, subfamily *Asteroideae*, and family *Compositae* (*Asteraceae*) (PANERO and FUNK, 2002; FERNÁNDEZ-MARTÍNEZ ET AL., 2010). The genus *Helianthus* originated in the temperate steppe of North America and contains 14 annual and 37 perennial species (SCHILLING, 2006). Soon after the discovery of America, Spanish explorers brought the sunflower to Europe, to the botanical gardens in Madrid. This most likely happened during the Spanish expedition in 1510 (HEISER, 1955; PUTT, 1997; SEILER & GULYA, 2016). The first published record of the sunflower appears in 1568 by the Belgian Rembert Dodoens, one of the famous herbalists of the era. After its introduction to Europe, the sunflower was used only as an ornamental plant for more than two centuries (GARAPOVA and KIRCHEV, 2021; TARIQ ET AL., 2018; PARK & BURKE, 2020).

The first attempt to use the sunflower as an oil crop was the registration of a patent for extracting oil from sunflower seeds for industrial use in 1716 in England. Sunflower is now one of the four most important oilseed crops in the world (along with palm, soybean and rapeseed) and one of the two most important oilseed crops in Europe, along with rapeseed. In contrast to other vegetable oils, about 90% of the total sunflower oil production is used for human consumption and only 10% is used for industrial purposes. It is grown on 25.56 million hectares, with an annual global production of about 40.64 million tonnes of seeds (U.S.

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DEPARTMENT OF AGRICULTURE, 2013), with a slight upward trend in both production area and seed production due to increasing seed yield per unit area (KAYA et al., 2012). The largest sunflower producers in the world are Russia with 7.20 million ha and Ukraine with 5.80 million ha. These two countries provide more than 50% of the total global sunflower production (JOCIĆ et al., 2015).

MATERIAL AND METHODS

The experiment was set up using a block method in 4 replications after a wheat predecessor in the fields of two different ecological regions – Thrace (Plovdiv region) and Dobrudja (Dobrich region), Bulgaria. Six sunflower hybrids were studied – P64LP170, breeded in Corteva, USA as a standart, and Bulgarian hybrids Dalena, Deveda, Enigma, Krasela and Sunny, breeded at the Dobruja Agricultural Institute - General Toshevo.

For the purpose of the study, the occurrence of the main phenological phases have been recorded according to Schneiter & Miller scale (ROBINSON, 1971; SCHNEITER and MILLER, 1981; HAMMER ET AL., 1982): sowing (V0), germination (VE), second pair of leaves (V2), the fourth pair of leaves (V4), budding (R1),beginning of flowering (R5), end of flowering (R6) and ripening(R9). Depending on the dates of the phenological phases, the duration of the interphase periods is calculated.

The meteorological conditions during the two years, as well as the long-term averages in both study areas, are described in another of our studies (TANCHEV and GEORGIEV, 2025).

RESULTS AND DISCUSSIONS

Each of the phenological phases occurs to a different extent earlier in the Plovdiv region than in the Dobrich region, which is completely explainable, as a result of the later warming in Northern Bulgaria than in Southern Bulgaria. Sowing in the first year of the study in Plovdiv was done on 24.03.2023, and in Dobrich - on 04.05.2023. Germination in Plovdiv began on 13.04 with hybrid P64LP170, and Sunny sprouted the latest - on 22.04. The reason for the large differences in germination in the Plovdiv region are the sharp temperature fluctuations in March, when sowing was carried out in suitable temperature conditions, but the subsequent sharp cooling after sowing also led to a reaction of the hybrids in terms of germination speed. In the Dobrich region, due to the later sowing and relatively stable temperature conditions in May, germination was recorded with small differences between the hybrids - the hybrids P64LP170, Dalena, Krasela and Sunny sprouted first and simultaneously, and a day or two later - Deveda and Enigma.

The formation of a second pair of leaves in Plovdiv was recorded at the end of April for P64LP170 and at the beginning of May for the other hybrids. In the Dobrich region, the same phenophase was recorded at the end of May, with the exception of the Enigma hybrid (02.06.2023). The next vegetative phenophase – formation of a fourth pair of leaves in Plovdiv takes place during the period 10-19 May, and in Northern Bulgaria – between 11-15 June.

The beginning of the reproductive period (R1) of sunflower development is recorded with the onset of the budding phase – between May 24 and June 5 in Southern Bulgaria and June 26-29 in Dobrudzha. Flowering in Plovdiv begins between June 13-21 and ends between June 25 - July 4. In Northern Bulgaria, flowering is recorded between July 10-15 and July 24-27.

Full maturity of the plants in the region of Southern Bulgaria was registered in August, with the earliest maturing hybrid in this ecological region being P64LP170, followed by the hybrids Dalena, Krasela, Sunny, Deveda and Enigma. In Dobrudzha, maturation was established in

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September, with Krasela and Sunny maturing earliest, followed by P64LP170, Dalena, Deveda and Enigma.

Table1

Dates of occurrence of the phenological phases of sunflower development

Stage	Region	Hybrids											
		P64LP170		Dalena		Deveda		Enigma		Krasela		Sunny	
		2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
V0	Plovdiv	24.03	02.05	24.03	02.05	24.03	02.05	24.03	02.05	24.03	02.05	24.03	02.05
	Dobrich	04.05	27.04	04.05	27.04	04.05	27.04	04.05	27.04	04.05	27.04	04.05	27.04
VE	Plovdiv	13.04	14.05	18.04	10.05	21.04	10.05	21.04	12.05	21.04	14.05	22.04	11.05
	Dobrich	17.05	10.05	17.05	10.05	18.05	11.05	19.05	12.05	17.05	11.05	17.05	10.05
V2	Plovdiv	25.04	28.05	02.05	22.05	05.05	22.05	05.05	26.05	04.05	28.05	06.05	23.05
	Dobrich	30.05	23.05	30.05	23.05	31.05	23.05	02.06	26.05	30.05	24.05	30.05	23.05
V4	Plovdiv	10.05	11.06	14.05	04.06	17.05	04.06	17.05	08.06	19.05	08.06	18.05	06.06
	Dobrich	12.06	04.06	11.06	04.06	14.06	07.06	15.06	08.06	13.06	05.06	12.06	05.06
R1	Plovdiv	24.05	26.06	30.05	22.06	03.06	22.06	05.06	26.06	04.06	24.06	01.06	20.06
	Dobrich	27.06	20.06	27.06	20.06	29.06	25.06	27.06	23.06	26.06	23.06	27.06	22.06
R5	Plovdiv	13.06	11.07	16.06	09.07	18.06	07.07	21.06	12.07	21.06	11.07	18.06	07.07
	Dobrich	15.07	05.07	13.07	04.07	14.07	05.07	13.07	06.07	10.07	04.07	12.07	05.07
R6	Plovdiv	25.06	25.07	29.06	20.07	04.07	20.07	01.07	24.07	02.07	24.07	01.07	22.07
	Dobrich	27.07	17.07	24.07	16.07	25.07	17.07	25.07	18.07	25.07	16.07	26.07	18.07
R9	Plovdiv	08.08	28.08	15.08	30.08	20.08	25.08	20.08	25.08	17.08	25.08	19.08	28.08
	Dobrich	14.09	06.09	14.09	06.09	15.09	07.09	15.09	06.07	13.09	07.07	13.09	07.07

Sowing in the second year of the study in Plovdiv was done on 02.05.2024, and in Dobrich – on 27.04.2024. Germination in Plovdiv began on 10.05 with the hybrids Dalena CLP and Deveda, and Krasela and Sunny IMI CLP sprouted the latest – on 14.05. Unlike the previous year, the provision of moisture and suitable temperatures helped the hybrids to sprout together in an interval of three to four days. Germination in the Dobrich region was also registered with small differences between the hybrids, with P64LP170, Sunny IMI CLP and Dalena CLP sprouting first on 10.05, and the other hybrids a day or two later.

In 2024, the formation of a second pair of leaves in Plovdiv was first recorded on 22.05 in the hybrids Dalena CLP and Deveda, and lastly in Krasela and P64LP170 on 28.05. In the Dobrich region, the same phenophase was recorded on 23.05 in P64LP170, Dalena CLP, Deveda and Sunny IMI CLP, and in the hybrids Enigma and Krasela on 26.05 and 24.05. The next vegetative phenophase – formation of a fourth pair of true leaves in Plovdiv takes place during the period 4-11 June, and in the Dobrich region – between 4-8 June.

Last year in the Plovdiv region, the reproductive period of the crop development began earliest with the Sunny IMI CLP hybrid on 20.06, followed by Dalena CLP and Deveda – 22.06, Krasela – 24.06 and P64LP170 and Enigma – 26.06. In Dobrudzha, the budding phenophase began earliest with the P64LP170 and Dalena CLP hybrids – 20.06, followed by Sunny IMI CLP – 22.06, Enigma and Krasela – 23.06 and last with Deveda – 25.06. Flowering in Plovdiv began between 9-12.07 and ended between 20-25.07. In 2024, flowering in Northern Bulgaria was recorded between 4-6.07 and 16-18.07.

Full maturity of the plants in the past year in the region of Southern Bulgaria was registered again in August, with the earliest ripening in this region and year being Deveda, Enigma and Krasela, followed by Sunny IMI CLP and P64LP170 and lastly Dalena CLP. In Dobruja, ripening occurs at the beginning of September, with P64LP170, Dalena CLP and Enigma ripening first, and the remaining hybrids a day later.

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Of primary importance for the development of sunflower is the duration of the interphase periods, which is a consequence of the meteorological conditions of the year and the region and of the genotypic differences between individual sunflower hybrids.

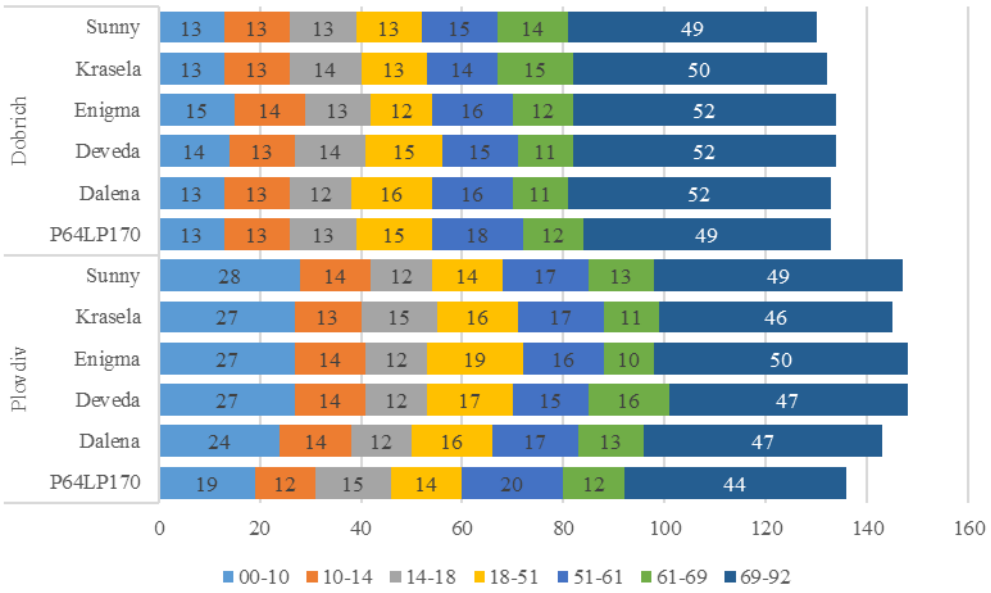

Figure 1. Duration of interphase periods – 2023

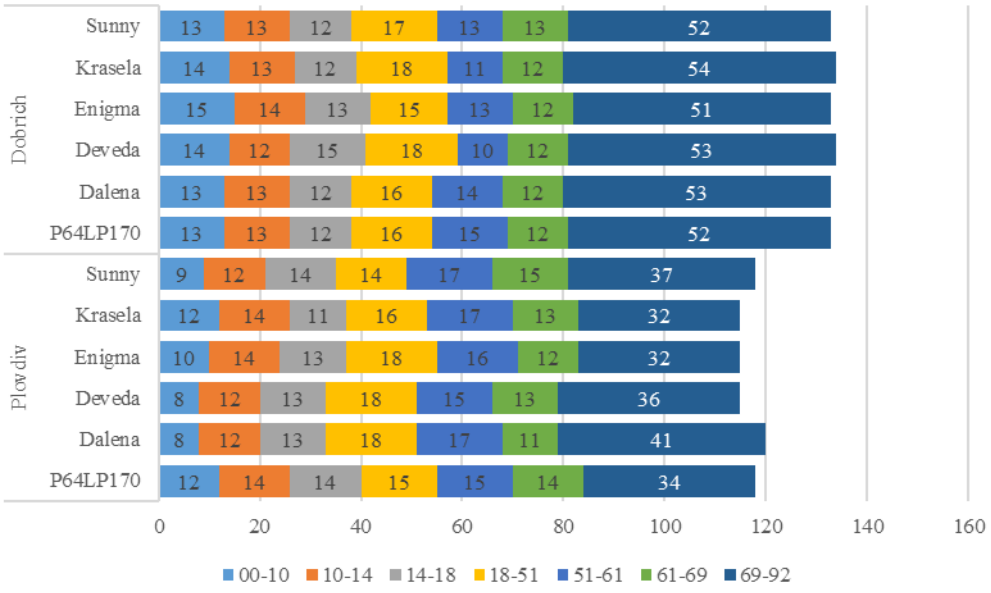

Figure 2. Duration of interphase periods - 2024

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The interphase period sowing-germination has a very different duration in the two regions – in Dobrich it lasts 13-15 days, while in the Plovdiv region it lasts 19-28 days. The reason for the long germination period in Southern Bulgaria is the low temperatures in March. The remaining interphase periods do not differ significantly between the two regions, nor between the hybrids. Although the ripening in Plovdiv is about a month earlier than in Dobrich, due to the long germination, the vegetation period in Southern Bulgaria is between 136-138 days, while in Dobrudzha the sunflower vegetation is between 130-134 days (Fig. 1).

In the second year of the study, the interphase periods did not differ significantly, both between the two regions and between the hybrids until the moment of the latter. Figure 2 clearly shows that the ripening period in the Plovdiv region is between 12-22 days shorter than that in the Dobrich region, with the largest difference being for the Krasela hybrid and the smallest for Dalena CLP. This difference is due to the extremely warm summer and the lack of precipitation of economic importance during the period in the Plovdiv region. Last year, the growing season in Southern Bulgaria was between 115-120 days, while in the Dobruja region it lasted 133-134 days.

CONCLUSIONS

Each of the phenological phases occurs to a different extent earlier in the Plovdiv region than in the Dobrich region, which is completely explainable, as a result of the later warming in Northern Bulgaria than in Southern Bulgaria. Of primary importance for the development of sunflower is the duration of the interphase periods, which is a consequence of the meteorological conditions of the year and the region and of the genotypic differences between individual sunflower hybrids. The interphase period sowing-germination has a very different duration in the two regions in the first year. The reason for the long germination period in Southern Bulgaria is the low temperatures in March. The remaining interphase periods do not differ significantly between the two regions, nor between the hybrids. In the second year of the study, the interphase periods did not differ significantly, both between the two regions and between the hybrids until the moment of the latter.

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