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Seed Protein and Oil Content of the Soybean Cultivars under Different Climate Condition *(Glycine max* (L.) *Merr.)*

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Abstract: Polymorphism in the collection of soybean cultivars (Glycine max (L.) Merr.) of maturation groups II and III has been studied in field experiments on oil content in the grain, depending on vegetation weather conditions. Cultivars of both groups differed on this factor - oil level in the grain in the studied populations ranged from 19 to 27%. Soybean cultivars with stable oil content under changing weather conditions have been selected during the study.

Key words: *Glycine max* (L.) Merr · Maturity group · Rate of development · Oil content · Environmental factors · Polymorphism

INTRODUCTION

Soybean is a leading crop among oilseeds on the amount of oil produced from its seeds, both on its qualitative characteristics and properties. The share of soybean oil in the total world production of vegetable oils is up to 50 %. Soybean seed contains 25% of high quality oil. It is widely used directly in food, is a raw material for food processing, canning, pharmaceutical industry, is widely used in paint, cosmetics and chemical industries. Of particular value soybean oil is for human nutrition, as it is related to the biologically most valuable fats. It contains several vitamins and other biologically active substances, has a number of medicinal and pharmaceutical properties [1-3].

The main way to increase oil extraction is to breed cultivars with high and stable oil content in the seeds. To create such cultivars, we have to study and identify the source material with high oil content that does not depend on environmental factors. However, this problem has not been studied properly yet [2-4].

The purpose of the work was to analyze a collection of soybean cultivars (*Glycine max* (L.) *Merr*.) in different groups of maturity for oil content in seeds during the years that differ in conditions of vegetation.

MATERALS AND METHODS

22 cultivars from the collection of the National Center for Genetic Resources of Ukraine in maturity group II (MG II) and 18 cultivars in maturity group III (MG III) have been chosen as the object of the study of different ecological -geographical origin (Ukraine, Russian, Belarus, Poland, France, Sweden, USA, Canada, China).

Plants were grown under field conditions at the experimental plot of Department of Plants Physiology and Biochemistry at V.N.Karazin Kharkov National University during the growing seasons of 2010 and 2011. Sowing was performed at optimal time (1-2 decade of May), with inter-row spacing of 30 cm, seeding rate of 600 thousand of viable seeds per 1 h a. The area of the account plot was 1 m ^{2}. Each soybean cultivar was grown in three replicates in randomized complete blocks on each site.

The experimental plot is located in the south-eastern steppe of Ukraine (Kharkov - 50°00 'north latitude and 36°15' east longitude). The soil in the area is a strong black soil, pH 5,6-6,0, nitrogen content-0.29%, phosphorus-0.17%, potassium - 1.95%. The climate of the region is temperate continental, the average annual temperature is + 7,8°C, the duration of the growing season - 198 days, the average annual rainfall 511 mm with variations from year to year from 263.0 to 805, 0 mm.

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Table 1: Average monthly temperature, rainfall and the sum of effective temperatures during the experimental years (Kharkov, Ukraine 50°nil. 36°15' el)

Month	2010	2011
	Average monthly temperature, °Ñ	
April	10,7	9,8
May	13,9	16,7
June	17,5	23,2
July	22,1	21,8
August	21,0	20,8
September	20,5	15,1
	The sum of rainfall, mm	
АПрелль	34,4	28,71
April	87,7	21,1
May	40,8	121,2
June	35,3	40,8
July	23,1	24,0
August	9,0	67,6
September	230,1	456,0
	The sum of effective temperatures, °Ñ (>10 °Ñ)	
АПрелль	58,8	72,3
April	140,6	219,0
May	224,6	397,7
June	386,0	363,8
July	347,8	319,2
August	315,4	158,6
September	1536,5	1527,5

The weather conditions during the studies are given in Table 1. Growing season 2010 was characterized by lower rainfall, but higher temperatures than the vegetation period in 2011. During seed ripening and maturation (August-September) in 2010, the air temperature was higher and precipitation was less than in 2011 (Table 1).

During the growing season phenological observations were carried out, noting the date of transition to flowering plants and the full maturation of the beans.

To determine the oil content a standard Rushkovsky gravimetric method was used [5]. Oil was extracted from the crushed seeds with sulfur ethyl ether three times in a Soxhlet apparatus. We determined the percentage of oil from the dry weight of seeds. All analyzes were performed in a two-time replication, the results have been processed statistically. Differences between cultivars on oil content were assessed by the criterion of LSD 0,5 and t (Student) at $P \leq 0,5$.

RESULTS

Maturity group II. The study results of phase duration shoots-flowering in MG II cultivars have shown that during both years of studies they differed in this parameter (Table 2). In 2010, the earliest flowering showed

Table 2: The duration of phase shoots-flowering, growing season and the oil content of soybean seed in the maturity group II

		Shoots-flowering, Day		Growing Season, Day		Oil Content, %	
Country of Origin	Cultivars	2010	2011	2010	2011	2010	2011
Ukraine	Nika	44	43	99	104	21,3	20,0
Russian	Soer 85-88	46	45	99	98	22,1	21,0
	Soer - 4	41	43	105	107	22,0	21,4
	Evans - 462	44	43	97	98	25,0	24,1
	USHI - 6	41	42	105	100	24,1	23,1
	Zakat	44	43	108	109	22,1	19,9
Belarus	Berezina	43	41	90	99	25,3	22,0
	Severnaya zvezda	44	47	95	99	25,7	25,0
	Snezhok	40	39	95	100	21,1	21,0
	ÑÍ – 23-42	36	34	95	100	21,1	21,5
	Alta	40	34	95	100	21,3	22,5
Poland	FL - 19	49	43	99	100	24,0	22,0
	Polan	41	36	88	97	23,5	22,0
	Aldana	38	36	99	101	24,0	22,5
	IHAR – NK	38	39	91	100	22,5	21,3
France	Major	38	34	95	100	23,2	22,0
Sweden	Fiskeby III	41	43	94	100	22,0	21,2
	Fiskeby V	41	39	85	99	22,4	21,0
Canada	073-2	42	43	97	98	23,0	21,1
	Maple Donovan	49	47	113	110	23,0	21,3
	Maple Isle	41	39	110	110	22,1	20,0
	Maple Ridge	34	34	110	110	23,0	19,5
$\bar{x}$		41,6	40,3	98,4	101,8	22,9	21,6
$LSD_{0,5}$		1,64	1,85	1,85	1.95	0,60	0,58

Table 3: The duration of phase shoots-flowering, growing season and the oil content of soybean seed in the third maturity group

		Shoots-flowering, Day		Growing Season, Day		Oil Content, %	
Country of Origin	Cultivars	2010	2011	2010	2011	2010	2011
Ukraine	Kievskaya 27	41	43	123	115	22,0	23,0
	Chernyatka	49	49	120	117	24,0	19,0
	Ustya	41	41	115	110	23,5	21,5
Russian	Soer-3	41	42	110	120	23,1	22,0
	Soer-3491	53	52	120	117	26,0	24,3
	CH 23-94	42	39	103	115	24,0	24,0
Belarus	Yaselda	50	47	115	110	23,1	22,5
	Stviga	43	41	115	110	24,1	24,0
	Pripyat	41	39	115	110	21,5	22,0
	CH 1470-20-1	49	47	125	115	24,5	24,0
Czech republic	UO 8-491	53	53	123	115	22,0	20,5
Germany	Lilablute	45	47	123	116	22,1	20,5
France	Sito	36	39	104	100	23,0	21,5
Canada	Gentleman	41	39	115	110	25,1	25,0
	FL-1	43	42	123	117	25,1	22,0
	PS-3008-1	41	42	120	117	27,0	22,0
China	Ke-Shuang	49	46	120	115	23,2	24,0
	Victoriya	53	53	123	117	24,0	24,1
$\bar{x}$		45,1	44,5	14,3	113,7	23,7	22,6
$LSD_{0,5}$		2,58	2,43	3,22	2,30	0,72	0,80

varieties of Aldana, CH - 23-42, IHAR - NK, Major (after 36-38 days, respectively). The latest bloom was noticed by varieties: Soer 85-88, FL - 19, Maple Donovan (after 46-49 days after shoots, respectively). The variation of this indicator (min ÷ max) was 13 days, with average duration of phase shoots-flowering - 41.6 days (Table 2). In 2011, most cultivars of this group significantly changed the duration of the phase shoots-flowering in comparison with 2010. Some varieties bloomed 5-6 days earlier in 2011 than in 2010 (Alta, Fl-19, Polan). The variation of this indicator in 2011 was 14 days with average of 40.3 days (Table 2). In general, populations of MG II varieties bloomed somewhat earlier in 2011, than in 2010.

Having studied the duration of the growing season for two years, we noticed that MG II cultivars showed some distinctions. Their growing season ranged from 85 to 113 days in population in 2010 and from 97 to 110 days in 2011. In 2011 most of the varieties matured 1-5 days later than in 2011 and varieties Berezina, Polan, IHAP-NK, Fisheby V - 9 and 14 days, respectively (Table 2). Two varieties of this group (MapleIsle and MapleRidge) matured simultaneously in both years of the research. The average duration of the growing season in the population cultivars in 2010 was lower than in 2011 (Table 2).

The study of the oil content in MG II seeds varieties has shown that in both years of research it depended on the variety genotype and varies from 19.5% to 25.7%. Thus, in 2010 a group of varieties with a relatively low oil content (21.1 - 21.3% - 4 cultivars), middle (22.0 -23.5% - 12 cultivars) and high (24.0-25.7% - 6 cultivars) was selected. The latter group includes varieties Evans-462-6 USKHI, Berezina, North Star, Fl-19 and Aldana (Table 2). In 2011, the overall level of oil in seeds varieties in this group was lower than in 2010. At the same time cultivars groups graduation changed on the level of oil in the seeds: a group with a relatively low content (19,5-20,0% - 3 varieties), middle (2 1,0-22,5% - 16 varieties) and high (23-25% - 3 varieties). The latter group includes varieties of Evans-462, USKHI-6, Severnaya zvezda (Table 2).

Group maturity III. The duration of phase shoots - flowering for varieties of third group maturity, in both years of study was greater than that of varieties of MG II (Table 3). The average duration of the phase shoots-flowering in population of this group varieties in 2010 and 2011 amounted 45.1 and 44.5 days in a big variation (min ÷ max) 17 and 14 days respectively (Table 3). The earliest flowering was in cultivar Sito in 2010 and 2011 - t 36 and 39 days later after germination, respectively. The vast majority of varieties of this maturity group in both years of research blossomed in 41-43 days after germination. The latest blooms (after 46-52 days after shoots) was observed for the varieties: Ke-Shuang, Chernyatka, Soer, 3491, Yaselda, CH 1470-20-1, Lilablute, Victoria (Table 3). In general, the population of this group of varieties bloomed in 2011 earlier than in 2010 (Table 3).

Table 4: Influence of weather conditions on the expression of varying levels of oil in seed cultivars of different maturity groups

			Statistical indicators					
Oil content	n†	Year	x, %	d, %	Sd	t_{05}		LSD_{05}
				Maturity group II				
Stable	5	2010	22,4					
		2011	22,0	-0,40	0,23	1,47	2,78	0,64
Variable	17	2010	23,1					
		2011	21,5	-1,60	0,25	6,30	2,12	0,53
				Maturity group III				
Stable	6	2010	23,9					
		2011	23,8	-0,1	0,13	0,13	2,57	0,34
Variable	12	2010	23,7					
		2011	21,9	-1,8	0,54	3,27	2,20	1,19

n†- number of varieties

MG III varieties (Table 3) the growing season ranged from 103 to 125 days in 2010 and from 100 to 120 days in 2011 with average of 117.3 and 113.7 days, respectively, according to the years (Table 3). Of the 18 varieties tested in this group in the 2011 a growing season was reduced by 16 varieties (3-10 days) and only two cultivars (Soer-3 and CH 23-94) increased its duration by 10 and 12 days respectively, compared to 2010 (Table 3). In general, the duration of growing season in 2011 for the population of this group of varieties was shorter than in 2010 by 3.6 days (Table 3). Cultivars of the MG III varied in oil content in both years of studies (Table 3). Depending on the cultivar, its content ranged from 21.5% to 27%. in 2010. The highest level of oil was in varieties Chernyatka, Victoria and CH 1470-20-1 (24%), Gentleman and Fl-1 (25.1%), Soer 3491 (26%) and PS-3008-1 (27%). Oil content varied from 22-23% in other varieties (Table 3). In 2011 oil content of most varieties of this maturity group decreased significantly, but differences between them according to this indicator persist- the scope of variation (min ÷ max) amounted to 19,0% ÷ 25,0%. Most significantly the level of oil has decreased in the cultivars Chernyatka (5%), Fl-1 (3.1%) and PS-3008-1 (5%) (Table 3).

Thus, the study results of the cultivars development have shown that within both groups they differ in the duration of shoots-flowering phases and growing period. In 2010 most of the studied varieties of the second group developed slowly and the third group - faster than in 2011. The results also showed significant polymorphism of the population of soybean varieties II and III groups maturity under study at the level of oil in the seed. They also reveal the influence of weather conditions in different years of research on the manifestation of this polymorphism.

The analysis of variability in the level of oil in seed of the tested cultivars has shown that they differ significantly on this basis, depending on vegetation conditions in the years of research. In both populations two groups of varieties have been distinguished: the first – varieties which did not change the level of oil in the seed during the years with different vegetation conditions and second – varieties, in which this trait varied significantly (Table 4). Thus, in a population of MG II varieties five varieties have been selected in which oil level in the seed was stable when the intensity level of environmental factors changed: Soer-4, Severnaya zvezda, Snezhok, CH-23-42 and Fiskeby III. The remaining 17 cultivars have been classified as the group with a significant level of variation in oil content in seed. In population varieties of third maturity group six varieties have also been selected, which do not change level of oil in the seed on environmental factors gradient: CH-23-94, Stviga, CH-1470-20-1, Gentleman and Victoria. In the remaining 12 varieties of this trait this factor changed considerably depending on vegetation conditions (Table 4).

DISCUSSION

The established differences between the studied varieties as to duration of the phase shoots-flowering and growing season are related to genetic characteristics of their interaction with environmental factors. It is shown that the phenotypic expression of differences in the rate of plants development depends on temperature, light intensity and duration. At the same time, depending on the rate of genotype reaction to the environmental factors, plants vary the intensity of metabolic processes and

phytohormonal status [6]. In our experiments, during the growing seasons in the both study years the tension level of the main environmental factors (temperature, precipitation, sum of effective temperatures) equally acted on the population cultivars under study. But, since it consisted of different varieties, the rate of their reaction to this effect was different. This resulted in phenotypic polymorphism in the rate of development of the studied cultivars. We have identified polymorphisms in the varieties studied on the level oil in seed. It is known that lipid synthesis in plants is a complex process. It requires carbohydrates, ATP, NADP (H), which are formed in the process of photosynthesis [7]. It is known that the intensity of photosynthesis depends on environmental factors [8].

Consequently, the lipid synthesis in plants is also associated with the level of environmental factors intensity. However, the reaction rate of the investigated varieties on these factors is different [9,3], which is manifested in the difference between oil content in seed. This is confirmed by published data [3,9,10].

In the studied collection of MG II and MG III cultivars we have identified the varieties in which oil level in the seed was stable under changing environmental factors. In our opinion, these varieties have a broad norm of reaction to changing conditions in the growing season. This property allows them to maintain a stable synthesis of oils in the seed when the intensity level of environmental factors changes.

Thus, the studied collection of varieties was characterized by significant polymorphism as to the level of oil in the seeds. We have selected varieties with stable high oil content in different years of research. They should be used as source material for creation of new high-quality soybean varieties.

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