PAPER • OPEN ACCESS

The estimation of growing season length of different soybean varieties and samples in the conditions of the forest-steppe zone of the Irkutsk region

The estimation of growing season length of different soybean varieties and samples in the conditions of the forest-steppe zone of the Irkutsk region

N B Katysheva, A V Pomortsev, A I Katyshev, N V Dorofeev, L G Sokolova and S Yu Zorina

Siberian Institute of Plant Physiology and Biochemistry, 132, Lermontova str., Irkutsk, 664033, Russia

e-mail: mitanova2014@yandex.ru

Abstract. The estimation of growing season length of soybean varieties and samples was carried out in the field conditions of the agro-ecological station of the Siberian Institute of Plant Physiology and Biochemistry. Depending on the growing season length, the soybean sample 15 is the earliest; the growing season is 98 days. The varieties Lira, Voronezhskaya 31, Veras are late ripening in these conditions; the vegetation period is 125 days. To develop the DNA markers to identify promising early samples, the varieties Lira, Voronezhskaya 31, Veras and sample No. 15 were selected which are the most contrasting and can be used for whole transcriptome analysis of the genetic mechanisms determining soybean ripeness in a long day.

1. Introduction

The rich and diverse chemical composition of soybean grain determines the uniqueness and multilateral use of the crop for feed, food and technical purposes. Soybean belongs to short-day plants, day length affects the duration of development phases, plant height, number of internodes and overall productivity. In this regard, soybean varieties occupy a limited area of cultivation, and have high productivity in a narrow range of agro-climatic conditions.

To date, there are many photoneutral varieties of soybean that do not react or are weakly responsive to day length. With the introduction of new early ripening varieties of the northern ecotype, a unique opportunity has appeared to cultivate soybean in conditions of a long light regime. As a result, areas, where this crop has not previously been cultivated but is cultivated now, have expanded significantly, for instance the Irkutsk Region.

The creation of varieties, samples of soybean using molecular-biological approaches in modern conditions will speed up the selection process of promising and early ripening samples of soybean. One of the molecular-biological approaches that allow investigating the genetic mechanisms underlying the formation of the early-ripening phenotype in plants is the high-resolution DNA microchipping method. Thus, using the whole transcriptome analysis, the genetic mechanisms underlying the heterosis of soybean [1] resistance to pathogens [3,5] and other stress factors [2, 4] are investigated.

The development of DNA markers to find promising early ripening varieties, hybrids, for further use of the samples as parental pairs in artificial hybridization, requires the presence of contrast soybean phenotypes grown in the vegetation period of the Irkutsk region conditions. The purpose of the research

was to estimate the early ripeness, yield and crop structure of the collection of soybean varieties in the field conditions of the forest-steppe of the Irkutsk region.

2. Materials and research methods

A collection seed-plot of soybean varieties was placed in the forest-steppe of the Irkutsk region at the experimental plot of the SIPPB SB RAS in 2018. The experimental field is located on the northeast slope. The highest point above sea level is 512 m, the lowest is 460 m. The coordinates of the experimental section are 53° 33'58.75"N and 102° 35'23.90"E. Soil of the experimental plot is gray forest; the humus horizon thickness is 25-35 cm; humus content is 2.8-3.5%; pHsol is 5.1-5.5; total nitrogen is 0.15-0.18%.

Sowing was done after the preceding crop by a naked fallow, sowing date is May 18; the seeding rate is 90 seeds per m^2. Depth of seed placement is 3-4 cm. The following soybean varieties were studied: Altom, Chera, USHI-6, Aldana, Lira, Voronezhskaya 31, Veras, Svapa, Svetlaya, Mageva, Okskaya, Bryanskaya Miya, Dan, Hei-He, sample 15. Plot area is 2.1 m^2, accounting area is 0.7 m^2. No fertilizers and plant protection products were used to eliminate their effect on the growing season length. Meteorological data for the growing season 2018 are given according to the data from the nearest to the experimental plot the Zalarinsk hydrometeorological station.

3. Research results

An analysis of the weather conditions of 2018 shows that the temperature conditions of the growing season differed from long-time average annual. May and June were warmer, and July was colder than average long-term observations. The average decade temperature in August and September was higher than the long-time average annual. The sum of average daily temperatures is higher than 10°C, in 2018 it was 1797°C, and according to average long-time average annual data, it was 1557°C. Consequently, the year 2018 was at 240°C warmer than the long-time average annual in this region. By the sum of positive temperatures, the greatest deviation from long-time average annual norm for this area, upwardly, was noted in the third decade of June and the first decade of September. The total rainfall for the period April-September 2018 was 273 mm, which is 5 mm more than the long-time average annual data. A significant deficit in the amount of precipitation in comparison with the average annual data, there was in June and amounted to 41.3 mm. It was especially seen in the second decade of this month.

During the entire growing season of soybean, phenological observations were made; the data are presented in the Table 1. The beginning of the seedling emergence in all varieties was noted simultaneously. Before the tilling phase, there were no significant differences in the growth and development of plants. Chera and Altom have a two-day lag. And by the beginning of the flowering phase, considerable varietal differences revealed.

Under the conditions of the Irkutsk region in 2018, Voronezhskaya 31, Veras, Lira were late ripening, the growing season was 125 days from sprouting, they showed a late fruit formation phase as well as a prolonged period of ripening of the beans.

Chera and USHI-6 are phenotypically characterized by a determinant form, the beans are compact, and the stem does not branch. In the growing season, the variety USHI-6 had a few days earlier flowering and fruit formation than the Chera variety. However, complete ripeness occurred simultaneously on September 24th. Vegetation period was 119 days. According to the obtained data, the varieties Svapa, Svetlaya, Mageva, Okskaya, Bryanskaya Miya, Dan, Hei-He, Shulma can be attributed to mid-season varieties. They had a complete ripeness on September 24. The vegetation period was 119 days.

The sample 15 ripened in the beginning of September (September 3), the vegetative period from sprouting was 98 days. This variety is characterized by the rapid passing of all development phases and early ripening of beans. According to long-term observations, the ripening of this variety falls on the second decade of September. Earlier ripening in 2018 is explained by the best conditions of this year in terms of the sum of positive temperatures above 10°C.

An analysis of the yield structure of soybean varieties and hybrids showed that the height of plants in a bundle of the varieties Veras, Altom, Voronezhskaya 31, Aldana was 117-121 cm, these varieties

showed as late ripening in the conditions of the Irkutsk region. The number of beans with attachment up to 12 cm was small at around 10%, and in the Veras variety - 17%. The seeds of the variety Lira were small, the weight of 1000 seeds was 115.1 g, the smallest compared to other varieties (Table 2).

Table 1. Phenological observations of the development of different varieties.

Variety	Sprouting	Tillering	Flowering	Fruit formation	Plumpness	Mellowing	Mellowness
Sample 15	28.05	22.06	4.07	13.07	7.08	21.08	3.09
Altom	28.05	24.06	13.07	15.07	7.08	21.08	24.09
Chera	28.05	24.06	13.07	15.07	7.08	21.08	24.09
UCKHI-6	28.05	22.06	4.07	13.07	7.08	21.08	24.09
Aldana	28.05	22.06	13.07	17.07	7.08	25.08	24.09
Lira	28.05	22.06	13.07	7.08	21.08	7.09	10.10
Voronezhskaya 31	28.05	22.06	13.07	7.08	21.08	7.09	10.10
Veras	28.05	22.06	4.07	7.08	21.08	7.09	10.10
Svapa	28.05	22.06	7.07	13.07	7.08	7.09	24.09
Svetlaya	28.05	22.06	4.07	13.07	7.08	7.09	24.09
Mageva	28.05	22.06	4.07	13.07	7.08	7.09	24.09
Okskaya	28.05	22.06	13.07	18.07	7.08	7.09	24.09
Bryanskaya Miya	28.05	22.06	13.07	18.07	7.08	7.09	24.09
Dan	28.05	22.06	4.07	13.07	7.08	7.09	24.09
Hei-He	28.05	22.06	13.07	24.07	7.08	10.09	24.09

The varieties Chera and USHI-6 have a similar phenotype; they are characterized by a determinant type of growth and no branching. When analyzing the yield structure of the Chera variety, it was noted that the mass of a bundle was more - 520 g in comparison with the mass of the USHI-6 variety - 344 g. The number of plants in a bundle and their height were approximately equal. The percentage of beans located up to 12 cm from the soil surface to the total number of beans was as follows: Chera - 7.6%, USHI-6 - 9.1% (within the normal range of 10%). Mass of 1000 seeds and crop productivity in variety Chera were higher than those of USHI-6. In terms of mass of 1000 seeds, these varieties occupied an intermediate position of all the studied varieties. These varieties are promising (determinant type of growth, compact arrangement of the beans on the stem, plant in 1 stem) and need further observation in subsequent growing periods.

In 2018, the Hei-He variety (North China) had a yield of 298.8 g/m^2, the seeds of this variety in the researched field conditions were small — 1000 seeds weight was 150.2 g. Percentage of beans arranged up to 12 cm to the total the number of beans - 4.1%.

The variety Mageva, in the conditions of the Irkutsk region, is the shortest compared to other varieties and the sample 15, mid-ripening. The height of the plants in a bundle was 68 cm; the weight of 1000 seeds was 163.1 g. The number of beans with an attachment point of up to 12 cm was up to 10% of their total number.

Table 2. The yield structure of the soybean collection.

Variety	Bundle weight, g	Number of plants in a bundle, pcs	Bundle height, cm	Number of beans per a bundle, pcs		Mass of seeds, g		Mass of 1000 seeds, g	Crop productivity, g/m² (excl. weight of beans up to 12 cm)
				up to 12 cm	higher than 12 cm	up to 12 cm	higher than 12 cm		
Svapa	480	11	84	18	509	9,6	186,9	204,0	267,0
Svetlaya	390	11	104	8	501	1,3	155,4	145,0	221,5
Mageva	440	12	68	35	500	12,6	172,4	163,1	246,2
Okskaya	420	10	99	19	461	4,7	139,6	158,3	199,4
Bryanskaya Miya	535	11	83	67	747	16,8	201,4	151,9	287,7
Dan	490	10	99	23	524	8,8	197,1	206,6	281,5
Hei-He	560	13	107	26	627	9,7	208,5	150,2	298,8
Altom	555	19	117	27	382	11,7	166,0	226,5	237,1
Chera	520	15	84	47	613	20,9	186,7	159	266,7
USKHI-6	344	16	80	50	547	17,7	140,4	143,2	200,5
Aldana	475	16	119	31	661	7,3	165,0	162,2	235,7
Lira	760	15	113	6	873	0,9	191,4	115,1	273,4
Воронежская 31	710	19	121	1	767	-	191,1	128	273,0
Veras	640	19	120	97	569	41,9	198,7	150,6	283,8
Sample 15	555	20	96	36	544	12,7	222,0	179,8	317,1

In terms of mass of 1000 seeds, the largest seeds were in the Alt variety - 226.5 g. The height of plants in the Alt variety in 2018 was 117 cm; the percentage of beans up to 12 cm to the total amount was within 10%.

In the conditions of the Irkutsk region, the varieties Bryanskaya Miya, Dan, Svapa showed a good yield of about 3 t/ha, but at the same time, compared with the hybrid 15, they were more late ripening. The ripening of these varieties in the conditions of 2018, which is favorable for the sum of positive temperatures during the growing season, was noted 21 days later than that of the sample 15.

Varieties with the smallest number of beans with attachment below 12 cm are Voronezhskaya 31, Lyra and Svetlaya. The Voronezhskaya 31 and Lira varieties are late ripening and ripened only on 10 October. The variety Svetlaya has an average ripening period of September 24 and is of interest as a possible donor for a high attachment of beans.

In terms of the growing season length, the sample 15 is the earliest compared to other studied varieties. The height of the plants in a bundle is 96 cm; the weight of 1000 seeds is 179.8 g. The yield of this variety sample was the highest - 317.1 g/m2.

4. Conclusion

For further research using the high-resolution DNA microarray method, in order to identify the genetic mechanisms that ensure the ripening of soybean plants in the conditions of a long day in Eastern Siberia, the following samples can be selected: the sample 15 is the earliest with the vegetation period is 98 days; Lira, Voronezhskaya 31, Veras are late ripening with the vegetation period 125 days. It is promising to include in the research data soybean varieties with a determinant type of growth and a compact attachment of the beans to the stem capable of ripening in years with good heat supply in the conditions of the Irkutsk region.

References

[1]   Zhang C 2017 Comparative transcriptome analysis of flower heterosis in two soybean F1 hybrids by RNA-seq *PLoS ONE* **12** e0181061

[2]   Chien V H 2015 Comparative analysis of root transcriptomes from two contrasting drought-responsive Williams 82 and DT2008 soybean cultivars under normal and dehydration conditions *Frontiers in Plant Science* **6** 551

[3]   Bencke-Malato M 2014 Genome-wide annotation of the soybean WRKY family and functional characterization of genes involved in response to Phakopsora pachyrhizi infection *MBMC Plant Biology* **14** 236

[4]   Tripathi P 2015 Transcriptomics analyses of soybean leaf and root samples during water-deficit *Genomics Data* **5** 164-6

[5]   Yadav K Y 2014 Differential soybean gene expression during early phase of infection with Mungbean yellow mosaic India virus *Mol Biol Rep* **41** 5123-34