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G. D. LAVROVA,
Ph. D. (Biology), Leading Researcher, Odesa
e-mail: bobovi.sgi@ukr.net

THE EVALUATION OF NEW ADVANCED SOYBEAN LINES WITH INCREASED PROTEIN CONTENT UNDER THE CONDITIONS OF THE SOUTH STEPPE OF UKRAINE

The F_4–F_6 progeny from four soybean crosses were evaluated in 2011–2013 under the extremely drought conditions. Forms with high yield, seed weight and protein content 40–42 % were obtained. According to regression analysis both stable for yield and responsive to environmental changes soybean lines have been determined. The widest range of valuable experimental strains has been obtained by crossing the cultivars Medeya and VIR 5048.

Key words*: soybeans, yield, drought resistance,experimental strains, protein content, seed weight.*

Introduction. Soybean production in Ukraine is increasing from year to year. In 2012 its harvest was 2 410 210 tons that is 143 800 tons more than in 2011 [1].

Ukraine has reached the ninth position in the world by soybean growing area. Soybeans are grown almost in all regions of our country, so high yielding varieties are required for every environment. (In 2013 the State register of plant varieties suitable for distribution in Ukraine included 130 soybean cultivars, from which 89 have been developed in our country).

Previous years have been characterized with high air temperatures and frequent periods of drought during the soybean vegetation. Rough changes of climatic factors unfavourably influence the plant growth and yield formation. Such weather conditions necessitate the availability of highly adapted varieties that are resistant to limiting factors and responsive to favourable ones. Especially it refers to the food type varieties with increased protein content that often perform less yield comparing to high-oil cultivars under droughty environment of the South Steppe of Ukraine.

The aim of our research was to develop genetically variegated material for breeding soybeans with improved seed quality. The obtained experimental strains have been estimated for the performance and stability of the yield, which is the main economical index that determines the propagation of a new variety.

Materials and methods. For obtaining breeding material of hybrid origin we made crosses of previously selected parental forms with economically valuable traits performed in the south Steppe of Ukraine [2,3,4,5].

This paper presents the data about yield, seed weight and protein content of the F_4–F_6 progeny developed from four crosses. The parental forms are:

1) two highly-productive varieties Medeya (with average protein content) and VIR 5048 (high protein, large seeds);

2) two average protein varieties Delta (high yield) and Valyuta (stable yield under different environments);

3) a drought-resistant experimental strain L-2 (from Orel, Russia) with average protein, high oil content and increased number of pods per node and seeds per pod, and a highly productive variety Kyivska 98 with high protein content and increased number of pods and seeds per plant;

4) a high protein strain ms_1Tonica x Tokyo x K-4937 (PBGI, Odessa) with increased number of pods per node and seeds per pod and a low protein, high oil variety Kiszelniska.

The national standard Yatran' (an adapted variety, responsive to favourable conditions) and Arcadia odes'ka (a drought- resistant, high protein variety with high crop stability) have been chosen as check cultivars.

The plants were grown in 2011, 2012 and 2013. Individual plots consisted of one 1,5 m row and were spaced 45 cm apart. Forty-five viable seeds were planted per row. The experimental strains were evaluated for yield, seed size (the weight of 1000 seeds), protein and oil percentage. The analysis of variance and the statistical analysis were made according to B. O. Dospiekhov [6]. The regression coefficient (b_i) was calculated according to S. A. Eberhart and W. A. Russell [7]. Best strains were selected every year, beginning from the F_3 generation. The PBGI biochemical laboratory performed protein and oil content determinations in 2010 and 2011 (F_4 and F_5 seeds) according to common used methods.

Results and discussion. The weather conditions in the years of investigation were different (table 1) but the droughts in August repeated every year. There were no rains in April and May 2012 and in May 2013, too. Under such conditions the yield of soybeans decreased greatly (for example, the variety VIR 5048 produced in average only 104,7g/m^2 seeds in 2011–2013 (table 2) comparing to more favourable years 2004–2006, when its yield was about 253 g/m^2 [3]). However, the extremely dry conditions helped to select valuable drought resistant breeding material.

According to G. T. Selianinov and S. A. Sapozhnikova [8] HTC in summer period above 1,6 characterizes extremely humid zones, from 1,6 to 1,3 — forest humid zones, 1,3–1,0 — Forest-Steppe (lack of humidity), 1,0–0,7 — Steppe (droughty zones), 0,7–0,4 — dry Steppe (extremely dry zones), below 0,4 — near desert and desert zones.

The best yield was produced by lines 25993/13 and 25994/13 descending from the cross Medeya x VIR 5048 (table 2). These breeding lines were 59,5 and 34,0 % superior to standard varieties by yielding performance. They belong to intensive type cultivars, i.e. respond to more favourable conditions with a significant yield supplement (their b_i is 2,73 and 2,38 respectively). Line

25993/13 is superior in yield to both standard and parental varieties. Plants of these lines have large seeds (1000-seed weight is 180 and 183 grams) whereas their protein percentage reached 40,4 and 40,7 %. It is important that their seed weight is quite stable (the regression coefficient of seed weight is 0,22 and 0,38 respectively). Among the lines with stable seed yield ($b_i \leq 1$) strains 25989/13, 25991/13, 25992/13, 25995/13 and 25998/13 performed the best results. Lines 25991/13 and 25992/13 had the same yield as the standards while the yielding performance of strains 25988/13, 25989/13 and 25995/13 exceeded the check varieties by 22.5, 10.6 and 19.6 %. Their 1000-seed weight ranged from 192,3 to 210,7 g (table 3). Line 25997/13 had the largest seeds in this cross (239,3 g/1000 seeds), which significantly exceeded both standard and parental varieties. This line is stable (b_i=0,38), has the same yield as Arcadia odes'ka and the average protein and oil percentage (38,9 and 19,9 % respectively). It can be used as a source of large seed weight in further crosses.

Table 1

The meteorological factors during soybean vegetation (2011–2013)

4 Factor	Year	Month					Sum	HTC* (hydrothermic coefficient)
		April	May	June	July	August		
Rainfall, mm	2011	28,5	27,5	92,6	25,1	3,0	176,7	0,62
	2012	9,0	55,5	28,3	10,8	14,0	117,7	0,37
	2013	39,1	4,8	49,1	79,6	3,6	176,2	0,58
	Average	34,0	39,0	42,0	49,0	34,0	198,0	0,75
Air temperature, °C	2011	9,7	16,3	20,9	23,5	22,4	2867,1	
	2012	10,9	19,4	22,4	25,7	24,0	3141,1	
	2013	11,2	19,1	21,9	23,1	23,9	3042,1	
	Average	9,0	15,1	19,4	21,4	21,2	2640,7	

*- HTC = (Σ rainfall/ Σactive temperatures) –10.

The highest protein content has also been observed among the progeny from the cross Medeya x VIR 5048 (table 3). It ranged from 41,2 to 41,6 in the seeds of strains 25988/13, 25989/13, 25990/13 and 25991/13.

The progeny from the crosses Delta x Valyuta and L-2 x Kyivska 98 haven't exceeded the yield of standard or parental varieties. The yield of hybrid lines from the cross [ms_1Tonica x Tokyo x K-4937] x Kiszelniska didn't exceed the yield of standard varieties and only two of them, 26002/13 and 25999/13, were 12,9 and 15,2 % superior to the best parental form.

Experimental lines from the cross Delta x Valyuta were superior in seed weight to the best parent Delta for 6,3–26,6 %. Such enlargement can be explained with transgressions of the genes that are responsible for seed size since neither of the parental varieties has large seeds. In this cross lines 26011/13, 26013/13 and 26014/13 had the highest seed weight (187.7, 183.3 and 189.0 grams).

Table 2

Yield stability of the best experimental strains of soybean (F_4–F_6) and their parental forms

Variety, line	Yield, g/m²				b_i
	2011	2012	2013	Mean	
Yatran', standard	148,1	25,1	50,5	74,6	2,37
Arcadia odes'ka, standard	92,7	41,2	57,5	63,8	1,01
♀ Medeya	106,7	38,5	134,8	93,3	1,53
♂ VIR 5048	163,0	88,9	62,2	104,7	1,32
Line 25986/13	130,4	32,6	135,6	99,5	2,10
–«– 25987/13	34,8	25,2	139,3	66,4	0,48
–«– 25988/13	99,3	39,3	135,6	91,4	1,38
–«– 25989/13	102,2	47,4	97,8	82,5	1,16
–«– 25990/13	75,6	11,1	83,0	56,6	1,40
–«– 25991/13	83,0	56,3	72,6	70,6	0,54
–«– 25992/13	84,4	28,1	105,2	72,6	1,26
–«– 25993/13	163,0	34,8	159,3	119,0	2,73
–«– 25994/13	152,6	36,3	111,1	100,0	2,38
–«– 25995/13	59,3	45,2	163,0	89,2	0,57
–«– 25996/13	51,1	30,4	65,9	49,1	0,48
–«– 25997/13	73,3	54,8	67,4	65,2	0,38
–«– 25998/13	102,2	43,7	117,0	87,6	1,29
♀ Delta	177,8	40,0	102,2	106,7	2,75
♂ Valyuta	74,1	55,2	47,4	58,9	0,33
Line 26011/13	63,7	28,9	39,3	44,0	0,75
–«– 26013/13	40,0	35,6	42,2	39,3	0,10
–«– 26014/13	27,7	32,6	43,0	34,4	-0,07
–«– 26016/13	99,3	44,4	19,3	54,3	0,97
–«– 26017/13	47,4	34,1	11,9	31,1	0,19
–«– 26019/13	48,9	26,7	34,1	36,6	0,44
♀ L-2 (Orel)	111,0	40,5	68,9	73,5	1,40
♂ Kyivska 98	121,5	33,1	54,8	69,8	1,72
Line 25976/13	24,8	35,6	34,1	31,5	-0,21
–«– 5977/13	85,9	34,8	64,4	61,7	1,04
–«– 25979/13	43,0	23,7	51,9	39,5	0,44
–«– 25983/13	36,0	19,3	75,6	43,6	0,46
♀ ms_1 Tonica x Tokyo x K-4937	51,9	30,0	66,7	49,5	0,51
♂ Kiszelniska	103,7	20,7	14,8	46,4	1,54
Line 26002/13	70,7	40,7	56,3	55,9	0,60
–«– 26003/13	36,3	5,9	28,9	23,7	0,63
–«– 26005/13	37,0	19,3	44,4	33,6	0,40
–«– 25999/13	123,5	21,5	25,9	57,0	1,93
LSD_{05}				45,0	

Table 3

Protein percentage and 1000-seed weight of the best experimental strains of soybean (F_4–F_6) and their parental forms

Variety, line	Protein content, %			1000-seed weight (mean of the years 2011–2013), g
	2010	2011	Mean	
Yatran', standard	37,5	38,7	38,1	140,0
Arcadia odes'ka, standard	39,4	39,6	39,5	132,0
♀ Medeya	37,9	37,6	37,8	155,7
♂ VIR 5048	39,7	40,2	40,0	202,7
Line 25986/13	39,7	39,0	39,4	180,7
–«– 25987/13	39,7	39,2	39,5	188,3
–«– 25988/13	42,0	41,1	41,6	202,7
–«– 25989/13	42,0	40,6	41,3	205,3
–«– 25990/13	42,0	40,5	41,3	178,7
–«– 25991/13	42,0	40,4	41,2	210,7
–«– 25992/13	40,3	38,6	39,5	204,3
–«– 25993/13	39,0	41,7	40,4	188,0
–«– 25994/13	41,3	40,1	40,7	183,3
–«– 25995/13	40,3	41,1	40,7	191,3
–«– 25996/13	40,6	39,9	40,3	168,3
–«– 25997/13	38,0	39,5	38,8	239,3
–«– 25998/13	38,0	39,7	38,9	192,3
♀ Delta	38,9	39,1	39,0	149,3
♂ Valyuta	37,6	40,3	39,0	118,7
Line 26011/13	37,0	39,2	38,1	187,7
–«– 26013/13	38,3	39,4	38,9	188,3
–«– 26014/13	39,3	40,3	39,8	189,0
–«– 26016/13	38,7	39,5	39,1	162,7
–«– 26017/13	39,2	39,3	39,3	158,7
–«– 26019/13	39,2	38,9	38,6	169,3
♀ L-2 (Orel)	36,7	38,3	37,5	136,0
♂ Kyivska 98	39,8	40,2	40,0	112,7
Line 25976/13	38,3	36,7	37,5	120,0
–«– 5977/13	37,7	36,1	36,9	133,3
–«– 25979/13	40,3	39,6	40,0	128,0
–«– 25983/13	40,3	39,6	40,0	116,3
♀ ms_1 Tonica x Tokyo x K-4937	42,3	41,0	41,7	101,3
♂ Kiszelniska	32,3	35,2	33,8	142,0
Line 26002/13	37,9	38,7	38,3	116,3
–«– 26003/13	39,0	38,8	38,9	110,0
–«– 26005/13	37,9	38,6	38,3	142,0
–«– 25999/13	38,3	40,0	39,2	123,0
LSD_{05}			1,6	29,9

Most of the Medeya x VIR 5048 progeny had 1000-seed weight above 200 grams. Four lines (25989/13, 25991/13, 25992/13 and 25994/13) exceeded the best parent VIR 5048 (202,7 g) by 0,8–18,1 %. Progeny from the crosses L-2 x Kyivska 98 and [ms_1Tonica x Tokyo x K-4937] x Kiszelniska had average seed size as to their parental forms.

The lines with the highest protein content occurred in the cross Medeya x VIR 5048 and most of them were superior to the best parent VIR 5048 (40 %) in the two years of research (table 3). Some strains from the cross Delta x Valyuta exceeded the protein percentage (39 %) of parental varieties.

Experimental lines from the crosses L-2 x Kyivska 98 and [ms_1Tonica x Tokyo x K-4937] x Kiszelniska haven't exceeded the protein percentage of their parents, although two lines from the cross L-2 x Kyivska 98 have reached the index of the best parent (40 %). The difference between protein percentages of parental forms was 2,5 % in this cross, while it was much greater in the cross [ms_1Tonica x Tokyo x K-4937] x Kiszelniska (7,9 %). Thus, it can be suggested that to obtain high-protein progeny, at least one of the parental forms must have high protein content, while the other — high or average one.

Conclusions. The research resulted in obtaining experimental strains with the combination of increased yield, high protein content and large seeds. They are:

– two highly productive lines 25993/13 and 25994/13 with high protein content from the cross Medeya x VIR 5048, which are responsive to favourable growing conditions;

– line 25997/13 (Medeya x VIR 5048) that can be a source of large seed size and yield stability;

– some transgressive forms with increased seed weight from the cross Delta x Valyuta.

Most experimental strains with high protein content have been obtained from crossing high protein varieties with average protein forms (the crosses L-2 x Kyivska 98 and Medeya x VIR 5048). Some Medeya x VIR 5048 lines were superior in protein content to the parental varieties and had 41–42 % of protein in seeds.

The strain tests were conducted in the extremely drought conditions so the obtained breeding material can be characterized as drought-resistant.

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ХАРАКТЕРИСТИКА ПЕРСПЕКТИВНИХ ЛІНІЙ СОЇ З ПІДВИЩЕНИМ ВМІСТОМ БІЛКА В УМОВАХ ПІВДЕННОГО СТЕПУ УКРАЇНИ

В екстремальних посушливих умовах 2011–1013 років було проаналізоване потомство четвертого-шостого поколінь чотирьох гібридних комбінацій сої. Виділені високоврожайні та крупнонасінні форми з вмістом білка у межах 40–42%. За результатами регресіиного аналізу визначені екологічно пластичні та стабільні за урожайністю селекційні лінії. Найбільше цінного вихідного матеріалу одержали від схрещування сортів Медея і ВІР 5048.

Таблиці — 3. Бібліографія — 8.

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Лаврова Г. Д. Сборник научных трудов СГІ–НЦНС. 2013. Вып. 22 (62).

ХАРАКТЕРИСТИКА ПЕРСПЕКТИВНЫХ ЛИНИЙ СОИ С ПОВЫШЕННЫМ СОДЕРЖАНИЕМ БЕЛКА В УСЛОВИЯХ ЮЖНОЙ СТЕПИ УКРАИНЫ

В засушливых экстремальных условиях 2011–2013 годов проанализировали потомство четвертого–шестого поколений четырех гибридных комбинаций сои. Выделены высокоурожайные крупносемянные формы, содержащие 40–42 % белка. По результатам регрессионного анализа определены экологически пластичные и стабильные по урожайности селекционные линии. Наибольшее количество ценного исходного материала получено при скрещивании сортов Медея и ВИР 5048.

Таблицы — 3. Библиография — 8.