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Genetics and Breeding

Characterization of the Bulgarian sunflower hybrid Valin

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Abstract. A male sterile two-linear sunflower hybrid was developed at Dobrudzha Agricultural Institute – General Toshevo using the method of inter-linear hybridization. The mother component is line 10517 which possesses cytoplasmic male sterility, and the father component is line 10595R, a fertility restorer of branched type. Both parental forms have very good general and specific combining ability. Hybrid Valin is medium early, with vegetation period of 110 – 115 days, plant height 165 – 175 cm and head diameter 17 – 18 cm. The percent of kernel in seed is within the range of 65 – 73%. Seeds have absolute weight 50 – 55 g, and oil content in seed is 46 – 50%. The hybrid is resistant to lodging and moderately resistant to phoma and phomopsis. The resistance to downy mildew is as high as 95 % up to race 700, and the resistance to the parasite *Orobanche* is 100% (races A-F). In the breeding fields of DAI the hybrid went through three-year testing according to a scheme and growing technology approved for this crop. During the first two years of the control testing it exceeded the mean standard by seed yield with 11.0% and 14.4%, respectively. During the third year, hybrid Valin was above the mean standard with 10.9% by seed yield and with 6.6% by oil yield in a unified competitive varietal testing. The maximum yield obtained at DAI was 4483 kg/ha, and the maximum oil content was 50.1%. In 2007 and 2008 hybrid Valin went through official testing within the structure of the Executive Agency of Variety Testing, Field Inspection and Seed Control of Bulgaria. By the index seed yield, the exceeding of the mean standard was 23.6 % in the first year, and in the second the yield was with 1.4 % below the standard. Oil content was a little below the standard in both years. The aim of this investigation was to make as full as possible a characterization of the new registered sunflower hybrid Valin on the base of biological, phytopathological and economical indices.

Keywords: sunflower, hybrid Valin, testing, seed yield, oil content

Introduction

Dobrudzha Agricultural Institute (DAI), General Toshevo is the only research center in Bulgaria dealing with breeding of sunflower. Developing of new hybrids is one of the priorities of the institute (Christov et al., 2009; Genova et al., 2012; Encheva et al., 2014; Encheva et al., 2014; Georgiev et al., 2015).

To achieve its aims, the breeding program encompasses several important aspects – investigation on variable initial material (Valkova et al., 2014; Valkova et al., 2015), developing of new lines and hybrids by combined use of the methods of conventional breeding and biotechnologies (Drumeva, 2012; Encheva et al., 2014), testing of experimental hybrids under changeable soil-and-climate conditions (Yankov et al., 2002; Christov et al., 2008; Georgiev et al., 2013; Van der Merwe et al., 2013; Georgiev et al., 2014) and seed production of parental lines of already developed and registered hybrids (Petrov et al., 1994). The knowledge on the peculiarities of the genotype and its specific reaction under stress allow developing suitable production technologies and higher profitability (Mihova, 2015; Dimitrova-Donova, 2016).

The aim of this investigation was to make as full as possible a characterization of the new registered sunflower hybrid Valin on the base of biological, phytopathological and economical indices.

Material and methods

Sunflower hybrid Valin was developed by the method of

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interlinear hybridization. It is a male fertile simple two-linear hybrid. The cross between the parental lines was made for the first time in 2003; after that it was involved in testing at the experimental fields of DAI according to a standard scheme for this crop. It included two-year testing in a competitive varietal trial and one-year testing in a unified varietal trial, already on several fields. The testing was carried out after previous crop wheat, and the agronomy practices were in accordance with the technology adopted for growing of sunflower (Georgiev et al., 1997).

The experimental plots were each 12 m², in a block design with three replications, at crop density 6122 plants/da. The standards used for this testing were the most widely distributed hybrids of DAI at that time – Albena, Merkuryi, Perfekt, as well as one of the most productive and traded foreign hybrids Diabolo. The traits seed yield, kg/da, oil content in seed, %, oil yield, kg/da were investigated.

In 2007 and 2008, the candidate hybrid Valin was presented for official testing within the structures of the Executive Agency of Variety Testing, Field Inspection and Seed Control. It was officially registered at the Patent Agency of Republic of Bulgaria with a certificate for a new plant variety No 10941 from 31.03.2011 and was included in the official varietal list of Bulgaria. The phytopathological characterization of the hybrid was done at Dobrudzha Agricultural Institute, General Toshevo. The resistance to downy mildew (*Plasmopara halstedii*) was determined according to the standard methodology of Year and Tourvieille (1987) adapted to the working conditions of DAI. The response of the hybrid to races 700 and 731 of the pathogen was expressed as percent of resistance. The resistance to grey spots on sunflower (*Phomopsis helianthi*) was

determined by the method of Encheva and Kiryakov (2002) under conditions of an artificial infection field. The type of attack was read one week after full flowering and at stage milk maturity according to the following scale: 0 – no symptoms; 1 – necrotic spot up to 5 cm in diameter; 2 – necrotic spot larger than 5 cm in diameter; 3 – several merging necrotic spots on the stem; 4 – stem broken at the place of infection. The resistance to black spots on sunflower (*Phoma macdonaldii*) was checked under artificial infection conditions in the field. Inoculation was done at budding stage at the beginning of flowering using the method of Maric et al. (1981). The reaction of the plants was read at stage yellow-brown maturity according to a 4-degree scale: 0 – no symptoms; 1 – a necrotic spot localized around the petiole; 2 – several merging necrotic spots on the stem; 3 – the entire stem covered by necrotic spots or broken. The resistance to the parasite broomrape (*Orobancha cumana*) was determined by

the method of Panchenko (1975). The evaluation was made under greenhouse conditions through the index percent of resistance.

The dispersion analysis was carried out according to the methodology of Clewer and Scarisbrick (2001). The experimental data were processed with the help of STATISTICA, release 7.0 (StatSoft Inc., 2004).

Results and discussion

Morphological description

During 2007 – 2008, hybrid Valin went through testing for distinctness, uniformity and stability at the Executive Agency of Variety Testing, Field Inspection and Seed Control experimental station in Brushlen. With a report of the agency it was acknowledged

Table 1. Morphological characteristics of sunflower hybrid Valin

No	Traits	Expression	Degree
1.	Hypocotyl: anthocyanin coloration	Present	9
2.	Hypocotyl: anthocyanin coloration	Very weak to weak	2
3.	Leaf: size	Medium	5
4.	Leaf: green color	Dark	7
5.	Leaf: blistering	Medium to strong	6
6.	Leaf: serration	Medium to coarse	6
7.	Leaf: shape of cross section	Weakly concave	2
8.	Leaf: shape of distal part	Acuminate	8
9.	Leaf: auricles	Medium	5
10.	Leaf: wings	None or very weakly expressed	1
11.	Leaf: angle of lowest lateral veins	Right or nearly right	2
12.	Leaf: height of the tip of the blade compared to insertion of petiole (at 2/3 height of plant)	Medium to high	6
13.	Stem: intensity of hairiness at the top	Medium	5
14.	Time of flowering	Early to medium	4
15.	Ray flower: density	Medium to dense	6
16.	Ray flower: shape	Narrow ovate	2
17.	Ray flower: disposition	Flat	1
18.	Ray flower: length	Medium to long	6
19.	Ray flower: color	Orange yellow	4
20.	Disk flower color	Orange	2
21.	Disk flower: anthocyanin coloration of stigma	Absent	1
22.	Disk flower: intensity of anthocyanin coloration of stigma	-	-
23.	Disk flower: presence of pollen	Present	9
24.	Bract shape	Rounded	3
25.	Bract: length of the tip	Long	7
26.	Bract: green color of the external part	Medium to dark	6
27.	Bract: attitude in relation to head	Not embracing or very slightly embracing	1
28.	Plant: natural height	Medium to tall	6
29.	Plant: branching	Absent	1
30.	Plant: type of branching	-	-
31.	Plant: natural position of closest lateral head to the central head	-	-
32.	Head: attitude	Turned down with strongly curved stem	8
33.	Head: size	Small to medium	4
34.	Head: shape of grain side	Deformed	6
35.	Seed: size	Medium	5
36.	Seed: shape	Narrow ovoid	2
37.	Seed: thickness relative to width	Medium	5
38.	Seed: main color	Black	7
39.	Seed: stripes on margin	Weakly expressed	2
40.	Seed: stripes between margin	None or very weakly expressed	1
41.	Seed: color of stripes	Grey	2

as clearly distinct from all other varieties, sufficiently uniform and stable. The morphological description of the hybrid (Table 1) was done according to the UPOV protocol (2002).

Biological and economic properties

Hybrid Valin is a male sterile two-linear simple hybrid developed by the method of interlinear hybridization. The mother component line 10517 possesses cytoplasmic male sterility, and the father line 10595R is a fertility restorer of branched type. Both parental forms have very good general and specific combining ability.

The hybrid is medium early, with growth season of 110 – 115 days, 4 – 7 days later than San Luka; the height of plants is 165 – 175 cm, and their head diameter is 17 – 18 cm. The absolute weight of seeds is 50-55 g, and their oil content is 46 – 50%. The hybrid is resistant to lodging and moderately resistant to phoma and phomopsis. Its resistance to downy mildew is up to 95% (all races up

to 700), and the resistance to the parasite *Orobanche* is 100% (races A-F).

The recommended seed production scheme for this hybrid is 10:2, i.e. 10 rows of mother line to 2 rows of father line. The flowering time of line 10595R is earlier and therefore it should be sown earlier than the mother line 10517A. The father line is branched and rich in pollen but nonetheless 2-3 well developed bee colonies are recommendable per ha to ensure better seed set and respective higher yields. The recommended crop density is 5500 – 6000 plants/da.

Testing at DAI, General Toshevo

Similar to any other candidate hybrid, Valin also went through a 3-year testing in the experimental fields of DAI (Table 2). The first two years were a competitive varietal trial where the best crosses are picked up, and the third year was a unified competitive trial for testing

Table 2. Testing of hybrid Valin at DAI, General Toshevo

Hybrid	Seed yield, kg/ha	% from mean standard	Oil content, %	Oil yield, kg/ha	% from mean standard
2004 – competitive varietal trial					
Valin	4026	111.0	48.2	1941	114.3
Albena - standard	3750	103.4	47.1	1766	104.0
Merkuriy - standard	3505	96.6	46.5	1630	96.0
Mean standard	3628	100.0	46.8	1698	100.0
2005 – competitive varietal trial					
Valin	3817	114.4	51.0	1947	118.4
San Luka - standard	3757	112.6	48.4	1818	110.5
Perfekt - standard	2917	87.4	50.2	1464	89.5
Mean standard	3337	100.0	49.3	1645	100.0
2006 – unified competitive varietal trial					
Valin	4483	110.9	50.1	2246	106.6
Perfekt - standard	3803	94.1	50.6	1924	91.4
Diabolo - standard	4280	105.9	53.6	2294	108.9
Mean standard	4042	100.0	52.1	2106	100.0

Table 3. Analysis of variance for grain yield and oil yield

Source of Variation	SS	df	MS	F	F crit
Grain yield					
Total	6174509.64	35			
Genotype (A)	1502385.19	3	500795.06	31.05	3.01
Year (B)	3127904.06	2	1563952.03	96.98	3.40
Interaction (A x B)	1157186.39	6	192864.40	11.96	2.51
Error	387034.00	24	16126.42		
Oil yield					
Total	173.34	35			
Genotype (A)	8.52	3	2.84	7.76	3.00
Year (B)	124.53	2	62.26	170.20	3.40
Interaction (A x B)	31.50	6	5.25	14.35	2.50
Error	8.78	24	0.36		

of all the best candidate hybrids of the year with the aim to determine which hybrids will be provided for official testing within the structures of the national Executive Agency of Variety Testing, Field Inspection

and Seed Control. Numerous traits and indices were read during these trials, the main ones being seed yield, oil percent in seed and oil yield.

The analysis of the variances showed that the percent of the genotype and of the environment for the formation of the traits were variable (Table 3). More significant was the percent of the year. The harvest years involved in this investigation were characterized by specific combinations of meteorological conditions and allowed good differentiation of the tested hybrids. The significant genotype x environment interaction showed that the response to the abiotic factors was directly related to their genetic peculiarities.

During both years of the competitive varietal trial hybrid Valin exceeded the mean standard with 11.0% in 2004 and with 14.4% in

2005 by seed yield. Similar was the situation with the trait oil yield. Oil content in seed was within the range 48.2–51.0%. It is worth noting at this point that Valin significantly exceeded the older hybrids of DAI such as Albena, San Luka, Merkurij, etc. by the index oil content in seeds, and this is an important breeding achievement.

In the unified competitive varietal testing, hybrid Valin reached a maximum of seed yield (4483 kg/ha) the exceeding being with 10.9%. Oil in seed was also highest for this period of testing – 50.1%. In this case Valin conceded to the foreign standard Diabolo by oil in seed but exceeded it by seed yield.

Table 4. Seed yield per da during the first year of official testing at the Executive Agency of Variety Testing, Field Inspection and Seed Control

Hybrids	Selanovtsi		Brushlen		General Toshevo		Radnevo		Burgas		Zimnitsa		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Valin	3400	117.2	2700	136.5	2000	90.4	3210	155.8	960	90.9	2550	98.6	2830	123.6
Diabolo standard	2790	96.1	1980	100.4	2380	107.3	2040	99.2	1000	94.9	2580	99.5	2300	100.4
Perfekt standard	3010	103.9	1970	99.6	2050	92.7	2080	100.8	1110	105.1	2600	100.5	2280	99.6
Mean standard	2900	100.0	1975	100.0	2215	100.0	2060	100.0	1055	100.0	2590	100.0	2290	100.0
GD 5%	390.0	13.9	200.3	10.2	340.6	14.5	240.4	11.9	170.7	12.7	310.1	13.0	275.4	12.7
GD 1%	510.7	48.5	270.0	13.6	450.9	19.3	320.4	15.8	230.5	16.8	410.3	17.3	365.5	21.9
GD 0.1%	670.1	24.1	350.1	17.7	590.6	25.1	420.0	20.6	300.5	21.9	530.6	22.5	477.0	22.0

Official testing

After having demonstrated very good results in the breeding fields of DAI, the candidate hybrid Valin was subjected to official testing within the structures of the Executive Agency of Variety Testing, Field Inspection and Seed Control in 2007 (Table 4).

During the first year the new hybrid was tested at 6 locations – 3 in the northern and 3 in the southern part of Bulgaria. At half of these locations hybrid Valin exceeded the mean standard based on the Bulgarian hybrid Perfekt and the foreign hybrid Diabolo. At locations Radnevo and Brushlen this exceeding was very high – 55.8% and 36.5%, respectively. In absolute values, the seed yield was highest

at location Selanovtsi – 3400 kg/ha, with an exceeding of 17.2%. Averaged for all locations, Valin demonstrated productivity of 2830 kg/ha, with an exceeding of 23.6% at all locations. The difference was significant at a high statistical level.

By the index oil in seeds, the new hybrid conceded to the foreign standard, but exceeded the Bulgarian one. Averaged for all locations, Valin demonstrated oil content 46.3%, which was with 3.9% lower than the mean standard.

During the second year of official testing, Valin was also compared to hybrid San Luka, the most widely distributed sunflower hybrid in Bulgaria at that moment (Table 5).

Table 5. Seed yield per da during the second year of official testing at the executive Agency of Variety Testing, Field Inspection and Seed Control

Hybrids	Selanovtsi		Pordim		Brushlen		General Toshevo		Radnevo		Burgas		Zimnitsa		Average	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Valin	3310	81.9	2640	86.7	5370	104.9	5430	108.3	4070	106.3	1530	93.6	2130	97.7	3500	98.6
Diabolo standard	4170	103.2	2980	97.9	5330	104.1	4850	96.8	4610	120.4	1600	97.4	2250	103.4	3680	103.7
San Luka standard	3910	96.8	3110	102.1	4910	95.9	5180	103.2	3050	79.6	1680	102.6	2100	96.6	3420	96.3
Mean standard	4039	100.0	3049	100.0	5116	100.0	5013	100.0	3830	100.0	1638	100.0	2175	100.0	3550	100.0
GD 5%	288.1	6.9	74.9	2.5	242.6	4.5	693.4	14.3	485.4	4.0	106.7	6.6	203.2	9.0	299.2	6.8
GD 1%	382.5	9.1	99.4	3.3	322.2	6.0	920.8	18.9	246.2	5.3	141.6	8.8	269.8	11.9	340.4	9.0
GD 0.1%	496.2	11.9	129.0	4.3	417.9	7.8	1194.4	24.6	319.4	6.9	183.7	11.5	350.0	15.5	441.5	11.8

In this year the locations of testing were already 7. At three of them the tested hybrid exceeded the mean standard. In 2008, the meteorological conditions were more favorable for development of sunflower and the Bulgarian hybrid Valin revealed its high production potential. The seed yield reached a maximum at the experimental field of DAI, General Toshevo - 5430 kg/ha; this absolute value exceeded each of the two standards, and the mean exceeding was with 8.3%. The situation was the same at the trial field in Brushlen – a yield of 5370 kg/ha and 4.9% exceeding of the standard. The

averaged yield from all locations was 3500 kg/ha, with 1.4% lower than the mean standard, but the difference was not significant. The difference was not significant with regard to the more productive standard Diabolo, as well. The oil content in seed in 2008 was also higher in comparison to the previous year and varied within 44.1-52.1%. By this index, hybrid Valin was lower than the mean standard with 1.2%.

Averaged for two years of official testing, the new hybrid exceeded the mean standard with 11.1% by the index seed yield per

da; this was the main reason for its official registration and including in the Varietal List of Bulgaria.

By that time Valin was involved in official testing in Russia and Ukraine, where the preliminary results were very good. Our Ukrainian partners are realizing seed production on large areas, and several thousand da of F1 have been sown.

Phytopathological characteristics

This evaluation was carried out in the infection field of DAI, General Toshevo, where all new materials of the Sunflower breeding department are subjected to tests for resistance to some of the economically most important diseases and to the parasite *Orobanche*. The results from these tests are given in Table 6.

Table 6. Phytopathological evaluation of sunflower hybrids against artificial infection background at DAI, General Toshevo

Hybrid	<i>Phomopsis helianthi</i>		<i>Phoma macdonaldi</i>		<i>Plasmopara helianthi</i>		<i>Orobanche cumana</i>
	Attacking rate	Rank	Attacking rate	Rank	Resistance to race 700, %	Resistance to race 731, %	Resistance to races A-F, %
San Luka	3/3(3)	3	1/3(1)	1	100.0	92.9	100.0
Perfekt	1/3(1)	1	1/3(1)	1	84.5	-	100.0
Diabolo	2/3(2)	2	1/3(1)	1	100.0	90.5	100.0
Brio	1/3(1)	1	0	0	100.0	100.0	100.0
PR64F50	1/3(1)	1	0	0	100.0	100.0	100.0
Meldimi	2/3(2)	2	1/3(1)	1	100.0	90.0	100.0
Valin	2/3(2)	2	1/3(1)	1	95.0	75.0	100.0
Mihaela	2/3(2)	2	1/3(1)	1	100.0	100.0	100.0
Gabi	1/3(1)	1	0	0	100.0	100.0	100.0
Alpin	2/3(2)	2	1/3(1)	1	100.0	100.0	100.0
Veleka	1/3(1)	1	0	0	100.0	100.0	100.0
Vokil	1/3(1)	1	0	0	100.0	90.0	100.0
Velko	1/3(1)	1	0	0	100.0	100.0	100.0
Dea	1/3(1)	1	0	0	100.0	70.0	100.0
Sevar	1/3(1)	1	0	0	100.0	100.0	100.0

Similar to hybrids Diabolo and Meldimi, Valin was moderately resistant to the fungal pathogen *Phomopsis helianthi*, like other more recent hybrids of ours such as Mihaela and Alpin. It was more tolerant to this disease than hybrid San Luka. Valin exhibited resistance to the other important leaf pathogen *Phoma macdonaldi*, similar to the Bulgarian hybrids San Luka, Perfekt, Mihaela and Alpin, and to the foreign hybrids Diabolo and Meldimi. The other genotypes presented in the Table demonstrated immune type of reaction.

The resistance of Valin to downy mildew (*Plasmopara helianthi*), more specifically to race 700, was 95 %, while the resistance to race 731 was lower. The resistance to the parasite *Orobanche cumana* was 100%, similar to all other hybrids involved in the testing.

Conclusions

Hybrid Valin is clearly distinct, uniform and stable. It is also highly productive. By the indices seed yield, oil yield and percent of oil in seed, it exceeded the older sunflower hybrids of DAI. It is resistant to the *Orobanche* races widespread in Bulgaria. This hybrid was officially registered at the national Patent Agency with a certificate of a new plant variety No 10941 from 31.03.2011 and was included in the official Varietal List of Bulgaria.

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Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows. IXth International Conference on Production Diseases in Farm Animals, September 11-14, Berlin, Germany.

Thesis:

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