SOME ASPECTS OF CREATION AND USE OF SELF-POLLINATED LINES OF TALL AND SHORT-STALK SUNFLOWER FOR HETEROSIS BREEDING

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ABSTRACT: Of special interest in heterosis breeding are short-stalk sunflower lines with the plant height of 70-100 cm, the best of which in terms of combining activity are used to obtain highly productive short-stalk and normal-height hybrid plants. More than 25,000 lines of short-stalk and tall sunflower lines have been obtained and studied in 1973-1994. At present the Don Branch has more than 40 homozygous CMS lines used to obtain experimental hybrids. Of special interest are Lines 8/10, 4/29, ВД 340, ВД 357, and ВД 1448 which show high seed yields (1.5-2.04 t/ha), high oil content (44-51%) and resistance to broomrape. Such highly productive hybrids as Orion, Donskoy 342, Donskoy 187, and Donskoy 22 occupied 450,000-500,000 ha in Russia and CIS.

Key words: sunflower, short-stalk forms, combining ability, yield, broomrape.

INTRODUCTION: Success in sunflower heterosis breeding depends largely on the variety of the genetic fund of self-pollinated lines used to obtain highly productive hybrids. The method of self-pollination in respect to sunflower has been used by many breeders (Y. M. Plachek, I. G. Yagodkin, 1937; V. V. Burlov, 1985; L. K. Voskoboinik, 1986; and others) to obtain valuable self-pollinated lines. All breeders, however, have used the tall forms (140-200 cm) of sunflower to produce self-pollinated lines for their application to heterosis breeding. At present much interest is paid to the short-stalk forms, standing 70-100 cm high. In this connection, our research was directed toward the obtaining and study of sunflower homozygous self-pollinated lines, both short and tall, the best of which were used, based on their general combining ability (GCA), to produce short and normal-height hybrid plants. During the years 1973-1994 we pro-duced and studied more than 25,000 lines of short and tall sunflower of different inbred generations (J_1 - J_{10}).

MATERIALS AND METHODS: The basic materials were short-stalk (70-100 cm) and normal-height (120-160 cm) sunflower varieties and lines of local origin, lines obtained from VNIIMK experimental network, lines and hydrids of VSGI (Odessa), UkrNIIR&S (Kharkov), samples from the collection of VIR (St.

Petersburg), as well as varieties and hybrids obtained elsewhere. Work was carried out under field and laboratory conditions. Assessment of self-pollinated lines was performed on 3-row 20-bed plots in double and triple replication. Hybrids were studied in quadruple replication, the plot area being 13-50 sq. m. Phenological observations, records and measurements were performed according to the method developed at the Don Branch; resistance to broomrape and downy mildew was assessed by the method of A. Panchenko (1965), the oil content was determined by the method of S. Rushkovsky (1957), while the GCA and SCA were found by the method of W. Wolf (1969).

RESULTS AND DISCUSSION: The averaged data for the last 7 years plotted in Fig. 1 show that even with the most thorough breeding for high productivity, the average year will produce only 1-2 lines close to standard as regards the seed crop yield, and only 1 line, which is better than the standard in this respect. The 7 years of breeding produced only 8 lines of short-stalk sunflower close to the standard variety as regards the crop yield.

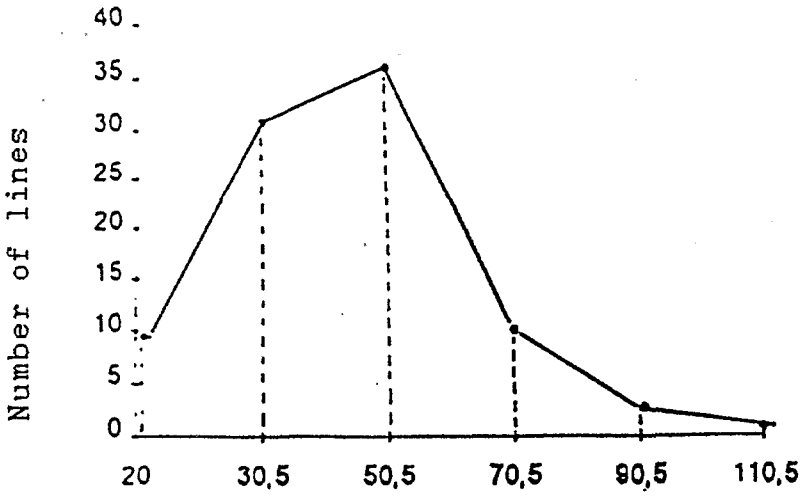

Fig. 1 Distribution of self-pollinated lines of short-stalk sunflower with respect to seed crop yield, % of the standard variety, 1973-1980.

The study of the short-stalk sunflower forms also showed that when the self-pollination multiplicity grew from J_1 to J_{10}, the inbreeding depression manifested itself not only in the seed crop yield, but also in other important breeding parameters, viz., shell-to-seed ratio, oil content, weight of 1,000 seeds, plant height, calathid diameter, etc. It should

be noted,too,that the self-pollinated lines obtained from the short-stalk forms were levelled as to the basic morphological features as early as in J_2-J_4, while such lines based on the tall-stalk forms could be obtained only in J_5-J_7.

In creation of self-pollinated sunflower lines the greatest attention is paid to selection of autofertile forms, which produce a large number of ovaries even without additional artificial pollination. Such a selection of autofertile lines allowed us to identify high-yield lines of short and tall-stalk sunflower. This is especially important for their multiplication in primary seed-growing and hybridization (see Table 1).

Of practical interest for heterosis breeding are Lines 8/10, 4/29, 4/30, 9/27, which combine short vegetation periods with high individual productivity. They also feature low shell-to-seed ratios (20.8 - 25.5%) and high weights of 1,000 seeds (75.6 - 92.7 g).

Simultaneously with the study of the self-pollinated lines' production characteristics,we assessed their topcross combining ability, starting from J2-J3. It was found that assessment of the short-stalk sunflower lines' combining ability required two testers, one with a high, and the other with a medium GCA. In our experiments the following combinations of varieties were the best testers: Chernyanka 66 and Zenit; Chernyanka 66 and Mayak; Lines ВД 340 and ВД 110; Lines ВД 340 and ВД 62.

GCA effects and specific combining ability(SCA) variance were determined both for the testers and the short-stalk sunflower lines. It was found that most of the studied lines were characterized by a mean GCA with regard to the main production indices (Table 2).

Out of the whole set of studied short-stalk lines, 10.2% of the lines had a high GCA with respect to seed yield, 15.8% with respect to oil content, 27.3% with respect to shell-to-seed ratio,and 4.1% with respect to weight of 1,000 seeds.

The lines in which the high GCA effects across the main production indices combine with high SCA variance are the most interesting for the breeder. In our experiments such were the Lines 3/102, 4/13, 3/95, 4/5 and others.

The self-pollinated lines, which were the best in terms of combinating ability, were transferred to the *Helianthus petiolaris* sterile substrate, which easily imparts male sterility to the created analogues and provides for a high ovaries' formation not only under paper isolators, but also in free bloom.

The above method for obtaining and assessment of the lines allowed us, in a short time (4-5 years), to obtain valuable lines with cytoplasmic male sterility (CMS) for heterosis breeding. At

present the Don Branch has 40 homozygous sterile analogues of the lines, which form part of the breeding program aimed at obtaining of experimental hybrids. The characteristics of the best CMS lines are shown in Table 3.

Of special value are the Lines ВД 123, ВД 53 and ВД 149,which combine a short vegetation period, a low shell-to-seed ratio (21.1 - 23.1%) and a high oil content of seeds (46-48%). The Line ВД 53 also features a high degree of resist-ance to broomrape.

For breeding of mid-ripening sunflower hybrids we chose the Lines ВД 340, ВД 357 and ВД 1448,which feature high oil content (47.5 - 50.9%), low shell-to-seed ratio (19.7-23.4%) and genetically preconditioned resistivity to the more virulent races of broomrape. All these lines show high seed yields.

By application of the appropriate methods for obtaining and use of self-pollinated lines, we have developed a scheme for breeding of sunflower hybrids, the best of which are shown in Table 4.

The hybrids shown in Table 4 satisfy the requirements of the agricultural industry to new varieties and hybrids in terms of seed crop yield, oil yield per hectare, weight of 1,000 seeds, height of plants, blooming, ripening,resistance to broomrape, applicability of intensive farming technologies, and others. In 1990-1995 these hybrids occupied the area of 450,000-500,000 hectares in Russia and CIS countries.

Table 1.
Characteristics of the best short-stalk self-pollinated lines with regard to the most important production indices.
Don Branch of All-Russia Research Institute of Oil-Bearing Crops,1977-1979

Line	Vegetation period, days	Plant height, cm	Yield, weight of seeds per calathid,g	Shell-to-seed ratio,%	Weight of 1,000 seeds, g
8/10	100	88	114	25.5	92.7
4/29	97	92	107	24.4	89.6
6/176	100	84	104	20.8	75.6
4/30	99	103	102	23.0	89.8
9/1	100	96	100	22.4	79.7
9/27	95	109	93	22.4	82.8
7/17	104	75	90	23.2	69.1
6/165	103	70	78	20.7	60.3
6/167	100	74	76	22.7	61.8
Chernyanka 66-control	95	107	102	25.3	91.4
Mayak - standard	104	167	122	20.7	9.5
LSD 095		23.1	14	2.2	9.4

Table 2
Distribution by the GCA levels of some production indices for short-stalk sunflower lines (% of the total number of studied lines). Don Branch of All-Russia Research Institute of Oil-Bearing Crops, 1974-1980

GCA assessment	Indices				
	seed yield	oil yield per hectare	seed oil content	shell-to-seed ratio	weight of 1,000 seeds
High	10.2	7.7	15.8	27.3	4.1
Medium	72.0	69.3	77.4	67.5	30.8
Low	17.8	23.0	6.8	5.2	65.1

Table 3
Characteristics of the best sunflower CMS lines with regard to the important production indices. Don Branch of All-Russia Research Institute of Oil-Bearing Crops, 1991-1994

Line	Vegetation period, days		Seed yield, tons/ha	Shell-to-seed ratio, %	Seed oil content, %	Weight of 1,000 seeds, g	Broomrape incidence, %	Plant height, cm
	from sprout to bloom	from sprout to ripening						
ВД 340	65	103	2.04	19.7	50.9	89	0	139
ВД 357	60	98	1.98	23.4	39.9	57	8.3	134
ВД 53	58	98	1.69	23.1	44.1	80	2.4	124
ВД 386	63	102	1.59	24.3	47.2	80	0	164
ВД 1448	64	102	1.49	19.7	50.3	69	5.4	137
ВД 350	62	98	1.40	20.7	49.4	71	1.0	126
ВД 123	57	97	1.31	21.1	44.5	81	28.9	95
ВД 356	62	100	1.28	22.4	47.8	70	6.0	129
ВД 149	54	94	1.09	23.4	40.8	67	30.4	80
ВД 255	53	90	1.04	24.4	38.7	67	32.1	79
Donskoy 60	59	98	2.79	21.7	47.4	103	5.9	139

Table 4
Characteristics of sunflower hybrids bred by the Don Branch of the All-Russia Research Institute of Oil-Bearing Crops, with respect to the main production indices

Hybrid (formula)	Vegetation period, days	Seed crop yield, tons/ha	Seed crop yield, +to standard	Seed oil content, %	Oil yield, tons/ha	Incidence, %, of broomrape	Incidence, %, of downy mildew
Mid-ripening group (1988-1990)							
Orion (ВД 340 x ВД 62)	103	3.32	+0.32	49.2	1.45	0	0
Donskoy 60 (standard)	101	3.00	-	49.5	1.33	7.8	0
LSD 095			0.18				
Intermediate early ripening group (1986-1988)							
Donskoy 187 (ВД 340 x ВД 105)	101	2.86	+0.51	49.5	1.27	3.5	0
Odessky 91 (standard)	99	2.35		47.4	1.01	2.6	0
LSD 095			0.25				
Early ripening group (1987-1989)							
Donskoy 342 (ВД 342 x ВД 110)	100	3.24	+0.42	49.0	1.41	0	0
Yubileiny 60 (standard)	102	2.82	-	49.3	1.20	0	0
LSD 095			0.27				
Fast-ripening group (1991-1992)							
Donskoy 22 (ВД 22 x ВД 192)	93	2.95	+0.38	44.3	1.19	8.2	0
Odessky 106 (standard)	93	2.57	-	44.7	1.12	0	0
LSD 095			0.24				