Three-way sunflower hybrids: promissing direction of investigations.

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SUMMARY

Sunflower is the main oil crop in Russia. Total acreage under this crop is about 4.1 – 5.1 million hectares annually. The weather conditions in different regions are greatly variable. Most of them have unfavorable condition for sunflower growth. Together with poor crop management it resulted in low yield – not more then 0.8 – 1.0 tons per hectare in average. This is the reason of a small acreage under hybrids in comparison with open-pollinated varieties in Russia. Sunflower hybrids occupy not more then 20 –25% of total acreage under this crop.

Specific climatic, economic and social problems of Russia require to have its own way in developing and introducing different types of sunflower hybrids.

Experimental work was conducted at All – Russia Research Institute of Oil Crops (VNIIMK). Simple and three-way hybrids were tested in 1991 –1998 for yield and yield stability, variation of height and other characters.

It should be noted that heterosis effect of simple and three-way hybrids was the same for yield, oil content and oil yield per hectare.

Simple hybrids were slightly more uniform in height than three-way one's (coefficient variation C_v=4.8 and 6.5 %, respectively).

Female forms of simple and three-way hybrids had significant differences in vigor, height, yield and oil content.

Average height of inbreds was about 1.18 m, yield was 1.20 t/ha, oil content was 40.8 %.

Sterile hybrids had height 1.73 m, yield 2.51 t/ha, oil content 50.1 %.

Both seeds of females and F_1 seeds of three-way hybrids had better emergence than the simple hybrids (differences 6-7%). Three-way hybrids were much more stable in yielding ability, than the simple hybrids under testing in different climatic conditions (coefficient variation C_v=17.4 and 31.2 %, respectively).

Three-way hybrids have some other merits:

- it is not necessary to make CMS-analogs for all females;
- it is possible to increase the total number of the experimental combinations (at least 5 times more);
- commercial seeds are chipper for producers (2 times less in average).

All of this reasons resulted in orientation of breeding program of VNIIMK (Central Experimental Office) for developing and introducing mainly three-way hybrids as the most preferable type of sunflower hybrids for Russia in the present day and in the nearest future.

Some of such hybrids were released in Russia (Kubanskiy 371, Kubanskiy 341, Kubanskiy 480, Kubanskiy 930).

Key words: heterosis, sunflower, simple and 3-way hybrids

INTRODUCTION

This work was carried out in order to gain further knowledge on the peculiarities of different types of sunflower hybrids. There are only two sunflower hybrid types grown in modern agriculture: simple and 3-way one's.

Some breeders believe that the heterotic effect of simple hybrids must be higher, than that of 3-way's, especially under favourable conditions (Fick, Zimmer, 1976).

Irrigation, extensive fertilizers application, effective weeds, diseases and insects control give an additional possibilities for better using of genetic background of simple hybrids (Vulpe, 1974).

At the same time the higher yielding stability of 3-way hybrids allows them to have advantages in mean yield under growing in different regions (Schuster, Friedt, 1988; Giri et. al., 1988).

Real breeding value of any sunflower hybrid depends on the combination of the high potential yielding capacity and yielding stability factors. That's why it is necessary to select the most preferable sunflower hybrid's type depending on the agriculture level (crop management), specific climatic, economic and even social peculiarities of the country.

MATERIAL AND METHOD

The crossing of 8 female parent lines VK-464, VK-392, VK-653, VK-389, HA-385, K-1721, VK-678, VK-499 and 3 restorers VK-541, VK-580, L-2796 as the male was done for producing of F_1 simple and 3-way sunflower hybrids. During 1997 … 1999 14 simple and 21 corresponding 3-way hybrids derived from the same lines have been tested.

Besides this, two released simple Krasnodarskiy 885 (VK-464xVK-541) and Krasnodarskiy 917 (VK-678xVK-571) and two released 3-way Kybanskiy 341 (VK-464xVK-678)xVK-541 and Kybanskiy 371 (VK-678xVK-464)xVK571 hybrids of the close origin were used. Competitive and ecological trials of the hybrids were done in 1991…1997.

Observation were carried out for vegetation period, height, yield, oil content, oil yield and some other characters. Location of the experiment were: VNIIMK and it's regional experimental stations.

Seeds of each genotype were planted by hand, the plots 24,5 m^2 with three replications was used. Each plot consisted of 4 rows 8,75 m long with 70 cm interrow spacing with a plant population of about 4 plants/m^2. Two middle rows in each plot were used for all the measurements and for harvesting. Oil content in seeds was determined by Nuclear Magnetic Resonance (NMR).

RESULTS AND DISCUSSIONS

HETEROTIC EFFECT OF SIMPLE AND 3-WAY HYBRIDS

No significant differences (during 1991…1997 in average) were observed between two simple (Krasnodarskiy 885 and Krasnodarskiy 917) and two 3-way sunflower hybrids (Kybanskiy 341 and Kybanskiy 371) in vegetation period, yield, oil content and oil yield (table. 1).

Table 1

MAIN BREEDING CHARACTERISTICS OF SIMPLE AND 3-WAY SUNFLOWER HYBRIDS

Krasnodar, 1991-1997

Hybrid's type	Vegetation period	Yield,	Oil content,	Oil yield,

	(days)	(t/ha)	(%)	(t/ha)
		1991 - 1997 (in average)		
Simple	84	2,91	50,9	1,32
3-way	84	2,92	51,2	1,33
		Under favorable (1992) conditions		
Simple	85	3,84	49,6	1,71
3-way	85	3,75	50,0	1,69
		Under stress (1997) conditions		
Simple	87	1,75	43,7	0,69
3-way	87	2,09	46,6	0,87

Simple hybrids weren't more productive even under favourable conditions, than 3-way one's. At the same time, stress conditions allow us to see a big advantages of 3-way crosses practically for all main breeding characters. Thus, 3-way hybrids are much more usefull for Russia's severe conditions, than simple hybrids.

The wider genetic background of 3-way hybrids gives certain advantages under testing in different year /region/ climatic conditions. There are significant differences for yield of the two types sunflower hybrids (in average) and 3-way's outyielded the single crosses (table 2). The same maximum but different minimum yield, rather big differences for yield variation ($x_{max} - x_{min}$), variation (Cv) and regression (bi) coefficient. It gives us a possibility to predict more wide ecological adaptability of 3-way hybrids in comparison with that of simple's (table 3).

Table 2

ECOLOGICAL TRIALS RESULTS OF SIMPLE AND 3-WAY SUNFLOWER HYBRIDS

1992-1996

Hybrid's type	Yield, (t/ha)							
	Voronezsh, 1992	Zaporozshie 1993	Lugansk, 1993	Rostov, 1995	Belgorod, 1995	Eisk, 1995	Zaporozshie 1995	Average
Simple Krasnodarskiy 917 (check)	2.96	3.06	2.15	3.39	1.71	1.29	2.63	2.46
3-way Kybanskiy 371	3.27	2.74	2.34	3.31	2.92	2.13	2.33	2.72
± against check	+0.31	-0.32	+0.19	-0.08	+1.21	+0.84	-0.30	+0.26
LSD_{05}	0.22	0.19	0.16	0.25	0.18	0.21	0.24	0.21

Table 3

VARIABILITY OF SIMPLE AND 3-WAY SUNFLOWER HYBRIDS UNDER ECOLOGICAL TRIALS

1992-1996

Hybrid's type	Yield, (t/ha)				Variation coefficient, Cv (%)	Regression coefficient, b_i
	average $\bar{X}$	maximum X_{max}	minimum X_{min}	variation ($X_{max} - X_{min}$)		
Simple (check)	2,46	3,39	1,29	2,10	31,2	1,18
3-way	2,72	3,31	2,13	1,18	17,4	0,83
± against check	+0,26	-0,08	+0,84	-0,92	-14,7	-

Reduced height variation of simple hybrids is a very much valued characteristic for developed countries market. It is some kind of attractiveness of the hybrids seeds, as a market product. In Russia's conditions open-pollinated varieties occupied about 70-75% of the total acreage under sunflower. Such situation is not favorable for sunflower hybrids breeding and seeds production. That's why height variation differences between simple and 3-way hybrids have not big signification for commercial sunflower seed production.

Table 4

PLANT HEIGHT VARIATION OF DIFFERENT SUNFLOWER HYBRIDS

Krasnodar, 1997-1999

Hybrid's type	Height, (cm)				Variation coefficient, Cv (%)
	average $\bar{X}$	maximum X_{max}	minimum X_{min}	variation $(X_{max}- X_{min})$	
Simple (n= 30)	170	187	161	26	4,8
3-way (n= 15)	172	187	159	28	6,5

There is no significant differences between simple and 3-way hybrids, both for average, maximum and minimum means (table 4). Simple hybrids were slightly more uniform in height then 3-way one's (coefficient variation Cv = 4,8 and 6,5 % respectively).

Maternal forms of simple and 3-way hybrids had significant differences in height, yield, oil content and huskness (table 5). Sterile simple hybrids are much more preferable as a maternal form of hybrids in comparison with inbred lines, especially under Russia's severe climatic conditions. Such favorable characters, as vigorous, high yielding sunflower plants, allow us to eliminate a lot of problems growing seeds hybridization plots. Seeds of 3-way hybrids are at least two times cheapper than that of simple's. Besides this, sterile hybrids are not so sensitive to weeds, water stress and so on, than inbred lines.

Sunflower hybrid seeds F_1 and their maternal forms had a certain differences in emergence, depending on the hybrid type (table 6). 3-way hybrids and their maternal forms had a better emergence (4-6 % more) than that of simple hybrids. Only under favorable conditions it is possible to grow seeds of simple hybrids without any problems in emergence. As for the stress conditions, it is quite difficult to make good inbred lines and simple hybrids F_1 seeds.

Table 5

COMPARISON OF SIMPLE AND 3-WAY SUNFLOWER HYBRID'S MATERNAL FORMS

Krasnodar, 1997-1999

Breeding material	Vegetation period (days)	Height, (cm)	Yield, (t/ha)	Oil content, (%)	Husk, (%)
Inbred lines (n= 8)	99	118	1,20	40,8	32,2
Sterile simple hybrids (n= 18)	97	173	2,51	50,1	22,9

Table 6

SEED'S EMERGENCE OF DIFFERENT SUNFLOWER HYBRIDS AND THEIR MATERNAL FORMS

Krasnodar, 1997-1999

Breeding material	Emergence (%)		
	1997-1999 (in average)	Under favorable (1998) conditions	Under stress (1997) conditions
	Hybrids seeds F_1		
Simple hybrids	88	92	86
3-way hybrids	94	96	91
	Maternal forms		
Inbred lines	87	90	83
Sterile simple hybrids	93	96	89

Inside our breeding program we try to develop high yielding, resistant to the main pathogens (Orobanche, Plasmopara, Phomopsis and some others) sunflower hybrids of different fatty acids and tocopherol content, early and middle-early group of vegetation period, stable under growing in different region (climatic conditions), profitable in hybrid seeds production, high oil content (50 – 52%), adapted to combine harvesting, seeds processing technology and so on. Released and promissing 3-way sunflower hybrid's characteristics demonstrate a progress of breeding from year to year (table 7).

Table 7

RELEASED AND PROMISSING 3-WAY SUNFLOWER HYBRIDS OF VNIIMK

Krasnodar, 1995-1999

Hybrids	Year of registration	Vegetation period (days)	Yield, (t/ha)	Oil content, (%)	Oil yield, (t/ha)	Pathogen resistance		
						Broomrape	Plasmopara	Phomopsis
Kubanskiy 371	1994	83	2,46	49,5	1,10	resistant	Pl_1	Middle-tolerant
Kubanskiy 341 (high oleic)	1994	86	2,70	50,5	1,23	resistant	$Pl_1Pl_2Pl_9$	Middle-tolerant
Kubanskiy 480	1996	85	2,82	51,6	1,31	resistant	$Pl_1Pl_2Pl_9$	Tolerant
Kubanskiy 930	1996	87	2,92	52,3	1,37	resistant	$Pl_1Pl_2Pl_9$	Tolerant
Kubanskiy 931	1998	87	3,08	52,0	1,44	resistant	$Pl_1Pl_2Pl_9$	High-tolerant

Breeding has big significance for protection of sunflower yield under phomopsis epiphitotia conditions (table 8). Mean losses for such important characteristics, as yield, oil content and oil yield are decreasing step by step from susceptible to high tolerant 3-way sunflower hybrids. Some new hybrids (Kubanskiy 931 and Kubanskiy 939) are very tolerant to phomopsis and resistant to Orobanche and Plasmopara. Here is so called "group resistance" to several dangerous pathogens – the most suitable protection's type for the modern agriculture conditions.

Table 8

ROLE OF BREEDING IN INCREASING OF YIELD STABILITY UNDER PHOMOPSIS EPIPHITOTIA CONDITIONS

Krasnodar, 1997-1999

Hybrids	Registration year	Mean losses		
		Yield, (t/ha)	Oil content, (%)	Oil yield, (t/ha)
SUSCEPTIBLE Krasnodarskiy 885 Krasnodarskiy 917	1988-1991	1,15	7,3	0,54
MIDDLE - TOLERANT Kybanskiy 341 Kybanskiy 371	1994	0,83	4,6	0,38
TOLERANT Kybanskiy 480 Kybanskiy 930	1996	0,38	2,4	0,17
HIGH - TOLERANT Kybanskiy 931 Kybanskiy 939	1998	0,15	1,2	0,07

As a result of our studies we concluded, that 3-way sunflower hybrids, whose yielding ability is the same as for simple hybrids, but higher ecological stability, more profitable hybrid seeds production, higher emergence F_1 seeds and their maternal forms, more effective and economic breeding scheme-are the most preferable type of sunflower hybrids for Russia in the present time and nearest future.

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