Kumarbek Urumbayev*, Vladimir Miklič, Ulan Almishev and Jelena Ovuka

Testing of Some NS-Sunflower Hybrids in the Northeast of Kazakhstan

https://doi.org/10.1515/helia-2017-0013
Received June 6, 2017; accepted October 19, 2017; previously published online November 28, 2017

Abstract: The main purpose of this study was to define the perspective of cultivating sunflower hybrids in the northeast of Kazakhstan. The trial included 10 hybrids that originated from the Institute of Field and Vegetable Crops, Novi Sad, Serbia (NS-sunflower hybrids). The study was conducted in the field and laboratory. Testing was carried out by PGTH technique (a preliminary testing of hybrids) ARRIOBC (All-Russian Research Institute of Oil-Bearing Crops) in quadruple frequency and as a production testing on big squares in single frequency. Phenological assessment, plant measurements, definition of oil content, 1000-seed weight and its nature were carried out by the standard methods. The experiments established the length of the vegetative period, growth indicators, yield, oil content and oil yield per hectare, 1000-seed weight and nature of the studied hybrids in three agro-climatic zones in the northeast of Kazakhstan. Two perspective locations for hybrid cultivation were allocated in Pavlodar and east Kazakhstan regions. Further research on developing seed farming technology of the perspective hybrids in Pavlodar region of Kazakhstanis planned.

Keywords: sunflower, testing hybrids, agro-climatic zone, agronomic and phenological assessment

Introduction

Sunflower is the main oil-bearing crop in Kazakhstan. Despite the expansion of its growing area, from 136.9 thousand hectares in 1990 to 740.7 thousand

***Corresponding author: Kumarbek Urumbayev,** S. Toraighyrov Pavlodar State University, Pavlodar, Kazakhstan, E-mail: kaurumb@mail.ru
Vladimir Miklič, Industrial Crops Department, Institute of Field and Vegetable Crops, Novi Sad, Serbia
Ulan Almishev, S. Toraighyrov Pavlodar State University, Pavlodar, Kazakhstan
Jelena Ovuka, Industrial Crops Department, Institute of Field and Vegetable Crops, Novi Sad, Serbia

hectares in 2015 (Statistical Agency, 2016), the production of sunflower oilseeds does not completely supply the internal needs of the country. The intensification of sunflower cultivation technology is necessary for increasing the production of vegetable oil raw materials. Seeds are the most important component of cultivation technology of any crop. Nowadays, both varieties and hybrids are used in the production of sunflower seeds. Crop acreage of sunflower is completely occupied with hybrids in technologically developed countries. In the Russian Federation there is an expansion of the areas of hybrids cultivation, and in 2006 hybrids occupied 30–35 % of the acreage (Bochkovoy, 2007). Sunflower varieties are generally cultivated in Kazakhstan and hybrids have been sown on small areas so far. The transition from cultivating sunflower varieties to cultivating sunflower hybrids is one of the ways to increase sunflower yield. The breeding of sunflower hybrids has been developed after the invention of a reliable CMS-Rf system on the basis of the sterility source received by Leclercq (1970, 1971). Sunflower is sown on large areas in many countries of Western Europe and the USA only after a successful development of heterotic breeding and creation of highly productive hybrids of this crop. The introduction of sunflower hybrids was successful in many countries (Brigham and Young, 1985; Buchuchanu *et al.*, 1986; Dymock, 2000; Fick *et al.*, 1985). The breeding of sunflower hybrids in Kazakhstan began in the 1980s. Hybrids such as Kazakhstan 1, Kazakhstan 341, Sunkar, and Kazakhstan 465 are the result of the domestic breeding and registered in the National Register of Breeding Achievements allowed to be used in the Republic of Kazakhstan. Some hybrids created by leading international sunflower breeding companies (Syngenta, Pioneer, Limagrain) are included in this register as well. NS-sunflower hybrids from the Institute of Field and Vegetable Crops, Novi Sad, Serbia occupy 3 million hectares of sunflower acreage in many countries of the world and can be quite a successful competitor to these companies on the Kazakhstan fields. The cooperation between the Institute of Field and Vegetable Crops, Novi Sad, Serbia and the Kazakh Experimental Station of Oil-Bearing Crops started in 1993 with a plan to sign agreements on the creation of joint sunflower hybrids, but unfortunately the initiative was not followed through. In 2015 S. Toraighyrov Pavlodar State University (Kazakhstan) and Institute of Field and Vegetable Crops, Novi Sad, Serbia signed the cooperation contract to carry out joint scientific projects on breeding and seed farming of sunflower hybrids.

During 2015–2017 based on this contract, a project was carried out to define the perspective to cultivate sunflower hybrids of NS-breeding from Novi Sad, Serbia in the northeast of Kazakhstan and to develop the technology of their seed production in Pavlodar region of the Republic of Kazakhstan. According to the developed time schedule of the project implementation, the testing of 10 NS-

sunflower hybrids breeding was carried out in three various agro-climatic zones of Pavlodar and east Kazakhstan regions in 2015. The results of these tests are presented in this paper.

Material and method

Ten NS-sunflower hybrids were the object of the study: NS Dukat, Sumo 1 PR, Sumo 2 OR, Rimi PR, Vranac, Orfej, NS Fantazija, Novosađanin, Duško, and NS Garavi. The earliest hybrids as well as the hybrids cultivated in accordance with the modern intensive Clearfield technologies (tolerant to herbicides from imidazolinone group) and SUMO hybrids (tolerant to herbicides containing the tribenuron-methyl as the active substance) were selected for the experiment. The study was conducted in the field and laboratory. Sunflower hybrids were tested in three farms located in Pavlodar and east Kazakhstan regions. In Pavlodar region the trials were conducted in CE (country economy) Shcherbakin Kachirskiy district and CE Sergey in the Aksuskiy district. In the east Kazakhstan region the trial was conducted at the Experimental Farm of Oil-Bearing Crops LLP (EFOBC LLP). The soil characteristics and climatic conditions of the locations where hybrids were tested are given in Table 1.

Table 1: Characteristic of soil and climatic conditions in 2015.

Location	Agro-climatic zone	Soil type	The sum of effective temperatures - higher than 10 °C	Annual sum of precipitation (mm)	The sum of precipitation for the vegetation period (mm)
EFOBC LLP	foreland-steppe	Chernozem usual	2450	480	300
CE Shcherbak	semi-dry climate	Chernic Kastanozem	2450	310	245
CE Sergey	dry	Haplic Kastanozem	2500	230	180

From the data presented in the Table 1 we can see that the optimum climatic conditions for cultivating sunflower are in EFOBC LLP, less favorable conditions are in CE Shcherbak of Kachirskiy district, and the most severe conditions for cultivating sunflower are in CE Sergey of Aksuskiy district. Two types of variety

testing were carried out on these farms. The study of the listed10 hybrids according to PGTH technique (a preliminary testing of hybrids) of the All-Russian Research Institute of Oil-bearing Crops (ARRIOBC) was carried out in EFOBC LLP and CE Sergey. Tests were put on the six-row the thirteen-local allotments with an allotment total area 19.1 m^2 from which four rows are registered with an area of 10.78 m^2. Experimental crop seeding was carried out by manual seeders - crackers according to the scheme of crops 0.7 m × 0.35 m. Frequency of experiment was quadruple, control was conducted twice. Hybrids Kazakhstan 465 and Kazakhstan 95 were controls in EFOBC LLP. Zarya variety and Kazakhstan 465 hybrid were control in CE Sergey. Yield results from the experiments were processed by the dispersive analysis method. The production variety testing of five hybrids was carried out in CE Shcherbak: Rimi PR, Vranac, Duško, Sumo 1 PR, NS Dukat, the hybrid Kazakhstan 465 was control in the experiment. The experiment was placed in the production crops of CE Shcherbak occupied with a Zarya variety in a single frequency on allotments of 2,800 m^2. Experimental crops were planted with a John Deere 7200, the 16-row seeder. Crops of every experiment were seeded with a distance of 250 m. Phenological assessment by ARRIOBC technique during which date of crops was noted, full (75 %) seedlings, the beginning (10 %) and the end (75 %) of flowering and maturing were carried out in all experiments. The usual growing technology was used, including inter-cultivation. In addition, the manual weeding of the experiment in EFOBC LLP was carried out. During the period of physiological ripeness approach measurements of plants height, head inclination (an inclination of plants) and diameter of a head were taken in each experiment. According to the technique the measurements were taken at 10 plants located nearby in a registration row. The oil content of seed pods was determined by the NMR (nuclear magnetic resonance) method as an average from two tests. NMR analyzer is AMB-1006M of the Russian production. Thousand-seed weight was determined by the standard technique — as an average from two tests on 500 pieces, nature — with use of a measured grain-unit scale.

Results

The main feature of the northeast of Kazakhstan is the shortened vegetation period that does not allow growing varieties and sunflower hybrids with vegetation period longer than 100–110 days. The most suitable for cultivation and yield in this region are sunflower varieties and hybrids with vegetation period lasting 95–100 days. Phenological assessment determined the terms of approach and

duration of development phases of plants of the studied sunflower hybrids which are presented in Table 2. According to the phenological assessment of the tested hybrids, NS Dukat (97 days from seedling to maturing) had the shortest vegetative period. All other hybrids had vegetation period longer than 100 days, the latest of the tested hybrids were NS Fantazija (105 days from seedling to maturing) and Rimi PR (108 days).

Table 2: Sunflower genotype phenological assessment in the northeast of Kazakhstan.

Genotype	Duration of the period (days)		
	From seedling to flowering		From seedling to maturing
	Beginning (10 %)	Absolute (75 %)	
C1	62	64	97
C2a	60	62	90
NS Dukat	59	60	97
Sumo 1 PR	66	69	104
Sumo 2 OR	65	67	102
Rimi PR	69	71	108
Vranac	66	68	102
Orfej	64	67	103
NS Fantazija	69	71	105
Novosađanin	64	66	101
Duško	65	67	101
NS Garavi	64	67	102

*C1 - control Kazakhstan 465; C2a - control Kazakhstan 95.

The plant height, head inclination and head diameter were measured in each experiment when the period of physiological maturity was approaching. The distinction of plant measurement results (Table 3) visually represents the distinction of climatic conditions of experiences venues. The head inclination is the indicator that shows distance from ground during maturing.

After taking measurements the following conclusions were made:

- Regardless of the experiment location, NS Dukat had the lowest height of plants among the tested hybrids (131 cm);
- In the conditions of Aksuskiy district of Pavlodar region (dry agro-climatic zone) plant size was twice lower than in EFOBC LLP of east Kazakhstan region (foreland-steppe agro-climatic zone).

In the experiments in EFOBC LLP and CE Sergey, the results of yield on repetition the experiment options were processed by the dispersive analysis

Table 3: Sunflower genotype plants measurements in northeast agro-climatic zones of Kazakhstan (cm).

Genotype	Agro-climatic zone (experience venue)								
	Foreland-steppe			Semi-dry climate			Dry		
	EFOBC LLP			CE Shcherbak			CE Sergey		
	Height	Head inclination	Head diameter	Height	Head inclination	Head diameter	Height	Head inclination	Head diameter
C1	159	130	17	147.5	133.6	12.5	97.3	81.3	12.3
C2a	156	108	16	–	–	–	–		–
C2b	–	–	–	–	–	–	104.1	85.5	11.3
NS Dukat	131	108	16	124.5	106.8	11.5	74.5	63.1	10.6
Sumo 1 PR	177	165	15	135.2	128.5	11.8	100.3	92.7	11.2
Sumo 2 OR	162	151	16	–	–	–	90.4	81.3	15.2
Rimi PR	188	159	17	131.7	123.5	11.5	103.0	95.4	10.4
Vranac	189	142	17	134.2	114.9	14.3	101.8	83.7	14.9
Orfej	184	138	17	–	–	–	87.5	74.7	11.5
NS Fantazija	201	167	17	–	–	–	99.5	89.2	11.6
Novosađanin	189	143	17	–	–	–	95.0	82.7	13.0
Duško	190	143	16	148.6	134.5	12.0	112.6	93.7	13.3
NS Garavi	190	147	16	–	–	–	101.6	87.8	13.0

*C1 - control Kazakhstan 465; C2a - control Kazakhstan 95; C2b - control Zarya.

Table 4: Sunflower genotype yield in foreland-steppe and dry zones of the northeast of Kazakhstan (centner/ha).

Genotype	EFOBC LLP			CE Sergey		
	foreland-steppe zone			dry zone		
		± from C1	± from C2a		± from C1	± from C2b
C1	28.9	–	+2.1	8.9	–	+2.0
C2a	26.8	−2.1	–	–	–	–
C2b	–	–	–	6.9	−2.0	–
NS Dukat	28.7	−0.2	+1.9	8.3	−0.6	+1.4
Sumo 1 PR	26.1	−2.8	−0.7	7.4	−1.5	+0.5
Sumo 2 OR	24.7	−4.2	−2.1	10.1	+1.2	+3.2
Rimi PR	27.2	−1.7	+0.4	5.4	−3.5	−1.5
Vranac	22.3	−6.6	−4.5	8.1	−0.8	+1.2
Orfej	28.5	−0.4	+1.7	9.7	+0.8	+2.8
NS Fantazija	26.8	−2.1	0	8.0	−0.9	+1.1
Novosađanin	30.8	+1.9	+4.0	10.9	+2.0	+4.0
Duško	25.6	−3.3	−1.2	8.3	−0.6	−1.4
NS Garavi	23.6	−5.3	−3.2	9.7	+0.8	+2.8
LSD_{05}	3.5			1.5		

C1 - control Kazakhstan 465; C2a - control Kazakhstan 95; C2b - control Zarya.

method. Yield is shown in Table 4, while the oil content and oil yield are presented in Table 5. Because of the low yields in the experiments, the results are expressed in centner per hectare (centner/ha), in contrast to the accepted designation of yield in tons per hectare (t/ha). In CE Sergey yield was much lower than in EFOBC LLP. In CE Sergey Novosađanin had a reliable increase of yield (+2 c/ha over C1 and +4 c/ha over C2b, LSD0.5 1.4 c/ha). In EFOBC LLP this hybrid authentically exceeded only early ripe C2a (+4 c/ha, LSD05 3.5 c/ha) and has yield increase within an experience error in comparison with C1 (+1.9 c/ha). NS Dukat was also singled in a group of studied hybrids, in connection with its early ripeness which authentically exceeded yield of C2b (+1.4 centner/ha) in CE Sergey. In comparison with other controls, NS Dukat had yield equal with them. In CE Sergey the essential increase of yield in comparison with C2b also was found in SUMO 2 OR (+3.2 centner/ha), Orfej (+2.8 centner/ha) and NS Garavi (+2.8 centner/ha) hybrids, but because of too long period of vegetation these hybrids are not absolutely suitable for cultivation in the northeast of Kazakhstan.

Hybrid Novosađanin showed high oil content (51.8 %) and oil yield (14.0 centner/ha) among the tested NS-hybrids. In EFOBC LLP it exceeded oil yield in comparison with the best of standards by 0.6 centner/ha and in CE Sergey by 0.8 centner/ha.

Table 5: Sunflower genotype oil content (%) and oil yield (centner/ha) in foreland-steppe and dry zones of the northeast of Kazakhstan.

Genotype	EFOBC LLP		CE Sergey	
	foreland-steppe zone		dry zone	
	Oil content	Oil yield	Oil content	Oil yield
C1	52.8	13.4	50.7	4.0
C2a	54.0	12.7	–	–
C2b	–	–	54.3	3.3
NS Dukat	49.9	12.6	47.9	3.5
Sumo 1 PR	50.2	11.5	49.4	3.2
Sumo 2 OR	49.7	10.8	48.2	4.3
Rimi PR	44.7	10.7	44.2	2.1
Vranac	47.0	9.2	46.6	3.3
Orfej	49.4	12.4	46.8	4.0
NS Fantazija	49.0	11.5	47.2	3.3
Novosađanin	51.8	14.0	50.4	4.8
Duško	49.8	11.2	47.9	3.5
NS Garavi	47.5	9.9	46.2	3.9

C1 - control Kazakhstan 465; C2a - control Kazakhstan 95; C2b - control Zarya.

The production testing of hybrids in CE Shcherbak - Rimi PR, by Vranac, Duško, Sumo 1 PR, and NS Dukat in comparison with C1 was carried out. Among these hybrids, NS Dukat is the most suitable for cultivation in the northeast of Kazakhstan regarding duration of the vegetative period, it has shown yield equal to a control hybrid.

Thousand-seed weight and volume weight (weight of one liter of seeds) of the studied hybrids were determined (Table 6).

In EFOBC LLP NS Garavi had the heaviest seeds (1000-seed weight was 74.3 g), in CE Sergey this indicator was the highest in Vranac (59.0 g). Thousand-seed weight of Vranac in EFOBC LLP was the second-highest in the trial (65.5 g).

The lowest 1000-seed weight was found in NS Fantazija in EFOBC LLP (44.1 g) and in CE Sergey (31.4 g). Both in the first and in the second experiment, Orfej had the largest volume weight, at the same time it was identical in both zones of test (476 g/l). Low volume weight in EFOBC LLP was shown by hybrid Vranac (385 g/l), and in CE Sergey by Sumo 1 PR (333 g/l), in CE Sergey Vranac also had low volume weight (357 g/l). In general, all tested hybrids had lower 1000-seed weight and volume weight in CE Sergey than in EFOBC LLP.

Table 6: Sunflower genotype 1000-seed weight (g) and volume weight (g/l) in EFOBCLLP and CE Sergey.

Genotype	EFOBC LLP		CE Sergey	
	1000-seed weight	Volume weight	1000-seed weight	Volume weight
C1	64.6	454	43.4	435
C2a	51.6	476	–	–
C2b	–	–	26.0	400
NS Dukat	54.6	454	39.0	435
Sumo 1 PR	49.8	454	32.9	333
Sumo 2 OR	52.0	435	36.7	435
Rimi PR	53.8	435	36.1	385
Vranac	65.5	385	59.0	357
Orfej	54.1	476	42.2	476
NS Fantazija	44.1	454	31.4	417
Novosađanin	47.1	476	38.9	454
Duško	48.8	476	45.0	454
NS Garavi	74.3	454	56.2	417

C1 - control Kazakhstan 465; C2a - control Kazakhstan 95; C2b - control Zarya.

Discussion

The large geographical area where sunflower is grown requires this crop to be adaptable to many stresses, including diseases, pests, and environmental factors (Seiler, 2002). Bearing in mind the fact that sunflower is an important plant species for the production of edible oil, breeders are creating hybrids with high potential for yield, and oil per unit area in a number of countries. The new hybrids are being tested in multiple environments in order to select hybrids and give recommendations to producers for planting. Great demand for better quality and more fertile hybrids requires a quick change to other varieties with better, more productive and stable sunflower hybrids. The amount and yield stability are the properties of most interest to the breeders and producers. The production of higher-yielding hybrids, as well as the application of the appropriate cropping practices that reduce the impact of the limiting factors in the production, increases the yields of sunflower (Miklič *et al.*, 2010). The majority of the tested hybrids belong to medium early group, with more than 100 days of vegetative period, so these hybrids are not suitable for cultivation in the east Kazakhstan and Pavlodar regions. NS Dukat and Novosađanin are the best hybrids for the northeast of Kazakhstan regarding vegetation term. Considering the fact that unfavorable environmental conditions represent a limiting factor in the

production of sunflower (Vranceanu, 2000; Škorić *et al.*, 2006), it is necessary to test, in addition to sites included as a factor and in order to better visualize the impact of agro-ecological conditions in achieving the genetic potential of hybrids. In the conditions of dry agro-climatic zone of the northeast of Kazakhstan, plant height was twice lower than in the foreland-steppe zone. NS Dukat had the lowest height of plants. However, Schneiter (1992) and Velasco *et al.* (2003) reported that hybrids with shorter stems had the same yield potential as hybrids of standard heights. In addition, Miller and Hammond (1991) pointed out that hybrids with lower stem height were better adapted to different environmental conditions and achieved higher yields. Lower stem hybrids have higher rates of photosynthesis, more solar energy, moisture, and nutrients are used, and have a lower intensity of transpiration and water deficit. Therefore, they are more interesting for many production areas, in regions with high fertility and soil moisture, and in regions with a distinct lack of moisture. The advantage of the hybrid with the reduced stem height is higher resistance to lodging, in particular around the frequent occurrence of strong winds, and in irrigated regions, such as Kazakhstan. Height and stability of sunflower hybrids seed yield are the most interesting traits for both the breeders and the producers. Sunflower seed yield is the product of three basic components - the number of plants per unit of area, the number of seeds per plant, and seed weight (Merrien, 1992). Contemporary hybrids have a high yield potential, which varies between 4.0 and 6.0 t/ha (Aksyonov, 2007). This potential is achieved in practice from 50 % to 60 %, or even less. There are considerable differences among hybrids, localities, and years of testing regarding seed yield (Schoeman, 2003). Novosađanin was revealed and assessed as the highest yielding in 2015. In the EFOBC LLP experiment, it exceeded C2a by 4 centner/ha, while C1 exceeded Novosađanin by1.9 centner/ha. In CE Sergey Novosađanin significantly exceeded C1 by 2.0 centner/ha, and C2b by 4.0 centner/ha. Good yield was also shown by NS Dukat in experiments. Oil yield is the main indicator of the productivity of each hybrid (Škorić *et al.*, 2005) and depends on the seed yield and oil content in seeds. High temperatures in the flowering period (> 25 °C) lead to reduced oil content, and consequently to reduced oil yield (Miklič *et al.*, 2009). Using the laboratory analysis of seeds quality, it was established that Novosađanin had the highest seed oil content (in EFOBC LLP 51.8 %, in CE Sergey 50.4 %) and the highest oil yield per hectare (in EFOBC LLP 14.0 centner/ha, in CE Sergey 4.8 centner/ha) among the studied hybrids. De La Vega and Hall (2002) reported that the main source of variation for sunflower oil content and oil yield was sowing date, although other sources of variation were significant. Miller *et al.* (1982) points out that sowing delay from early May to early June reduced oil yield because of seed filling period took place during the

hot days and shortened growing season. Gontcharov and Zakharov (2008) reported that oil content is generally determined by the length of time of flowering to physiological maturity. In dry year soil content is lower than in wet years, particularly when lack of moisture occurs in the period flowering - maturation (Tardieu, 2013). Vranac and NS Garavi had the largest seeds, and the highest volume mass was found in Orfej. It is considered very important that a hybrid has a high value of 1000-seed weight, because it has more food reserves, developed embryo and plant that develop growing faster, which is particularly important in extreme climatic and edaphic conditions.

Conclusion

On the basis of results of NS-sunflower hybrids 2015 testing conducted in three various agro-climatic zones of the Pavlodar and east Kazakhstan regions, the following conclusions and recommendations can be drawn:

1. Hybrids Novosađanin and NS Dukat are the most perspective for cultivation in the northeast of Kazakhstan among the NS-sunflower hybrids tested in 2015.
2. Production testing of Novosađanin and NS Dukat should be carried out in various agro-climatic zones of the Pavlodar and East Kazakhstan regions in 2016.
3. Experiments should be set up to develop seed farming of Novosađanin and NS Dukat sunflower hybrids technology under irrigation in Pavlodar region in 2016.

References

Aksyonov, I., 2007. Effect of cultivation measures on index of photosynthesis and yield of sunflower. Helia 30: 79–86.

Bochkovoy, A.D., 2007. VNIIMK breeding program as reflection of scientific and technical progress. Agro-Industrial Newspaper of the South of Russia 74–75: 9–10.

Brigham, R.D., Young, J.K., 1985. Genetic potential of dwarf sunflower hybrids in Texas. *In:* Proc. 11th Int. Sunflower Conf., Mar del Plata, Argentina, Vol. 2, pp. 787–788.

Buchuchanu, M.I., Rotaru, F.G., Lesnik, V.S., Karadzhova, L.V., 1986. Results of breeding sunflower for heterosis in Romania. Selektsiia I Semenovodstvo 2: 58–61.

De La Vega, A.J., Hall, A.J., 2002. Effects of planting date, genotype, and their interactions on sunflower yield. I. Determinants of oil-corrected grain yield. Crop Sciences 42: 1191–1201.

Dymock, P. 2000. Oilseed economics and agricultural policies. 15^{e} Conférence internationale du tournesol: économie et technologie du tournesol, Journée de Printemps de l'AFECG, Toulouse, France. OCL - Oléagineux, Corps Gras, Lipides 7 (3): 237–242.

Fick, G.N., Caroline, J.J., Auwater, G.E., Duhigg, P.M., 1985. Agronomic characteristics and performance of dwarf sunflower hybrids. *In:* Proc. 11th Int. Sunflower Conf., Mar Del Plata, Argentina, Vol. 2, pp. 739–742.

Gontcharov, S., Zaharova, M., 2008. Vegetation period and hybrid sunflower productivity in breeding for earliness. *In:* Proc. 17th International Sunflower Conf., Cordoba, Spain, pp. 531–533.

Leclercq, P., 1970. Sunflower hybrids using male sterility. *In:* Proc. 4th Int. Sunflower Conf., Memphis, Tennessee, pp. 123–126.

Leclercq, P., 1971. La sterilite male cytoplasmique du tournesol. I. Premieres etudes sur la restauration de la fertilite. Annals Amelior Plant 21: 45–54.

Merrien, A., 1992. Some aspects of sunflower crop physiology. *In:* Proc. 13th Int. Sunflower Conf., Pisa, Italy, Vol. 1, pp. 481–498.

Miklič, V., Balalić, I., Jocić, S., Marinković, R., Cvejić, S., Hladni, N., Miladinović, D., 2010. Stability estimation for seed and oil yield of NS sunflower hybrids in small-plot trials and recommendations for 2010 sowing season. Ratarstvo I Povrtarstvo 47: 131–146.

Miklič, V., Balalić, I., Jocić, S., Marinković, R., Cvejić, S., Hladni, N., Stojšin, V., 2009. Productivity of NS sunflower hybrids in multilocational small-plot trials and recommendations for 2009 sowing season. Zbornik Radova Instituta Za Ratarstvo I Povrtarstvo 46: 293–310.

Miller, B.C., Oplinger, E.S., Rand, R., Peters, J., Weis, G., 1982. Effect of planting date and plant population on sunflower performance. Agronomic Journal 76: 511–515.

Miller, J.F., Hammond, J.J., 1991. Inheritance of reduced height in sunflower. Euphytica 53: 131–136.

Schneiter, A.A., 1992. Production of semi dwarf and dwarf sunflower in the northern Great Plains of the United States. Field Crops Researcher 30: 391–401.

Schoeman, L.J., 2003. Genotype × environment interaction in sunflower (*Helianthus annuus*) in South Africa. PhD thesis. University of the Free State, Bloemfontein, South Africa.

Seiler, G.J., 2002. Wild sunflower germplasm: A perspective on characteristics of use to sunflower breeders in developing countries. *In:* Proc. 2nd Int. Symp. Sunflower in Developing Countries, Benoni, South Africa, p. 10 http://www.isa.cetiom.fr/symposium/seiler.htm.

Škorić, D., Joksimović, J., Jocić, S., Jovanović, D., Marinković, R., Hladni, N., Gvozdenović, S., 2005. Evaluation of production characteristics of NS sunflower hybrids. Zbornik Radova Instituta Za Ratarstvo I Povrtarstvo 41: 21–33.

Škorić, D., Joksimović, J., Jocić, S., Jovanović, D., Marinković, R., Hladni, N., Gvozdenović, S., 2006. Results of a two-year study of Novi Sad sunflower hybrids in small - plot trials. Zbornik Radova Instituta Za Ratarstvo I Povrtarstvo 42: 61–74.

Statistical Agency of the Republic of Kazakhstan, 2016. Retrieved from www.stat.gov.kz/faces/wcnav_externalId/homeNumbersAgriculture?

Tardieu, F., 2013. Plant response to environmental conditions: Assessing potential production, water demand, and negative effects of water deficit. Frontiers Physiological 4: 17. doi: 10.3389/fphys.2013.00017.

Velasco, L., Domínguez, J., Munoz-Ruiz, J., Perez-Vich, B., Fernandez-Martinez, J., 2003. Registration of "Dw 89" and "Dw 271" parental lines of sunflower. Crop Science 43: 1140–1141.

Vranceanu, A.V., 2000. Floarea-sourelni hibrida. Editura Ceres: 1–1147. Bucharest, Romania.