HIGH OLEIC SUNFLOWER HYBRID OXY WITH CHANGED SEED TOCOPHEROL CONTENT

Yakov DEMURIN, Nikolay BOCHKAREV, Oxana BORISENKO

All-Russia Research Institute of Oil Crops (VNIIMK), Filatova 17, Krasnodar 350038, Russia

e-mail: yakdemurin@yandex.ru

ABSTRACT

Single cross sunflower hybrid Oxy was developed in VNIIMK, Krasnodar and registered by Russian State Commission on testing and protection of breeding achievements in 2014. Hybrid Oxy is considered an innovation from biochemical genetics to breeding for oil quality. All of the hybrid, female and male parent lines are homozygotes for a dominant high oleic mutation *Ol*, as well as recessive tocopherol mutation *tph1*, *tph2* and *tph3*. The main breeding character of the hybrid Oxy is increased oil oxidative stability up to 14 times due to high content of oleic content, gamma- and delta-tocopherols. Tocopherol mutations in sunflower seeds were originated from spontaneous mutagenesis within a gene pool of cultivated plants of *Helianthus annuus* L. All *tph1*, *tph2* and *tph3* mutations are monogenic recessive and non-lethal. The recombination of these mutations allows producing nearly any types of tocopherol profiles with four known alpha-, beta-, gamma- and delta-homologues. Mid-ripening hybrid Oxy possesses acceptable seed yield potential about 3 t/ha, broomrape resistance to race A-E, phomopsis tolerance and stay-green stem. Seed oil content averages 48%, hull content – 23%. Hybrid Oxy is not a GMO. The oil of the hybrid is intended to be used in the area of native oil with maximum level of oxidative stability i.e. for frying purposes.

Key words: Oil, Stability, Breeding, Oleic Acid, Tocopherol, Mutation

INTRODUCTION

Genetic research has led to an entirely new level in the global plant breeding for oil quality associated with overcoming interspecific barriers in genetic variation of seed lipid composition between different oil crops. For example, sunflower can produce oil similar to olive in fatty acid composition and flax - to sunflower. Plant varieties are developed with industrial-commodity targeting.

Sunflower breeding for oil quality based on the current trends to transfer the individual steps of industrial technology in the cells of living organisms. This process allows obtaining the desired substances of natural origin with ecological clean biosynthetic approach. Breeding strategy in this case is to create varieties with new types of oil determined by its use. There is selection of genotypes both on the extreme manifestation of the trait, i.e. minimum or maximum and the optimum content of desired substances. It is obvious that each type of oil has individual quality parameters.

Unlike breeding for yield increase, when traits of productivity, resistance to diseases and abiotic stresses are formed and implemented in the field during harvesting, breeding for improved quality deals with so-called “cross-cutting” characters of chemical composition of the seeds. These traits are formed in the plant in the field conditions and pass to the raw

materials and products of technological processing, i.e. they are realized in the industrial or consumer sectors.

The quality of the oil, i.e. its nutritive, biological and technological properties, depends on composition of fatty acids of a triacylglycerol molecule, and presence of related compounds. One of the important problems in improving of oil quality is to increase its resistance to oxidation for preventing toxic products of rancidity during storage and use.

The degree of unsaturation of fatty acids which correlated positively with the ability to oxidation and the presence of natural antioxidants, especially tocopherols, protecting against the free radical accumulation are the main factors of oil oxidation (Velasco *et al*., 2003, 2004; Warner *et al*., 2008).

HYBRID OXY DEVELOPMENT

The first major achievement in sunflower breeding for oil oxidative stability was held with high oleic variety of Pervenets in VNIIMK, Krasnodar (Soldatov, 1976). This variety has become a unique donor of the high oleic mutation in breeding programs worldwide.

Found in further studies the effect of synergism in the joint action of fatty acids and tocopherols on the stability of oil to oxidation has opened up opportunities in sunflower breeding by combining the desired genes (Demurin, 1993; Demurin *et al*., 1996). As a result of this work sunflower commercial hybrid, named Oxy, was developed in VNIIMK. It has both traits combined of high oleic acid and the high content of powerful antioxidants such as gamma- and delta-tocopherols (Table 1).

Table 1. Composition of fatty acids and tocopherols in the oil of sunflower hybrid Oxy

Hybrid	Fatty acid composition, %				Tocopherol composition, %			
	palmitic	stearic	oleic	linoleic	α	β	γ	δ
Standard	5,1	3,5	31,2	60,2	100	<1	<1	0
Oxy	4,3	3,8	86,2	5,7	<1	<1	60	40

Single-cross sunflower hybrid Oxy was obtained in the framework of breeding and genetic program to improve the quality of oil by the crossing inbred lines VK876 A × VK195. All parent forms, including female CMS analogue and maintainer, as well as a male fertility restorer are homozygous on four genes controlling the trait of high oleic acid content (dominant mutation *Ol*) and high content of powerful antioxidants such as gamma- and delta-tocopherol (triple homozygote for recessive mutations of *tph1*, *tph2* and *tph3*). The main valuable character of the hybrid Oxy is increased to 14-fold oxidative stability of the oil compared to the normal genotype due to the simultaneous change in the composition of fatty acids and tocopherols, which gives this hybrid world priority (Table 2).

Table 2. Breeding characteristics of the sunflower hybrid Oxy

Trait	Standard	Oxy
Vegetation period, days	94	94
Seed yield, t/ha	3,3	3,1
Seed oil content, %	51,8	47,8
Oil yield, t/ha	1,5	1,3
Oil type	linoleic, α-tocopherol	high oleic, γ- and δ-tocopherols
Oxidative stability, hours (Rancimat-test, 120 °C)	3,1	44,3

Hybrid Oxy belongs to the middle ripening group. The seed yield does not differ from the standard. The hybrid is resistant to broomrape (A-E), downy mildew, tolerant to phomopsis (stay-green). The vegetation period from germination to biological ripeness is 94 days, the achenes oil content of 48% and hull content of 23%. It is obvious that this hybrid is designed to produce special oil, i.e. for long shelf-life or frying. Hybrid Oxy has been included in the Russian state register of admitted and protected varieties since 2014.

CONCLUSIONS

Thus, sunflower hybrid Oxy was developed with common breeding methods without the use of transgenic techniques. The seed oil possesses the highest level of oxidative stability by combining high oleic acid content with the increase concentration of gamma- and delta-tocopherols asstrong endogenous antioxidants. This natural oil without any chemical modification and addition of exogenous ingredients can be useful in the industries with high demands for resistance to oxidation.

LITERATURE

Demurin Ya.N. (1993). Genetic variability of tocopherol composition in sunflower seeds. Helia,V.16, №18: 59-62.

Demurin Ya., Skoric Dr., Karlovic Dj. (1996). Genetic variability of tocopherol composition in sunflower seeds as a basis of breeding for improved oil quality. Plant Breeding, V.115: 33-36.

Soldatov K.I. (1976). Chemical mutagenesis in sunflower breeding, In: Proc. 7-th Int. Sunflower Conf., Krasnodar, USSR: 352-357.

Velasco, L., and J.M. Fernandez-Martinez. (2003). Identification and genetic characterization of new sources of beta- and gamma-tocopherol in sunflower germplasm. Helia, 26 (38): 17-23.

Velasco, L., J. Dominguez, and J.M. Fernandez-Martinez. (2004). Registration of T589 and T2100 sunflower germplasms with modified tocopherol profiles. Crop Sci. 44: 361-362.

Warner K., Miller J., Demurin Y. (2008). Oxidative stability of crude mid-oleic sunflower oils from seeds with high γ- and δ-tocopherol levels. J Am Oil Chem Soc. V.85: 529-533.