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Innovation Project: Cryomutation Selection of Sunflower for Winter Resistance (*wint*), Ephemeral State (*pervotsvet*) and Leaflessness (*aphylla*)

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Abstract: Based on long-term work on induced mutations using dimethyl sulfate (DMS) at medium doses (concentrations) a large number of mutagenic lines was obtained. The source cultivar for obtaining the mutants was VNIIMK 8931. The mutations were obtained by changing the growth period, plant height, stem form, changes of the head (size, form, and shape), changes of the leaves (color, size, form, serratedness, petiole length), and changes of the size, shape, color and levels of oil and protein and their quality. The most important mutations presented in this paper pertain to resistance to low temperatures (up to −30 °C) in what can be termed winter sunflower (M-2002-Morzh and M-1701-Ice King). Of great value is also the mutant M-1880-Udochka (aphylla leafless) with its small leaves and short petioles, which enables the increase in plant population of up to 500,000 plants/ha.

Keywords: cryomutation, sunflower, DMS, mutation, winter sunflower, ephemeral state, reduced leaves

Results and discussion

Creatively developing the scientific heritage of the academician V.S.Pustovoit, Dr Kalaidzhyan developed 8 dwarf column-type low-capacity population forms of sunflower which are absent in selections by domestic and foreign breeders and geneticists such as:

- M-2002-column (habit), author's testimony N° 38562;
- M-1248-whit;
- M-1701-Pervotsvet (ephemer), Frigidum;
- M-1820-Akselerat (quick-growing);
- M-1880-Udochka (weak leaf, Parvifolium);

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– M-1946-Yantar' (olive);
– M-1976-Snezhana (white pollen);
– M-1990-Terminator, female sterile. (Kalaidzhyan, 1990; 1998; 2013; and Kalaidzhyan *et al.*, 1987; 1991; 1996; 1999; 2000a; 2000b; 2002; 2007; 2008; 2009; 2010; 2011).

On the basis of M-2002, M-1701 and M-1880 there was offered the innovation project: "Cryomutation selection of creation of sunflower":

1. **M-2002–Morzh** (Figure 1) fast-ripening, winter resistant to minus temperature stress (–30 °C) – factors in autumn – winter – early spring period of juvenile growth and development of plants with seed productivity of 6.0 t/ha and oil harvest of 3.5 t/ha.

Figure 1: M-2002-Morzh.

2. **M-1701–Ice King** (Figure 2) ephemeral winter with seed productivity of 4.0 t/ha and oil harvest of 2.0 t/ha;

Figure 2: M-1701-Ice King (Ephemer).

3. **M-1880–Udochka (aphylla leafless)** (Figure 3) analogical to Anabasis leafless – *Anabasis aphylla* L., Saxaul leafless – *Haloxylon aphyllum*. Minkw. IIjin, Sarsazan knobby – *Halocnemum strobilaceum* Pall.Bieb., Anabasis salsa C.A.Mey.Benth.) with seed productivity of 7.0 t/ha and above;
4. Area of crown in these forms amounts to 1,100 cm^2, as compared to the common 6,500 cm^2 that allows to cultivate them at increased density of sowing (300,000 plants per hectare) analogical to winter grain crops, which leads to the decrease of fuel rate to 45 % per hectare (or 20 liters/ha).

Figure 3: M-1880-Udochka (Weak leafy).

Seeds of M-2002, M-1701 and M-1880 are treated by chemical mutagens and undergo small (sharp) and large (chronic) minus temperature stress-factors with the interpretation on worked out special method and are sown in the field in rows.

Selection nursery of Mutants M_1 and M_2

Figures 4–9.

Figure 4: Plants of M-2002-Morzh (Date: November, 05 2014, temperature –6.3 °C).

Autumn period

Autumn period (October and November) of sowing of mutant population M-2002 showed that plants in the phase of first, second and third pairs of leaves undergo repeated actions of decreased plus temperatures (frost), light frosts of –3 °C, frosts of –8 °C, gusty winds with autumn cold rains or snow and sometimes ice-covered ground and other unfavorable weather attributes. To these unimportant abiotic temperature drops, there was added the autumn absolute plus of +22 °C and a night minus of –15 °C temperature air drops. The unimportant death of induced micro mutant plants of sunflower amounts to –15 % from these enumerated stress-factors.

Figure 5: Plants of M-2002-Morzh (Date: December, 04 2014, temperature –12 °C).

Winter period

Winter period (middle of December, end of January) is the most necessary time interval for mutation selection. It is necessary to notice that preserved plants in winter period as a rule undergo more severe abiotic actions. So, sun warms up the air to +15 °C, and at night temperature drops to –20 °C and more accompanying by repeated actions of rain, wet snow or snow cover of up to 25 cm, ice-covered ground and other unfavorable factors of south Kuban "bad roads". The action of these abiotic stress-factors is more strengthened in the absence of snow cover, presence of hurricane winds and an absolute minimum of air temperature which drops to –30 °C. These extreme attributes of winter existence for

Figure 6: Sowing of seeds M_1 Morzh on snow at 10 cm (Kalaidzhyan, A. A., Date: January 08, 2015, temperature –8 °C).

sunflower operating as negative factors on induced micro mutant plants leads to their considerable death (83 %).

Early spring period

In early spring period (end of January beginning of February), the remaining micro mutant plants (2 %), leaving a state of suspended animation, begin to grow and develop. These hardy, overwintered "brave" sunflower plants brought us not only spiritual joy but the further optimism in making our dream true.

1. The germination of M1 plants was out of the inherent conditions that contributed to the induction of cold-resistant micro-mutant forms.
2. The juvenile stage of M2 mutant plants in the phase of 1-3-pairs of leaves occurred in cold, light frosts, heavy frosts, snowfalls, ice-covered ground, gusty wind and other attributes of the winter of existence accompanied by alternating daily temperatures of plus and minus night differences of air t° contributed to the induction of micro-mutant plants resistant to these abiotic aggressive environments.

Figure 7: Plants of M-2002-Morzh under the snow layer of 15 cm, (Date: February 16–21, 2015, temperature –18 °C).

Cryomutation selection with application of repeated treatments by chemical mutagens does not preclude the induction of an unknown phenotypically modified form affecting the variability of stem, leaf, inflorescence, root system, controlled by the new genetic code sunflower plants can tolerate absolute maximal plus (+30 °C) and minus (–30 °C) and more fluctuations of daily air temperatures in the autumn-winter-early spring period of juvenile growth and development of mutant plants.

Evidently, the horizon for practical embodiment into life of this *Khow-How* becomes more really from selection works on the creation of winter sunflower (Kalaidzhyan, 1990; 1998; 2013; and Kalaidzhyan *et al.*, 1987; 1991; 1996; 1999; 2000a; 2000b; 2002; 2007; 2008; 2009; 2010; 2011).

Figure 8: Plants of M-2002-Morzh in snow (Date: February 23, 2015, temperature –5 °C).

Conclusion

Kalaydzhyan Ashot Andranikovich – the breeder of the Krasnodar region, Russia's outstanding breeder and geneticist in the field of chemical mutagenesis, working in agriculture for more than 20 years. His most famous work is the "Chemical mutagenesis in sunflower breeding" (Kalaidzhyan, 1998), where Dr Kalaydzhyan was able to show the ability to create a short, massive, frost-resistant and very early varieties of sunflower crop for cultivation with "No-till" technology. At the same time, great attention was paid to the temporal characteristics of vegetation and manifestation of oil content, as well as the

Figure 9: Plants of M-2002-Morzh after overwintering. (Date: March 01, 2015).

establishing of regularities for the inheritance of traits in Fj and their variability in M2. The material for such investigations was obtained from the Krasnodar Agricultural Biotechnology Center and the Institute of Oilseeds Vasyl Pustovoyt (VNIIMK) (Figure 10, Kalaidzhyan *et al.*, 2016). Later on, Dr Kalaydzhyan became the creator of the first type of sunflower giving white honey and pollen grains, containing the largest amount of antioxidants to date and resistance to strong frosts, named "Vasiliy" (Figure 11). Another of its know-how has become cold-resistant peas characterized as sweet and mild flavor and 3 times higher yield due to the huge size.

Works of Doctor Kalaidzhyan are devoted to the biology of sunflower development: selection, genetics, immune system, plant growing, cultural practice, botany, ecology, evolution, systematics, 425 scientific papers published in

Figure 10: Monograph (in press) "Sunflower of V.S.Pustovoit – 100 years of triumph" (Kalaidzhyan *et al*., 2016).

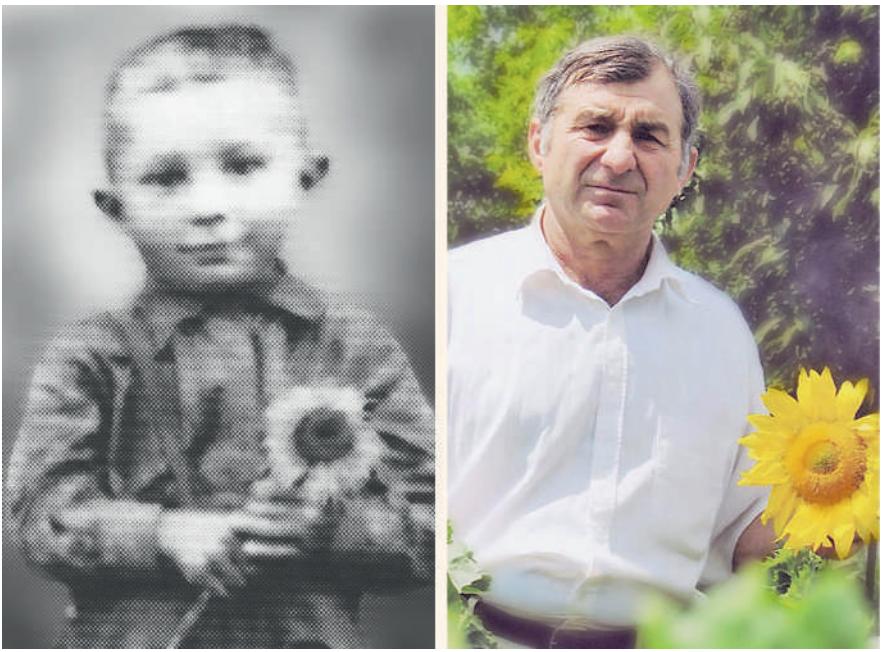

Figure 11: Kalaidzhyan Ashot Andranikovich in 6 (1952) and in 60 (2006).

co-authorship including in 5 foreign editions in English and in 11 cited foreign scientists, 6 monographs, 2 author certificates on inventions, one patent as well (Škorić, 2012).

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