# SOME ASPECTS REGARDING THE GENETIC AND BIOTECHNOLOGICAL PROGRESS OF THE *HELIANTHUS ANNUUS* L.

**Elena BONCIU[1], Olimpia PANDIA[2], Aurel Liviu OLARU[1], Ion SARACIN[1], Elena ROSCULETE[1]**

[1]University of Craiova, Faculty of Agronomy, 19 Libertatii Street, Craiova, Romania, Phone/Fax: +40251418475, Emails: elena.agro@gmail.com, liviu.olaru.dtas@gmail.com, ion_saracin@yahoo.com, rosculeta2000@yahoo.com
[2]University of Agronomic Sciences And Veterinary Medicine Bucharest of Bucharest, 59 Marasti Boulevard, Bucharest, Romania, Phone: +40213182266, Fax: +40213180466, Email: olimpia_pandia@yahoo.com

***Corresponding author***: liviu.olaru.dtas@gmail.com

***Abstract***

*The genetic and biotechnological progress of the Helianthus annuus L. (sunflower) it can be catalogued through two major directions, namely: tissue culture and meristems in vitro, for the induction and selection of useful characters and genetic engineering or DNA manipulation, for plants transformation. In general, sunflower tissues are very easy to grow, but the problem arises due to the low reproducibility, sunflower being one of the most difficult species from this point of view. The two methods of the vitrocultivated sunflower regeneration are organogenesis and embryogenesis, the difference between them being given by the different number of cells from which the neoplants are formed. To date, a limited number of sunflower genotypes have been found for regeneration. For this reason, several methods are sought for the regeneration of this plant, as it is a necessity to find new, stronger genotypes that adapt to the current conditions. From this point of view, the use for vitroculture of tissues initiated from immature sunflower embryos is an effective strategy for plant regeneration. So far, good results have been obtained in the reproductive genetics of this plant but other future results are being sought, when it is expected that genetic and biotechnological progress will continue. One of the basic research methods of genetics and genetic engineering remains the study of gene expression and the elucidation of new aspects at the genome level of the species H. annuus.*

***Key words***: *sunflower, genetics, biotechnologies, vitroculture, DNA*

## INTRODUCTION

Biotechnologies generally refers to all techniques and applications that use biological systems, living organisms or derivatives thereof in order to modify or create new products, with improved production, nutritional and quality characteristics.
The sunflower culture, an oleic plant of global interest, has developed progressively and has gone through several stages, determined by the progress made in the genetic improvement of this noble plant. Worldwide, sunflower areas have grown significantly over the years, especially due to their high adaptability [6]. Sunflower is a plant with various uses, in the feeding of humans and animals but also for industrial and energy uses. The sunflower is a crucial source of pollen and nectar in early summer for honeybees. Also, its contribution to the aesthetic value of landscape should be highlighted. In the present and future context of climate change, sunflower cropping offers a wide range of options for adaptation.
According to Vrânceanu (2000), the four major stages of sunflower progress are: the stage of local population selection, with low oil content; the stage of improved varieties, with good stability and adaptability, with medium oil content; the stage with of high oil varieties and the stage of the F1 hybrids, created by crossing the inbred lines [31]. This stage, which began in the 70's, is still ongoing and the hybrid sunflower is experiencing an unprecedented expansion and the production of vegetable oils has spectacular increased.
Within the genus *Helianthus* naturally occur diploid, tetraploid and hexaploid species. In contrast, haploid sunflower plants appear spontaneously at a reduced frequency.

Through polyploidy, biotechnology in general and genetics in special are involved to increase the frequency of formation of diploid tissues and normal sunflower gametes. Wild forms of the genus *Helianthus* are currently used as a very important material for modern sunflower enhancement [16].

The cytogenetics of sunflower is based on the study of heredity on the level of chromosomes and other cellular organisms. The genetic information about this taxon comes from the analysis of interspecific hybrids and molecular studies [11, 29].

The objectives of improving the sunflower are improve the productivity, by increasing the seed production and the oil content; genetic resistance to diseases and pests and increasing the level of ecological plasticity through adaptability to various environmental conditions [2, 3, 4, 31]. A very important objective especially for it is made of very good quality oils that meet the needs of consumers, is to diversify the quality of the oil, by creating new hybrids, with high oleic acid content. It is worth mentioning that some environmental conditions, such as temperature, may change the ratio of oil and linoleic acids to sunflower hybrids [18].

Efficient methods of sunflower regeneration are useful for facilitating breeding programs for improved cultivars by providing rapid multiplication of plants having desirable traits. The availability of a large number of regenerated plants increases the speed of selection and further breeding cycles. It is also of considerable interest to apply the methods of plant genetic engineering to develop improved sunflower cultivars. The application of these methods to sunflower improvements requires the development of methods for the efficient production of plants which have been transformed to contain foreign DNA.

This reason is motivating to encourage more methods of regeneration for the sunflower plant, wanting to be of a physiologically better quality in the plant creator.

For this reason an important role is engineering genetics, where the qualitative reproduction of the sunflower plant is pursued. Foreign DNA obtains rapid application, reducing the number of genetic methods to care for information on obtaining quality soils or hybrids.

## MATERIALS AND METHODS

This is a bibliographical study, in which we have tried to render the some recent results communicated by different authors, regarding the sunflower recent development from genetic and biotechnological point of view. Various electronic and printed resources were used for documentation.

## RESULTS AND DISCUSSIONS

Sunflower is widely grown in the world [6]. Newly created hybrids of sunflower, which possess genetic resistance to diseases and pests, high production capacity but also resistance to some unfavourable environmental factors, such as drought, for example, have contributed to this expansion.

Since 1948, A.V. Vrânceanu, a Romanian researcher with pioneering in the field of the hybrid sunflower, presented a morphological and physiological ideotype for this plant, that is, a model capable of providing a higher quantity of quality seeds and oil, under certain environment conditions well defined [31]. His scientific activity in the field of sunflower breeding has a major contribution to the genetic progress of this species. In 1975, as recognition of the Romanian priorities in sunflower genetics, it is assigned to A.V. Vrânceanu coordinating the International Research Network F.A.O. in this domain [15].

A sunflower model has been proposed by other authors to determine the changes printed by certain factors (e.g. latitude) on oil yield and quality [22].

Agro-engineering and mechanization are two important factors on which the regeneration of other varieties or hybrids of the sunflower with much improved character depends. For this reason, all the general characteristics of this plant were evaluated and where they had the best performances according to the area of establishment of the culture.

Generally, the evaluation of genetic progress is performed with the results obtained from the cultivar trials performed in different areas.

According to Follmann et al. (2017), just the genotypes with high yield characteristics are suitable for on-going assessment [14].

Historically, moisture and temperature during flowering time had significant impacts on the absolute levels of linoleic fatty acid (polyunsaturated) and oleic fatty acids (monounsaturated), and therefore on their ratios [22].

Sunflower seed grown in cooler climates yielded generally higher linoleic acid contents, while seed produced under warmer conditions saw higher oleic acid contents. In a very general sense, the inverse relationship results in a one percent increase in oleic acid approximating a simultaneous one percent decrease in linoleic acid and vice versa, depending on the climate. The other fatty acids see only limited changes. Some research has been leading to the development of high oleic sunflower varieties with oil that may approach or exceed 90% oleic fatty acid content [29].

In addition to using biological systems for various useful transformations [1, 31], modern biotechnology also involves the use of new technological innovations, some of which are based, for example, on allelopathy [5] or various biochemistry researches [7, 27].

In some cytogenetic studies, the heritability of quantitative and qualitative characters in crop plants is controlled by several genes, both dominant and recessive [9, 28]. In this sense, sunflower oil depends for example on the common action of the embryonic and maternal genomes [19].

The leaves and roots of the plants form the vegetative system that through specific growth processes puts in action the root and foliar sensors. The development of the leaf surface is of major importance on photosynthesis and transpiration. The total leaf surface area per plant is determined as a logistic function of the anthesis and the thermal time from sunrise, while the distribution of the solar radiation at the leaf level is determined by the ISF, the angular distribution of the leaves [21, 21].

Application of plant protection measures and an optimal management of agricultural culture establishment create favourable conditions for the photosynthetic process and improving the physiological status of the plants [1, 8, 25, 26].

Although it is recognized as a drought-resistant plant, sunflower does not produce high yields of seeds and oil under high heat conditions and low humidity conditions. Therefore, genetic progress follows the selection of new plants, capable of tolerating the loss of leaf turgescence.

The modern management of drought in the sunflower includes a series of practices that can have the effect of maintaining its productivity (Figure 1).

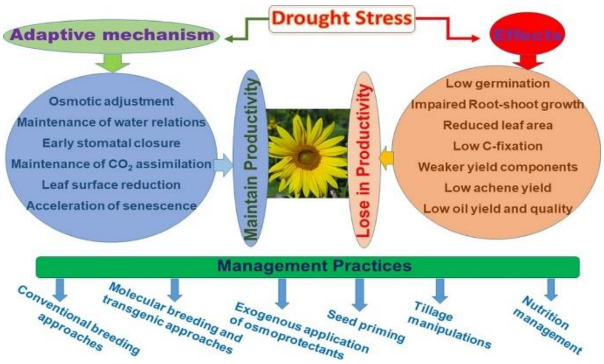


Fig. 1. The drought stress and management practices to sunflower
Source: Mubshar et al., 2018 [17].

Improving of the drought resistance is not straightforward, due to the complex and polygenic nature of this feature. Genetic progress from this point of view implies the improvement of a whole set of characters that will contribute to increasing the tolerance of the sunflower to water stress.

The studies of correlations to sunflower are important for the breeder in order to associate all the possible valuable features in the newly created genotypes. The oil yield is the trait with greater economic interest in sunflower and its increase has being achieved in sunflower with increasing grain yield [14].

One of the secondary products of the oil extraction is seed hulls. They can be ground and used in the feeding of ruminant animals or in the manufacture of fibreboard plaques. Another use of sunflower seed hulls is to obtain the fodder yeast, a valuable protein product for animal and poultry feed.

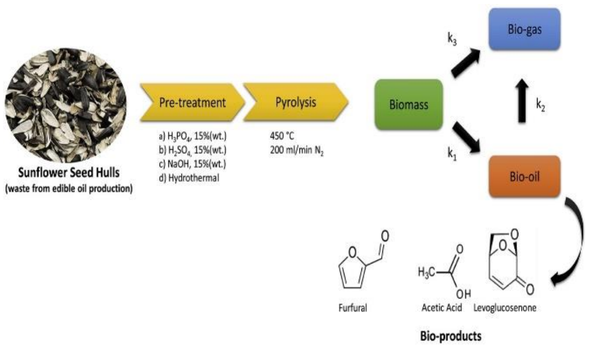


Fig. 2. The involving of biotechnology in transformation of the sunflower waste into bioproducts
Source: Casoni et al., 2019.

However, these secondary products can be transformed, thanks to modern biotechnology, in furfural (Figure 2), widely used in organic synthesis, as well as other types of bio-products, who can be obtained through certain processes such as acid hydrolysis [12].

Another implication of modern biotechnologies in the genetic progress of the sunflower is given by the genetic transformation of the plants and selected of the transformed cells [13]. This transformation is made through the infection with *Agrobacterium tumefaciens*, the technique of bombardment of tissues with microprojectile, respectively the direct absorption of DNA in protoplasts [31].

There are some studies involving transgenic sunflower plants to increase yield, oil content, insect/fungal resistance, stress tolerance and production of biopharmaceutical proteins [10, 23, 24]. As the selection for disease resistance within the genus *Helianthus* remains, for the time being, a sensitive issue, genetic and biotechnological research for sunflower is oriented towards the original source of genes for resistance to diseases, namely, wild species. Using the direct organogenesis method in interspecific hybridization, fertility restorer lines were developed which possess very good combining ability in hybridization and resistance to some economically important diseases and parasites on sunflower.

In the plant biotechnology, the vitroculture and micropropagation can be effective techniques for rapid multiplication a large number of sunflower genotypes. The indirect somatic embryogenesis, with intermediary callus formation, is useful in researches regarding the vitroculture for the resistant forms to biotic and abiotic stress factors. Therefore, extension of time to maintain the callus at culture medium is utile, because can favorized the increase of genetic variation within grown calluses and between regenerated plants. Embryogenesis can be performed directly from the explant source or indirectly from the callus.

The explants used for the sunflower vitrocultivation can have their origin from different tissues of the plant: tips of shoots or apical meristems, stem nodes, hypocotyls, cotyledons of mature and immature embryos, leaves, etc. However, the most used are immature embryos, because the tissues initiated from them allow the reproductive regeneration of sunflower neoplants. Along with immature embryos, sunflower cotyledons also have a high potential for direct regeneration of shoots.

The basic culture medium for sunflower cultivation is made up of different components (mineral salts, amino acids, source of carbon, agar, water, etc.). The most widely used culture medium is MS medium (Murashige-Skoog), supplemented with different concentrations of phytohormones, such as, for example: naphthalene acetic acid, indolyl acetic acid, cytokines (benzyl adenine and benzyl amino purine) and kinetin.

In the present and future context of climate change, sunflower cropping offers a wide range of options for adaptation. That's why we can talk about a high sustainability of the sunflower within an efficient management and genetic control.

## CONCLUSIONS

Globally, the expansion of sunflower occurred with the introduction of new genotypes, with improved production qualities and high resistance to stress conditions.

The agricultural biotechnological research with precise targeting toward sunflower brings together results on complex genetic mechanisms that control the manifestation of important traits for improving and understanding the genetic control of seed production and oil quality.

In perspective, genetics and biotechnology must propose new approaches in analysing the genotype-environment interaction at sunflower.

Genetics and biotechnologies represents the future in sustainable sunflower management, by increase the yield, oil content, insect/fungal resistance, stress tolerance and production of biopharmaceutical proteins.

## REFERENCES

[1]Bonciu E., 2012, Agricultural biotechnologies, balance factor for the sustainable development of the socio-economic system, Annals of the University of Craiova, Series Biology, Horticulture, Technology of Agricultural Products Processing, Environmental Engineering, Vol. 17(1):69-74.

[2]Bonciu, E., 2013, Aspects of the pollen grains diameter variability and the pollen viability to some sunflower genotypes, Journal of Horticulture, Forestry and Biotechnology, Vol. 17(1):161-165.

[3]Bonciu, E., 2013, Variability of the mitotic activity to some foreign sunflower genotypes, Journal of Horticulture, Forestry and Biotechnology, Vol. 17(3):126-129.

[4]Bonciu, E., 2019, The behavior of some sunflower genotypes under aspect of variability of the productivity elements, Current Trends in Natural Sciences, Vol. 8(15):68-72.

[5]Bostan, C., Butnariu. M., Butu, M., Ortan, A., Butu, A., Rodino, S., Parvu, C., 2013, Allelopathic effect of *Festuca rubra* on perennial grasses, Romanian biotechnological letters, Vol. 18(2):8190–8196.

[6]Bran, A., Ion, V., 2018, Sunflower Varieties and Hybrids Registered for Cultivation in Romania in the Last Century, Sciendo, Vol. 1(1):22-31.

[7]Butnariu, M., 2012, Butnariu M. An analysis of Sorghum halepense behavior in presence of tropane alkaloids from Datura stramonium extracts, Chemistry Central Journal, Volume: 6, Article Number: 75, Published: Jul. 28, 2012 (Accession Number: WOS: 000308021600001, PubMed ID: 22839364.

[8]Butnariu, M., Caunii, A., 2013, Design management of functional foods for quality of life improvement, Annals of Agricultural and Environmental Medicine, Vol. 20(4):736–741.

[9]Butnaru, G., Căpâlnăşan, I., Sărac, I., Jurca, M., Baciu, A., Popescu, C., Avramescu, A., 2004, Chromosomes - morpho-functional features in plants and animals, Mirton Press, Timisoara, pp. 60-71.

[10]Çalışkan, M., Dangol, S., 2016, Genetic engineering studies on sunflower, International Sunflower Conference, Vol. 19:651-655.

[11]Capatana, A., 2006, Molecular and genetic aspects of heterosis at sunflower (*Helianthus annuus* L). PhD Thesis, Moldova State University, Chisinau.

[12]Casoni, A.I., Gutierrez, V.S., A.Volpe, M.A., 2019, Conversion of sunflower seed hulls, waste from edible oil production, into valuable production, Journal of Environmental Chemical Engineering, Vol. 7(1):102893.

[13]Durante, M., Vannozzi, G., Pugliesi, C., Bernardi, R., 2002, The role of biotechnologies in the development of sunflower cultures in the world, Helia, Vol. 25(36):1-28.

[14]Follmann, D.N., Cargnelutti Filho, A., Lorentz, L.H., Boligon, A.A., Caraffa, M., Wartha, C.A., 2017, Genetic progress in sunflower crop in Rio Grande do Sul State, Brazil, Genetics and molecular research: GMR, Vol.16(2):1-9.

[15]I.C.C.P-I.N.C.D.A. Fundulea 1957-2017, 60 years of Scientific Research in support of Agriculture, https://www.incda-fundulea.ro/60ani/INCDA60.pdf, Accessed on November 10, 2019.

[16]Liu, Z., Seiler, G.J., Gulya, T.J., Feng, J., Rashid, K.Y., Cai, X., Chao-Chien Ja, C.C., 2017, Triploid Production from Interspecific Crosses of Two Diploid Perennial *Helianthus* with Diploid Cultivated Sunflower (*Helianthus annuus* L.), Gene, Genomics, Genetics, Vol. 7:1097-1108.

[17]Mubshar, H., Shahid, F., Waseem, H., Sami, UA., Mohsin,T., Muhammad, F., Ahmad, N., 2018, Drought stress in sunflower: Physiological effects and its management through breeding and agronomic alternatives, Agricultural Water Management, Vol. 201:152-166.

[18]Neto, A.R., Rauen de Oliveira Miguel, A.M., Mourad, A.L., Henriques, E.A., Vercelino Alves, R.M., 2016, Environmental effect on sunflower oil quality, Crop Breed. Appl. Biotechnol., Vol. 16(3):197-204.

[19]Nikolova, V., Ivanov, P., 1992, Inheritance of the fatty acid composition of oil in some sunflower lines, Helia, 15(16):35-40.

[20]Pandia, O., Sărăcin, I., Olaru, L., 2019, The importance of knowledge of foliage surface index (ISF) influence on production, Scientific Papers Series Management, Economic Engineering in Agriculture and rural development, Vol. 19(2):317-321.

[21]Pandia, O., Sărăcin, I., Olaru, L., 2019, The importance of knowledge concerning resistance to draught for some types of seeds cultivated on sandy soils, Scientific Papers Series Management, Economic Engineering in Agriculture and rural development, Vol. 19(2):311-315.

[22]Pereyra-Irujo, G.A., Aguirrezábal, L.A.N., 2007, Sunflower yield and oil quality interactions and variability: analysis through a simple simulation model, Agricultural and Forest Meteorology, Vol. 143(3-4):252-265.

[23]Peter van Esse, H., Reuber, T.L., Dieuwertje van der Does, 2019, Genetic modification to improve disease resistance in crops, New Phytologist, Vol. 225:70–86.

[24]Qi, L., Long, Y., Talukder, Z.I., Seiler, G.J., C. Block, C.C., Gulya, T.J., 2016, Genotyping-by-Sequencing Uncovers the Introgression Alien Segments Associated with *Sclerotinia* Basal Stalk Rot Resistance from Wild Species-I. *Helianthus argophyllus* and *H. petiolaris*. Frontiers in Genetics, Vol. 7:219.

[25]Rosculete, C.A, Rosculete, E., Bonciu, E., 2018, The role of forests in the sustainable development of Romania, Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, Vol. 48(2):140-149.
[26]Rosculete, C., Bonciu, E., Rosculete, E., Olaru, L., 2019, Determination of the Environmental Pollution Potential of Some Herbicides by the Assessment of Cytotoxic and Genotoxic Effects on *Allium cepa*, International Journal of Environmental research and Public Health, Vol. 16(1):75.
[27]Samfira, I., Butnariu, M., Rodino, S., Butu, M., 2013, Structural investigation of mistletoe plants from various hosts exhibiting diverse lignin phenotypes, Digest journal of nanomaterials and biostructures, Vol. 8(4):1679–1686.
[28]Sărac, I., 2017, Genetica, Agroprint Publishing House, Timisoara, pp. 173-179.
[29]Skoric, D., Jocić, S., Lecic, N., Sakac, Z., 2007, Development of sunflower hybrids with different oil quality, Helia, Vol. 30(47):205-212.
[30]Vencovsky, R., Morais, A.R., Garcia, J.C., Teixeira, N.M., 1988, Progresso genético em vinte anos de melhoramento do milho no Brasil. In: Congresso Nacional de Milho e Sorgo, 16:300-307.
[31]Vranceanu, A.V., 2000, Hybrid sunflower, Ceres Publishing House, Bucharest, alexandru_viorel-p1002221.