# FIFTY YEARS OF BREEDING IN FIELD CROPS, AT THE NATIONAL AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE FUNDULEA, ROMANIA

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## ABSTRACT

**The National Agricultural Research and Development Institute (NARDI) Fundulea celebrates, in 2007, fifty years of research on field crops at Fundulea. The paper is a short presentation of the main results obtained in field crops breeding during this period. It summarizes the contribution of the institute to the genetic improvement of important crops, such as wheat, maize, sunflower, forrage crops etc. The Fundulea Institute had pioneering activity in breeding hybrid sunflower, releasing the first commercially grown hybrids in 1971. Many hybrids bred at Fundulea were registered and have been cultivated in countries like Italy, France, Spain, China etc. Semidwarf winter wheat varieties bred at Fundulea have been grown on half to two-thirds of Romania's wheat acreage for the last 30 years, and some of them are registered in Hungary, Canada, Turkey etc. Genetic progress in breeding triticale made this new crop a reality in Romanian agriculture. In maize Fundulea Institute contributed to the rapid replacement of local populations and open-pollinated varieties by introduced double hybrids, and then to replacing those with better adapted single hybrids, obtained with adapted inbred lines. During 50 years of maize breeding, 82 hybrids with large diversity of traits were released. Semidwarf winter durum cultivars with suitable winterhardiness for Romania were released. Nineteen cultivars of six-row and two-row winter barley and eight early maturing rice varieties were released. As result of over 40 year of breeding at Fundulea, 36 varieties of soybeans, beans and peas with improved adaptation were registered. In fodder crops, breeding work resulted in the release of 60 varieties, including 20 alfalfa cultivars, 2 sainfoin, 2 field peas, 1 vetch and 35 grasses varieties (8 orchard grass, 6 Italian ryegrass, 4 hybrid ryegrass, 2 perennial ryegrass, 3 tall fescue, 1 smooth brome, 5 Sudan grass and 6 millet). In total 316 cultivars have been released by the institute, representing an important contribution to higher and more stable yields in field crops.**

**Key words:** breeding, field crops, cultivars, hybrids.

## INTRODUCTION

The National Agricultural Research and Development Institute (NARDI) Fundulea celebrates, in 2007, fifty years of research on field crops at Fundulea. However, NARDI continues a longer tradition of agricultural research in Romania, being the main successor of the former Romanian Agronomical Research Institute (ICAR) in Bucharest, founded in 1927. During the 50 years of activity at Fundulea, the Institute changed the name several times, from „Research Institute for Maize Crop" in 1957, to „Research Institute for Cereals and Industrial Crops" in 1962, then to „Agricultural Research and Development Institute" in 2002 and to its present name in 2007. The activity however continued and developed without interruption.

NARDI is the largest agricultural research institution in Romania, as it has the mission to provide to farmers scientifical results for the progress of several of the main agricultural crops (cereals, grain legumes, oil and fiber crops, forrage crops), which occupy most of agricultural area of Romania (91% in 2004) and have a large share of agricultural revenues (28.4% in 1999) (Verzea, 2007).

The main directions of NARDI Fundulea have been:

- breeding varieties or hybrids adapted to the Romanian environment, and especially to the Southern plains of the country, in cereals (small grains, maize, sorghum), grain legumes, oil crops (sunflower, linseed), and forrage crops;
- improving crop management practicies, including those for organic agriculture, adapted to the Romanian environment;
- recommending integrated plant protection measures, based on pest biology and monitoring studies;
- fundamental research on genetics, biotechnology, plant physiology, biochemistry etc. to support applied research on breeding and agronomy;
- producing basic seed of own cultivars and providing seed to seed multiplying farmers;
- extension of research results to the farmers.

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This paper is a short presentation of the main results obtained in plant breeding at Fundulea so far.

## MATERIAL AND METHODS

All breeding programs at Fundulea have been based on the use of a large genetic diversity, including local populations and cultivars (especially in maize), related species and genera (especially in sunflower and wheat), intensive germplasm exchanges with international breeding centers (CIMMYT, ICARDA etc.), germplasm banks and other breeding institutions. Large working collections are maintained and continuously improved, in each crop. Breeding lines selected in Institute's breeding programs are continuously added to the working collection and are increasingly used as parents in crosses, based on principles of recurrent selection.

Various recurrent selection methods in population breeding as initial material, and selection methods of inbreeds and hybrids have been used, especially in maize and sunflower, in order to increase the yielding capacity and its stability.

A strong point in breeding at Fundulea has been the possibility to base selection on data collected in many cooperating research stations, situated in a large diversity of environments. This, together with the use of artificial tests for many of the important adaptation traits (winterhardiness, drought resistance, disease resistance etc.), and the recent use of molecular markers for specific traits, contributed to the adaptation of released cultivars to the targeted environment.

Most breeding programs perform own small research projects on pre-breeding and genetics to enlarge and improve the knowledge of the genetic basis of physiological and quality traits of the biological material used in breeding.

## RESULTS AND DISCUSSION

**In wheat** the five decades history of Fundulea work on improving the genetic basis of wheat production in Romania can be divided in four periods (Saulescu et al., 2007):

- First period started in 1958, when it was realized that wheat breeding results in Romania lagged behind those obtained in other countries. The Fundulea Institute recommended the introduction of several foreign cultivars, which significantly over yielded the old local cultivars. At the same time breeding work began to increase adaptation to local conditions.
- Second period (1971-1979) included the release of 9 standard-height cultivars with better adaptation to Romanian conditions, from Dacia, Excelsior and Favorit, released in 1971, to Fundulea 29, which was grown on 40% of the wheat area in Romania and had outstanding results in the International Winter Wheat Performance Nursery in 1980 and 1981.
- Third period (1984-1993), included the release of the first 6 semidwarf winter wheat cultivars, well adapted to the conditions of Southern Romania. Flamura 85, Fundulea 4 and Dropia have been particularly successful, being grown each on more than 20% of the wheat area.
- Fourth period (1998-2006), is illustrated by the release of 8 new semidwarf cultivars, including Ardeal, Boema, Delabrad, Faur, Glosa and Gruia, now under multiplication, which brought further genetic progress and diversification.

Genetic progress for yield was earlier estimated at about 50 kg/ha/year or about 1%/year. This was accompanied by an improvement in bread-making quality and in yield stability, due to improved lodging resistance, earliness, disease and drought resistance. From 1977 on, wheat cultivars released from Fundulea have been grown on more than half of the wheat acreage in Romania. Several cultivars created at Fundulea were registered and are grown in countries like Canada, Hungary, Turkey, Kyrgyz Republic and Bulgaria.

In durum wheat, work started in 1967 resulted in the creation of semidwarf winter durum cultivars Topaz, Rodur, Pandur, Condurum and Grandur, which opens the possibility of durum production in South Romania.

The introgression of new genes from wheat relatives and from international germplasm exchanges into the adapted semidwarf cultivars released so far, opens new prospects of progress in

the near future. Genetic progress has been accelerated in recent years, by routinely using the *Zea* system of producing doubled haploids from most interesting crosses (Giura et al., 2007).

**In triticale**, from the start of the program (1971) to present, an original triticale germplasm adapted to the Romanian environment was created and 8 varieties were registered. Two triticale cultivars bred at Fundulea are registered in Hungary and USA.

The genetic progress for yield estimated over a 22 years, period was 1.06% year$^{-1}$, similar with the progress obtained in the most dynamic triticale breeding programs in the world. The yield improvement was based on improving the number of kernels per spikes, the weight of the kernels per spikes, test weight and on the reduction of the plant height (Ittu et al., 2007). Due to the genetic progress achieved by breeding, triticale is already grown on a significant area in Romania.

**In winter barley**, as a result of the breeding program at Fundulea, 19 cultivars were released, 14 out of them winter barley (Intensiv 1, Intensiv 2, Miraj, Productiv, Precoce, Dana, Adi, Madalin, Orizont, Andrei, Compact, Regal, Liliana and Univers) and 5 winter two-rowed barley (Azuga, Victoria, Grivita, Laura and Andra). After the release of varieties Intensiv 1 and Intensiv 2, which brought a significant progress in winterhardiness, the release of Miraj in 1974, represented a milestone in improving lodging resistance and yielding ability. This variety was already grown on the whole barley area only five years after it release. Each successive release represented a step ahead in yielding ability, resistance to biotic and abiotic stress, technological quality and germoplasm diversity (Bude and Vasilescu, 2007).

Beginning from 1992, the „*bulbosum*" system of obtaining doubled haploids has been used, to rapidly achieve genetic uniformity and to accelerate genetic progress.

**In rice** breeding work started in 1961 at the Rice Experimental Center Chirnogi, belonging to the Fundulea Institute, aiming to release varieties with the main agronomic and adaptation traits useful to Romanian conditions, at the Northern limit of rice growing area. First varieties, from this program, Sidef and Ariana, were registered in 1975 and 1984 respectively.

Diversification of parents used in crossing, by using germplasm from various parts of the world (Asia, America, Africa and Australia) and selection in material obtained by induced mutations, allowed significant progress in adaptation and performance of the breeding material and the release of new rice varieties: Speranta (1994), Dunarea (1998), Elida (2001) and Zefir (2003), obtained by crossing followed by individual selection and Oltenita (1991) and Magic (2005) obtained by induced mutations. These varieties produce yields up to 8.0 t/ha and have different grain shapes and superior quality (Alionte et al., 2007).

**In maize,** during the first period, the Fundulea Institute had a decisive contribution to the rapid replacement (in only 7 years) of local maize varieties and populations, which were dominant when the Institute was founded, with double crosses between foreign inbreds, identified as valuable under Romanian conditions, by extensive testing organized by the institute. This provided a 31-43% yield increase in yield trials, reflected in a 500 kg/ha (39%) increase of average maize yield of the country, from 1270 kg/ha during 1951-1955 to 1770 kg/ha during 1961-1965.

The successive replacement of foreign double crosses with own formula double crosses and further on, with newly released, Romanian double crosses, better adapted to specific conditions of Romania and then, with more performant Romanian single and three-way crosses determined a genetic progress, during 1963-1985, of 105 kg/ha/year. This contributed to the increase of country's average yields to 4080 kg/ha during 1981-1985.

The genetic progress estimated during 1978-1996, was maintained at a high level (83 kg/ha/year – 80% vs. previous period), although the same hybrid types were bred and new targets were added (Sarca et al., 2007).

During 50 years of maize breeding, 82 hybrids with large diversity of traits were released and registered, in accordance with farmer requirements and with modern breeding aims.

**In sorghum**, breeding work, started at Fundulea in 1960 and has resulted so far in the release of grain sorghum hybrids F.31 (in 1965), F.21 (in 1979), F.30 (in 1981), F.32 (in 1979). Promising high lysine grain hybrids F. 261 hld and F.380 hlp were also created.

Remarkable results were obtained for yield without irrigation in hybrids F.32 (9270 kg/ha) and F.380-83 (8798 kg/ha), for crude protein yield in hybrids F.380-83 hlp (1179 kg/ha) and F.32 (1025 kg/ha), for lysine content in hybrids F.389-83 hlp (2.98 g/100 g protein) and F.261 hld (2.82 g/100 g protein), for fat content in F.261 hld (4.9-6.1%), for starch content in F.32 (74%), for vitamin B3 content in F.261 hld (1.20 mg/100 g dry matter), for vitamin E content in F.32 (2.96 mg/100 g dry matter), and for vitamin PP content in F.261 hld (2.76 g/100 g dry matter) (Antohe, 2007).

**Forage sorghum - Sudan grass hybrids,** for green fodder and silage, released so far include F.1104 (in 1971), Tutova (in 1992), Tinca (in 1996) and Tereza (in 2003). Tereza produced 88.7 tons/ha green matter when harvested at pre-boot stage and 108.9 tons/ha at milk stage, or 23.7 t/ha dry matter at pre-boot stage and 28.1 t/ha at milk stage. The share of leaves and panicles from total plant dry matter was 56%, as compared with 49.2% in the check F.1104, and protein content was 18.7% at pre-boot stage and 13.4% at milk stage. Twenty-eight days after harvesting the forage contained 31.1 mg HCN/100 g dry matter, making it suitable for feeding livestock at paddock or by grazing, fresh or 4-5 days after frost (Antohe, 2007).

**In sweet sorghum**, breeding started at Fundulea in 1981 and resulted in the release of hybrids Rosa (in 1991), Doina (in 1996), Prut (in 2000) and F.135 ST (in 2004) and of variety Carmen (in 1994). Remarkable results were obtained with the hybrid F.135-ST, which produced 81-120 t/ha fresh biomass, 34.6-43.8 t/ha dry biomass, 5.4-8.7 t/ha total sugar, 5.4-9.7 t/ha grain yield and 5.5-7.5 t/ha lignocelluloses (Antohe, 2007).

In **broom-sorghum**, breeding started at Fundulea in 1978 and resulted in the release of varieties Siret (in 1996), Denisa (in 1998) and Donaris (in 2003). Denisa is noticeable for panicles yield (7.9 t/ha) and number of branches per panicle, while Siret had the highest average panicle length (64 cm) (Antohe, 2007).

**In grain legumes**, as result of over 40 year of breeding at Fundulea, 36 varieties of soybeans, beans and peas were released and registered.

In soybeans, with the release of varieties Flora and Violeta (in 1972), Precoce 90 (in 1979), Tomis (in 1981), Danubiana (in 1983) and Atlas (in 1986) yielding ability increased from 3000 kg/ha to over 5000 kg/ha, and protein content from 37% to 43.5%.

Next released varieties: Lena and Stil (in 1988), Victoria (in 1990), Columna (in 1995), Triumf (in 1996), Românesc 99 (in 1999) and Daciana (in 2006), continued the progress in yielding ability and stability.

In field beans, the release of varieties F.332 and F.416 (in 1965), Progres (in 1968), Orizont (in 1977), Premial (in 1978), Avans (in 1981), Aversa (in 1983), Astra (in 1991), Star (in 1989), Ami (in 1991), Diva (in 1995), Vera (in 1996), Delta (in 2003) and Lizica (in 2005) resulted in incresing yielding ability from 1300-2400 to 2500-4000 kg/ha and in improving quality.

In field peas from the variety F.53-54, registered in 1962 to the new aphyla type varieties Mona and Aurora, registered in 1999 and 2003 respectively, there was a continuous improvement in yield and stress resistance.

The accumulation of valuable genes into the current germplasm allows solving new challenges, especially those related to climatic changes (David, 2007).

**In sunflower**, breeding results made the Fundulea Institute known worldwide. Concomitantly with classical selection work, resulting in the release in 196 of variety Record, which overyielded best Russian varieties by about 7% and had an oil content of 47-50%, research on producing hybrids between inbred lines was initiated. On this basis, in 1971 first hybrids, Romsun 52 and Romsun 53, were released, with lines carrying male-sterility genes linked with marker genes, controlling anthocyanin presence in plantlets. These were the first hybrids produced commer-

cially and Romania became the first country to grow hybrid sunflower on a large scale.

Later, new hybrids were released, based on the use of cytoplasmic male-sterility and restoration of pollen fertility, a system that is much more efficient for hybrid seed production.

Genetic progress in the period 1965-1982 was estimated at 64 kg/ha/year for yield and at 0.3%/year for oil content. At the same time significant progress has been achieved for disease resistance, based on the identification of efficient resistance genes for mildew, for the parasite *Orobanche cumana* etc. Progress was also achieved in improving pollen selfcompatibility and hybrids with 60-70% selfcompatibility were obtained.

Since 1971, thirty three hybrids have been released and widely grown, not only in Romania, but also in countries like France, Spain, Turkey, Greece, Italy and China.

In the last years, a special emphasishas been put on breeding for high oleic acid content and for resistance to herbicides (imidazolinone and sulfonylurea). The first „high oleic" hybrids are now in the comparative trials, and first sunflower hybrids resistant to herbicides will be obtained in the next two years (Pacureanu et al., 2007).

**In linseed and flax,** breeding work at Fundulea continued the research, initiated at the Romanian Agronomical Research Institute (I.C.A.R.) in 1938. Sixty linseed and flax cultivars, adapted to the Romanian environment, have been released so far. They show a significant genetic progress in *Fusarium* resistance, oil or fiber content, lodging resistance and yield. Several yellow seed cultivars wih improved disease resistance and oil content over 45% have also been released. Beginning from 1957, the whole linseed acreage in Romania has been cultivated with Romanian cultivars, and some of them have also been registered in other countries, such as Germany and U.K. (Doucet and Doucet, 2007).

**In fodder crops**, breeding work, initiated in 1949 at the former Romanian Agronomical Research Institute (ICAR), and transfered in 1961 to RICIC Fundulea, resulted in the release of 60 varieties, during the last 50 years. They include 20 alfalfa cultivars, 2 sainfoin, 2 field peas, 1 vetch and 35 grasses varieties (8 orchard grass, 6 Italian ryegrass, 4 hybrid ryegrass, 2 perennial ryegrass, 3 tall fescue, 1 smooth brome, 5 Sudan grass and 6 millet).

The most important results were obtained in alfalfa breeding, the first released cultivar being Fundulea 652 registered in 1962. After that, in the 70s, the extensive cultivars Luxin and Lutetia were released. The cultivar Gloria (1982) represented a new stage, by utilization of a male-sterility source, which allowed a high level of heterosis for fodder yield and resistance to diseases.

The release of cultivars Selena, Topaz, Magnat, and Sigma was considered as an important progress in alfalfa breeding, followed by other 10 cultivars with high nutritive value of fodder registered in the last ten years (Schitea and Varga, 2007).

In grasses, besides the release of synthetic cultivars consisting of clones, the synthetic cultivars of hybrid ryegrass were considered an important achievement.

They were obtained from progenies selected from interspecific hybrids Italian ryegrass x perennial ryegrass (*Lolium multiflorum* x *Lolium perenne*).

## CONCLUSIONS

Fifty years of breeding at Fundulea, using a large diversity of germplasm, including local populations and cultivars and related species, and testing in many diverse locations, resulted in a significant genetic progress and in release of many successful cultivars in field crops.

These cultivars, along with numerous valuable breeding lines and populations, represent a solid basis for further progress in breeding for adaptability, yield and quality and in meeting new challenges, both locally and globally.

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