

# Update on pear breeding program at CREA Centro di ricerca Olivicoltura, Frutticoltura e Agrumicoltura

Giuseppina Caracciolo, Sandro Sirri, Gianluca Baruzzi

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Centro di ricerca Olivicoltura, Frutticoltura e Agrumicoltura, Forlì (Italy);

## **Abstract**

The pear breeding activity at CREA Centro di ricerca Olivicoltura, Frutticoltura e Agrumicoltura of Forlì (FC) started 50 years ago. The first controlled crossings were made in 1968 and 7 varieties were released: 'Tosca' (1993), 'Carmen<sup>pvr</sup>', 'Norma<sup>pvr</sup>' and 'Turandot<sup>pvr</sup>' (2000), 'Aida<sup>pvr</sup>' and 'Bohème<sup>pvr</sup>' (2003) and 'Falstaff<sup>pvr</sup>' (2012).

In the past, the breeding program has been funded by several public research projects. In the last decade, it has been co-funded by New Plant Consortium of Forlì which brings together three growers' associations, Apofruit Italia, Orogel Fresco and Apoconerpo. The main objectives of the program are: extension of the harvest time; high fruit quality and shelf-life; resistance and/or tolerance to diseases, as fire blight (*Erwinia amylovora*) and insects (*Psilla pyri*); high nutraceutical fruit characteristics; red skin and flesh. In recent years, the European trend has been focused on red-skin or red-blushed pears to diversify the market. The market needs new varieties to diversify the product and to ensure the maintenance of high market shares. Interspecific hybrids (*P. communis* × *P. pyrifolia*) have become an interesting goal thanks to their organoleptic characteristics (very crispy, juicy and aromatic flesh). 'Falstaff<sup>pvr</sup>' is the first variety released in the frame of the New Plant co-funded breeding activity. It is a red-skin pear variety, with harvest starting in early September (25-30 days after William and at the same period as 'Abate Fétel') in Emilia-Romagna areas. The skin is yellow, with red over-color on about 80% of the surface becoming very attractive during cold storage. Fruit taste increases during cold-storage reaching excellent levels after three-four months, when it often has a peculiar spicy aftertaste. For its commercial exploitation a "club" managed by New Plant has been set up.

Some of the most interesting selections at an advanced stage of evaluation will be described here.

**Keywords:** *Pyrus* spp., ripening time, fruit quality, storability, red skin, disease resistance.

## **INTRODUCTION**

According to Prognosfruit data, in 2018, the European pear production has reached 2.33 million tons and the Italian pear production 741,000 tons (32%) (WAPA, 2018). In Italy, 85% of the whole production is concentrated in northern regions. Emilia-Romagna region is the most important pear-cultivated area in Italy: Modena, Bologna and Ferrara provinces cover about 65% of the total Italian pear-cultivated surface. The high vocation of the environment led to obtain the PGI (Protected Geographical Indication) identifying that the product is linked to its geographical origin. Pear represents the fourth most widely consumed fruit product in Italy with almost 400,000 tons marketed in 2017, with a + 13% increase compared to the average of

the last 10 years. The dominant cultivar is 'Abbé Fétel' (46%) followed by 'Williams' (22%) 'Conference' (9%), 'Kaiser' (6%), 'Doyenne del Comice' (5%), 'Max Red Bartlett' (2%) 'Santa Maria' (2%), and the Italian cultivar 'Carmen<sup>pvr</sup>' (2%), bred by CREA breeding activity, conducted in Po valley, Italy (CSO, 2017). This breeding program started in 1968 and for forty years was mainly financially supported by the Ministry of Agriculture. In 2007, a new private/public program has started, the New Plant Consortium including 3 important growers' associations, Apofruit Italia, ApoConerpo and Orogel Fresco (Baruzzi et al., 2013), joined the project co-founding the CREA breeding activity. In addition to 'Carmen<sup>pvr</sup>', other six varieties were released: 'Tosca' in 1991, 'Norma\*' and 'Turandot \*' in 2000, the two fire blight tolerant cultivars 'Aida<sup>pvr</sup>' and 'Bohème<sup>pvr</sup>' in 2005 (Rivalta et al., 2002; Rivalta e Dradi, 2002; Rivalta et al., 2004) and 'Falstaff' in 2012 (Faedi and Sirri, 2012). The last one is commercially managed by New Plant with a "CLUB" detected in the European Union.

In this paper an update of the Project will be reported, and several advanced selections will be described.

## **MATERIALS AND METHODS**

The main objectives of the program are: extension of the harvest time; high fruit quality and long shelf-life; resistance or tolerance to diseases; high nutraceutical fruit characteristics; red skin and flesh; interspecific hybrids. New Plant on the basis of the current and future needs of its associated producers. New Plant also performs the final test of new genetic material comparing it with the reference varieties in order to evaluate, even from commercial point of view, the value of the new accession. This action is carried out by New Plant in two fields located in Modena area (Campogalliano). The previous actions of the program (crosses, seedlings selection and evaluation of the first level selections) were carried out at CREA experimental farm in Magliano-Forlì (North East of Italy). Since 1968, more than 1,400 intraspecific and interspecific cross combinations have been performed with a production of over 100,000 seedlings. Currently 17,000 seedlings, 240 first level selections and 50 second level selections, are under evaluation. Seeds are rowed the same year of the cross. In the next spring, seedlings are set up in experimental fields and the selection starts after 3-4 years and ends after 6-7 years. Year by year seedlings selected (new selections), on the basis of a mix of positive characteristics of plants and fruits, are grafted on 'Farold®40' for the first level fields, three plants of each selection are set up in the field, in comparison with the check cultivars. This step is 6-8 years long. Plant and fruit characteristics are evaluated, and the best selections will be evaluated in second level fields, in collaboration with New Plant. This final step adds 6-8 years to the total selection scheme.

## **RESULTS AND DISCUSSION**

### **Extension of the harvest time**

One of the main goal, until few years ago, was the extension of the ripening season in the early period. This object had a great success. Five varieties, among seven released ones ('Tosca', 'Carmen<sup>pvr</sup>', 'Norma<sup>pvr</sup>', 'Turandot<sup>pvr</sup>', 'Bohème<sup>pvr</sup>') are, indeed, early season cultivars (mid-late July). In recent years, the demand for summer pears has decreased because summer pear production occurs in a period (late June-July) when the concentration of other summer fruit (e.g. peaches, apricots, plums, melons and watermelons) is high and consumer prefers them. For this reason, the selection is now oriented to new autumn-winter ripening varieties with a high storability in refrigerated cells for at least six months, so as to remain

on the market until April – May.

Among early season selections in advanced stage of evaluation, there are 'CREA 194' and 'CREA 327' (Tab. 1; Fig1). The first, soon to be released, is an early ripening selection, (+10 days compared to 'Carmen \*'; Ancarani et al., 2017) better described in the paper 'CREA194', the new pear cultivar soon to be released by CREA Centro di Ricerca Olivicoltura, Frutticoltura e Agrumicoltura" of this Volume. 'CREA 327', obtained from 'Bohème<sup>pvr</sup>' and 'S. Maria Morettini' cross, is characterized by regular, medium-sized quince shaped fruits, with an attractive red overcolour on about 20% of the surface; the flesh is fine, juicy with sour taste. Another early period advanced selection is 'CREA 71-18', obtained by CREA 100-125 (a red skin breeder line) and Carmen\*, that is picked in mid-late July, is the first early-season red-skin selection and has a good appearance and flavor (Tab. 1; Fig. 2).

Among the advanced selections harvested after 'Williams' the most promising are 'CREA 87', 'CREA 42', 'CREA 171', 'CREA 399' and 'CREA 185' (Tab. 1; Fig. 2). The first is characterized by fine texture, juicy and aromatic fruits. The second, obtained from 'Mellina' × 'Doyenne du Comice' cross, is tolerant to fire blight. Green-colored fruits have russet widespread on 20-30% of the surface, the flesh is medium-fine, juicy and aromatic. 'CREA 171', 'CREA 185' and 'CREA 399' (harvest time in September) are red-skin selections and are better described in the "Red Fruit Skin" paragraph.

### **Tolerance and resistance to diseases and insects**

With a view to fruit growing sustainability, focusing on the reduction of chemical inputs, the identification of new varieties with single or multiple resistance/tolerance, is a priority objective. In *pyrus* spp., the main biotic agents to be contrasted are *Erwinia amylovora* and *Cacopsilla pyri*. The inheritance of fire blight resistance seems to be regulated by multiple genes. Only less than 50% of the phenotypic variability sensitive to the bacterium would be due to genetic factors, while more than 50% to the environmental component. Considering the high influence of the environmental component, the evaluation of a parent is also based on the GCA (general combining ability), evaluated carrying out progeny test. Within the framework of national and international projects (Rosati et al., 2002; Bergamaschi et al., 2006), fire blight tolerant genotypes have been identified and the first two varieties tolerant to the bacterial disease, 'Aida<sup>pvr</sup>' and 'Bohème<sup>pvr</sup>', were obtained. 'Aida<sup>pvr</sup>' harvesting time is mid-late August and fruits are attractive with crispy juicy flesh and very regular fruits; 'Bohème<sup>pvr</sup>' is a very early cultivar (first week of July), with juicy, aromatic and fine texture fruits.

Pear psylla resistance is considered to be a polygenic trait (Pasqualini et al. 2006; Lespinasse et al. 2008), characterized both by ovipositional deterrence and feeding inhibition, expressed by nymphal mortality and delayed development (Bell and Stuart, 1990). The breeding activity aiming at the resistance to *Cacopsilla pyri* began in 1968 when appropriate cross combinations were made with 'Spina Carpi' and 'Porporata'. We obtained different selections tolerant to the insect. Some of these are interesting also for the fruit quality characteristics and for the tolerance to fire blight. This is the case of 'CREA 133' (Tab.1; Fig. 1), which is picked in late August. It is productive, with red-blushed and medium-sized fruits, good flesh flavor and texture.

### **Red fruit skin**

The innovation of the 'pear product' seems to be the only way to obtain a modification of the varietal standards of this species. The consumer is increasingly attracted by red fruits,

not only for their appearance but also for their content in biologically active compounds, such as polyphenols and anthocyanins, which give the characteristic red color skin.

Obtaining new varieties with bright red skin color was possible by crossing red-skin varieties, such as 'Max Red Bartlett' (William's gem mutation) where the red color is related to monogenic and dominant genes (Dondini et al., 2008). The selections obtained mainly ripens in autumn-winter season, which is the period of greatest demand by the consumer.

In 2012, 'Falstaff<sup>pvr</sup>', the first cultivar in the frame of the New Plant co-funded breeding activity was released (EU Community Plant Variety Rights n. 47553). This is a red-skin cultivar with harvest starting in early September (25-30 days after William and at the same period as 'Abbé Fétel') in Emilia-Romagna areas,. The skin is yellow, with red over-color on about 80% of the surface becoming very attractive during cold-storage. Fruit taste increases during cold-storage reaching excellent levels in winter, when it often has a peculiar spicy aftertaste.

For its commercial exploitation a "club" managed by New Plant has been set up (Tab. 1; Fig2).

Other red skin hybrids, interesting for fruit quality and harvesting time are listed here below (Fig. 1, Pallotti, et al., 2016).

'CREA 179' is an autumn-winter selection (harvest time: last week of August) coming from 'Cascade' x 'Piros Wilmos' cross. Red skin fruits (65% of the surface) are medium-large sized with a turbinate shape similar to 'Doyenne du Comice'. The flesh is white-yellow, fine, sweet and juicy, with good taste.

'CREA 171', obtained from 'Super Elliott' x 'Max Red Bartlett' cross, is harvested in mid-late September. Fruits are medium-large sized, with dark red color on 100% of the skin. The storability is good and at the end of the coldstorage the dark color lightens slightly, making fruit more attractive. Fruit flesh is fine, with very good flavor.

'CREA 185' obtained from 'Conference' x 'Cascade' cross, is an autumn-winter hybrid (first week of September). Fruits are bright red (60%), short quince shaped, juicy, with a fine texture and sweet flavor.

'CREA 125', obtained from the 'Conference' and 'Piros Wilmos' cross, is earlier than previous hybrids (mid August). Fruits are medium-sized, with an orange-red overcolor on about 70% of the surface. Fruit flesh is white-yellow, fine, juicy and sweet.

'CREA 71-18' and 'CREA 41-18', obtained from Carmen\*, are summer selections (respectively mid-late July and early-mid August). Fruit are bright red, with a big size and good flavor.

'CREA 399', obtained from a cross between two CREA selections, is an autumn-winter hybrid (second week of September). Fruits are bright red, very attractive, juicy, with a fine texture and a sweet-sour balanced flavor.

### **Interspecific hybrids and red flesh fruits**

In the perspective of a fruit diversification, in 1988 the first interspecific crosses were carried out between European (*Pyrus communis*) and Asian (*Pyrus pyrifolia*) varieties. 'CREA 89', 'CREA 655', 'CREA 509' have been selected for the plant fertility, juiciness and crispness of Asian pear, but for aroma and fine texture of *P. communis* (Tab.1; Fig. 1). Fruits are ready-to-eat at picking time, though showing a rather good storability.

Aiming to obtain red flesh types, some crosses between some CREA advanced selections and the ancient red flesh cultivar called 'Cocomerina', belonging to Emilia-

Romagna germoplasm, were carried out. In the last two years, new genotypes were selected and will be observed.

Table1. Forlì - 2013/2018. Average harvest date and fruit quality traits of CREA advanced selections.

Cultivar/selection	Harvest period	Average fruit weight (g)	Fruit firmness (kg cm <sup>-2</sup> )	Soluble solid content (°brix)
Carmen <sup>PVR</sup>	mid July	180±22	5.0±0.5	15±0.8
CREA 194	late July	164±18	5.2±0.7	15.7±0.9
CREA 327	late July	184±16	5.5±0.4	14.2±0.7
CREA 71-18	late July	280±17	5.0±0.6	14.0±1.3
CREA 41-18	early august	255±15	5.5±0.3	13.5±1.0
CREA 42	mid August	219±10	6.2±0.7	14.8±0.8
CREA 125	mid August	170±18	5.3±0.4	13.7±0.7
CREA 87	mid august	208±15	5.8±0.3	15.9±0.3
CREA 179	late August	234±14	5.6±0.4	15.0±0.6
CREA 185	late August	281±15	6.1±0.3	14.3±1.0
Falstaff*	late August	265±21	5.0±0.5	15.6±0.7
CREA 133	late august	210±13	5.2±0.3	14.5±1.2
CREA 171	mid September	259±18	6.5±0.4	16.0±0.5
CREA 399	mid September	229±14	6.3±0.3	14.0±1.4
CREA 89	Last June	<b>200±16</b>	<b>5.7±0.6</b>	<b>13.6±0.7</b>
CREA 655	Mid september	<b>230±11</b>	<b>5.3±0.3</b>	<b>12.5±0.5</b>
CREA 509	Mid october	<b>245±14</b>	<b>5.5±0.5</b>	<b>13.3±0.3</b>

Data are the mean of 10 replicates.

± Standard deviations

## CONCLUSIONS

In the framework of fruit growing increasingly focused on environmental sustainability and climatic changes, the identification of new genotypes tolerant/resistant to biotic and abiotic adversities and endowed with good hardiness that can reduce the chemical and energetic inputs, is a crucial objective. At the same time, the consumer asks for a crispy, juicy product with a longshelf-life and a good content in bioactive substances. Finally, new type of fruits (interspecific hybrids and red flesh) may be important in the future. CREA pear breeding program is working on these goals and several new varieties will be released in the next future.



Figure 1. From upper left fruits of interspecific hybrids: 'CREA 89', 'CREA 655', 'CREA 509';  
From bottom left fruit of red blushed advanced selections: 'CREA 194', 'CREA 133' and 'CREA 87'.



Figure 2. Fruits of red skin advanced selections and varieties.  
From upper left: 'CREA 399', 'CREA 171' and 'Falstaff\*'; From bottom left: 'CREA 179', 'CREA 185' and 'CREA 125'.

## ACKNOWLEDGEMENTS

This research was supported by “Programma regionale di sviluppo rurale 2014-2020 – Tipo di operazione 16.1.01 – Gruppi operativi del partenariato europeo per l’innovazione: Produttività e sostenibilità dell’agricoltura”. *Focus Area 2A – Project “Nuovi genotipi per la frutticoltura e l’orticoltura sostenibile”*



## Literature Cited

- Baruzzi, G., Castagnoli, M., Sirri S., Faedi W. (2013). Le varietà realizzate in Romagna dal CRA – Unità di Ricerca di Forlì. *Frutticoltura* 10, 14-19.
- CSO Italy (Centro Servizi ortofrutticoli) (2017). Italia consuntivo 2017: pere.
- WAPA (2018). Pear forecast and market outlook 2018. Prognosfruit, 8-10 August, Warsaw - Poland.
- Ancarani V., Caracciolo G., Sirri S., Baruzzi G. (2017). Le varietà di pera adatte per i nuovi impianti 2017. *L'informatore Agrario*, 45.
- Bergamaschi, M., Rivalta, L., Sirri, S., Biondi, E., Ramilli F., Bazzi C. (2006). Reactivity to Fire Blight of new promising pear selections. *Acta Horticulturae* 704 571-576
- Dondini, L., Pierantoni L., Ancarani, V., D'Angelo, M., Cho K. -H., Shin, I. -S., Musacchi, S., Kang, S. -J., Sansavini, S., (2008). The inheritance of the red colour character in European pear (*Pyrus communis*) and its map position in the mutated cultivar Max Red Bartlett. *Plant and breeding* 127, 524-526.
- Faedi W., Sirri S. (2012). Falstaff, una nueva variedad de pera roja. *Revista de Fruticultura* 9, 14-15.
- Lespinasse, Y, Chevalier, M, Durel, CH.-E., Guérif, PH., Tellier, M., Denancé, C., Belouin, A., Robert, PH., (2008). Pear breeding for scab and psylla resistance. *Acta Horticult* 800:475-482.
- Pallotti, G., Baruzzi, G., Caracciolo, G., Sirri, S. (2016). Nuovo interesse per le pere rosse, prime osservazioni sui cloni del Crea. *Frutticoltura*, 10: 12-17.
- Pasqualini, E, Civolani, S, Musacchi, S., Ancarani, V., Dondini, L., Robert, PH, Baronio, P. (2006) *Cacopsylla pyri* behaviour on new pear selections for host resistance programs. *Bull Insectology* 59:27-37.
- Rivalta, L., Dradi, M. (2002). 'Turandot', 'Norma' and 'Carmen': Three new early pear cultivars for high-quality production. *Acta Hort.* 596, 275-278. <http://doi.org/10.17660/ActaHortic.2002.596.42>.
- Rivalta, L, Bergamaschi M., Sirri S. (2004). Bohème e Aida due nuove cultivar di pera tolleranti al colpo di fuoco batterico. *Frutticoltura* 9, 36-40.
- Rivalta, L., Dradi, M., Rosati C. (2002). 'Thirty Years of pear breeding activity at ISF Forlì, Italy. *Acta Hort.* 596, 233-238. <https://doi.org/10.17660/ActaHortic.2002.596.33>
- Rosati, C., Rivalta, L., Dradi, M., Le Lezec, M., Belouin, A., Chartier, R., and Lecomte, P. (2002). Fireblight evaluation of advanced Italian selections and cultivars of pear. *Acta Hort.* 596, 279-282.

<https://doi.org/10.17660/ActaHortic.2002.596.43>