

# Cultivation, market and breeding of apple

## Diffusion and production of apple

In temperate areas of the world, apple is the most cultivated fruit crop. World production is around 65 M ton, slightly less than bananas (77 M ton) and similar to the global production of grape (ca. 67 M ton), and oranges (63 M ton). Apples represent 13% of the global fruit production. China contributes almost 50% of global apple production although only a small fraction is exported. Worldwide Italy ranks 6<sup>th</sup> with a production of 2 M ton 60,000 hectares.

**Table 1. Apple production in 2008 (World Apple Review 2009, Belrose Inc.)**

Ranking	Country	Production (MT)
1	China	28.5
2	USA	4.5
3	Iran	2.6
4	Turkey	2.5
5	Poland	2.5
6	Italy	2.0
7	India	2.0
8	Russia	1.8
9	France	1.7
10	Germany	1.6

In Italy, ca 70% of the apple production is concentrated in Trentino Alto-Adige which produces 1,4 M ton grown on 28,000 hectares (ISTAT 2008).



## Apple varieties and their breeding

The number of domesticated apple varieties including those present in germplasm collections, is around 3-4,000. In spite of this large number, only 20-40 cultivars are of commercial relevance and ten (Fuji, Golden delicious, Red delicious, Gala, Granny Smith, Idared, Jonagold, Braeburn, Pink Lady ed Elstar, in order of importance) cover around 70% of total world production. The actual production of Fuji apples, largely cultivated in China, can only be estimated.

**Table 2. Origin of the most relevant apple varieties.**

Variety	Origin	Country	Year of introduction
Fuji	Breeding	Japan	1939
Golden Delicious	Casual	USA	1890
Red Delicious (group)	Casual	USA	1879
Gala (group)	Amatorial	NZ	1939
Granny Smith	Casual	Australia	1868
Idared	Breeding	USA	1942
Jonagold	Breeding	USA	1953
Braeburn	Casual	NZ	1950
Pink Lady™	Breeding	Australia	1973
Elstar	Breeding	Hungary	1955

It is interesting to note how apple production is dominated by varieties which were not recently released (like Fuji), or by varieties, like Golden Delicious, Red Delicious e Granny Smith, which do not derive from breeding programs (found along field

edges and deriving probably from naturally dispersed seeds of domesticated varieties). Among the top ten world varieties, only Pink Lady™ has been the outcome of a recent apple breeding program (1973). Several private companies and public institutions are currently releasing more and more new varieties, some of which are very promising because they combine high fruit quality and resistance to *Venturia inaequalis*, the fungus which causes the most destructive disease of apple.

A modern apple breeding program consists of 4 different steps:

- 1) definition of a prototype (ideotype) of plant variety combining quality traits important for the consumer, with a long term storability of the fruit and the adaptation to a particular environment, resistance to the major diseases and insects included;
- 2) production of hybrids crossing available varieties showing those traits identified during the definition of the ideotype;
- 3) cultivation in greenhouses and fields of the hybrid progenies with several replications in different years and locations;
- 4) registration and patenting of the most promising selections.

The complete process may last for 15-20 years and the selection step involve tens of thousand of plants. In a modern breeding program, like the one currently carried out by the E. Mach Foundation, the selective step is assisted by the use of molecular markers. To introduce in apple breeding new traits predicted to be necessary in the future, frequently the elite varieties are crossed to wild apple accessions showing positive attributes, like disease resistance and new skin colors, but with a small size of the fruit, frequently also associated to poor edibility. It is from similar crosses that, starting from about 30 years ago, several cycles of backcrossing to high quality varieties has made today possible to release varieties resistant to the scab disease elicited by *Venturia*.

A further innovative approach concerns clonal selection: the identification of clones derived via mutagenesis from superior varieties. These clones are genetically very similar to the original variety, but differ because of a better fruit (color, size) or plant traits (vigor). For instance, several derived clones are available for the varieties Red Delicious and Gala.

## The role of molecular genetics in apple breeding

The approach to apple breeding based on molecular genetics has a major impact in reducing dramatically the time necessary to carry out those steps indicated as crossing and selection; the new procedure results in what it is known as “marker assisted selection, MAS”. Genomic data and the mapping position of apple genes in the 17 chromosomes of the species, allow to individuate in the chromosomes of specific varieties or wild accessions those genes which are responsible for superior traits.

Following this, it become possible to understand which version of an important gene has superior attributes and in which genotype this version is present. The molecular proof of presence is simple and can be routinely carried out also on young seedlings, if not directly on single seeds. For this reason the time necessary to select apple varieties may be reduced from 4-5 years needed in standars breeding to 4-5 months. In addition, planning of foundation crosses and of new breeding cycles can be based on very precise molecular information on positive and negative traits.

The priorities assigned to applied apple molecular genetics consider the identification of the genes responsible for i) resistance to biotic and abiotic stresses such as fungal diseases (scab and mildew), bacterial diseases (fire blight), phytoplasmas, aphyds and Lepidoptera; ii) qualit traits of the fruit (juiciness, crispness, firmness, sweetness, texture, acidity, skin and flesh color); iii) fruit conservation; iv) plant architecture (plant vigor and shape)



### References

- World Apple Review 2009 Edition. Belrose Inc.
- Il melo. 2008. Collana Coltura e Cultura, coord. Renzo Angelini,