Chapter

Advances in Breeding of Peach, Plum and Apricot

Rimpika and DP Sharma

Abstract

Research on the expression of fruit specific genes may allow breeders in the future to selectively manipulate through gene transfer in certain aspects of fruit development/quality in their advanced breeding lines thus reducing the time necessary for cultivar development. This would be particularly useful in breeding programmes, hybridizing standard cultivars with exotic germplasm of low fruit quality. The use of exotic germplasm will be important for the expansion of the peach germplasm base and the development of stress resistant cultivars. More immediate results of research on fruit specific gene expression will provide a better understanding of fruit development and quality. It is required to learn how the differences at the gene level correlate with quality characteristics. With the continued cooperation of fruit biochemists it is expected to obtain a better definition of fruit quality and a better understanding of fruit biochemistry. The potential will exit to generate a range of "anti-sense mutants" i.e. transgenic plants expressing anti-sense gene contstructs that reduce or nullify the effects of the normal gene. The phenotypes of these mutants could help to define the biochemistry, genetics and quality of peach fruit. The development of efficient regeneration and transformation system in peach will be useful not only for the modification of fruit characteristics, but also for the transfer and manipulation of genes affecting stress resistance and other economically important characters.

Keywords: breeding methods, genetic resources, peach, plum, apricot

1. Peach

1.1 Introduction

The peach is an important fruit crop of temperature region all over the world. Important centers of commercial fruit production usually lies between latitudes 30° and 45° North and South. According to geographical distribution, the peach cultivars have been divided into three groups namely, Northern, Southern and European or Persian group. Peach cultivars can also be divided into two groups, high chilling and low chilling on the basis of their chilling requirements. Low chilling cultivars developed in Florida during last three to four decades have become very popular in the sub-mountainous Himalayan region. Peach is a temperate fruit rich in proteins, sugar, minerals and vitamins. At low latitudes the winter requirement is not met. Cultivars with less than 100 hours of chilling requirement are known. Strains of peach are grown throughout the subtropical and tropical zones, especially at higher elevations, where the heat of low-elevation tropics is ameliorated.

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1.2 Origin and distribution

The peach with its smooth skin mutant is nectarine. Nectarines can be used in the same way as peaches, and may be considered as substitutes for peaches. Peaches and nectarine [*Prunus persica* (L.) Batsch] are native to China and their culture dates back to at least 4,000 years and spread to the rest of the world by means of seeds [1]. It is a species well adapted to temperate and sub-tropical regions, between latitudes of 30° and 45° North and South [2]. Numerous forms and cultivars have been developed over the years. There are atleast 77 wild species of prunus and most of them found in central Asia. From China the peach reached Mediterranean basin from Persia was reiterated by early Greek and Roman writers. The Romans spread the peach throughout their realm. Its spread through the European Mediterranean countries was mainly by the Romans. The primary centre of peach diversity are believed to be the mountainous areas of Tibet and South west China while the secondary centres of diversity are Iron, Central Asia, Caucasus, Italy, Spain and California [3].

In India, high chilling peaches and nectarines are being grown in the mid hills of the Himalayan range in the states of Jammu and Kashmir, Himachal Pradesh and Uttrakhand, whereas, low chilling peaches are grown on a limited scale in foot hills of northern western plains of Punjab, Haryana. Uttar Pradesh and Nilgiri hills.

1.3 Evolutionary biology and taxonomy

The peach is the most widely grown species in.

A very important genus containing the European plum (*P. domestica* L.), Japanese plum (*P. salicina* Lindl.), apricot (*P. armeniaca* (L) Koatina), almond (*P. amygdalus* Batsch), Sweet cherry (*P. avium* L) and Sour cherry (*P. cerasus* L.). peach belongs to the family Rosaceae and the sub genus Amygdalus (**Table 1**).

1.4 Cytology

There are 17 species closely related to peach all belonging to same subgenus *amygdalus* that range in ploidy from 2x to 22x, all with basic chromosome number of x = 8. Peach is self pollinated diploid (2n = 16) and has small genome size of

Kingdom	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Rosales
Family:	Rosaceae
Genus:	*Prunus*
Subgenus:	*Amygdalus*
Species:	*Prunus persica*
Binomial name	*Prunus persica* (L.) Batsch

Table 1.
Taxonomy of peach.

approximately 5.9×10^8 base pair/diploid nucleus (Barid *et al*. 1994). The chromosome number of peach is 2n = 16, X = 8. Other sub genres of *Prunus, Euprunus* and *Cerasus* exhibit naturally occurring euploid series (2n = 16, 32, 48 and even higher numbers), exceptioned to 2n = 16 are rare in subgenus *Amygdalus* and have been of no importance in development of cultivars.

1.5 Floral biology

The flowers of *P. persica* are commonly borne on one-year old shoots, with very few spurs forming. One or two flower buds form laterally to the vegetative buds ut some cultivars may form upto si or more flower buds per node. The flowers are mostly one per bud, anthesis is with or before leafing. The flowers are perfect, complete, perigynous, usually with a single pistil. There are five sepals and five petals, which are arranged alternately. Stamens number 30 or more. The filaments are long and thin, bearing the four loculed anthers which are reddish-yellow to yellow. The corolla cup is marked by the presence of nectarines, which vary in color from greenish through yellow to orange.

1.6 Genetic resources

The list of cultivars changes more rapidly than any other fruit tree

- Short span life of the tree
- Requirement of cultivars having hardiness to climate, soil, disease and pest reaction.
- Possibility of procuring improved cultivars through various breeding methods
- Less time required in establishing new peach orchard.

Choice of suitable cultivars for any region is governed by factors such as, type of market to be served, distance to market and adaptability to the local soil and climatic conditions. For table purpose, the cultivars should be yellow fleshed, freestone, regular producer and relatively free from fuzz. For canning purpose, the fruit should have yellow flesh, freestone, small non-splitting pit, good symmertrical size and should mature evenly.

1.7 Breeding objectives

Investigations in peach and nectarine breeding are concerned less with the inheritance of qualitative characters and more with an understanding of the transmission of quantitative traits. The manipulation of major genes to develop desired types of cultivars as free stones, canning cling stones or nectarines is basically understood. Development of efficient breeding system to maximize transmission of favorable variations is now of greater interest and importance. Extension of season of maturity makes an important objective in many breeding programmes. Improvement in flavor quality, both dessert and processed use, has become an important additional objective in most current breeding programmes. The main objectives in peach improvement and breeding programmes are:

1. High yield: Development of cultivars giving high yield at low cost production is essential in order to increase net returns that a triple income can be obtained by high density plantation than standard orchards.

2. Extension of season of maturity: Two factors account for this:

   a. Existing cultivars are deficient in desirable traits at the extreme of the seasons.

   b. Market opportunities are greatest at these times.

3. Processing purposes: Development of cultivars suitable for processing. Firmness of flesh, absence of tip on the pit, absence of split pits, freedom from loose fiber, fine texture, attractive color, non-browning of the flesh, flavor quality are all important traits needing improvement for processing outlets.

4. High fruit quality: It involves size, shape, skin color, flesh color, firmness, texture, freedom from loose fibers and non-browning of the flesh. Besides nutritive value, improvements of all these traits are needed to produce fruits of better quality.

5. Canopy modification: Increase in mechanization requires modification of tree structure and thus fruiting response. Therefore, canopy modification by controlling tree vigor to aid in mechanization and to lower the cost of manual labour in pruning, thinning and harvesting is a part of these changes.

6. Resistant varieties: Resistant varieties are the cheapest and most convenient methods of disease and insect control. The varieties resistant to disease (Leaf spot, Leaf curl, Blight, Crown ball, Brown rot, Mosaic etc.), pests (Fruit fly, Moth, Borer) and nematodes and to biotic and abiotic stress are needed to be evolved for successful cultivation. Recently, techniques like in vitro micrografting as a method for inoculation and slot-blot hybridization, with a digoxigenin (DIG)-labeled cRNA probe derived from PNRSV RNA3, for virus detection (Prunus necrotic ring spot virus) was evaluated and it was concluded that the system was suitable for rapid year round peach germplasm for resistance to PNRSV.

Similarly, the results of molecular hybridization have been effective for tomato ring spot virus detection in Prunus and substantiate the tomato RSV resistance of Marianna 2624 [4].

7. Broadening of genetic base: Reliance on distinctive gene source to meet the limiting requirement of environment conditions should be broadened so that the variants needed for diversity are available and the tendency of the breeding programmes to become highly inbred be stopped.

8. Evaluation of low chilling varieties: Main objectives of peach breeding programme for low chilling areas are:

   a. Low chilling requirement and tolerance to high summer temperature.

   b. Improvement of fruit quality for table use and processing.

   c. Varieties which mature early between 60 and 70 days after full bloom.

   d. Resistance to root knot nematode, water logging, pest and diseases.

   e. Dwarfness of scion and rootstock.

   f. Nutrient deficiencies like Fe-Chlorosis, Zn deficiency.

1.8 Heritability

Heritability can be considered as that portion of observed variability due to heredity. Its estimation requires the partition of observed variability between gene effects and environmental effects. Traits of high heritability are subjected to large genetic gain, under selection per generation and those with low heritability may not be capable of significant advance through selection. Such studies are common in agronomic crops and are sparse for tree crops. The heritability estimates are given for several of the traits in specific peach population. Ripe date had an extremely high heritability of .84, this indicate that the population contained a great deal of additive genetic variability for this trait. So the investigation of heritability in peaches to proceed by evaluation of measurement applied to characterize traits and that only those that are adequate be used.

1.9 Breeding methods

1.9.1 Introduction and selection

Selection of planting material as candidate for introduction as a new cultivar is largely subjective based on the experience of the plant breeder and the characteristics of the established cultivars against which the new selection must complete. It is usually based on the heritability studies, as phenotypes appear to be the best measure of the genotypes. So depending upon the climatic requirements and the performance desired, cultivars are introduced from time to time.

Eighteen indigenous and five exotic (Kanto 5, Somerset, Dawne from USA and Shimizu Hakuto and Okubo from Japan) cultivars were planned in H.P. Shimizu Hakuto and Kanto-5 were found promising and recommended for mid hills of H.P. [5]. Out of 34 introductions made from Australia, Bulgaria and other countries, four cultivars viz. Stark Earliglo, Stark Early White Giant, Starking Delicious and Candore were considered good for mid hills of H.P. as these mature by the first and second week of June escaping rainy season [6]. Flordasun, Sun Red, 16–33, Floradared, Florda Balle, Early Amber, 15–39 bred in Florda (USA), Bonita, Rochan and Vantura bred in California (USA) were introduced during late sixties at PAU, Ludhiana [7, 8]. Flordasun, Sun Red, 16–33 and Flordared were found to be successful and became more popular than Sharbati and Khurmani, TA 170 has been released in Punjab.

1.9.2 Outcrossing

Outcrossing in the peach is the range of 15–30%. The immediate goal was elucidation of the method of inheritance of several polymorphic traits really observable in the cultivars of that time such as foliar gland types, flower size, fruit flesh color etc. Selection of parents at these initial efforts relied on clones that were more or less unrelated, but that exhibited the contrasting characters to be studied. Later breeding programmes also relied on selection of unrelated parents but based on particular quantitative traits that, if combined would yield ultimate commercial variety. For eg: "Early Craw ford" used for its superior flavor, University of California, Davis through conscious outcrossing tried to incorporate higher processed fruit flavor in canning cling stone cultivars. Initially, a hybridization of identified sources of quality with so called conventional canning Cling stone was made and later selection of the improved quality derived from several such hybrid sources sill unrelated were combined with further hybridization. Finally the development of disease or pest resistant cultivars or seed sources, exemplified by the development of seed cultivars for root knot nematode resistant has relied on crossing of unrelated parents.

1.9.3 Inbreeding

The most peach breeding programmes involve outcrossing initially, but then resort to some form of inbreeding, usually through the use of related selections for continued advance through the selection procedure to maintain heterozygosity. Inbreeding is attained most quickly and in highest degree by continued selfing, and many peach breeding programmes have relied heavily on self-pollination following original crosses between more or less unrelated parents. Major disadvantage of inbreeding is that much of the cultivars improvement carried out traces back to a few clones and hence to a limited gene pool [9]. Because of the apparent homozygosity within lines. Lesley, 1957 proposed that new cultivar might be developed by crossing between such highly inbred selections. The seedlings of such crosses would presumably be so nearly homogenous that variability among them would be insignificance. The problem connected with Lesley's suggestion for the development of cultivars in this manner is the number of inbred lines needed to supply the type diversity required by the peach industry. Diversity could be generated only if additional inbred lines would develop.

1.9.4 Hybridization

In India, planned breeding programmes for developing varieties suited to sub-tropical region was initiated in 1957 at the Horticultural research institute, saharapur (up). As a result of crosses made between Sharbati, Elberta, Bidwill Warly, Tinston and Flordawon, 84 hybrids were evolved. But there is no record available about the release of any hybrid [10, 11].

Singh and Sirohi [10] suggested an improved technique for peach hybridization by emasculation and pollinating all the ready to emasculate buds on a branch followed by covering them in a large glassine bag as a faster method. By this method, success in crossing could be increased by 28% over the earlier method of single bud emasculation and pollination.

The varieties identified for use inhybridization were Gujrati for dwarf stature, SRE6, Safeda Early cream and happen for earliness and large fruits, sharbati for fruit quality and flordared, Flordawon and Okenawa for low chilling requirement [10].

Besides the study of Mendalian Characteristics in the above Table, there is today a renewal of interest for quantitative genetics which includes characteristics like ripening date, full bloom date, amount of bloom etc. the detail of heritability of which under different conditions is given in the Table below:

Interspecific hybrids involving the peach are summarized in table. Scorza and Okie [12] crosses between the peach like species *p.persica and pdavidiana, p.mira and p.kansuensis* have been reported. Crosses between *p.persica and p.davidiana* have been used in the development of nematode resistant rootstock. Hybrids between *p.persica Xp. Amygdalus* or the reciprocal have also been widely tested as rootstocks because of their vigor and graft compatibility with either peach or almond. Meader and Blake reported on F1 and F2 population of *p.persi Xp.kansuensis.* The F1 plants were vigorous and some what intermediate. F2 plants showed various segregations for some of the distinguishing characters.

1.9.5 Mutation breeding

Induction of mutations usually by X-rays or gamma radiations or by certain chemicall is termed as mutation breeding. With the objective to increase mutation rated over those observed naturally. Two aspects that need to be studied adequately are:

1. Production of micromutants with lower doses.

2. Irradiation of pollen.

Pollen irradiation requires the growing of second and third generation progenies to uncover recessive mutants. It may prove useful in the long run in the development of useful variations due to ability to sexually transmit the mutation. Nectarine rose as peach mutants and their inheritance pattern is consistent with glabrous skin characteristics controlled by a single recessive gene [13]. A nectarine mutant is having higher chilling requirements and shorter fruit development periods.

1.10 Morphological and physiological traits

Trees that have a prudent growth habit can easily be pruned in high density orchards are important goal in breeding programs. There are several single, recessive genes that cause extreme size reduction viz.; dwarf (dw, dw2, dw3), semi-dwarf (n).

1.11 Genetic mapping

Large number of molecular linkage maps have been identified for peach and its relatives. Five maps are identified for *prunus persica*, two for almond x *p.persica*, two of *P.persica* x *P.davidiana* and one each of *P.persica* x nectarine, *p.persica* x p.ferganensis and myrobalan plum x almond-p.persica hybrid. Molecular markers also been used to differentiate between peach cultivars, measure their relatedness and determine their origins. A genome-wide framework physical map of peach was constructed using high-information content fingerprinting (HICF) and FPC software by Zhebentyayeva et al.

1.12 Molecular markers

Modern breeding of the species *Prunus* is based on a very limited number of genotypes, because of this and its high degree of natural self-pollination, peaches are known to have a quite narrow genetic base [9]. To avoid misidentification of cultivars and to protect plant varieties, efficient tools are needed such as DNA fingerprinting. The large number of cultivars and their limited genetic diversity make cultivar differentiation and finger printing of this species particularly challenging [14]. Most of the work in peach has been done either to detect diseases, usually of viral origin or to conctruct linkage maps based on DNA banding patterns. The information can be used for the characterization of the genotypes, marker aided selection and for isolation of genes of interest

1.12.1 Genetic linkage and identification of genotypes

Jun-JH found that (SCAR) markers, Sequence Characterized Amplified Region to be adequate to identify the F/f gene (Flesh adhesion gene) in segregating progenies and commercial cultivars. Randomly Amplified polymorphic DNA (RAPD) were performed to detect markers linked to F/f gene and it is established that these markers can reliably be used in the marker assisted selection of peach cross seedling at an early development stages of a trees.

1.13 Somaclonal variation and in vitro selection

In vitro selection and somaclonal variation can be used effectively to obtain peach trees with increased levels of resistance to the bacterial spot. In vitro selection of peach cells for insensitivity to pathotoxin produced by Xanthomonas compestris Pv. Pruni and subsequent regeneration of plants from the selected cells were carried out by Hammerschlag. Selection in vitro could be used in conjunction with mutagenesis to develop variants of established cultivars. For eg. Scorza and cordts found a differential response to cytokinin (benxyladenine) in vitro between 'Redhaven' and its compact mutant' Com-pant Redhaven'. Mutagenesis and selection on high cytokinin medium could produce compact mutants of other cultivars. Hammerschlag and Ognjanov screened peach varieties for resistnce to Xanthomonas compestris pv. Pruni and *pseudomonas syringae* pv. Syringae, the causal agent of bacterial cacker.

1.14 Rootstock breeding

The objectives of rootstock breeding:

- Resistant to nematodes, pest and soil borne diseases.
- Tolerant to heat, cold and drought conditions.
- Control of tree vigor for HDN system.
- Consistent, quality and quantity yield.
- Ease of propagation

Peach seedlings are the most usual rootstock for peaches. Generally peach seedlings are susceptible to nematode attack with the exception of "Nemaguard" and "Okinawa "seedling rootstock. "Nemared" is a descendant of "Nemaguard" are used specifically where root knot nematode are a problem [15]. Peach plum hybrid *(p. belsianaX yunam)* myran is tolerant to drough, poor soil, root knot nematodes and armillaria and vertilillarium diseases. Marianna GF 8–1 (*p. domestica Xp.munsoniana)* are better adapted to heavy soils [16]. Danis J et al developed a procedure for screening prunus species and related genotypes for resistance tolerance ot the root lesin nematode *pratylenchus vulnus allen and jensan.* However "Nemaguard" rootstock which was resistant to root knot nematode are highly susceptible to these root lesion nematodes, whereas plum root stock Marianna 2624 and Myrobalan 29C have been determined to be moderately to highly tolerant to lesion nematodes. Flordaguard is a root Knot resistant rootstock from the University of Florida [17]. "BY520–9 was released to provide resistance to peach tree to short life in SE-United States and Ausralia. Somaclonal variation as a result of tissue culture and its use in obtaining disease resistance variants at the cellular level with particular attention to the variants of peach with increased levels of resistance to bacterial spots *Xanthomonas campestris pv prunni,* bacterial canker and root knot nematode.

INRA peach interspecific breeding programme in France aimed at creating rootstocks with general grafting compatibility, waterlogging tolerance, Selection for resistance to root knot nematodes, tolerance of chlorosis, drought, salinity and crown gall. The studies reveal that the *myrobalan* plum having one dominant gene (Ma) resstance to melodiogyne species. A new interspecific breeding programme was initiated to combine the myrobalan nematode resistance source in a "Nemared" peach background to cerate highly resistant rootstocks. Massair R et al. tested the salinity to lerance on four different rootstocks (Mr S2/5, G.F. 655/2, G.F.677 and found that the rootstocks G.G. 655/2 were least affected by the slts. Sirio (peach x almond rootstock Gf 677) is suitable for high density planting system even in fertile and calcareous soils [18].

1.15 Achievements and missing gaps

Peach and nectarine breeding is one of the brightest facet in all tree fruit breeding achievement.

- New producing regions have come to the fore through the efforts of peach and nectarine breeders.
- Fruits are available in the market for a greatly expanded period of time
- Cultivars for processing have been developed for regions not commonly recognized for such production.
- Some disease problems have been alleviated
- The genetics of the peach i.e. molecular mapping and gene transfer approaches to genetic improvement are being explored.
- Emphasis us given on the fundamental problems involved in such interrelated traits as climatic adaptation, tree and fruit disease and pest resistance, fruit quality and processing and cultural management and production.

1.16 Conclusions

Research on the expression of fruit specific genes may allow breeders in the future to selectively manipulate through gene transfer in certain aspects of fruit development / quality in their advanced breeding lines thus reducing the time necessary for cultivar development. This would be particularly useful in breeding programmes, hybridizing standard cultivars with exotic germplasm of low fruit quality. The use of exotic germplasm will be important for the expansion of the peach germplasm base and the development of stress resistant cultivars.

More immediate results of research on fruit specific gene expression will provide a better understanding of fruit development and quality. It is required to learn how the differences at the gene level correlate with quality characteristics. With the continued cooperation of fruit biochemists it is expected to obtain a better definition of fruit quality and a better understanding of fruit biochemistry. The potential will exit to generate a range of "anti-sense mutants" i.e. transgenic plants expressing anti-sense gene contstructs that reduce or nullify the effects of the normal gene. The phenotypes of these mutants could help to define the biochemistry, genetics and quality of peach fruit.

The development of efficient regeneration and transformation system in peach will be useful not only for the modification of fruit characteristics, but also for the transfer and manipulation of genes affecting stress resistance and other economically important characters. It is clear that an understanding of the genetic, molecular biology, and biochemistry of peaches and other perennial fruit crops along with a development of the technologies to manipulate these crops at the molecular level will be important for efficient progress in genetic improvement.

2. Plum

2.1 Introduction

Plum is an important temperate fruit, which is used both as fresh and in preserved form. Of the stone fruits it next to the peaches in economic importance. Plum belongs to family Rosaceae and sub-family Prunoideae. It require certain period of chilling during winter to break dormancy, thus grown in areas where winter is cold. Fruits are rich source of minerals, vitamins, sugars and organic acids in addition to protein fat and carbohydrates. Plums with high sugar content which can be dried with stones in them and without fermentation, are known as prunes. In India, plum was introduced by Alexander Coutts and two types i.e. European (*P.* domestica) and Japanese (*P. salicina*) were introduced during 1870 in Himachal Pradesh. After evaluation, only Japanese plum has been recommended for commercial cultivation in the temperate region of northwestern Himalayas. Most plums in commercial production today are classified as European (hexaploid) or Japanese (diploid) types. European plums *(Prunus domestica* L.) are adapted to cooler regions. Within *P. domestica,* several groups of cultivars are recognized, such as Green Gage or Reine Claude types, and Prunes.

European plums with a high enough sugar content so that they can be dried with the pit intact are referred to as prunes. Japanese plums (*Prunus salicina* Lindl., formerly *P. triflora* Roxb.) originated in China, but were further developed in Japan and the United States. The term "Japanese plum" now encompasses a wide range of fresh-market plums developed by intercrossing various diploid species.

2.2 Origin and distribution

There are at least five centres of origin for different species of plums. (1) *P. domestica*t (European plum) Euiope. (II) *P. salicina* (Japanese plum) China, (III) *P. inititia (*Damson plum) Western Asia and South Eastern Europe, (IV) *P.cerasifeni* (Cherry plum) Western and Central Asia, and (V) *P. americana* (American plum) North America.

Prunus domestica is believed to have originated by doubling of chtomosomes of a hybrid between *P. cerasifera* (2n 16) and *P. spinosa* (2n - 32); because it pos sesses 48 chromosomes.

The major plum producing countries are Germany, Yugoslavia, USA, Russia, Romania, France. Turkey and China, In India, plums are cultivated on a commercial scale in Himachal Pradesh, Jammu and Kashmir, hills of Uttar Pradesh and Arunachal Pradesh. It is also ultivated on a small scale in Nagaland, Sikkim and the Nilgiri Hills.

2.2.1 European plums

Historically, *Prunus domestica* has been the most important plum species. Crane and Lawrence suggested that it originated in Asia Minor as a hybrid between *P. cerasifera* Ehrh. (2n = 16, x = 8) and *P. spinosa* L. *(2n* = 32), which then doubled to produce a fertile hexaploid. Such natural hybrids could have been the progenitors of *P. domestica,* which may then have been spread by seed from Iran and Asia Minor across Europe. Several characteristics of *P. domestica* suggest such an origin, including skin and flesh colors and the presence of both citric acid (from *P. cerasifera)* and tannins (from *P. spinosa)* (Komarov et al. 1941). In Soviet Georgia, natural *P. spinosa* have been found with *In* = 16, 32, 48, 64, or 96. Natural hybrids *(2n* = 48) between *P. cerasifera* and *P. spinosa* were also found (Bajashvili 1991). Endlich and Murawski (1962) produced F_2 plants of this cross, some of which were hexaploids that resembled *P.domestica.* Most of the wild *P. spinosa* fruit are black, bitter, and unpalatable, although some are used for drying and processing. Fossils of stones of this species have been found dating back to Neolithic period. It ranges from Scandinavia across Europe to Asia Minor. The northern forms are quite cold hardy, occurring up to 68°N in Norway.

Some authorities distinguish the wild forms as a separate species, *P. divaricata* Ledeb. Yoshida suggests that *P. cerasifera* is the progenitor of all plum species, because of its native range and cross- and graft-compatibility with many other species. The name "myrobalan" apparently resulted from resemblance of this plum to fruits of the tropical genus *Terminalia* (formerly *Myrobalanus),* which collectively are known as myrobalans and are used in tanning, dyeing, and medicine.

2.2.2 Asian plums

In China, *P. salicina* may have originated in the Yangtze River Basin (Yoshida 1987) but now is found across eastern China. The history of 'Zhui Li' cultivar goes back 2500 years. Numerous local selections have since been developed, but plum has never been as important in China as peach, either commercially or culturally. According to Zhang et al. plums in southern China are concentrated in seven provinces, but especially in Fujian and Zhejiang, where over 20 million plum trees and about 200 cultivars are found. Truly wild stands are rare but are reported to still occur in Hubei and Yunnan, where some trees in Zhongdian County are over 100 years old.

Plum stones have been found in Japan dating back to the Yayoi Era, about 2300 years ago. Japanese books dating back 1500 years mention cultivated plums. Plums have been common garden plants in Japan for centuries, but improvement efforts have occurred only in the last century. Low-chilling types are found in southern China and Taiwan. Cold-hardy plums in northern China have been classified as *P. ussuriensis* Kov. and Kost. and *P. gymnodonJa* Koehne, but are otherwise very similar to *P. salicina.* Modem breeding programs, especially in the former USSR, have utilized this source of hardiness. Western taxonomists have described other Chinese species, such as *P. thibetica* Franch., and *P. consociiflora* Schneid., but these are not listed in Chinese taxonomic references as distinct species and probably represent variants within *P. salicind.*

Prunus simonii Carr. was described by Western botanists based on cultivated specimens. This species (probably the same clone each time) was used in developing California cultivars because of its firm flesh and strong flavor. Chow describes it as native to north China, and occasionally cultivated. It has some characters reminiscent of apricot and was thought by some to have descended from a natural hybrid, but more likely is just an upright variant of *P. salicina.*

2.2.3 Japanese plums

Wilson's Early, Billington, Duffy's Early Jewel,Black Amber, Black Diamond, Fortune, Queen Rosa and Santa Rosa.

2.2.4 American plums

Native American plum species were already being grown by Native Americans. On the northeast coast, *P. maritime* Marsh, was grown. Across the eastern United States *P. americana* Marsh, was used. *Prunus angustifolia* Marsh, was widely grown by Native Americans, who may have extended its original range across the southeastern part of the country. The only edible plum native to the west coast, *P. subcordata* Benth., was grown in northern California, where better quality forms occur. Apparently the xerophytic species were not used due to the lack of edible flesh.

2.3 History of improvement

Roach cites Gerard's report in 1597 that he had a collection of 60 of the best European plums, suggesting that slow but steady selection was occurring. Several cultivars known at that time are still grown, such as 'Reine Claude'. One of the earliest plum breeders was Thomas Andrew Knight in England, whose work encouraged two English nurserymen, Thomas Rivers and Thomas Laxton. Rivers released *Eaily Rivers' in 1834, followed by 'Early Transparent Gage', 'Czar', 'Monarch', and Tresident'. Laxton's cultivars were less enduring. Early settlers to North America brought European plums with them but the plums thrived only in more northern areas. A few selections were made but improvements were minor. Luther Burbank also developed European plums but only 'Giant', 'Sugar', and 'Standard' were important commercially.

2.4 Modern breeding objectives

The principal objective in a plum breeding program is the development of plums that can be grown successfully in a particular locality and that can be marketed profitably. A salable fruit must have an attractive appearance, adequate size and firmness, and acceptable flavor and texture. To be grown successfully, the trees must be productive and must be resistant or tolerant to local problems, that is, they must be hardy in northern regions, meet low chilling requirements for buds in southern regions, and be resistance to diseases and physiological problems. Suecessful marketing involves orchard location, proximity and types of markets, and the fruit's intended usage—shipping, canning, drying, or processing.

2.5 Breeding techniques

The techniques used in plum breeding are similar to those that are used for other deciduous fruits. They involve pollen collection, emasculation and pollination of flowers, seed collection and germination, and an evaluation study of the progeny.

2.6 Biotechnology

Because clonal rootstocks are being used for plum, particularly in Europe, tissue culture has been developed for commercial production. Much of the industry now uses rootstocks produced through tissue culture. Some plums, such as 'Santa Rosa', Marianna, and myrobalan, are relatively easy to multiply and root in vitro. Thermotherapy, meristem culture, and micrografting are commonly used to obtain virus-free propagating wood of both scions and rootstocks. Virus-free material is routinely available in North America and Europe. In some cases virus-free material grows much faster than infected plants. Micrografting may be more suitable than thermotherapy because it is less stressful to the plant material. In vitro methods have also been used to screen plums for resistance to crown gall caused by *Agrobacterium tumefaciens*. Druart and Gruselle summarize results in *Prunus* meristem and shoot-tip culture. Meristems can be obtained during the dormant or growing seasons. Rosettes and young shoots can then be multiplied

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with the addition of a cytokinin such as 6-benzylaminopurine. Rooting is enhanced by the addition of auxin and vitamin E, and a dark period. European scientists have isolated plum pox (sharka) virus RNA, sequenced the virus coat protein gene, and constructed sense and antisense containing vectors. Scorza et al. reported the development of transgenic *P. domestica* plants from hypocotyls slices carrying the papaya ring spot virus coat protein gene. These plants are being tested for resistance to plum pox, which is a related potyvirus. Techniques for cryopreservation of dormant buds are being developed for long-term storage of genetic material.

2.7 Interspecific plum

"Cherry Plum" Hybrid myrobalan plum x Japanese plum (*P. cerasifera* and *P. salicina*).

Pluerry™ complex *Prunus* hybrid, primarily of plum and cherry (*P. salicina and P. avium*) with dominant parentage of plum and having fruit resembling plum.

Pluot® complex *Prunus* hybrid with dominant parentage of plum (*Prunus salicina*) and having fruit resembling plum.

Plumcot simple cross of plum and apricot (*Prunus salicina and P. armeniaca*).

2.8 Selection

The selection of parents in breeding new cultivars is most important. Parents should be strong in the particular characters desired in the progeny. Parents are often chosen to complement each other's deficiencies. The purpose is to recombine desired traits into a single individual. Small-fruited parents seldom give large-fruited progeny; thus at least one parent should be large-fruited. Parents should be selected for time of maturity, firmness of flesh, flavor, or other characters. Progeny will tend to be intermediate in various characters that are quantitatively inherited, with occasional seedlings possessing certain characters beyond the range of either parent.

2.9 Rootstocks

Mariana (uncertain origin, possibly *Prunus cerasifera* x *P. munsoniana*).
Pixie (*P. insititia*).
St.Julian X (*Prunus institia*).
St. Julian A (*Prunus institia*).
Myrobalan B (*Prunus cerasifera hybrid*).

3. Apricot

3.1 Introduction

Apricot belongs to the Rosaceae family, subfamily Prunoidese, genus Prunus L., subgenus Prunophora (Neck.) Focke, section Armeniaca. The Prunus genus comprises other tree crops of high economical importance in temperate regions, including peach, cherry, almond and plum. In term of economics, apricot is the third most important species of the stone fruit crops Apricot is diploid (2n = 16). Breeding programme of apricot has a long tradition in Europe and has achieved many very interesting results in some countries.

3.2 Origin and distributation

The apricot fruit moved westward from central Asia through Iran and transcaucasus region and reached Italy during first century, to England in 13th century and to North America by 1720. The major apricot producing countries are China, USSR, Turkey, Italy, Spain, Greece, France and USA. Commercial cultivation of apricot in India is at recent origin and was started by European settler and missionaries after 1870. there are three important regionsas origin of apricots although Armenia had been supposed apricot's origin and named as *Prunus armeniaca*, previously. These are;

a. The Chinese center (China and Tibet).

b. The Central Asian center (from Tien-Shan to Kashmir).

c. The Near-Eastern center (Iran, Caucasus, Turkey).

3.3 Floral biology

The apricot has a perfect, perigynous flower with a single pistil. The petals are usually white, though some are tinted and occasionally even deep pink in color. Pollen sterility occurs and is inherited as a single recessive (Hesse, personal communication). Cultivars may be either self-compatible or self-incompatible. Careful breeding work in the future may well demonstrate an allelic series forself-incompatibility like that known for sweet cherries, since T. Toyama, USDA, Prosser, Washington (personal communication), has observed that some crosses between self-incompatible selections have been unsuccessful.

3.4 Flowering, pollination and fruit set

In apricot, usually three buds develop in the axil of a leaf at each node on a shoot and spur. The central one being a vegetative bud, the two side buds are floral. Time of flowering and its duration varies with the variety and the prevailing weather conditions. Under mid hills condition the flowering in apricot comes in the month of March and higher hills in end of March & April. Most of the commercial as a apricot are self fruitful and set fruits without pollinizer. However, varieties Charmagz and Perfection have been reported self incompatible. There is generally a good fruit set in the apricot Cvs growing in appropriate climatic conditions. There is 40–60% fruit set in the cultivars commercially grown in mid hills, but fruit drop is to the extent of 79% in these cultivars, which occurs mostly in second week after fruit set.

3.5 Modern breeding objective

The major objective in most apricot breeding projects is climatic adaptation. The development of apricots with a long period of winter development of the flower buds (i.e., a long chilling period) that will withstand fluctuating temperatures in late winter is probably the most important objective for extending the region where apricots can be grown. In addition to the slow development of flower buds in midwinter, it is important that the flower buds respond very slowly (require relatively high amounts of degree days of heat) to waning temperatures in the spring after their rest has been satisfied. The combination of these two characteristics will likely give the ultimate in late blooming so that the buds or flowers may escape spring frosts Apricots, because they are the earliest to bloom of the cultivated stone fruits, frequently encounter periods of cool, windy, cloudy, wet weather during or after the bloom period, often with a negative effect on fruit set Later blooming would be helpful in avoiding late spring frosts. Apricot trees that grow well and ripen fruit under humid growing conditions are objectives of many breeding programs. Trees with a lower chilling requirement or trees with a high chilling requirement that is met at a higher threshold are needed to extend the production of apricots into warmer regions. Should be an objective:

- High yield
- Climate adaptability
- Extension of season of maturity
- Processing purposes
- High fruit quality
- Canopy modification
- Resistant varieties
- Broadening of genetic base
- Evaluation of low chilling varieties

3.6 Recurrent mass selection

This statement should provide the basic perspective for apricot breeders. In any breeding program at any one time it is necessary to budget the total resources of the *project* among the several objectives. Chances are increased for achieving a given objective, in the absence of progeny testing, when two or three phenotypes that seem equally promising for that objective are used. Consequently, after deciding on the budget (the total number of seedlings that can be afforded for the given breeding objective), a breeder raises several intennediate-sizea progenies, rather than trying to choose a single pair of parents for one large population. We agree with Hansche that progeny testing is an inefficient technique because of time. But where progeny test date are available, as is the case for many of the cultivars in the collection of the Nikitsky Botanic Garden, they should be considered in the choice of parents.

3.7 Interspecific hybridization

Aprium- complex Prunus hybrid primarily of apricot and plum (*Prunus armeniaca* and *Prunus salicina*) with dominant parentage of apricot and having fruit resembling apricot.

Color-Cot- complex Apricot hybrid (*Prunus armeniaca* hybrid) having fruit resembling apricot with pubescent skin strongly blushed red or orange-red.

Peacotum-complex apricot-plum-peach hybrid (*P. persica*, *P. armeniaca*, *P. salicina*) with dominant parentage of apricot and having fruit resembling apricot.

3.8 Modified backcrossing

Certain characters, such as *disease* resistance, cold hardiness, and late blooming, can be effectively incorporated with other desirable pomological characters through a modified backcrossing program. Important considerations for the success of such a program are (1) an adequate screening procedure so that the desired phenotypes may be identified efficiently in each generation, and (2) the use of different high-quality backcross parents in successive generations. This practice allows the breeder to incorporate a greater variety of pomological characters into the breeding lines and at the same time to avoid the deleterious effects of inbreeding that are associated with repeated backcrossing to a single cultivar.

3.9 Biotechnology

Biotechnology has obvious implications as a new tool that can be employed in apricot breeding. Potential areas for its application include regeneration and micropropagation, virus elimination, and genetic improvement which could include somaclonal variation, protoplast culture and fusion, embryo rescue, and haploid induction. Recombinant DNA technology might also be employed to carry out genetic transformation and gene characterization. With the exception of micropropagation, embryo rescue, and virus elimination Fridlund, biotechnology has not yet been fully employed as a tool in apricot breeding.

3.10 Mutation breeding

Early Blenheim' was selected following thermal neutron irradiation and was introduced by Lapins as an early ripening cultivar tor local markets. Lapin's work is the only report of achievement from mutation breeding with apricots.

3.11 Rootstock breeding

The objectives of rootstock breeding:

- Resistant to nematodes, pest and soil borne diseases.
- Tolerant to heat, cold and drought conditions.
- Control of tree vigor for HDP system.
- Consistent, quality and quantity yield.
- Ease of propagation
- Soil and Climate adaptability
- Stock-scion interaction
- Nursery handling feautures.

3.12 Genetic diversity of apricot based on molecular markers

Apricot is a temperate and subtropical zones fruit. China, the Irano-Caucasian region (Turkey and Iran), Central Asia, Europe and North America are the main producer regionsin the world. The Central Asia is the oldest and the primary genetic source of apricot groupis the Central Asian accessions are self-incompatible; the Irano-Caucasian apricots which aremostly the cultivated ones are mostly self-incompatible, with large fruits and low chillingrequirements. The European and the

North American apricots are originated from Irano-Caucasia has relatively narrow genetic diversity and are self-compatible with large fruits. For a long period, genetic diversity in apricot was studied with pomological, morphological and phenological characteristics. DNA-based markers that have been used in the last decade clarify the relationship among the apricot accessions. For breeding and commercialization of promising apricot cultivars, a precise characterization and discrimination of the cultivars are prerequest. Different types of markersuch as morphological, molecular, biochemical systems have been used for genetic analysisin horticultural plants. However, due to the effects of environmental factors, asessment of morphological and pomological traits may be ambiguous. Therefore, markers in dependent from the environment are necessary for reliable identification and discrimination of genotypes and cultivars. DNA markers are well known independent from environmental interactions and they show high level of polymorphism. Therefore, they are considered invaluable tools for determining genetic relationships/diversity. Various types of DNA markers are now available. Among them, RAPD developed by Williams et al. has been commonly used method in apricot to assess genetic variability and relationshipsamong cultivars techniques has also been used in apricot tocharacterize different cultivars belongs to diverse eco-geographical groups. The diversity determined between apricot cultivars was probably due to crosses betweenwild and cultivated apricots and cultivars from different eco-geographic origin. Microsatellite analyses suggested that European cultivars might have originatedthrough hybridization among Irano-Caucasian genotypes and also most of the European cultivars have originated by hybridization with genotypes from the Irano-Caucasian group. The heterozygosity of the apricotgenotypes narrowed while apricot transfer from China to Europe. Pedryc et al. show that Middle European and Chinese apricot are distantly related. Molecular markes have created new era in genetic diversity researches since early nineties. Restriction fragment length polymorphism (RFLP), and PCR based markers such asrandomly amplified polymorphic DNA (RAPDs), sequence-related amplifiedpolymorphism (SRAP), single nucleotide polymorphism (SNPs), microsatellites or simplesequence repeats (SSRs) are mostly used marker systems in plants and also in apricot genetic divesity researches. Microsattelites among all is a very useful tool for apricotdiversity studies, and most promising to cleary genetic relation among the apricots andtravel routes of apricots. Amplified fragment length polymorphism (AFLP) molecular markers assesment for thegenotyping of 118 commercial apricot accessions and some related apricot species. The researchers clustered the apricots into four groups corresponding to theirgeographic distribution; (1) Mediterranean apricots, (2) Chinese apricots, (3) apricots ofcontinental Europe and (4) Europe-North American apricots. Their data confirmed that themigration of apricot from the East to West. They also showed with molecular markers that*Prunus sibirica* and *Prunus mandshurica* are different from *Prunus armeniaca*, but they grouptogether with Chinese accessions. In anohter study Romero et al. studied apricots by using of SSR markers to determine the genetic relationships amonggenotypes from different eco-geographical groups. They observed that Western Europeanand North American subgroups clustered together in aggrement with their common originsfrom ancient European cultivars. However their study placed Hungarian cultivars closer to the Central Asian group than tothe other European cultivars.

Hayashi et al. studied Japanese apricot (*Prunus mume*) germplasm and reported thatthe genetic diversity and relationships among 127 Japanese apricot germplasms assessed by SSR markers. Their study supported the two hypotheses that Japanese apricot cultivated inJapan had been introduced from China and that fruiting cultivars had been selected fromflower-ornamentals.

Turkish germplasm was studied by Yilmaz and Uzun et al. and geneticdiversity and relationships among the accesessions were determined using RAPD, ISSR, SRAP and SSR markers. The researchers reported the high genetic diversity in Turkishapricots. Four high chilling requiring cultivars originated from Eastern Turkey clustered apart from the rest. European, South African, North American and other Turkish cultivarswere not clearly grouped regarding to their geographic districts. Therefore the researcherssuggested that these cultivars, despite their different geographic origins, have similargenetic background.

3.13 Achievements and prospects

The first apricot cultivars from controlled pollinations were introduced in Russia Recently cultivars have been introduced in Canada, the United States, South Africa, Australia, Argentina, Romania, Hungary, France, and Czechoslovakia. A large proportion of these are from open pollination. Until now, such new cultivars have made no appreciable impact on production in established areas. Some of the cultivars from eastern North America, as well as some from the breeding programs in European Russia, seem to be more winter hardy and resistant to disease. Thus they give promise that the range of commercial apricot production can be extended into the humid, temperate fruit-growing regions that are close to concentrations of population.

The variability existing in desirable fruit characters assures the breeder that new cultivars can be produced that will be readily accepted in competition with other fruits, and the range in ecological adaptation indicates that apricots can be grown much more widely, so they certainly can become a greater part of the world's fruit production. But the limited ecological adaptation of any one genotype is the challenge to apricot breeders. Cultivars must be bred for each producing area and for each marketing opportunity. It is exasperating to realize that whenever a new character is introduced from another region into a breeding program it will likely be associated with unadapted attributes. With this perspective in mind, it becomes obvious that ambitious and persistent breeding programs are essential to expand the apricot industry throughout the temperate fruit regions.

The fruit qualities acceptable to consumers in the great centers of population will be quite similar, so the breeding programs will have similar objectives. Also, the ecological inflexibility of any genotype will require parallel bleeding programs. Certainly, it will be most efficient to have coordinated interregional and international breeding programs using a common gene pool and, in some cases, even common seedling populations that an understanding of the genetic, molecular biology, and biochemistry of peaches and other perennial fruit crops along with a development of the technologies to manipulate these crops at the molecular level will be important for efficient progress in genetic improvement.

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Author details

Rimpika* and DP Sharma
Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan,
Thunag, Mandi, India

*Address all correspondence to: rimpikathaur1989@gmail.com

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