Fig(Ficus carica L.)

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CHAPTER 12

FIG

(*Ficus carica*)

Akath Singh, Jai Prakash, P.R. Meghwal and S.A. Ranpise

CONTENTS

1. INTRODUCTION

Fig (*Ficus carica*) is one of the oldest known fruit trees in the world. Turkey produces 26% of the world's figs and Egypt, Iran, Greece, Algeria, and Morocco together produces around 70% of the world's fig production (FAO, 2006). In India, its cultivation is mostly confined to western parts of Maharashtra (Pune) and Gujarat, Uttar Pradesh (Lucknow and Saharanpur), Karnataka (Bellary, Cnitradurga and Srirangapatna) and Tamil Nadu (Coimbatore). Fig is especially well adapted to Mediterranean climates, with cool winters and hot- dry summers, but can be grown in more humid regions including the tropics and subtropics. Fig is extremely drought tolerant once established and commercial production is preferred in dry hot summer but needs regular irrigation for achieving higher yields.

Figs can be eaten fresh, dried or canned and are often used in preparation of jam. As a fresh fruit, it has a luscious taste. Fruits have been prized over centuries for the medicinal and dietary properties. Fig is a highly nutritious fruit. It is rich in calories (269), proteins, and calcium (higher than milk), iron and highest fibre content. Fig has nutritive index of 11, as against 9, 8 and 6 for apple, raisin and date, respectively. The chemical composition and flavour of fig varies with the cultivar. The total sugar content of fresh

fig is 16 % and of dried is 52%. The edible portion of fresh figs (100g) contains moisture (88.1%), protein (1.3g), fat (0.2%), minerals (0.6%), fibre (2.2%), carbohydrate (7.6%), calcium (35mg), phosphorus (22mg), iron (0.6mg), vitamin A (80 IU), vitamin C-2 mg, calorific value-80 and thiamine (0.1 mg). The edible portion of dried figs (100g) contains moisture (23.0%), protein (4.3g), fat (1.3 %), minerals (2.4 %), fibre (5.6 %), carbohydrate (69 %), calcium (200 mg), phosphorus (77 mg), iron (4 mg), vitamin A (100 IU), vitamin C-2 mg, calorific value-306 and thiamine (0.1 mg). Fig is a very poor source of Vitamin C but very rich in sugar next to dates. The latex from fig contains (ficin) rennin, which has 3 to 100 times milk clotting capacity as compared to animal rennin prepared form calf stomach mucosa. Fig leaves are used medicinally for their diuretic, demulcent, emollient and antihelmintic properties. Three new constituents viz., calotropenyl acetate, lupeol acetate and oleanolic acid were isolated by Ahmed *et al* (1990). Fig is valued for its laxative properties and is used in the treatment of skin infection. The fruits help to maintain acid alkali balance of the body. Latex is useful to coagulate milk (Morsli *et al*., 1985). Many medicinal virtues have been ascribed to the fig. It is considered a restorative food which helps in quick recovery after prolonged illness. It removes physical and mental exertion and endows the body with renewed vigor and strength. It is an excellent tonic for the weak people who suffer cracks in lips tongue and mouth.

2. DOMESTICATION

It was perhaps first brought into cultivation in the southern parts of the Arabian Peninsula by at least 3000 BC. It later spread into Iran, Syria and Turkey and into all the Mediterranean countries. During the age of exploration following the discovery of America by Columbus, the fig was taken to most subtropical areas of the western hemisphere. Dushevskii and Kazas (1985) described two forms of *Ficus carica* from the vicinity of Mangup Kale, a settled area on Mt. Baba-Dag in Crimea abandoned in 1783. They are thought to be descendants of figs cultivated on the plateau from the 12th century.

3. TAXONOMY

It belongs to family moraceae, genus *Ficus,* is a monoecious, deciduous tree or large shrub. The subgenus *Eusyce* to which *Ficus carica* belongs is characterized by having unisexual flowers only and gynodioecism (Storey, 1975). The inflorescence is unique, consisting of a syconium (the fig), which encloses many unisexual flowers that can be accessed via the ostiole by pollinating wasps that may give the true fruits. Tiny pedicellate druplets usually called the 'seed' (Storey, 1975). Morphologically *Ficus carica* is considered gynodioecious but functionally dioecious.

4. CENTERS OF ORIGIN /CENTERS OF DIVERSITY

It is thought to be a native to southern parts of Arabian Peninsula, Italy, the Balkan Peninsula and the former USSR (Tutin, 1964). According to El-Ray and Llacer (1995),

the fig originated in the east Mediterranean region (Turkey, Syria, Saudi Arabia), from where its cultivation expanded to the whole of the Mediterranean region.

5. OBJECTIVE OF IMPROVEMENT

Main fig breeding objectives are (Storey, 1975; Jona and Gribaudo, 1991):

i. Development of high yielding cultivars.
ii. Improvement in fruit quality - High fruit eating quality with improved storage-ability.
iii. Elimination of caprification.
iv. Transfer of nematode and insect resistance characters of wild fig varieties to high yielding good quality cultivars.
v. Persistence of syconia to ripeness.
vi. Resistance to pests and diseases.
vii. Hardiness to environment constraints.

6. CYTOGENETICS

The common fig *(Ficus carica)* is diploid, the somatic chromosome number is 2n = 2x = 26 (Storey, 1975; Jona and Gribaudo, 1991) while *F. elastica cv.* Decora is triploid in nature. *Ficus carica* is gynodioecious, bearing either hermaphrodite or female fig on separate plants. Males are the heterogametic (GA/ga) and female are the homogametic (ga/ga) (Storey 1955). Short-style female flowers and male flowers are determined by a pair of dominant genes on the same chromosome (GA); recessive alleles result in long-style female flowers and suppression of male flowers (ga).

7. INHERITANCE OF PATTERN

Knowledge of magnitude of genotypic and phenotypic variation, genetic gain and genetic advance are the major tools for selecting efficient breeding programme. In fig, quantitative inheritance is a feature of many important traits, such as yield, quality and disease resistance. Among the different traits those of high discriminating level were leaf dimensions, shoot dimensions, petiole color and dimensions, depth of sinus, fruit shape and color, fruit weight, dimensions, ostiole diameter, peel colour and juice acidity. Among these characters, some were good criteria for discriminating between cultivars. Several studies showed a positive correlation between yield and fruit weight, fruit diameter, dry matter. A positive correlation between polyphenols content and fruit weight and with flesh thickness; the ostiole diameter with flesh thickness and ostiole opening are commonly observed. Ostiole size has interrelationship with pests and diseases as large ostiole an undesirable property because pests and pathogens enter the fruit. Wide phenotypic and molecular diversity found in fig germplasm indicates a considerable potential for improving this crop.

8. PROBLEMS IN BREEDING

Fig breeding is a complex because of involving two tree morphs (Caprifig and Edible fig), three floral forms (long-styled female, short-styled female, and male flowers), and the insect pollinator (Beck and Lord 1988*)*.

i. Occurrence of Parthenocarpy and seedlessness.
ii. Complex pollination mechanism i.e. caprification.
iii. Lack of reference collections.
iv. Lack of universal descriptor list to differentiate different varieties/species.
v. Presence of large intra-variety diversity.
vi. Closeness of wild types to cultivated plants in some regions.

9. FLORAL BIOLOGY

9.1. Flower Bud Initiation

Morphological and developmental studies conducted by Duric *et al.* (1992) during dormancy and growth on cv. Tenica bearing a single crop and cv. Petrovaca bearing two crops per year reveal that three types of buds occur on one-year-old shoots. (i) Flower buds which are spherical, have 3-5 scales, with the inflorescence axis in the internal cavity enclosing female primordia differentiated to varying degrees depending on the position of bud on the shoot. These buds produce parthenocarpic fruits only in cv. Petrovaca. (ii) Mixed buds are conical, made up of 5-8 scales, and inflorescences on shoots arising from these buds produce fruit in both cultivars. (iii) Vegetative buds, made up of 3-5 scales, which usually remain dormant and only rarely produce shoots..

9.2. Flowers

The flowers are three types.

i. male flowers with 1-5 stamens
ii. female flowers with ovary and long style, each resulting one seed
iii. gall flower resembles female flower, short styled, ovary swollen, hivers fig wasp and does not set seed.

The flowers are hollow and born in the leaf axils, reduced to essential organs i.e. male and female and are produced inside globose pear shaped receptacles with narrow mouth (ostiole). Flowers are born axillary on previous growth and also on current growth. Near the ostiole male flowers are borne and towards the stalk female flower are present.

In Capri fig all three types of flower occur inside each fig whereas, in other types (dioecious), the male and gall flowers are produced in same inflorescence on one tree and female inflorescence on another tree.

Fig is a monoecious, deciduous tree or large shrub. The subgenus *Eusyce* to which *Ficus carica* belongs is characterized by having unisexual flowers only and gynodioecism (Storey, 1975). The inflorescence is unique, consisting of a syconium (the fig), which encloses many unisexual flowers that can be accessed via the ostiole by pollinating wasps that may give the true fruits. Tiny pedicellate druplets usually called the 'seed' (Storey, 1975; IBPGR, 1986). Morphologically *Ficus carica* is considered gynodioecious but functionally dioecious. According to the sex of the flowers in the syconium, two main types of trees can be distinguished. The first one is the caprifig in which the syconia contain short styled pistillate flowers distributed over most of the inner wall and staminate flowers around the interior of the ostiole. The other one is female fig tree with the syconia containing only long-styled pistillate flowers. Normally, only the later one produces edible figs (Valdeyron and Lloyd, 1979; Storey, 1975).

Ficus carica is a gynodioecious species, having two distinct forms of trees; the capri-fig is monoecious, and the common fig is pistillate (Storey, 1975). Smyrna fig produces male flower and proves to be unisexual from inception and shows ontogenetic divergence at primordial stage, whereas male flowers are initiated as hermaphrodites and undergo gynoecium abortion at the magaspore mother cell stage. A caprifig is seen as expressing two pathways to unisexuality. Smyrna fig inflores-cence produces abortive hermaphrodite flowers at the same position as the male flowers in caprifig (Beck and Lord, 1988).

9.3. Pollination

Carles (1985) working with fig in France reported that for early fig production for fresh consumption (which is more economic) pollination is to be avoided. Pollination is necessary for late figs which are used for processing. Valizadch *et al.* (1987) studied the pollen flow in 4 female plants (domestic fig) and 5 functionally male plants (caprifig) and found that each synconium was pollinated to about 80 per cent by a single insect despite being visited by several. The probability that a male plant pollinates a female plant was negatively correlated with the distance between them, but at distance over 10-20 m the correlation could be marked by competition between female plants. In fact, Smyrna type figs will never set fruit without pollination from caprifrg.

The pollination and development of flowers of the caprifig and female fig clone were studied by Tanriver *et al.* (1997) in Turkey. The development of the pistillate and staminate flowers was monitored by stereomicroscope. In the female tree, the synconia of the main crop were initiated on 10-15 March; initiation of the pistillate flowers was observed on 22 April. At the end of May, some fig *wasps (Blastophaga psenes)* entered the synconia and pollinated the pistillate flowers. On 21 June, the style had turned brown, the ovule was swollen and the testa was hardened. In the male trees, in early and mid-April, the wasps released from the mammoni crop (initiated on current growth in the summer: matures in autumn**)** entered into the synconia of the profichi crop (initiated in spring from latent buds

on the previous season's wood; matures in summer) and laid their eggs into ovary. The gall and male flowers were already mature (mid-April and early June, respectively *when* the female flowers were initiated at the time when the wasps were ready to emerge and enter the svnconia of the mamme crop (initiated in autumn on current season's growth, matures in spring) to lay eggs. The fragrance of the receptive fig attracts and stimulates fig pollinators *(Blastophaga psenes)* (Gibernau *et al.* 1998). Fig species emit specific compounds in order to attract pollinating wasps. Volatile compounds released by receptive figs from 13 tropical *Ficus* species have been identified. They are mainly terpenoids. but also include benzenoids and non-terpenoid oxygenated compounds. Pollen is actually transferred by a small wasp *(Blastophaga psenes)* which over winters in the pollen producing caprifig **(** Gerdts and Clark, 1979).

The figs commonly grown in India are parthenocarpic in nature and do not need any cross-pollination from wild fig (*capri fig*) which is very common in other fig growing countries. However, fruit setting here is also inhibited under certain conditions. It has been suggested that parthenocarpy is favoured or inhibited in a given type by climatic condition of the place where it is growing. Thus, Pune, Black Ischia and Brown Turkey have been found to be parthenocarpic at Kadur, while Turkish White has failed to set fruit without caprification. Likewise, Pune and Black Ischia do not set fruits without caprification in Allahabad. In fact, Smyrna type figs will never set fruits without pollination from capri fig.

9.3.1. *Pollination Mechanism (capriûcation)*

Fig has interesting pollination mechanism involving a symbiotic relationship between the plant and its pollinator wasp *Blastophaga psenes* L. The ûg relies upon the wasp for seed production, and the wasp complete life cycle within the inflorescence or syconium. Female and male unisexual flowers are produced but female flowers mature before the males. Within the syconium, the female wasp lays her eggs and pollinates the female flowers. There are two types of female flower within the syconium, short styled and long styled. The wasp penetrates the short-styled flowers with its ovipositor and lays an egg in the ovary. These short-styled flowers become galls as the developing wasp larvae feed on the ovary tissue. The style of the long-styled flower is longer than the ovipositor, and these flowers are pollinated by the female wasp with pollen collected from a male stage syconium. The syconia and its seed then develop slowly as the wasp larvae grow. When the wasps, both female and male, have emerged from their galls within the syconium, the male flowers of the syconium are mature. The wasps mate within the syconium, and the males then die, having spent their whole life in this enclosure. Fertilised females collect pollen from the male flowers, leave the male stage syconium and carry the pollen to a female stage syconium, entering via the ostiole. This whole process is termed as capriûcation.

The caprifigs (with wasp inside) are collected and placed in small bags or wire baskets that are hung in the fruiting Smyrna type trees. The emerging wasps covered with

pollen, enter the Smyrna fruits and pollinate the long styled pistillate flowers inside (Galil and Necman, 1977). In China, Yang *et al*. (1999) observed that fig is dependent on fig wasps of the family Agaonidae for pollination and in turn the fig wasps are dependent upon the galls (ovaries) of the figs for larval development and a complicated symbiotic (mutualistic) relationship between the two has developed. Ramirez and Malavasi (1998) reported that pollination of the pistillate fig flowers *(Ficus* spp.) has crucial effects for the figs and the pollinating wasps. It allows normal development of seeds and wasps. Thus, for fruit setting *of the Symrna fig,* caprifig trees as well as the *Blastophaga* wasps are necessary. In addition to pollination, these fig wasps also carry propagules, mainly of *Fusarium verticillioides* [formerly *F. moniliforme (Gibberella fujikuroi)]* and other *Fusarium spp. which* cause endosepsis, from pollinizer figs to the edible Calimyrna figs in California. Michailides and Morgan (1998) found that endosepsis decreased with distance from the source, decreasing faster to the south than in other directions from the source.

The fragrance of the receptive fig attracts and stimulates fig pollinators *(Blastophaga psenes)* (Gibernau *et al.* 1998). Fig species emit specific compounds in order to attract pollinating wasps. Volatile compounds released by receptive figs from 13 tropical *Ficus* species have been identified. They are mainly terpenoids. but also include benzenoids and non-terpenoid oxygenated compounds. Pollen is actually transferred by a small wasp *(Blastophaga psenes)* which over winters in the pollen producing caprifig **(** Gerdts and Clark, 1979). Thus, for fruit setting of the Symrna fig, caprifig trees as well as the *Blastophaga* wasps are necessary. However, caprification is a cumber-some and expensive process.

Considerable success has been achieved by substituting plant growth regulator sprays for caprification. Of the numerous substances tested, IBA, NAA, 2,4,5-T and 4-CPA proved effective in inducing early maturing parthenocarpic figs (Crane and Blondcau, 1949, 1950). The parthenocarpic fruits develop to a normal size and have desirable sugar content, but as they are completely seedless, the baking industries, which use most of the Calimyrna figs produced in the USA, do not want to use it, because they lack the crunchy quality imparted by fig seeds. Subsequently, Crane (1952) found that BOA induced parthenocarpy and the formation of drupelets with hollow, sclerified endocarp, but it is still not acceptable to the industry.

9.4. Fruit

The edible fig is a multiple fruit. Botanically it is known as syconium which consists of a fleshy hollow receptacle with a narrow aperture at the tip and numerous small flowers lining the inner surface. The true fruits are the tiny drupelets inside the cavity of the fused peduncle. The fig is an aggregate fruit composed of individual small drupes; each is termed a drupelets. The fig fruits are borne in the axils of the leaves; two inflorescences and one vegetative bud are present at the same lateral position in the leaf axils. But in cultivars such as ‘Mission’ and ‘Brown Turkey,’ usually only one inflorescence develops into a syconium, while in ‘Kadota’

and 'Calimyrna' cultivars, often both inflorescences at a node may develop. Fig fruit development follow double sigmoid curve with three defined growth periods (Crane and Brown 1950; Crane and Baker 1953*)*. During II phase of growth, about 70% of the total dry weight and 90% of the total sugar content is accumulated in the fruit.

9.4.1. *Bearing Behaviour*

The fig may start bearing a few fruits a year or two after planting, but this crop is not allowed to develop, because the crop may reduce the vegetative growth of the plant. Usually, steady yield can be obtained from the fifth year onwards. The trees continue to bear good crops for 30-40 years before they begin to decline. The fruits start ripe-ning from March-May in western India and May-June in northern India. In South India, the fig bears twice a year - once in July-September and again in February-May. The figs commonly grown in India are parthenocarpic in nature and do not need any cross-pollination with wild fig (caprifig), which is a very common practice in other countries. However, fruit setting is also inhibited under certain conditions. It has been suggested that parthenocarpy is favoured or inhibited in a given type by climatic con-ditions of the place where it is growing. Thus, Pune, Black Ischia and Brown Turkey have been found to be parthenocarpic at Kodur, while Turkish White has failed to set fruits without caprification (Naik, 1949). Likewise, Pune and Black Ischia do not set fruits without caprification in Allahabad (Hayes, 1957).

9.4.2. *Fruit Growth and Development*

Fig is a gynodioecious species and some female type's need pollination while others set fruits parthenocarpically. Pollination is effected by a wasp, which develops inside the syconium of male fig. This symbiotic relationship is a classical case of co-evolution between a plant and insect. Fig fruits show a double sigmoid growth curve- two periods of rapid growth being separated by a period of slow growth (Crane, 1948). In an investigation on fruit ripen-ing in cv. Rampelina, samples were collected at four fruit growth stages during June, July, August and September and divided by weight into 6 groups :0-5, 6-10, 11-15, 16-20, 21-30 and >30 g.

Fruit development followed a double-sigmoid pattern. Respi-ration and ethylene production decreased sharply during cell multiplication in the first growth period, remained constant in the stasis period and then increased rapidly prior to the onset of the second growth period upto the climacteric. Respiration decreased sharply in the smallest fruits, whereas it increased in the largest fruits during mid-August in conjunction with the onset of the second rapid growth period. Ethylene production was initially high in the smallest fruits but decreased progres-sively with the onset of maturity; only fruits >30 g showed an increase in ethylene production concomitant with the onset of ripening. Reducing sugar content remained low throughout in smaller fruits but increased with ripening in the largest fruits (Chessa *el al.,* 1992).

Growth of syconium in 8 cultivars was studied by El-Kassas *et al.* (1992c). The rapid growth cycle period I lasted 5 to 6 weeks in all cultivars. How-ever, period II varied substantially

among cultivars and lasted 8 weeks in Sultani, 5 weeks in Abiad Asswan, Kahramani and Brown Turkey and 3-4 weeks in Conadria, Abboudi, DiRedo and Black Mission. The third growth phase was characterized by an accelerated increase in diameter of syconia until fruit was ripe. Period III lasted 5 weeks in Brown Turkey, 4 weeks in Conadria, Black Mission and DiRedo and 3 weeks in Sultani. Overall, syconia developed over a period of 12-16 weeks. It has been known since the third century BC that growth and maturation of the fig fruit can be advanced by a few days if a drop of olive oil is applied to the ostiole (eye) during the ten-day period following the time at which all drupelets in the fruit have turned red (Sand *et al.,* 1969). This period brackets the transition from stage two to stage three of fruit growth. The stimulating agent is ethylene, which is produced as a breakdown product of olive oil, especially when the oil is exposed to solar radiation.

It has been found that application of ethylene exogenously in the first growth phase usually retards fruit growth, but accelerates development and ripening when applied in the second growth phase, the fruits are ripen within a week after application (Marei and Crane, 1971; Puech *et al.,* 1976). During the second period of syconinm growth of 2 successive seasons, shoots of fig cv. Sultani trees were subjected to one of the following treatments: a single spray of 100, 200 or 300 ppm ethephon. girdling, manual removal of the 5 least mature fruits at the end of the shoot (thinning), girdling + ethephon, manual thinning + ethephon. In both seasons, all treatments except manual thinning significantly hastened fruit maturity and improved quality, compared with untreated controls. The most effective treatment was 300 ppm ethephon combined with shoot girdling. Application of 500 ppm ethrel resulted in 82% of the fruits being harvested at the first of 3 harvests compared with 56% from untreated trees. Damage caused by insects or fungal infection was less (Ferguson *et al.,* 1990).

The typical growth curve of the Bursa Siyahi fig fruit was shown to be a double sigmoid with the length of growth periods I, II and III being 44, 35 and 13 days, respectively (Celikel *et al.,* 1998). Ethrel (ethephon) at 100, 250, 500 or 1000 ppm was sprayed at intervals during growth phase II, on the leaves and fruits of the cultivar Bursa Sivahi. Ethrel at 250 or 500 ppm sprayed at a late stage of phase II stimulated growth and shortened the time to maturity without affecting fruit quality. Ethrel-treated fruits ripened 5 days earlier than the control. Ethylene treated fruits attain normal size, colour, texture and flavour much earlier than the untreated ones; they also show a higher content of total soluble solids and dry weight (Ben-Yehoshua *et al.,* 1970; Gerdts and Obenanf, 1972; Mougheith and El-Banna. 1974).

Rapeseed oil injected through the ostiole of fig cv. Masui-Dauphin fruits harvested before the climacteric induced rapid ethylene evolution, similar to that obtained by treating with exogenous ethylene (Gao *et al.,* 1991). Ethylene.-forming enzymc (EFE) activity increased rapidly, reaching a level 12 times higher than the control after 24 h, but ACC content increased slowly. Oil-induced ethylene production was almost completely inhibited by aminooxyacetic acid (AOA) an inhibitor of ACC svnthase. Apart from the basic essential oil, 2-ethyl-1, 2-dihydrothiophene, the ripe fruits have volatile phenols, in particular vanillin o-heterocvclic compounds, acetone, aliphatic acids, terpene alcohols, aliphatic and aromatic alcohols and aldehydes (Pisarnickii *et al.,* 1986).

The quality breba fruits of figs are affected by plant nutrition in addition to cultivar characteristics and ecological conditions during ripening (Sahin *et al.,* 1999). Irget *et al.* (1999) reported that fruits from trees given Ca(NO3,)2**,** were harder in texture when dried than those from trees given KNO3. Ferrara (1999) reported that bagged fruits showed faster growth and could be har-vested 6-8 days before unbagged controls in the same area and 20-30 days before inland and hill orchards.

10. DIFFERENT SPECIES

The genus *Ficus,* which is comprised of about 700 species, classified into six subgenera, characterized by a particular reproductive system (Berg, 2003). It is native to the Middle East particularly southern Arabia where wild and caprifig trees are still to be found (Condit, 1947; Zukovskij, 1950; Storey, 1975).

Ficus carica (Common fig)

It is a small to moderate-sized deciduous tree, 6-8 m high with a short twisted trunk, crown with irregular branches; frequently shoots develop at the base of the trunk. The bark is pale grey. Terminal buds are short and stout. Leaves are broad, ovate or nearly orbicular, more or less deeply 3-5 lobed, rough above and pubescent below; long stalked, leaf blade 10-25 cm long, dark green with pronounced venation. The female fig plants have larger leaves and denser, more spreading crowns than males. Leaf fall begins earlier in males. The leaves and the spongy parenchyma tissues are thicker in females. The leaf thickness is 125.5 µm in females and 111.8 µm in males (Kotaeva *et al.,* 1982). Fruits are mostly solitary, axillary, green or yellow, brown, purplish or even black depending on cultivar, more or less pear-shaped with either a velvety or glabrous skin, in certain cultivars upto 6 cm in diameter, but normally of moderate size.

11. TYPES AND CULTIVARS

Depending upon the nature of flowers and the method of pollination, there are four pomologically distinct classes of fig: (i) Common fig or Adriatic fig, (ii) Capri fig (iii) Smyrna fig and (iv) San Pedro fig.

11.1. Common Fig

In this type the individual flowers are pistillate and the fruits develop without the stimulation of pollination and fertilization. Some cultivars of this type are Kadota (Dottato), Mission, Adriatic, Brown Turkey, Celeste and Conadria.

11.2. Capri Fig

It is the most primitive cultivated type with short styled pistillate flowers and functional staminate flowers. Most caprifig are not edible but are grown because they harbour a small wasp, *Blastophaga psens* which is necessary for pollination and setting of fruits.

11.3. Smyrna Fig

In this type, the fruits do not develop unless the flowers are pollinated with pollen carried from the male flowers of the caprifig by the tiny *Blastophaga wasp*. Calimyrna is the most common and widely grown cultivar of Symrna type.

11.4. San Pedro Fig

It is an intermediate type in which the first crop known as 'breba'. The crop is completely parthenocarpic and does not require pollination and fertilization of flowers, but the second crop develops only if the flowers are pollinated as in the case of Smyrna type. San Pedro, King and Gentile are common cultivars of this type.

Four types of figs are described based on cropping and pollination characteristics.

Table. Horticultural classification of fig

Type	Popular varieties	Flower type	Mode of pollination	No. of Crops	Other features
Edible Fig	Poona, Kadota, Conardia, Mission, Brown Turkey	Long styled pistillate flowers	Fruits develops parthenocarpically without pollination	1-2	Some varieties produce a small breba or first crop
Smyrna	Calimyrna (Sarilop), Zidi, Taranimt	Long styled pistillate flowers	Female wasps emerging from the spring caprifig enter smyrna fig for oviposition & in the process of pollination	1	In addition to main or second crop originated from the caprifig. The fertile seeds contribute to the excellent fruit quality
Sanpedro	King, Gentile, San Pedro, Dauphine, Lampeiria	Long styled pistillate flowers	First crop (breba) develops without pollination but the main (second) crop requires pollination	2	Commercially not important some white large fruited types are grown in mediterranean countries
Wild fig/ caprifig (male/goat fig)	Roadin3, Samson, Stanford,Brawley	short styled pistillate flowers & functional staminate flowers near the ostiole	Self fertile (persistent) syconia	3	A primitive type. Fruits have almost no edible value, provides the source of pollen for commercial plantings of cauducous figs.

(Saleeb and Storey 1975)

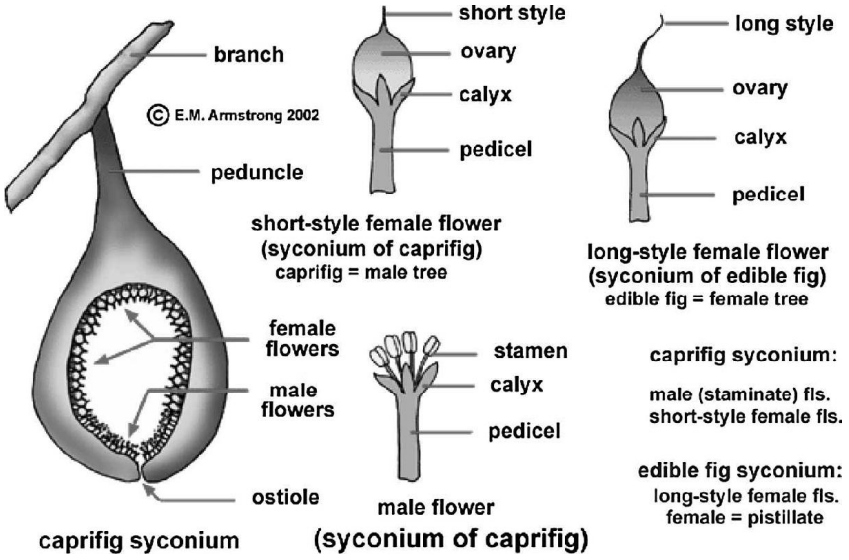

Fig. Floral morphology in caprifigs and edible figs. (Armstrong, 2006)

Of these four types, Smyrna fig is commercially most important and is extensively grown in Europe and USA. The cultivars Kadota. Krymskii 43 and Bianco Grosso were recommended for cultivation in Southern Uzbekistan (Mysina, 1985). It has a superior nutty flavour due to presence of fertile seeds. In India, common fig is mostly grown. It is considered to be a hybrid between imported *F. carica* and indigenous species. A large number of cultivated forms are grown in which the fruits vary in shape, size, colour of skin, colour and flavour of flesh and period of ripening. Some of the cultivars grown in India are Black Ischia, Brown Turkey. Turkish White, Kabul and Marseilles. The figs grown in many parts of India are named after locality, but they do not exhibit any special distinction that warrants varietal names. Pune fig is of medium size, bell-shaped and light purple in colour with a rosy flesh. In South India, Pune fig and Marseilles are commonly grown the latter thriving well in the hilly regions. The fruits of Marseilles are medium size, pale green on the rind with a whitish sweet flesh. Condit (1955) gave a good account of 711 cultivars of figs and listed 946 synonyms in addition to 98 which he mentioned as having been described by other workers.

Lauri *et al.* (1993) classified edible fig cultivars into three horticultural categories: Smyrna, San Pedro and Common. San Pedro and Smyrna types require caprification (unlike the common type), the first produces breba and main (or second) crops, whereas the second produces only main crops. Morphological observations on cultivars Grise de Tarascon (breba and main) and Rouge de Bordeaux or Pastiliera (main only) during their fourth year of growth showed that breba and main crops have distinct distri-butions along the annual gradient; brebas are located on the neoformed part of shoot axes, while main crop figs are on the preformed part. This work investigated relationships between vegetative growth and spatial distribution of syconia along a shoot axis, and distribution of axes within the crown as determined by architectural analysis.

12. CROP IMPROVEMENT METHODS

Although fig has been under cultivation for many centuries and is now distributed in many countries of the world, relatively little work has been done for its improvement. The earliest reports on fig breeding are those of Swingle (1912), Hunt (1912), Burbank (1914), and Condit (1928). A project entitled 'Genetics, cytology, morphology and breeding of figs *(Ficus carica)* is being operated at the University of California since 1922 and as a result of continuous planned breeding work eleven new American cultivars have been developed.

12.1. Selection

Although fig has been under cultivation for many centuries and is now distributed in many countries of the world, relatively little work has been done for its improvement. Most of the fig cultivars cultivated today are selections made by unknown persons in Asia and Europe in the past centuries from wild seedling trees and chance seedlings. Since then these have been maintained clonally by rooted cuttings and in course of time, have acquired names. Three fig cultivars were selected by Ozeker and Isfendiyaroglu (1998) in the Ciftlikkoy region in Turkey (C1, C2 and C4) from 12 fig cultivars that bear early breba fruits. The average fruit weight ranged between 30-90 g, the total soluble solids content in fruit juices was between 16 and27.6% titrable acidity as citric acid between 0.06 and 0.15 g/ml, pH value between 4.73-5.90 and the fruit flesh firmness was between 0.20-1.20 kg/cm^2. In Italy, Grassi (1998) identified 442 clones from different regions. Morphological, phenological, productive and carpological observations cleared up many synonymies and led to the grouping of many clones with similar characteristics into only 50 groups of different values in cultivation.

Chen *et al.* (1997) evaluated 21 cultivars over a year period for growth of shoots and fruits, freezing injury and other characteristics in Xuchang area in China. The best varieties for Henan province were Masui Dauphine, Brunswick, He 18, and entries 8 and 10. The freezing injury could be alleviated by training of branches into a compact form. In Tunisia, there is a large varietal diversity with some varieties being threatened by extinction. Development of successful modern production would depend on varietal selection and improvement combined with resolution of some of the problems currently plaguing the industry fruit cracking, handling problems environmental impact.

12.2. Hybridization

The classical breeding approaches in fig were summarized by Condit (1947), Storey (1975), Obenauf *et al.* (1978), Ferguson *et al.* (1990), and Mars (2003). Fig breeding is a complex because of involving two tree morphs (Caprifig and Edible fig), three floral forms (long-styled female, short-styled female, and male flowers), and the insect pollinator (Beck and Lord 1988*)*. Two breeding programs were conducted in the beginning of the 20th century at the University of California, led by I. J. Condit and N. B. Storey and by

E. N. O'Rourke Jr at Louisiana State University. In addition, fig crosses and their evaluation has been described in Japan (Awamiira, *et al*., 1996). Hybridization began in 2003, and by the end of 2006, about 4,000 hybrid fig seedlings were planted at the Volcani Center, Bet-Dagan, Israel. The U.S. breeding program in Davis, California by Condit and Storey produced 300 hybrid progenies totaling more than 30,000 seedlings (Storey 1975). The most significant achievement of the California fig breeding programme was development of five hybrid cultivars: 'Conadria', DiRedo', 'Flanders', 'Tena', and 'Excel'. More recently Doyle and Ferguson (2005) released the cultivar 'Sierra', a common fig type with green fig color and late summer maturity.

12.2.1. *Breeding Technique*

Storey (1975) described in details the breeding technique being followed in fig. Trabut (1922) and Condit (1947, 1950) tried interspecific hybridization involving *F. carica, F. palmata* and *F pseudocarica.* However, the hybrids thus obtained were not of much commercial value. In the Badkhyz area of Turkmenistan (former USSR) where *F. afghanistanica* coexists with *F. carica,* spontaneous interspecific hybrids have been found which are intermediate between parents (Petrova and Popov, 1979). New early flowering caprifigs were bred at the Nikita Botanical Garden in Crimea (former USSR) using seedlings obtained by intervarietal and interspecific hybridiza-tion. Twelve new caprifigs were selected which arc early flowering and produce an abundance of viable pollen (Arendt and Aleksandrova, 1971). Arendt (1974) reviewed the breeding work done in former USSR. She obtained best results by interspecific hybridization using a hardy triploid species referred to as the Afghanistan fig *(F afghanistanica)* and *F. carica* Yellow. The most significant achievement in the history of fig breeding, however, comes from the researches done in California. The fruit characters of eleven new hybrids released and adapted for commercial cultivation in California.

To clarify the effect of various seed parents on frequency distribution of partheno-carpic characteristic among progenies of fig *(Ficus carica),* selected fig cultivars were pollinated with pollen from incomplete parthenocarpic caprifig cv. Caprifig 6085. After separating the seedlings into a caprifig or a common fig type, the occurrence of parthenocarpy in the first or second crops was investigated. In the first crop of caprifig type, a high frequency of parthenocarpy was found in progenies from San Pedro-type cultivar, whereas the common-type cultivar set a moderate number of parthenocarpic fruit in the first crop. In the second crop, the common-type cultivar produced proge-nies with a high frequency of parthenocarpic fruit. Almost no parthenocarpic seedlings were produced when a non-parthenocarpic Smyrna-type cultivar was used as a seed parent (Awamura *et at.,* 1996).

Fruit characters, fruit weight (FW) and soluble solids content (SSC) in the juice of hybrids of 9 cross combinations were investigated by Awamura *et al.* (1997). Family means of the groups, namely caprifig-type first crop, fig-type first crop and fig-type second crop, were determined. There were positive correlations between the FW of the

3 groups and mid-parental values, and between the SSC of fig-type first and second crop, and mid-parental values. There were negative correlations between the FW of caprifig-type and fig-type first crop and the mid-parental SSC value, and between the SSC of fig-type second crop and mid-parental FW value.

O'Rourke (1966), Puls *et al.* (1967) and Puls and O'Rourke (1967) have reported significant progress in breeding figs for root-knot nematode *(Meloidogyne incognita* var. *acrita)* resistance in Louisiana. A fairly high order of resistance was found in individual seedlings in progenies of the commercially grown cultivars Hunt and Celeste.

Cultivar LSU was developed from the pollination of Hunt by an unknown Californian caprifig designated as Cl. LSU Purple is parthenocarpic, so there are few seeds or kerfs in the pulp. The flavour is good and mild and sugar content is high. The tree is vigorous, upright, above average for cold tolerance and resistant to leaf diseases and root nematodes (O'Rourke, 1992). Diploid apogamy was induced in *F. carica* and *F. afghanistanica* by application of *Lilium candidum* pollen and various physiologically active substances. Adenosine triphosphate stimulated apomictic seed development in *F. carica,* as did naphthy-lacetamide in *F. afghanistanica* (Romanova, 1979). Neeman and Galil (1978) showed that artificial pollination of bagged spring and summer caprifig syconia resulted in seed set and sweet figs were obtained.

12.3. Mutational Breeding

Induced mutations may play an important role in fig improvement for important traits such as small ostiol size, large fruit size, fruit flesh quality, and tree productivity as considerable diversity for fruit shape, color and tree vigor exist in many clonally derived cultivars (Santoni *et al*., 2000). Mutational variation can be induced either by specific treatments with physical and chemical mutagens or by tissue culture. The effect of gamma radiation on cuttings, seeds, and pollen in figs has been well reported. The frequent finding was dwarfness and acceleration of fruiting (Mars 2003). Some mutants were used in breeding programs and the cultivar Bol' obtained by seed irradiation followed by selection (Akhuid-Zade 1981). In addition, spontaneous mutants can occur in commercial orchards. Recently 'Red Kadota', a mutant of 'Kadota' selected from commercial orchard in Israel is similar to 'Kadota' cultivar, but has red skin that develops during fruit maturation; therefore, it was named and registered as 'Red Kadota' (Flaishman *et al*., 2007). In vitro tissue culture methods may also be very useful in selecting new cultivars from somaclonal variation (Muriithi *et al*., 1982; Pontikis and Melas 1986), but none have been released yet from tissue culture mutagenesis (Mars 2003).

12.4. Biotechnology

12.4.1. *Molecular Breeding*

Compared to traditional breeding techniques, application of genetic engineering to homologous and/or heterologous genetic material into fruit trees, offers the potential of

obtaining improved planting stocks in a short period of time. Efficient transformation can also be used for the production of heterologous polypeptides having nutritional and/or pharmaceutical value. Yakushiji *et al.* (2003), reported adventitious shoot regeneration in tissue culture in *F. carica*. They also reported a method for the induction of organogenesis from leaf explants of *F. carica* using phloroglucinol (PC). Yancheva *et al.* (2005), reported an efficient and reproducible system for regeneration of 'Brown Turkey' and 'Smyrna' fig. In addition, efficient and reproducible transformation systems for both cultivars were also reported by Yancheva *et al.* (2005). Similar to regeneration, the orientation of the leaf surface during organogenesis was a key factor for successful transformation. Leaf explants of in vitro propagated plants were co-cultivated with the disarmed *Agrobacterium* strain EHAI05 harboring the plasmid pME504 that carried the uid A-intron, *bar* and*nptll* genes. Transformants were obtained by selection on the antibiotic 'I Kanamycin at variable transformation efficiencies in different cultivars (Yancheva *et al*., 2005). The transgenic nature of the regenerated plants was confirmed by PCR and Southern blot and gave typical staining for the reporting gene GUS. Histo-chemical localization of 13-glucuronidase (GUS) activity confirmed that the cauliflower mosaic virus (CaMv) promoter functions in cells of the fig syconium.

12.4.2. *Micro Propagation*

Micropropagation of fig is also possible. Pontikis and Melas (1986) developed a micro-propagation technique in which shoot tips of cv. Kalamon were cultured on Murashige and Skoog's medium containing several growth regulators. Shoot proliferation occurred in media containing phloroglucino at 89 mg/l. The shoots were then rooted in media containing IBA or IBA and NAA. The best rooting (80%) was obtained with IBA at 1 mg/l. The rooted plants were successfully transferred to sterile vermiculite and after acclimatization to pots containing equal parts of peat and vermiculite.

A procedure for multiple-shoot induction and plantlet regeneration was developed by Kumar *et al.* (1998) with apical buds collected from 7–to 8–year–old trees of *Ficus carica* using MS medium supplemented with 2. 0 mg GA and 0.2 mg NAA/1. The *in vitro*-regenerated shoots were further multiplied on MS medium supplemented with 2.0 mg BA and 0.2 mg NAA/1; an average multiplication rate was four per subculture. Excised shoots were rooted in liquid half strength MS medium supplemented with 2.0 mg IBA/l and 0.2% activated charcoal.

Apical shoot tips of the fig cultivars Berbera and Lampa were cultured by Nobre and Romano (1998) on Muriithi or Jonard culture medium supplemented with the antioxi-dants like polyvinyl pyrrolidonc [(*polyvidone)*] (PVP-40) (0.025, 0.05, 0.1, 1.0% v/v) or ascorbic acid (56.8 or 113.6 μM*)*. Growth and development were best on Muriithi medium supplemented with *0.05*%PVP. Single node explants of shoots obtained in the establishment phase were cultured on basal MS medium supplemented with 3% sucrose and BA (0.7, 1.1 or 2.2 μM) alone or in combination with NAA (1.0 μM). After 3 weeks, the highest

multiplication rate (5.3 shoots/culture) was obtained in the medium supplemented with 2.2 μM BA without NAA. Plantlets were success–fully acclimatized. Micropropagated plants produced fruits within 2 years after field–establishment. Apart from standardization of protocol for micropropagation, biochemical and molecular markers have been used in the identification of genotypes of fig.

12.4.3. *Biochemical and Molecular Markers*

Characterization of fig germplasms has been conducted by means of isoenzyme electrophoresis on horizontal starch gel applied on cork tissue (Chessa *et al.,* 1998). Seventeen enzymes systems were analyzed and acid phosphatase (AcPH), diaphorasc (DIA), fumarase (FUM), glutamate oxalacetate transaminase (aspartate aminotransferase) (GOT), malate dehydrogenase (MDH), peroxidase (PRX) and phosphoglucoisomerase [glucose-6-phosphate isomerase] (PGI) showed high resolution of the bands and reproducibility of the analysis. Only FUM had a mono-morphic pattern, while the other enzymes tested allowed the characterization of almost all fig varieties. The degree of electrophoretic similarity between varieties was determined by calculating a similarity index value based on three enzyme systems : AcPH, GOT and MDH.

Elisiario *et al.* (1998) used isoenzyme and RAPD markers to differentiate 55 traditional varieties of fig in Portugal. Six isoenzyme systems were revealed after starch gel electrophoresis of leaf extracts: glucose-6-phosphate isomerase (PGI), phosphoglucomutase (PGM), isocitrate dchydrogcnase (IDH), malate dehydrogenase (MDH), aspartate aminotransferase (GOT) and cytosol aminopepti-dase (LAP). Three isozyme systems, PGM, IDH and GOT revealed four polymorphic loci and were used for variety characterization. Several clones shared identical isoen-zyrne banding patterns and could not be distinguished by these markers. RAPDs were used in a second step of molecular characterization. Sixty decamer primers were tested. Forty-three primers generated amplified products and were used to distinguish among all the clones, either within groups of identical or different isozyme patterns. Similarly, identification of 21 fig accessions *(Ficus carica)* representing different varieties was performed using the RAPD technique (Khadari *et al.,* 1995). The 19 RAPD markers used provided 17 different banding patterns. The RAPD markers showed sufficient polymorphism for genotype discrimination, clonal stability, environmental stability and experimental reproducibility.

12.4.4. *Marker-Assisted Selection*

Marker assisted selection or marker aided selection (MAS) is a process whereby a marker (morphological, biochemical or one based on DNA/RNA variation) is used for indirect selection of a genetic determinant or determinants of a trait of interest (e.g. productivity, disease resistance, abiotic stress tolerance, and/or quality). Yield, quality, and disease resistance etc are important quantitative inheritance. Means of analyzing quantitative variation and especially of uncovering its potential genetic basis are therefore of major

importance for breeding purposes. Many studies have been interested in the development of other methods for cultivar identification. For instance, protein polymorphisms in common figs were suitable for characterizing fig varieties. However, the success of varietal identification depends on the number of isoenzymatic systems and alleles studied. Unfortunately, this number is often limited, which leads to insufficient polymorphism among closely related genotypes. Various DNA profiling methods are currently available and consist of two main categories according to the information provided: specific locus and co-dominant markers and arbitrary and dominant such quantitative variation results from the combined action of multiple segregating genes and environmental factors. The joint analysis of genotype marker segregation and phenotypic values of individuals or lines enables the detection and location of loci affecting quantitative trait loci (QTL). In a fig breeding program, QTL can be used through the application of molecular markers, providing basis for so-called marker-assisted selection (MAS). Molecular identification of fig cultivars has been carried out using isozyme markers (Cabrita *et al*., 2001), random amplified polymorphic DNA (RAPD) (Cabrita *et al.,* 2001; Galderisi *et al.,* 1999; Papadopoulou *et al*., 2002), Mitochondrial DNA (mtDNA) Restricted Fragment Length Polymorphism (RFLP) (Khadari *et al*., 2005) or amplified fragment length polymorphism (AFLP) (Cabrita et al. 2001). Khadari *et al*. (2001) identified 8 microsatellites in fig. More recently, Giraldo *et al.* (2005), reported 26 additional microsatellites that were tested in a group of 15 known fig cultivars. These tools can be very useful in future evaluation of fig progenies in fig breeding programs.

13. VARIETAL WEALTH

There are many cultivated varieties in each class of figs. In fact, among several hundreds of described cultivars, 75 % were of 'Common type', 18 % of 'Smyrna type' and the rest (7 %) are of 'San Pedro type' or caprifigs (IBPGR, 1986). Over 700 varietal names are in use but many are synonyms. Poona fig is most popular cultivar grown in India. Bangalore, Bellary, Coimbatore, Daulatahad, Dindigual, Ganjam, Hindupur, Lucknow and Saharanpur, have clearly acquired the name from the location in which they are cultivated. Most of them resemble in plant and fruit morphology to that of Poona fig. Possibly these are either clones or ecotypes. Dinker, an improvement over Daultabad for yield and fruit quality, is gaining commercial significance. Some well known fig hybrids from California have performed well in India in comparison to Poona fig. Excel and Conardia figs that develop smaller canopies are suitable for high density planting and free from fruit splitting. Conardia, Excel and Deanna are good for drying, canning and table purposes, respectively.

Table: Comprehensive list of fig varieties

Smyrna-type figs with skin green or yellow; pulp white, amber, or very light red	Borsamele, Eisen, Kaab el Ghazal, Khazouri, Malaki, Rosa, Sari Lop (Calimyrna, Aidin), Sciento Snowden. Sultanie

[Table Contd.

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Smyrna-type figs with skin green or yellow; pulp various shades of red	Abate, Abiarous, Aboucherchaou, Akca, Alekake, Amesas, Aranim-Amellal, Bardajic Blowers, Castelhano Branco, Changelge, Chefaki, Cheker Injir, Choer, Cueritesto, Djaferi, Djebali, Fietta, Hilgard,Isly, Jadi, Kalamata, Karayaprak, Kassaba, Khadir, Kouffi Vert, Lebi, Madoui, Malaki Blanc, Mamari, Maple-Leaved Merchini, Mota , Mouzai, Panettaro, Pasulito, Pazzo, Rixford, Sesso, Sigilli, Souaba-el-Adjia, Blanche, Stanford, Sultane Bi-longue, Sultani, Tabelout, Tabelout, Tadefouit, Taharit, Takourchit, Tameriout, Taranimt, Taurisano, Tazarift, Três um Prato, Verdescone, West, Wilson, Yediver
Smyrna-type figs with skin dark (various shades of violet to black); pulp white or amber	Euscaire, Hamriti, Scancaniso
Smyrna-type Figs with Skin Dark (Various Shades of Red, Brown, or Violet to Black); Pulp Various Shades of Red	Abougandjour, Adjaffar, Aghan, Agouarzguilef, Agoussim, Aranim-Aberkane, Averane, Avouzegar, Azendjar, Bardakjik Black, Barli, Belmandil, Besoul-el-Khadem, Biddin-el-Brel, Bou-Ang, Bou-Harrak, Castelhano Preto, Habtir, Kara Injir, Khalouli, Kouffi Rouge, Lugliatico, Marabout, Mor, Mor Güz, Napoletana, Passacanne, Purple Bulletin Smyrna, Purple Smyrna, Rherabi, Salatello, Soltanine, Taklit, Taroumant, Techich, Turco, Zafrani
San Pedro-type figs with skin green; pulp red	Cachopeiro, Branco, Colombro, Gentile, Khdari, King, Noce, Pietri, San Giovanni, San Pedro, San Vito
San Pedro-type figs with skin bronze or violet;pulp amber or red	Buino, Carvalhal, Castle Kennedy, Chiajese, Dauphine , Drap d'Or (syn. Royal Vineyard), Fracazzano Rosso, Lampeira, Ottato Rosso, Petronciano, Pied de Boeuf
Common-type figs with skin green or yellow; pulp amber or white	Albo, Angelina, Blanche, Brindisino, Castellana, Citrato, Colombo Bianco, Dorée Nobis, Dottato, Early White, Edeisi, Florentine, Fracazzano, Hdadi, Hdeidarmal, Jaune de Toulouse, Kahramani, Kargigna, Magdalen, Minuto Bianco, Mshaki, Ojo de Perdiz, Pallaro, Pelo de Buey, Poppa, Raby Castle, Reine, Schifo, Seirolles, Tossico, Urjal, Verdeccio, Verdillo, Yaffawi, Zonto,
Common-type figs with skin green or yellow; pulp various shades of red	Abakor, Aberdin, Angélique, Arneo Bianco, Barnissotte Blanche, Bayoudi, Bontard, Bouin, Boukrati, Brianzola, Buttafarro, Carabaseta, Carlina, Cimeirenca Blanca, Col de Dame, Cotignacenque, Dame Blanche, Darji, Datte, Daurada, Doree, Du Roi, El Khadri, Genoa, Gota de Mel, Grassale, Grasse, Grosse Jaune, Harraki, Kaffi, Kommathri, Limoncello, Lucano, Marseillaise, Martigiano, Meou , Monaco, Monstrueuse, Moresca, Mussega, Neimi, Pajajero, Panachee, Perticone, Pissalutto, Pounchuda, Quarai, Ravignon, Salerne, Sfari, Sicile, Signorella, Slati, Sucrada, Sulomo, Sydawi, Tbani, Tordo, Toscana, Troiano, Unnequi, Verdale Blanche, Verdeal, Verdino, Verdone, Verte, Vescovo, Violada Blanca, Yellow Neches, Zamozujica, Zimitza,

[Table Contd.

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Common-type figs with skin green or yellow; pulp color not designated	Agulla, Alicantina, Biter Abiod, Caseta, Castagnola, Cervone, Cistallino, Comadre, Du Japon, Espagnole, Graissane, Jorba, Levant, Llimonenca, New French, Parejal, Pelosa, Pilosella, Précoce, Ragusa, Reginella, Serra, Sextius, Sultani, Tassiret, Tiboulenque, Tira , Vacal
Common-type figs with skin dark (various shades of red, brown, or violet to black); pulp white or amber	Abboudi, Albanera, Archipel, Barbillone, Beall, Brunswick, Datil, Leon, Marinera, Marsaoui, Matelassa, Mwazi, Osborn Prolific, Reggitana, Roja, Scavello
Common-type figs with skin dark (various shades of red, brown, or violet toblack); pulp various shades of red	Adam, Amarouna, Azaich, Bargemon, Barnissenca, Barnissotte, Bec de Perdrix, Becuelle, Bellona, Betada, Blavette, Bocarde, Bordeaux, Bouche-barrique, Bourdissotte Noire, Briasca, Briasca, Doussa, Brown Turkey, Caiana, Calabresa, Calderona, Caravanchina Negra, Cascitello, Castagnolo, Celestine, Cernica, Claveu, Col de Dame Noir, Colombo Nero, Constantine, Coucourelle Gavotte, Cumpini, Cuore, Curigo, Dame Noire, Datte Quotidienne, Dattero, Djerbi, Early Violet, Eva, Ferguson, Figue Fleur, Ford, Franche Paillard, Franciscana, Frette, Galluccio, Ghzali, Gouraud Rouge, Guiliana, Hmari, Hunt, Imperial, Ischia Black, Ischia Brown, Jasper, Jerusalem, Kahili, Kus, Lardaro, Levenssana, Madeline, Malmaison, Malta, Mappafero, Marseillaise Black, Marseillaise Long, Martinique, Meirana, Melagrano, Melinga, Melouba, Merengiana, Merioun, Merlinga, Monaie, Moscatel Preto, Mouissonne, Mourenao, Napolitaine, Negrette, Noir Moutier, Noral, Observantine, OEil de Perdrix, Paradiso, Pardo, Pastiliere, Peau Dure, Peconjudo, Penna, Perroquine, Pissalutto Nero, Poona, Poulette, Precoce de Barcelona, Pregussata, Preston, Ramsey, Recousse Noire, Regina, Rei, Rocarde, Rose Blanche, Rose Noire, Rose Peyronne, Royal, Saint-Esprit, Saint Jean, Salada, San Piero, Sarreigne, Sbayi, Selteni, Shunnari, Shunnari Asmar, Signora, Smari, Sofeno, St. Domingo, Sukkari, Sultane, Sultani, Temri, Toulousienne, Tributaria, Verdal, Verdal de Valence, Verdal Round, Vernino, Verte Brune, Violet Sepor, Violeta Negra, Zaiti, Ziza Kheden

Source: Condit, 1955

13.1. Important Fig Varieties Grown in India

13.1.1. *Dinkar*

Selection made from local Daulatabad trees. External skin colour is dark red; flesh colour is dark pink and pear shaped fruits. Average length of fruit is 6.80 cm, diameter is 11.81 cm, fruit weight is 25.76 g. Average volume is 20.16 ml, specific gravity is 1.2774 m/v; moisture is 74.0 %, TSS is 18.36 %, total acidity is 0.23 %, reducing sugars is 13.40 %,

non- reducing sugars is 1.89 % and total sugars is 15.29 %. High yielding variety producing big sized fruits (70-100 g). It is resistant to rust disease. Average yield is 60-70 kg per tree. The cultivar is recommended for Maharashtra state except Konkan region.

13.1.2. *Poona Fig*

It is the most popular cultivar grown for consumption as fresh fruit. External skin colour is reddish green, flesh colour is pink and pear shaped fruits, sweet and good flavor. Average length is 6.58 cm, Average diameter is 12.00 cm, fruit weight is 24.60 g. Average volume is 18.80 ml, Specific gravity is 1.3076 m/v, Moisture is 76.0 %, TSS. is 19.34 %, total acidity is 0.21 %, reducing sugars is 13.76 %, non- reducing sugars is 2.25 % and total sugars is 16.01 %. Most of the fig grown in Mangalore, Bellary, Coimbatore, Daulatabad, Ganjam, Lucknow and Saharanpur resembles in plant and fruit morphology to that of Poona Fig.

13.1.3. *Conadria*

First artificial hybrid fig. External skin colour is greenish, flesh colour is creamy pinkish and pear shaped fruits, mildly sweet. Average length is 7.07 cm, Average diameter is 13.80 cm, fruit weight is 38.76 g. Average volume is 33.68 ml, Specific gravity is 1.1580 m/v, Moisture is 80.0 %, TSS. Is 20.15 %, total acidity is 0.17 %, reducing sugars is 15.66 %, non- reducing sugars is 2.08 % and total sugar is 17.74 %. Good fresh, excellent dried. More productive than Adriatic. Light breba crop. Tree vigorous, tends to excessive growth under irrigation, best in hot climates.

13.1.4. *Deanna*

External skin colour is golden yellow, flesh colour is creamy white and bell shaped fruits. Average length is 7.81 cm, diameter is 16.03 cm, fruit weight is 46.64 g, Average volume is 44.76 ml, specific gravity is 1.0478 m/v and moisture is 78.0 %. TSS. is 21.20 %, total acidity is 0.15 %, reducing sugars is 17.25 %, non- reducing sugars is 1.79 % and total sugar is 19.04 %. Highest yield of dried product is 19.82 %. Dried fig could be stored more than 180 days at low temperature maintaining its physicochemical characters and high organoleptic score.

13.1.5. *Excel*

External skin colour is greenish yellow, flesh colour is creamy and bell shaped fruits. Average length is 6.52 cm, Average diameter is 11.87 cm, fruit weight is 24.72 g, Average volume is 21.16 ml, Specific gravity is 1.1675 m/v, Moisture is 75.0 %, TSS. Is 19.36 %, total acidity is 0.19 %, reducing sugars is 14.86 %, non- reducing sugars is 1.62 % and total sugar is 16.48 %. Fruits are very sweet, excellent, multipurpose fig. Light breba crop, similar to Kadota but more productive.

13.1.6. *YCD - 1 TIMLA*

It is an introduction and released from Horticultural Research Station, Yercaud. Trees are well adapted to the rainfed situations of Shevroys hills and to the poor shallow and rocky soils. Trees showed high drought tolerance besides its exceptionally hardy nature and free from any pest or disease including the common fig rust. The plants are spherical in canopy and are elegant with dense dark green leaves often growing to a height of 7.0 m with a spread of 12.0 m. Fruits are in attractive reddish purple color and are large in size measuring 7.0 cm in diameter, each weighing 100-200g. Higher harvests are made from each tree, the maximum being 4000 fruits. The bearing is throughout the year excepting winter months. Fruits are a rich source of vitamin C (500 mg/100g) besides â carotene and lycopene.

13.1.7. *Celeste*

Pear-shaped, ribbed, sometimes with a short neck and slender stalk to 3/4 in (2 cm) long. Eye (opening at apex) is closed, fruit is small to medium. Skin purplish-brown or bronze tinged with purple and covered with bloom. Pulp whitish or pinkish amber, of rich flavor and good quality; almost seedless. Main crop is heavy but of short duration. Celeste figs are most commonly grown in Texas.

13.1.8. *Brown Turkey*

Broad-pyriform, usually without neck, medium to large, copper-colored. Pulp is whitish shading to pink or light red, good to very good quality with few seeds. The tree is prolific. The main crop, beginning in mid-July, is large; the early, breba, crop is small. This cultivar is well adapted to warm climates. Fruits are excellent for jams, canning, drying or eating fresh. It is grown on all the islands of Hawaii.

13.1.9. *Brunswick (Magnolia)*

Leaves narrow-lobed; fruits of main crop are oblique-turbinate, mostly without neck. Fruit stalk thick, often swollen; fruit of medium size; bronze or purple-brown. Pulp whitish near skin, shading to pink or amber, hollow in center, of fair to good quality, nearly seedless. Ripens over a long season. Breba crop poor; large, bronze-skinned, flesh light-red, coarse.

13.1.10. *Marseilles (White Marseilles, or Lemon)*

Fruits of main crop round to oblate without neck, on slender stalks to 1/4 in (6 mm) long; of medium size. Those of breba crop, turbinate with short, thick neck and short stalk; yellow-green with small green flecks; pulp white, sweet; seeds large, conspicuous. Marseilles is commonly found in California.

13.1.11. *Adriatic (White Adriatic, or Grosse Verte)*

Turbinate with short, thick neck and short stalk; above medium size. Green to yellowish-green with red pulp; of distinctive flavor and very good quality. In early, minor, breba crop the fruits are oblique-pyriform, large, green, often tinged with purplish-red with dark-red pulp and strong flavor. Adriatic fig trees can sometimes be found in the state of Washington.

13.1.12. *Genoa (White Genoa)*

Pyriform or turbinate, very faintly ribbed; neck thick and short, or absent Medium in size; skin downy, greenish-yellow; pulp greenish-white near skin. Mostly amber tinged with red; hollow; of fair quality. Fruits of breba crop oblique-obovate with thick neck and short stalk; yellowish-green externally. Pulp light-red; of fair to good quality. This is common variety of Chile and Argentina.

13.1.13. *Purple Genca (Black Genoa; Black Spanish)*

Oblong, broad at apex, narrow at base; large; very dark-purple with thick blue bloom; Pulp yellowish becoming reddish to red at the center; juicy, with sweet, rich flavor.

13.1.14. *Black Ischia (Blue Ischia)*

An Italian heavy bearer variety; main crop is elongated pear shaped with small fruits; Short neck and short to medium stalk; large, 2 1/2 in (6.35 cm) long and 1 1/2 in (3.8 cm) wide; dark purple-black except at the apex where it is lighter and greenish; There are many golden flecks; skin is wholly coated with thin, dark-blue bloom; eye open, with red-violet scales; pulp is violet-red, of good quality. In the breba crop, there are few rlbs and mostly indistinct; the fruit is small, about 1 1/2 in (3.8 cm) long and of the same width at the apex; the pulp is red to greenish-amber; of poor flavor. The tree is particularly ornamental and the leaves are glossy, only shallowly 3 lobed. It is a heavy bearer.

At Saharanpur, India, ‘Brown Turkey’, ‘Bangalore’, ‘Black Ischia’ and ‘Lucknow’ are successfully grown. Around Mumbai, there is only one variety, ‘Poona’.

13.2. Cultivars in Other Countries

13.2.1. *Ventura*

Compact large tree, long green fruit with deep red flesh and excellent flavor. Good as fresh or dried. Good breba crop. Late cultivar but matures well in cool areas.

13.2.2. *Kadota (Gentile, White Endich, Dottato)*

Medium, skin is yellowish green, flesh amber, tinged pink at center with rich flavor. Little or no breba crop. Tree upright, requires annual pruning to slow growth. Prefers hot, dry climate for best quality. This variety is the commercial fig of California.

13.2.3. *Sari Lop (CALIMYRNA)*

A very large and delicious, smyrna type, yellow fig with amber flesh possessing a rich, nutty flavor. Fruit is oblate-spherical. The most important commercial fig grown in California.

13.2.4. *Tena*

This is the first hybrid to have 'Calimyrna' (Sari Lop) on both sides of its pedigree and released in 1975. The fruits are medium to large size with a greenish yellow skin and a white to light strawberry flesh. The eye is very tight and this helps prevent spoilage during unfavorable weather. It has a very sweet, excellent flavor when fresh or dried, best suited in hot, dry areas.

13.2.5. *Alma*

This heavy bearing, very sweet fig was released from Texas A & M University's in 1975. It has golden brown skin and very tasty, amber-tan flesh. It has a small eye which prevents spoilage during adverse weather conditions. The plant is a hardy, small tree with a heavy main crop that ripens very late. Highly resistant to fruit rots.

13.2.6. *Black Mission*

Tree very large, fruits all-over black purple, elongated, Flesh watermelon to pink, fairly good taste. Easily dried at home. Breba crop is prolific.

13.2.7. *San Pedro*

San Pedro fig is a mid season (mid-Feb) variety. The fruits are large and round and vary from a purple to pale green skin, and has sweet, creamy pink flesh. Moderate to heavy crops. They prefer full-sun, shelter from the wind, in a well-drained, loamy soil.

Fruit characteristics of the fig cultivars Bursa Sivahi, Yesilguz, Bardakci, Sultan Sclim, Karabakunva, Beyaz Orak and Sarilop were studied by Kaynak *et al.* (1998). Bursa Siyahi had the heaviest fruits and Karabakunya the lightest. Fruit width was greatest in Beyaz Orak, Sarilop and Bursa Siyahi, and Bursa Siyahi had the longest fruits. Bursa Siyahi, Sarilop and Yesilguz were the easiest to peel. Bardakci, Bevaz Orak, Bursa Siyahi and Yesilguz had the least ostiolc and skin cracking. The plastid pigments in the fruit skin of fig are chloro-phyll-a and -b, B-carotene, lutein, violaxanthin and neoxanthin (Puech *et al.,* 1976).

Mars *et al.* (1998) analyzed the diversity among 22 cultivars of the southern arid regions in Tunisia using morphomctric studies. Cultivar characterization and multivariate analysis made on the basis of 18 physical and chemical fruit characters of 22 main crop

varieties suggested that fig germplasm is diverse. It was also possible to differen-tiate three cultivar groups and two distinct cultivars.

In Israel, Assaf *et al.* (1999) divided the best cultivars with regular yields and high fruit quality, into 4 groups on the basis of fruit colour : (i) green-yellow figs (Kefar Uriyya, Jafa Kadouri, Kurt, Shahmani) (Nazarati types, Nazareth and Smirna); (ii) green-violet figs (Big Red, Hamoudi, K 16 and Sbaii), (iii) brown striped figs (Gzali and Hortemani) and (iv) black figs (Italian Black, Haroubi (all types), Robinb and Shaltouf El Abed). It was noted that of the spring figs, the Nazareth was best. Growing under net protection and importing of new cultivars are suggested for improving quality.

Seventeen fig cultivars were assessed in trials at Valenzano, Italy and cv. Petrelli was judged best for producing first crop figs (brebas) and cv. Donato for second crop figs. Cultivars like Fico Regina di Gioia del Colle and Zingarello Nero produced good crops of both types (Ferrara and Petruzzella, 1992). Masui Dauphine, an important Japanese cultivar, was evaluated for 5 years in the Zhenjiang area in China. It produced large (80-100 g), elongate-oval, purple-red fruits with 15% soluble solids content and high aspartic acid content (0.22 mg/100 g). The fruit was suitable for fresh consumption and processing (Yang *et al.,* 1994). El-Kassas *et al.* (1992a) evaluated the growth of four local and introduce cultivars in Egypt. The cultivars DiRedo, Conadria, Sultani and Black Mission were best in terms of tree vigour.

Evaluation of yield and quality of svconium also showed marked variation in different cultivars (El-Kassas *et al.,* 1992b). The yield of the breba crop of DiRedo, Conadria and Black Mission was >15% lower than that of the second (main) crop. Other tested cultivars yielded negligible numbers of breba fruits. Longer bearing units (15 buds) produced more breba syconia. Tlic percentage of ripe syconia/shoot in Kahramani, Black Mission and Abboudi was 83.6-85.2%. In Brown Turkey and Sultani this value was 76%, in Conadria and Abiad Asswan 69% and in DiRedo 63.1%. Sultani and Black Mission yielded approximately 10 kg ripe fruits/tree and Kahramani and Abiad Asswan 3-5.6 kg/tree. Most fruits ripened from the third week of July; those of Sultani and Brown Turkey began to mature in the second week of August. Average fruit fresh weight ranged from 11.8 g in Abboudi to 40 g in DiRedo. Total soluble solids and sugar contents were highest in Black Mission and Conadria (>25°/o and >17.9% respectively). Brown Turkey had the lowest values for these parameters (16 and 13% respectively).

In Bert region in Albania, 23 cultivars of fig were evaluated by Nici (1989). Kaliamata, Roshnikas, Perdhikulia, Adriatik and Bajun i Shkodres were most suitable for jam production, and the first 3 of these varieties (together with Bishtkugi i Zi i smokthines to some extent) were the best for drying. Varieties with a high sugar percentage were judged best for making candied fruit jelly, fig cake and the alcoholic spirit 'raki'. For high fruit production. Some varieties of the caprifig type needed artificial fertilization (caprification) to produce a second crop.

14. FUTURE THRUST

Rich genetic diversity available in the different part of the country should be exploited systematically for selection and screening of genotypes which may suitable arid and semi arid regions too and under problematic soil. Genotype selected must have high sugar content and better shelf life so as value added and export oriented processed products may be developed. Diverse patterns of fruit characteristics could be the basis of a programme assisted by a molecular genetic marker approach. Moreover, the development of varieties more adapted to industrial uses and dried fig must take in consideration. Further studies are needed involving chemical, biochemical, and molecular markers for estimation of genetic variation at the molecular level. In many places, threat of genetic erosion is evident, particularly for cultivars of "Smyrna type". Alternative methods for genetic resources management must be considered. There should be effective strategy for Fig Mosaic Disease as it remains a serious pathological constraint during fig germplasm exchange.

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FIG (*Ficus carica*)

Conadriya

Deanna

Dinkar

Excel

FIG (*Ficus carica*)

Fig

Poona Fig

Ripened fruit

Unripe fruits