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Physiological disorders in fruits in arid region- A review

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Abstract
Physiological disorder are distinguished from other disorders in that they are not caused by living organisms, but are caused by non-living, abiotic situations and cause a deviation from normal growth. Most of them are not reversible once they have occurred. The present review attempts to address this issue taking into account the fruit in general and fruits of arid region in particular.

Key words: Physiological disorder, ber, pomegranate, bael, fig

The arid region are having nutrients deficient sandy soils along with fragile edaphic and climatic conditions. Growing of annual crops during the most congenial part of the year is the only source of livelihood for the people of the arid region. These crops often encounter abiotic stresses like drought, hot and desiccating winds, nutrient deficiency during their growth period leading to poor productivity. These regions have tremendous potential for cultivation of perennial fruit trees. The arid regions have been identified for successful fruit production zones. The overall scenario of arid region in the country indicates three to four distinct production system. The parts of Rajasthan and Haryana adjoining to Punjab having a network of canal irrigation with predominance of light textured sandy soil are being utilized for fruit production like citrus, kinnow, ber, anola, grape, pomegranate, date palm, etc. The southern part of Rajasthan and northern part of Gujarat adjoining Madhya Pradesh having comparatively heavier soil and moderate rainfall are being utilized for cultivation of different arid and sub-tropical fruits. The plateau region of Madhya Pradesh, Maharashtra, Karnataka and Gujarat having semi-arid climate with predominance of light textured rocky soils having poor water holding capacity are being utilized for production of various arid, semi-arid, subtropical and tropical fruit crops. The western part of Rajasthan, parts of Punjab and Haryana and Kachchh region of Gujarat are suitable for date palm cultivation (Singh and Dhandar, 2007).

Sustainable fruit production under these fragile agro-ecosystem encounter different kinds of biotic and abiotic stresses. The effects of these abiotic stresses are expressed in forms of different physiological disorders. The physiological disorders observed in different fruit plants can be broadly categorized into nine types depending on the causal factors inducing them. However, the interaction of different factors plays major roles in inducing some of the most important physiological disorders. Physiological disorders in fruit crops can be grouped as given in table 1.

Table 1: Major physiological disorders of fruit crops.

Disorder groups	Physiological disorders	Fruit crops affected
Nutrient related disorders	Necrosis/internal browning	Aonla
	Black tip	Mango
	Fruit cracking	Pomegranate, ber, bael
	Gummosis	Peach, Mango, lemon
	Leaf scorch	Mango
Temperature related disorders	Scorching	Litchi
	Puffiness in citrus	Citrus
	Unfruitfulness	Aonla
	Spongy tissue	mango
	Chilling injury of rind	Pomegranate
	Internal browning	Pomegranate
	Frost/low temperature injury	Aonla, Lasoda, ber,
Water/moisture stress related disorders	Fruit cracking	Pomegranate, litchi, lemons,

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Water/moisture stress related disorders	Fruit cracking	Pomegranate, litchi, lemons,
	Granulation of juice vesicles	Citrus
	Shrinking of fruits	Grapes
Heat/Radiation related disorders	Sun burn, scorching	Pomegranate, Bael
Disorders due to harmful gases	Black tip	Mango
Disorders related to genetic factors	Short berries in grapes	Grapes
	Fruit cracking	Ber
Disorders due to lack of pollination	Jhumka in mango	Mango
	Misshaped fruits	Custard apple
	Fruit drop	Mango, Date palm
Disorders due to plant conditions	Alternate bearing	Mango
Disorders due to phenolic oxidation	Husk scald	Pomegranate
	External browning	Pomegranate

Fruit drop

Fruit drop is a serious disorder of many fruit species. In general, large fruit set has been observed initially out of which only few remain till the maturity. Fruit drop start just after fruit set and continue till the maturity. The mechanism of fruit drop is considered to be the formation of abscission layer at the stalk end of the fruit. The amount of drop varies with environmental condition, cultural operation and more so ever with the cultivars in different fruit crops. Three stages of fruit drop *i.e.* initial fruit drop, advanced fruit drop and pre mature fruit drop has been very common. The complex of situations like lack of pollination and fertilization, embryo abortion, internal nutrient imbalance, hormonal imbalance, moisture stress due to high temperature, low humidity and strong winds are considered as the principal factor for the fruit drop. The major fruit crops suffered with fruit drops are mango, litchi, citrus among tropical and sub tropical fruits, apple, peaches, pears and stone fruit among temperate fruit, aonla, ber, bael, date palm, wood apple, tamarind among the fruit grown under fragile agro ecosystem of arid and semi arid regions. The problem of fruit drop become sometime alarming under the poor soil moisture, high temperature, low humidity and strong winds situations which is a common feature in the arid region. Therefore, the understanding of the problem and its timely management has special significance in sustainable fruit production under fragile agro ecosystem.

The detail account of information regarding fruit drop has been generated in important crops like mango, ber, bael, custard apple and aonla. Mishra *et. al.* (1973) has also noticed two distinct phase of drop, found a complex of a number of internal (failure of fertilization, embryo abortion, hormonal imbalance) and external factor (mineral nutrition, high temperature, low humidity, strong winds and attack of insect) along with, stage of the plant (older plants encounter higher drop) associated with fruit drop. In case of mango, it has mentioned three distinct phase i.e. pinhead drop (fruit measuring 4mm diameter and below during April), post setting drop and May drop under north Indian condition. The different factor considered for this physiological disorder in mango include deficient nutrition, lack of cross pollination, poor pollen transference, low stigmatic receptivity, defected perfect flower, self incompatibility competition between developing fruit lets, drought condition, inadequate irrigation, high wind velocity and natural calamities like hail storms, severe biotic pressure like powdery mildew, mango hopper along with varietal characteristic . Similarly in case of aonla, it has been mentioned three stages of fruit drop based on the fruit growth. The July drops takes place when the fruit are at pea size stage. The main region for this drop is due to lack of pollination, and imbalance of nutrient. The August-September drop of the developing aonla fruit is mainly due to attack of fruit borers and incomplete fertilization. The October drop which is more harmful for the orchardist is mainly due to moisture stress and internal necrosis due to micro nutrient deficiency.

Thus, it has been found that fruit drop is a serious physiological disorder in many fruit crops leading to 15-20% loss of crop in many fruit. A suitable strategy is need of the hour to manage this malady. Attempts have been made to control the fruit drop. In litchi spray of 20-25ppm GA, and NAA have been found effective in minimize the fruit drop (Singh and Lal, 1980). Mishra *et al* (1973) reported that two sprays of NAA (20ppm), first at the time of fruit set and the second at pea size stage reduced the fruit drop considerably. Xiang *et. al.* (1994) stated that pollination and fertilization stimulate cytokinin, IAA and GA content and decreases abscissic acid content in the ovary after anthesis which is conducive for good fruit set. Lin (1994) reported that the fruit drop can be reduced by flower panicle thinning and reducing the density of flower buds during early stage of flowering. In case of mango, foliar application of NAA (10ppm), 2,4-D (20ppm), Zinc sulphate (0.2%), Boric acid (0.4%), during April has been found effective to control the fruit drop. In case of aonla two sprays with NAA (10ppm) + Boric acid (0.4%), 1st-at pea stage during July and 2nd-after one month of the 1st spray reduces the fruit drop and improves the quality of aonla fruit.

Fruit cracking

Fruit cracking or fruit splitting is a serious problem in many tropical, subtropical and arid fruit, like litchi, mango, citrus, pomegranate and bael. The fruit cracking generally occur during last stage of fruit development due to environmental factor. Splitting of fruit skin occurs due to differences in growth of mesocarp and pericarp. The developing mesocarp exerts an internal pressure on pericarp causing the cell to stretch. Since no cell division takes place in the pericarp at the last phase of development, the skin can't bear the internal pressure and finally cracks. Nutritional and water deficiency, genetical factor, anatomical factor, environmental factor, hormonal factor, nutritional and soil moisture factor also play an important role in the many fruit. In mango infection due to bacterial canker and black tip also aggravates the pericarp splitting. In arid fruits like pomegranate, ber and bael fluctuation of soil moisture and existence of dry weather condition are considered as the main cause for fruit cracking. Under these circumstances due to high moisture content, the mesocarp develops rapidly than the pericarp due to more diversion of water from to main sink (mesocarp) than skin. Simultaneously, due to more water absorption the pericarp become more turgid and prone to splitting under environmental stress. In litchi and pomegranate fruit cracking causes more than 20% loss the detail factor responsible of fruit cracking in litchi have been discussed.

(1) Genetical factor- The various cultivars of litchi varies with respect to fruit cracking.

Chadha and Rajput (1969) observed that fruit cracking in litchi varies from 0.3% (Seedless) to 27.4% (Dehradoon). It has been observed that early maturing cultivars of litchi are more susceptible to fruit cracking than late maturing cultivars. Cultivar like, Swarna Roopa, Hong Kong and China are found to be moderately resistant to resistant against cracking.

(2) Anatomical factor Teaotia and Singh (1970) suggested that during drought period strengthened tissue developed in xylem and phloem. Loss of their ability to divide and enlarge soon after a dry spell if water supply is increase, the meristematic tissues quickly resume growth owing to differential growth rate and harder tissue raptures. It was also suggested the some incipient cracks originate on hypertrophied lenticels. The lenticels hypertrophy may be caused by excessive retarded transpiration accompanied by more water supplies to regions of hypertrophy. During the growth phase, the rapid flush growth synchronized with the period of high temperature and low humidity resulting in localized light brown blotches on the fruit skin directly faces the sun rays. The blotches become more intense and dry up gradually leading to a small radial rapture on the skin

(3) Environmental Factor- Environmental condition like temperature, relative humidity and rain fall are also associated with fruit cracking. Hot dry condition along with desicating wind at the time of ripening are the main cause of fruit cracking. Temperature more than 38°C coupled with relative humidity less than 60 % is the most favorable conditions for fruit cracking. Sharp fluctuation in day and night temperature along with heavy irrigation after dry spell causes fruit cracking. High temperature and low humidity at maturity and prolonged rains at maturity also cause cracking in litchi, mango and lemon.

(4) Hormonal factor- Lower level of auxin in skin and seed and higher level of auxin in the aril are found responsible for fruit cracking in litchi.

(5) Nutritional factor- Micro nutrients such as zinc and boron are associated with the fruit cracking in litchi and other fruits. The low level of these micro nutrients causes the fruit cracking in litchi because the spray of these micro nutrients is effective in reducing the fruit cracking in litchi.

(6) Soil moisture- The loss of soil moisture and prolonged irrigation interval during fruiting season have been found to be associated with severe fruit cracking in litchi. Inadequate moisture during early growth period of fruit results in hard and inelastic skin resulting in the cracking at the time of rapid aril growth after irrigation (Menzel, 1984).

Water berries in grapes

The disorder is characterized by shriveling of berries in the beginning followed by drying. Shrivelling is usually at the tip of the bunch however, it may be scattered within bunch also. Affected berries look like cellophane bags, half filled with sap and remains hanging from the bunch. The berries become soft, watery and dull in colour though almost normal in size. Frequent irrigation and nitrogen application during berry growth period lead to development of water berries. Injury of wood due to faulty girdling and water stress during the course of healing of girdle also contribute towards this disorder.

In this condition berries lack normal sugar, flavor and keeping quality. The disorder is mainly due to overbearing and inadequate nourishment to the affected berries in a cluster. Avoid injury to wood while girdling, which is recommended to improve fruit quality in grapes.

Spongy tissue

Spongy tissue is a serious physiological disorder of mango in Maharashtra, Karnataka, Gujarat and Andhra Pradesh. It is characterized by development of non edible, sour, yellow sponge like patches with or without air pocket in mesocarp of fruit during ripening. It is also known as internal breakdown. The fruit become unpalatable and affected tissues are visible when ripe fruits are cut. The severity of disorder is up to 30% in some varieties of mango.

The disorder is associated with different factors like cultivar susceptibility, location of orchard, age of plants, nutritional conditions of the plant, etc. Alphanso is the most affected cultivar. Cultivars like Pairi, Neelam, Dashehari are almost free from the disorder. Alphanso orchards near coastal belts are found to be more affected by spongy tissue. Trees near base of hills are more affected than those on slops and at the higher altitudes. Older plants have more severity than young plantations. Lower content of calcium and magnesium in the leaves are associated with more severity of spongy tissue (Joshi and Roy, 1985). Intense solar radiation particularly at the time of fruit maturity is considered to be the most important factor for spongy tissue. Gunjate *et al* (1979) noticed that sod culture and mulching of orchard floor with dry grasses during fruit development and maturity reduces the incidence of spongy tissue in fruit of Alphanso mango. They also suggested that removal of field heat from the fruits by dipping the harvested fruits in cool water containing calcium chloride (2%) also checks the spongy tissue.

Black tip

Black tip is a nutrient and harmful gas related disorder of mango particularly in north India and does not occur in any other country. It has been reported to occur in regions of West Bengal, Uttar Pradesh, Bihar and Punjab in orchards located in close proximity of a brick kiln. South India is free from this disease. The symptoms manifest as small etiolated area at the distal end of the fruit, which gradually spreads, turns nearly black and covers the tip completely. Before the etiolation is complete, isolated grayish spots appear which become dark brown, enlarge and coalesce into a continuous necrotic area. The brown discoloration spreads to the neighboring parenchyma and the deposits also appear in the ducts. The browning and deposits gradually spread throughout the mesocarp and the affected cells disintegrate and coalesce into a dead tissue. In severe cases, the necrosis extends to the endocarp and affected fruit drops from the tree. The control measure lies in keeping the brick kilns away from the mango orchards. The use of telescoping chimney 12-15 m high has also been recommended. Spraying of borax (0.6%) at 10-15 day intervals has been recommended (Reddy and Kapoor, 1965) to control black tip problem in mango.

Alternate bearing

Alternate bearing, irregular bearing and erratic bearing are a major problem in many fruits in India and abroad. The problem is more severe in ever green fruits like mango, litchi, etc. the deciduous fruit plants which respond to pruning and bearing takes place on comparatively new shoots, this problem is quite low. However the health of plants particularly the internal nutrient content plays a crucial role in regular bearing. Fruits are the great sink and major source of nutrients removal from the tree. Generally after good crop the plants are exhausted which may yield low in the next season if they are not fed properly and the problem of irregular or alternate bearing exist. Factors like genetically, nutritional, crop load, hormonal (florigen formation) are also found to be associated with alternate bearing.

Appropriate cultural practices like nutrition (dose, period and method), pruning (period and severity), thinning of fruits and flowers at early stage may bring the plant in uniform bearing every year.

Gummosis

The occurrence of gummosis is a serious problem in citrus, mango and other fruits but is more severe in citrus in all the citrus growing areas especially in the high rainfall areas. Even there is no comprehensive survey of the disorder has been made so far. There are some reports on the prevalence of this disorder, in South India by Rajan and Aiyappa (1944), Ramakrishnan (1954) in Maharashtra, by Cheema and Bhat (1928) in Gujarat; by Frazer and Singh (1966) in Mysore; in Punjab by Kapoor and Bakshi (1967); and in Assam by Chowdhuri (1951). It is caused by more than one species of *Phytophthora*, i.e., *P. nicotianae* var. *parasitica* (Dastur) Comb, is widespread in Assam and is often associated with *Fusarium lateritium* Nees (Chowdhuri 1951). *P. nicotianae* var. *parasitica* is also predominant in Karnataka, whereas *P. palmivora* (Butl) is prevalent throughout. *Phytophthora* produces symptoms of decline through: (1) a rotting of the rootlets, (2) a girdling of the trunk and a dropping of blighted leaves. The plants usually blossom heavily and die before fruits mature. The fruits lying on the ground are liable to invasions by the pathogens and develop brown rot. *P. citrophthora* has also been reported to cause the foot and root rot. In mango and temperate fruits the problem is caused due to deficiency of nutrients particularly copper and calcium.

Symptoms: Certain parts of trees are more susceptible to Gummosis than others and the different expressions of the disorder syndrome vary accordingly. The disease manifests itself in the form of large water soaked patches on the basal portion of the stem near the ground level or it may spread further. Bark on the lower part of trunk is more susceptible to infection than the bark below the ground level. In some very wet areas, the infection is observed quite high on the trunk and even on limbs. The gumming is sometime noticed on higher branches also. Initially, the bark is firm but with ageing of the lesion it shrinks and cracks, leading to shredding in lengthwise strips as it dries. The necrotic area is at first flush with the healthy bark, but with time it shrinks and becomes sharply delimited. The live bark at the advancing margins frequently develops a callus roll that checks further spread particularly in an upward direction. Symptoms on leaves are similar to those produced by *Phytophthora infestans* on the foliage of potato. Blighted leaves drop, and if defoliation is heavy the impression is given that the tree is in decline. Penetration of trunk tissue may be by way of wounds or by way of growth on cracks that develop with the emergence of adventitious shoots near the bud union.

Role of root stock: The predominance of resistant and moderately resistant clones was observed in pummelo, sweet lime, trifoliate orange and trifoliate orange hybrids (Grimm and Hutchinson 1977). In their earlier studies conducted in 1973, it is reported that *Citrus macrophylla*, *C. miaray*, *Severinia buxifolia*, Cuban shaddock, Ogami Pummelo and Sour orange were rated resistant. In Turkey, Carrizo Citrange has been reported to be highly resistant (Cinar and Tuzcu 1976).

Control measures: Adoption of tolerant rootstocks like sour orange, Cleopatra mandarin, trifoliate orange, Rangpur lime, etc., had been observed. A variety resistant in one region may be susceptible in other. The use of nursery stock grown under *Phytophthora* free conditions and prevention of water standing in contact to the susceptible portions of the bark above the bud union by way of good drainage. The disease can further be prevented to some extent by dusting of walls and bottom of planting pits with zinc-copper lime in ratio of 5:1:4 (Ramakrishnan 1954). The exposed wood can also be covered with zinc copper lime (3:1:3.5) wash or bordeaux paste which should be followed by application of white lead or any wound dressing agents (Ramakrishnan 1954). Desai *et al* (1966) achieved complete control of spraying Khagzi lime trees infected with *P. citrophthora* with aureofungin 3 g/30 ml of liquid soap/30 gallons of water applied 2-3 times. Somani and Patel (1970) got good control of gummosis incited by *P. nicotianae* var. *nicotianae* by Aureofungin as soil drench and spraying of foliage twice at an interval of one month. Drenching of Ridomil MZ (0.2%) has also been found effective against gummosis. Captafol (3 g/l), copper ammonium carbonate and cupric hydroxide are effective for foot rot (Timmer 1977). Dipping of seedlings in captan solution before planting is recommended in U.S.A. (Grimm and Whidden 1966). Fumigation of nursery bed with methyl bromide has proved most effective to avoid nursery infection (Grimm and Alexander 1971). Leaf fall and fruit rot could be controlled by spraying bordeaux mixture (1%) or bordeaux mixture plus tin sulphate or difolatan (0.3%). In addition, spraying of Ridomil MZ and Aliette (0.2%) have also been reported effective (Rawal 1990). Diseased leaves and fruits may be collected and burnt or burried deeply.

Malformation

It is the most important malady of mango and was first reported by Burn (1910). It causes the losses from 50-80 per cent. It is also reported to be due to other disorders like physiological and acarological, however, the role of fungus *Fusarium moniliforme* var. *subglutinans* Sheldon has been widely accepted. Indications of its viral origin has also been postulated (Vasudeva 1959). The maximum incidence of the disease has been recorded in the north, north-west and north-east parts of the country. The incidence is, however, less in western and southern India. There are two types of symptoms, namely, floral malformation and witches broom or bunchy top or vegetative malformation with a proliferation of infected tissue. The flowering panicles turn into a compact mass of flowers. This compact mass is very hard and not soft like normal panicle. Individual flower is greatly enlarged and has a large disc. The percentage of bisexual flowers in malformed panicles is very low. In bunchy top, compact leaves are formed in a bunch at the apex of shoot or in the leaf axil. A similar bunch consisting of small rudiments crowded together on short shootlets is seen in vegetative malformation in which the growth of shootlet is arrested. Vegetative malformation is more pronounced in young seedling and seedling trees. The malformed heads dry up in black masses and persist on the trees for a long time. The malformed inflorescences contain more of endogenous cytokinins than healthy ones (Nicholson and van Staden 1988).

The variety Zebda has been reported to be resistant in Egypt (El Ghandour *et al.* 1979). Considerable incidence reduction has been reported by spraying 100-200 ppm NAA during October (Majumdar 1977). Use of disease free planting material and prophylactic spray of insecticides and fungicides can keep the orchards healthy. In areas with less than 5-10 per cent infection, pruning of diseased plants should be made compulsory; pruning of diseased parts along the basal 15-20 cm apparently healthy portions. This is followed by the spraying of Bavistin (0.1%) or Captaf (0.2%). Partial control of malformation has been achieved by spraying Mangiferin-Zn2 and Mangiferin-Cu2+chelates (Chakrabarti and Ghosal, 1988).

Physiological disorders of arid zone fruit crops

Ber (*Ziziphus mauritiana* Lamk.)

Fruit drop and cracking

In ber cv. Seb, fruit drop as well as cracking has been observed, which can be controlled by twice foliar spray of zinc 0.5 and 1.0% and borax (0.5%) and urea 1.0 per cent at 10 days interval (Singh and Vashishtha, 1997) in semi- arid conditions. Immediately after fruit set, a heavy drop occurs which is largely due to the lack of fertilization or degeneration of ovule. During the early stage, the drop was mainly due to shriveling of fruit which occurred up to December (Singh 1976). After December shriveling was negligible. The maximum fruit drop took place up to 26 October in the early fruiting cultivars 'Gola', 'Seb', 'Mundia'and 'Jogia', up to 16 November in 'Ponda'and up to 23 December in the late maturing Íllaichi'.

In western Rajasthan, very heavy drop of 68.6 per cent and 60.2 per cent occurred respectively in Íllaichi'and Áliganj'and the lowest in 'Ponda' (24.1 per cent). At Hissar, 55.29 per cent drop was observed in 'BanarsiKaraka'(Singh *et. al.*, 1970). The maximum amount of drop was recorded between the last week of January and the last week of February just before a sharp increase in weight of the developing fruit was registered.

Exogenous applications of growth regulator have been very effective in controlling fruit drop. Dhillon and Singh(1968) found 2,4-D at 10 ppm to be the most effective in reducing fruit drop (from 60-61 per cent in control to 50.8-56 per cent) whereas 25 ppm GA and 2,4,5-T at 5 and 10 ppm showed little promise in 'Dandan', 'Kaithili'and Úmran'. Singh *et. al.* (1970) found that the percentage drop was not influenced by GA and NAA treatments. Singh (1976) found that sprays of NAA, 2, 4-D and MENA at 10,20,30 ppm did not reduced drop in 'Banarasi'exept 30 ppm, 2,4,5-T where the reduction over the control was 14.19 per cent.

The intensity of fruit cracking, a physiological disorder was recorded in different genotypes of ber. The incidence of fruit cracking was observed in all the majopr varieties of ber such as 'Gola', 'Seb', 'Mehrun. 'Badami', 'Maharwali', 'Bagwadi', 'Narikeli', 'Surati', 'BS-75-2'etc. The occurrence varied from 2- 8 % in ripe fruits. However, it was recorded to the tune of 60% in ripe fruits of variety Kathaphal. The severity of cracking increased with the advancement of maturity in ber varieties. The nature of cracking was predominantly radial combined with flesh cracking except in variety 'Surati', wherein the nature varied from skin cracking to transverse and oblique types of cracking (Anonymous 2012).

Pomegranate (*Punica granatum* L.)

Husk Scald

Husk scald is a temperature related disorder of pomegranate which limits the opportunities to store and market pomegranates.

Symptoms: Scald is a brown superficial discoloration restricted to the husk. There are no internal changes of the arils or the white segments as occurs with chilling injury. At advanced stages, the scalded areas became moldy. The scald symptoms became evident after 8 weeks of storage at 2°C(36°F) on the cultivar 'Wonderful'. Symptoms will appear earlier at higher storage temperatures. Husk scald development of pomegranate may be due to phenolic oxidation.

Control: Late harvested fruit is less susceptible than earlier harvested fruit. Scald development may be delayed up to 6 weeks on 'Wonderful' stored at 2°C(36°F). Other potential treatments must be evaluated under California conditions before commercial recommendations can be made.

Fruit cracking

Pomegranate is a drought resistant fruit species and is well adapted to the arid and semi arid parts of the world including Mediterranean region. Fruit cracking is a most serious physiological disorder in pomegranate which limits its cultivation. In young fruits it could be due to boron deficiency but fully grown fruits crack due to moisture imbalances as these are very sensitive to variations in soil moisture and humidity. Prolonged drought causes hardening of peel and if this is followed by heavy irrigation or down pour then the pulp grows and the peel cracks. This problem can be overcome by a) Maintaining soil moisture and not allowing wide variations in soil moisture depletion, b) Cultivation of tolerant varieties, c) Early harvesting and not allowing the fruits to crack and d) Spray of calcium hydroxide on leaves and on fruit set.

Hepaksoy, *et. al.* (2000) studied the differences among the cultivars in respect to fruit cracking, the most important physiological disorder and reported significant differences among genotypes. Studies conducted on six pomegranate varieties out of which two classified as sensitive to cracking (Koycegiz and Siyah), two resistant to cracking (Kadi and Lefon) and two intermediate (Cekirdeksiz Seedless and Feyiz). Primary nutrients (leaf and fruit), leaf gas exchange properties, leaf water potential and fruit characteristics were investigated and correlated with the ratio and tendency of cracking.

Six-year-old pomegranate cv. Jodhpur Red trees sprayed with 0.2, 0.4 or 0.6% H_3BO_3 and $ZnSO_4$; and 10, 20 or 40 ppm 2,4-D and NAA 15 and 30 days after fruit set in Haryana, to determine the effects of micronutrients and plant growth regulators on fruit cracking in pomegranate. In general, the percentage of premature cracking was higher compared to mature cracking. $ZnSO_4$, H_3BO_3, NAA and 2,4-D application resulted in lower mean percentage of mature, premature and total fruit cracking compared to the control, with 10 ppm 2,4-D recording the lowest values for premature cracking (5.2%), mature cracking (3%) and total fruit cracking (8.3%).

Thirteen pomegranate cultivars (Jalore Seedless, Ganesh, P26, Mridula, Jodhpur Red, GKVK, Dholka, P23, Bassein Seedless, Malta, Bedana Suri, G 137 and Kandhari) were screened to determine their suitability for better growth, yield and fruit quality under arid ecosystem. Inter-varietal differences were highly significant for vegetative growth, yield, and fruit size, cracking of fruits, number of arils, total soluble solids, acidity and juice. Plant height was highest in Jalore Seedless (2.86 cm) whereas spread was highest in Jodhpur Red (2.6 cm). G 137 recorded the highest tree girth (4.9 cm). The highest yield was recorded in Jalore Seedless (10.5 kg/tree. Fruit length was highest in Jalore Seedless (1.18 cm). Fruit cracking was highest in Jodhpur Red (72.4%) and lowest in Malta (5.2%). G 137 had the highest aril number per fruit (186), while Kandhari recorded the highest total soluble solids (19.7 °Brix). Jodhpur Red had the highest acidity percentage (1.68%). The highest juice content was recorded in Jalore Seedless (51.3 kg). Based on the best performance for desired characters, Jalore Seedless, P 23, G 137, Ganesh and Mridula are the most suitable for cultivation in arid and semiarid regions for table purpose and local market.

The experiment conducted in arid parts of Rajasthan on six-year-old plants of pomegranate with four levels of drip irrigation (4, 8 and 12 litres water h-1 applied for 3 h daily at flowering and fruiting time and a control with basin irrigation system) based on pan evaporation at 60 litres m^{-2} of basin. The results reveal that plants treated with drip irrigation were more vigorous than those treated with basin irrigation. Drip irrigation at 8 litres h-1 day-1 for 3 h increased the yield from 17.7 kg plant-1 under the control to 28.2 kg plant-1, with a considerable reduction in cracking. Fruit quality in terms of weight, size and juice content was better in drip-irrigated plants than that in the control plants. However, the TSS of the juice was slightly reduced in drip-irrigated plants compared with the control plants.

A study conducted in Rajasthan, to find out the effect of spray of boron (0.1, 0.2, 0.3 and 0.4%) and GA_3 (10, 20, 50, 100 ppm) spray on control of fruit cracking and its intensity during different pickings in pomegranate var. Jalore Seedless. The least cracking was obtained with the application of boron at 0.2% which in turn produced the highest average yield of 13.4 kg/tree. Intensity of cracking was highest in fruits picked during December and lowest in fruits picked during January however fruits harvested during January did not develop aril colour. The evaluation of germplasm against fruit cracking showed that 150 germplasm were susceptible to cracking but percentage varied from 10-40% among genotypes/cultivars under Bikaner conditions. Better flowering/ fruiting were observed in ambe bahar but proper aril colour was not developed because of high temperature. Fruit cracking was low in this bahar but quality of fruits was not good with respect to colour of arils, juice and sweetness (Annon, 2011). Mohamed (2004) reported that percentage of fruit splitting gradually increased from the early waves of fruit set time to the later one. All the treatments greatly decreased the fruit splitting percentage comparing to the control. The most effective treatment in this respect was spraying with GA_3 at 150 ppm where it led to the lowest fruit splitting percentage followed by spraying with mixture of GA_3 at 100 ppm+ BA at 40 ppm. The average fruit weight was gradually decreased from the early fruit set times to the later waves. Most treatments led to increase of fruit weight. Spraying with GA_3 gave the heaviest fruit weight. Concerning rind weight percentage (attributed to the fruit weight), differences among early and later waves of fruit set were not observed. The effect of treatments on increasing rind weight percentage was little during the two years. The percentage of total soluble solids (TSS) was decreased in the later times of fruit set compared to the early ones. The treatments had slight effect on the TSS percentage. The total acidity percentage was gradually increased from the early fruit set times to the later one. All the treatments caused high increase of acidity percentage. As concentration of GA_3 or BA increased, the acidity percentage increased.

Chilling Injury

The incidence and severity of chilling injury depend upon storage temperature and duration. The minimum safe temperature is 5°C (41°F) for up to 8 weeks. Chilling injury can be a major cause of deterioration of pomegranates during marketing following exposure to temperatures below 5°C (41°F) during storage and transport for longer than 4 weeks.

Symptoms: External symptoms include brown discoloration (scald) of the skin, pitting, and increased susceptibility to decay. Internal symptoms include brown discoloration of the white segments separating the arils and pale color (loss of red color) of the arils.

Physiology: Pomegranate are susceptible to chilling injury if stored longer than one month at temperatures between their freezing point (-3°C or 26.6°F) and 5°C (41°F). Upon transfer to higher temperatures, respiration and ethylene production rates increase and other chilling injury symptoms appear: their severity increases with lower temperatures and longer durations of chilling exposure. External and internal browning is related to oxidation of phenolics by polypherol oxidase. Storage in a 2% oxygen atmosphere at temperatures below 5°C (41°F) reduces severity of chilling injury symptoms.

Control: Avoid exposure of pomegranates to temperatures below 5°C (41°F).

Frost injury

Pomegranate plants are susceptible to frost or low temperature under hot arid environment and leaves and thin branches dried. Fruits skin becomes black after two days of frost injury. The affected plants recovered fast after employing irrigation and fertilizer with increasing temperature during month of February.

Blackening of arils

The browning of arils in pomegranate has been identified as problem which is believed to be a genetical, environmental and soil moisture related disorders. In this disorder, some of the mature grains of healthy fruits become soft and brown which reduces the market value of the fruits. The problem is similar to that of spongy tissue of mango in which the disorder appears after cutting of fruits. Solar radiation and fluctuation in temperature during fruit development and ripening are believe to be the main cause of the disorder. Some cultivars have been found less affected with the disorder. No varieties are free from this problem however; intensity is varied from variety to variety. Concentrated research on causal factor and its management is under progress.

Bael (*Aegle marmelos* Correa.)

Fruit cracking

The fruit cracking is the major physiological disorder in bael and its degree of damage depends according to genotype/varieties and locality (Singh *et al*, 2011). It has been takes place twice in a year *i.e.* winter season (December-January) in developing immature fruits and during summer season (March-April) when fruits are mature and in ripening phase. Mishra (2000) reported that in some genotypes of Bael cracking occurs just before ripening. Moisture fluctuations in the environment during the fruit development stage are the main cause of fruit cracking in bael besides skull thickness. It is genetic feature in some genotypes. However, application of boron has minimizes the cracking in bael besides maintenance of soil moisture in arid region. Saini *et al* (2004) reported that cracking can be minimized by maintaining optimum soil moisture regime and by provision of wind breaks against hot desiccating wind. Organic mulches like paddy straw, subabul loppings can effectively utilized in maintaining soil moisture in tree basin particularly during summer under rainfed conditions in semi arid region.

Fruit drop

Fruit drop is natural phenomenon, but its extent of damage is a matter of concern. The extent of fruit drop varied according to genotypes/ varieties and locality. Immature fruit drop (marble size) has also been observed. Sometimes ball size fruits also fall down. The extent of fruit drop in bael can be reduced effectively by adopting better orchard management practices and application of growth hormones like NAA (15-20 ppm / litre).

Fig (*Ficus carica* L.)

The status of fig production in the Black Sea Region of Turkey was studied using a questionnaire in the provinces of Artvin, Rize, Trabzon, Giresun and Ordu revealed that 182 122 fig trees were established in these areas, 165 317 of which were fruit-bearing. The total production was 3243 tonnes and the yield per tree was 19.62 kg. Fifteen local cultivars were grown in the region, with cultivars Patlican, Siyah and Beyaz being the most common. Fig was cultivated in a mixed cropping system with other fruit trees established as border trees. Fruit ripening commenced on 15 July-15 September and continued for 1.5 to 2.0 months. Harvested fruits were intended for fresh consumption. Crop damage by rain was lower in Ardu and Ordu (50%) than in the other provinces (80-100%). The incidence of fruit skin cracking due to rain was high in cv. Sari grown in Artvin but low in cv. Ipek grown in Giresun. In general, pruning and irrigation was not practiced and fertilizers were not applied. The economic maturity of fig was attained in approximately 25-30 years. Fruits that were sold in the local markets comprised 30-40% of the fruits harvested. Fig jam was highly preferred in the region except in Artvin. Fig trees were mainly propagated from cuttings (90%). Some of the most common physiological disorders of fig are:

Fruit cracking

Fruit cracking in fig is a serious problem in Middle East countries where it is being grown at commercial scale. The problem is mainly nutrient and cultivar related. Studies were carried out in a private orchard in Al-Abbasyia, Najaf, Iraq, for two growing seasons during 2000/01 to investigate the effects of spraying nitrogen (N), iron (Fe), zinc (Zn) and/or potassium (K) in 0.3% concentration on fig (cv. Asowd Diala) trees when the fruit of third crop reaches 30 days after fruit bud appearance. The results indicated that trees treated with nutrient elements, alone or in combination, had increased leaf area, total leaf chlorophyll content, weight, volume, number of days to fruit ripening and reduced the percentage of fruit drop, fruit cracking, anthocyanin, total soluble solids (TSS) and acidity. Treatment with N + Fe + Zn + K recorded the longest time to fruit ripening, the highest average leaf area, total chlorophyll, weight and volume of fruit, but the lowest percentage of fruit drop, fruit cracking, anthocyanin, TSS and acidity for both growing seasons.

A foliar spray of 1% $CaCl_2$ was applied to fig cultivars Bursa Black, Goklop and Sarilop (synonym Calimyrna) (which differ in their susceptibility to fruit cracking) towards the end of the second phase of fruit development. Leaf N content increased significantly in the latter 2 cultivars only. Leaf Ca content increased in Bursa Black and Sarilop but not in Goklop, which had the highest Ca content. Leaf Fe, Zn and Mn contents were all reduced by $CaCl_2$ application but Cu contents increased. Significant responses to $CaCl_2$ application were found only in fruit Na and Fe contents. The number of both severely and moderately cracked fruits decreased significantly on treated trees.

Aonla (*Embelica officinalis* Gartn.)

Necrosis or internal browning

Necrosis is the main disorder of aonla in sodic soil where many micro nutrients become unavailable to plants. It is mainly nutrient related disorder however some newly developed cultivars have been found comparatively free from the disorder. Francis cultivar is severely affected with this malady. Evaluation of aonla cultivars NA-6, NA-7, NA-10, Kanchan and Chakaiya at NDUAT, Faizabad (Singh *et al*, 2003) reveal that these cultivars exhibited higher productivity and fruits were free from necrosis or internal browning, indicating their suitability for fruit processing. Cultivar Francis and NA-9 was most affected with necrosis. Data were also recorded for average fruit weight, acidity, and pulp, fibre, seed, total soluble solids (TSS), ascorbic acid and phenol contents. NA-6 recorded the lowest fibre content, high pulp and TSS contents, and moderate fruit size and ascorbic acid content. NA-7 showed average physico-chemical composition with high content of ascorbic acid.

To control the necrosis, an experiment with foliar feeding of $ZnSO_4$ (0.5%), borax (0.2%), $CuSO_4$ (0.4%) and their combinations on the growth, fruit quality and yield of aonla cv. Francis (most susceptible cultivar) resulted the highest plant height (19.67 m), trunk girth (26.10 m), plant spread (23.39 m), fruit length (3.98 cm), fruit width (4.43 cm), fruit weight (47.97 g), total soluble solids (11.67%), acidity (1.70%), and ascorbic acid content (589.0 mg/100 g) with the combined spray of $ZnSO_4$ + borax + $CuSO_4$. Fruit yield was highest (43.0 kg/tree) with borax + $CuSO_4$ treatment. The percentage of fruit necrosis was lowest (1.21%) with $ZnSO_4$ + borax + CuSO4 treatment which was at par with borax + $CuSO_4$, $ZnSO_4$ + $CuSO_4$, and $ZnSO_4$ + borax treatments. Thus, it is confirmed that necrosis is a micro nutrient deficiency related physiological disorder.

Off season flowering

Recently, off season flowering has been a serious problem in aonla production. Survey of aonla growing areas of Uttar Pradesh reveals that few cultivars like Chakaiya, Kanchan and NA-7 are the most affected cultivars in Pratapgarh, Sultanpur, Faizabad and Varanasi districts. The problem has also been noticed in Jharkhand and Madhya Pradesh. The study conducted by Rai *et al* (2002) reveal that a complex of situation are responsible for this malady. They reported an economical loss of 30-40% due to off season flowering in aonla. The main reason of this disorder would be global warming or due to some disturbance/ interruptions in the tree physiology due to externally governed internal mechanisms. The condition leads to non-occurrence of distinct phase of dormancy after fruit harvest. Plant comes in partial flowering with predominance of male flowers which do not set fruits but exhaust the plants and disturbs the physiology and reduce the crop load in the main season crop. In any case if some fruit sets, they do not develop properly and drops subsequently.

The off season flowering can be controlled by forcing the plant to enter in dormancy by spraying 10% urea after fruit harvest. Restricting soil moisture build up near root zone can help plant to enter in to dormancy.

Lemon (*Citrus* sp.)

The disorder occurs mostly on mature fruits due to excessive absorption of moisture by the plant and it is more severe when a period of drought is followed by rains or heavy irrigation. In addition to water imbalance, bioregulators, nutrients and weather conditions which promote differential growth rates of peripheral and cortex tissue, may also result n cracking of lemon fruits.

Two sprays of 20 ppm NAA or 40 ppm GA_3 or 8.0% potassium sulphate during second fortnight of May also reduce fruit cracking.

Date palm (*Phoenix dactylifera* L.)

In date palm, drop of berries at initial stage after fruit set has been observed which is vary from variety to variety .Thinning of berries are required in date palm for improvement in fruit quality, hence drop of berries in small amount is not much harmful but high percentage of dropping decrease the bunches' yield. Proper soil moisture is essential in plants basin during fruit growth and development period in summer months to reduce dropping of berries.

Custard apple (*Annona squamosa* L.)

Misshapen fruits

In custard apple, about 15-20 per cent fruits do not attain the characteristic feature of the distinct cultivar. This is mainly due to improper pollination and fertilization and non favorable environmental conditions at the time of fruit development. Since custard apple is an aggregate fruit in which development of false areoles in higher number is considered good for commercial yield, however the misshapen fruits fetch less price in the market. Proper pollination and maintenance of high relative atmospheric humidity (80-90%) should be ensured at the time of fruit development. Hand pollination is a simple and fast technique that results not only good fruit set but also produces big size and attractive uniform shape fruits with no loss in edible attributes (Anon 2009).

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