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Review on Physiological Disorders of Tropical and Subtropical Fruits: Causes and Management Approach

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Abstract

Apart from insects, pests and diseases, physiological disorders are one of the major threats to fruit industry which cause economic losses worldwide. Many tropical and subtropical fruit crops (Mango, Banana, Citrus, Grape, Papaya, litchi, loquat *etc*.) are vulnerable to different physiological disorders like spongy tissue, chock throat, granulation, pink berries, bumpy fruits, fruit cracking and purple spot respectively. Adverse environmental conditions such as high or low temperature, moisture content, nutritional and hormonal imbalance, improper pollination or fertilization *etc*. cause abnormal external or internal conditions as well as abnormal growth pattern of fruits collectively known as physiological disorders. Most of the disorders associated with more than one factors like environment and nutrition but some disorders are mainly occur due to one factor only. So, there is need to understand the reason behind a particular cause and way to overcome it with a specific management approach. Among the nutritional disorders, the deficiencies of micronutrients (Zn, Bo, Mn *etc*.,) are more prevalent in Indian orchards rather than macronutrients. This review not only describes the cause of physiological disorders of fruit crops which lead to huge losses to fruit growers but also discusses the management practices to prevent it and retain the quality for higher market value.

Highlights

- To know the cause of physiological disorder is important to mitigate the particular disorder through sustainable management approach.
- To overcome the physiological disorders which are barrier for quality fruit production is possible with the use of different management strategies like good agricultural practices, nutrient management, chemicals, use of cultivars *etc*.

Keywords: Fruit crops, physiological disorders, causes, management approach

In general, the problems arise due to unfavourable environmental conditions and improper cultural practices which affect the normal plant growth and development is called as physiological disorders of plant. Ladaniya, 2008 noted that the physiological disorders are most important non-pathological problems faced by present day fruit growers which are the results of disfunction or malfunction of the physiological processes of the fruit tissues due to abiotic stresses like temperature, relative humidity, moisture/water stress, chemicals, nutrient excesses and deficiencies. The productivity as well as the quality of fruits is affected to a greater extent due to the physiological and nutritional disorders. Fruit cultivation and its potential quality yield is affected by many physiological disorders like fruit drop, irregular bearing, fruit cracking *etc*. (Campostrini *et al*., 2010) noted that disturbance in the plant metabolic activities are almost related to environmental factors which in certain cases, are difficult for growers to prevent. According to (Chatenet *et al*., 2000; Paull and Reyes, 1996) the physiological disorders which caused by different factors are common in many fruit species. The physiological disorders in different fruit crops can be categorized in various types on the basis of causal factors (Table 1). The micro nutrient related disorders arises in commercial orcharding due to inadequate use of organic manures, adoption of ultra-high density planting systems, use of unsuitable root stocks for example citrus granulation in mandarin when grafted on Jatti Khatti rootstock and imbalanced fertilizer application.

To maintain fruit quality and good yield the micronutrient deficiencies have to be detected before visual symptoms are expressed. In India, deficiencies of Zn, Mn and B are common in sweet orange, acid lime, banana, guava and papaya. To correct both visual and hidden micronutrient deficiencies, appropriate foliar and soil applications are necessary. The description of physiological and nutritional disorders in crops include a number of technical terms like bronzing (development of bronze or copper colour), chlorosis (loss of chlorophyll), die-back (collapse of the growing tip affecting the younger leaves) *etc*.

Causes and Management Approach of Physiological Disorders in Different Fruit Crops

Mango

Fruit Drop

In mango, there is a heavy drop of hermaphrodite flowers and young fruits. Generally, 0.1% or less hermaphrodite flowers develop fruits to maturity. The number of hermaphrodite flowers with functional ovules is too low in mango (Davenport and Nunez-Elisea, 1997). Dahsham and Habib (1985) reported that the abscission occurs at three stages during post setting in two month of fruit age, second stage when fruit are 60-75 days old and preharvest *i.e*. just before fruit harvest. The maximum drop of fruits in 'Langra' and 'Dashehari' take place in first three weeks of April and differs significantly from the drops in the following weeks. Fruit drop is to varietal character, as the variety 'Langra' is more prone to fruit drop than 'Dashehari'. Deficient nutrition of many developing embryos may be internal factor leading to post-fertilization drop in mango. This results due to competition among the overcrowded fruitlets on panicle. Degeneration of embryo in the initial stages of its development may yet be another cause of this disorder. The primary phytohormones regulating the activity of abscission layer are ethylene acting as the inducer of abscission layer and auxin acting as the suppressor of abscission. The role of cytokinins, gibberellins, abscisic acid and polyamines are not clear, in this respect but these may involve in regulation of auxin and ethylene biosynthesis or their metabolism or action. This occurs invariably, if the flowers are self-pollinated. The foliar application of NAA @ 20 ppm at pea stage of fruit was found to be effective in controlling fruit drop in mango (Mishra *et al*., 1973). Foliar application of GA 10 ppm, 2,4,5-TP @ 20 ppm at full bloom and panucle initiation stage respectively, whereas Ethrel @ 50 ppm and Alar 1000 ppm at flower bud differentiation was found to be effective treatment for fruit drop reduction in mango (Sharma, 2005a).

Alternate Bearing

It is one of the major problems in the north, east and central parts of India. Most of the commercial cultivars like Alphanso, Dashehar, Langra, Chausa *etc*. are vulnerable to this disorder. The term biennial or alternate or irregular bearing generally signifies the tendency of mango trees to bear a heavy crop in one year (On year) and very little or no crop in the succeeding year (Off year). Therefore this characteristic of bieniality exists even in regular bearing variety (Singh, 1990). The tree produces heavy crop in one season due to which it gets nutritionally exhausted, unable to put forth new flush consequently results in poor or no yield in the following season. The problem has been attributed to the causes like genetic, physiological, environmental, nutritional and hormonal (Bhargava *et al*., 2011). Some regular bearing cultivars like Amrapali, Pusa Arunima, Ambika, Neelphanso, Neeleshan, *etc*. have been evolved by breeding using one of the parents as regular bearing variety. The nutrient management has not shown any relationship with regularity in bearing. The regular bearing trees characteristically put forth vegetative flush immediately after harvesting or simultaneously during flowering. For overcoming biennial bearing, deblossoming is recommended to reduce the crop load in the 'On' year so that it is balanced in the 'Off year. Sindhe *et al*. (2000) standardized the dose and time of application on tree canopy diameter basis for regular cropping in Alphonso mango. They reported that application of Paclobutrazol @ 0.75g/m was well as 1.25 g/m on crown diameter basis.

Mango Malformation

Mango malformation is a serious disease comes under disorder affecting mango production of North Indian mangoes. (Burns and Prayag 1920) reported this disorder. The mango malformation occur widely in northern, central, eastern, and western parts of India such as Uttar Pradesh, Punjab, Bihar, Madhya Pradesh, Delhi, Gujarat, Haryana, West Bengal and Orissa (Prasad *et al*., 1965). The southern region of India is comparatively free from this malady. About 50-80% losses occur due to this disorder (Singh and Chakravarti, 1935). The mango malformation is of two types- vegetative and floral. Vegetative malformation occurs in young seedlings (Nirvan, 1953). An abnormal growth of vegetative buds appear in the leaf axils or at the apical meristem of the young plants, which are compact rosette like shootlets bearing tiny leaf rudiments. It is also referred as bunchy top as many shots arise together to form a bunch like structure. The vegetatively malformed panicles continue on the tree without flowering and fruiting limiting the growth of the tree or branch (Khan and Khan, 1962). During flowering stage this disorder leads to conversion of the healthy panicle to a barren and also adversely affects the fruit production. In severe form, the affected panicle appears like a compact mass, being more green and sturdy.

Recently Ansari *et al*. (2013a) reported that fungus *Fusaruim mangiferae* leads to the malformation of mango by producing ethylene and probably stimulating stress ethylene production in malformed tissue of mango and further they found that low temperature induced 'stress ethylene' is responsible for malformation. Sirohi *et al*. (2005) proposed that application of NAA @ 200 ppm and methyl-1-2 benzimidazole carbamate (0.1%) at flower bud differentiation and panicle emergence stage reduce the floral malformation significantly. Level of mangiferin could be considered as a potential biochemical indicator for screening mango genotypes to malformation (Singh, 2006). Chitinase and beta-1, 3-glucanase activities are negatively correlated with the intensity of mango malformation hence they are reliable screening markers and can be exploited for developing malformation resistant or less susceptible mango cultivars (Ebrahim *et al*., 2011).

Spongy Tissue

Spongy tissue is a major physiological disorder of 'Alphonso' mango which causing about 30% fruits loss in mango growing region of Maharashtra, Gujarat, Andhra Pradesh and Karnataka (Bhargava *et al*., 2011). Fruit possesses non edible sour yellow sponge like patches with or without air pocket in the mesocarp during ripening. The peculiar feature of this disorder is that external symptoms are not apparent at the time of picking or at the ripe stage. These can be detected only on cutting the ripe fruit. Due to this malady the fruit become unfit for human consumption. (Joshi and Roy, 1985) found that lower content of calcium and magnesium in the leaves are associated with more severity of spongy tissue. Katrodia (1988) has however observed the convective heat as the main cause of spongy tissue. *In situ* seed germination in Alphanso mango is another cause of promoting spongy tissue as reported by Ravindra and Shivashankara, 2004. Gunjate *et al*. (1979) noticed that sod culture and mulching of orchard floor with dry grasses during fruit development and maturity reduce the incidence of spongy tissue in fruit of Alphanso mango. They also suggested that removal of field heat from the fruit by dipping the harvested fruit in cool water containing calcium chloride (2%) also checks the spongy tissue. The use of wind-breaks for protecting the orchard from warm air during May, and use of proper precautions at post-harvest stage checks the disorder as avoidance regarding direct exposure of fruit to sunlight. Recently, Indian Institute of Horticultural Research, Bengaluru, for the first time in the world, developed an environmentally-safe formulation 'Arka Saka Nivarak' for prevention of spongy tissue. "Arka Saka Nivaraka' liquid formulation needs to be applied twice at pre-harvest stage between 40 to 60% maturity, either by dipping the fruits (while on the tree) in solution or by spray on the fruits, @ 100 to 125ml/ litre. Dipping ensures

100% prevention of spongy tissue, while, spray results in 95 to 98% success as a few fruits may escape contact with the formulation.

Black Tip

This disorder of mango was first reported by Woodhouse in 1908 (Zhang *et al.*, 1995). It is a serious disorder, mainly in the cv. 'Dashehari'. The damage to the fruit begins right from marble stage with a characteristic yellowing of tissues at distal end which results in colour change to brown and then black. At this stage, further growth and development of the fruit is checked and black ring at the tip extends towards the upper part of the fruit. Several gases like carbon monoxide, sulphur dioxide and acetylene constituting the fumes of brick kiln damage growing tip of fruits and develop symptoms on fruit, and its incident inversely proportional to distance of the orchard from the brick kiln. Beside these factors, irrigation, condition of the tree and management practices also plays an important role in deciding the severity of the disorder. The affected fruits become unmarketable and reduce the yield to a great extent. Planting of mango orchards in North-South direction and 1.8-2.0 km away from the brick kilns may reduce incidence of black tip to a greater extent. The height of chimney of brick kiln should be at least 18-20 m. The incidence of black tip can also be minimized by spraying Borax (0.6%) at flowering initiation, during full bloom and after fruit set or other alkaline solutions like caustic soda (0.8%) or washing soda (0.5%) during 2nd week of March and 3rd week of April (Sharma, 2005a).

Leaf Scorch

When soil and/or irrigation water contain high amount of salt, rich in chloride ions, lead to scorching from the leaf margin towards midrib and from tip towards petiole and on the leaf simultaneously. In severe condition the leaf gives a burning effect and fall down from the tree leading to slowly dying of the shoots. The excess of chloride in soil or irrigation water makes potassium unavailable which leads to the deficiency of potash in the leaf. However, mango cultivation in such kind of soil and irrigation water should not be practiced. This deficiency can be overcome with spray of potassium sulphate 5% on young leaves of each new flush (Pandey and Sharma, 1979).

Clustering/Jhumka

Clustering in mango is characterised by the development of fruitlets in clusters at the tip of panicles appear as bunchy tip known as 'Jhumka'. These fruitlets are dark green in colour and having deeper curve in sinus beak region. Such fruits cease to grow beyond pea or marble stage and drop down after a month of fruit set. Inadequate population of pollinators in the orchards is the major cause.

The other reasons causing the disorder are old and overcrowding of trees, indiscriminate spraying against pests and diseases, use of synthetic pyrethroids, monoculture of 'Dashehari mango' and bad weather during flowering. Introduction of bee hives in the orchards during flowering season for increasing the number of pollinators and restricting insecticidal sprays at full bloom to avoid killing of pollinators will be helpful for reduction of this malady. Spraying of NAA @ 200-300 ppm during October-November is beneficial (Sharma, 2005a).

Fruit Pitting

A recent problem 'fruit pitting' has been observed in some Indian mango orchards. There is a development of some unattractive small sunken pits on the peel of developing fruit (Sharma and Shukla, 2006). These pits appear on all sides of the fruit with variable proportion and increase in size as the size of fruit increases. Development of such pits gives unattractive and unhealthy look to fruit, which affects the consumer acceptability. The variability in the incidence and degree of fruit pitting among the cultivars may be attributed to genetic differences (Sharma *et al*., 2006). Exotic cultivars suffer less than Indian cultivars due to the fact that all the exotic cultivars exhibit lesser dense canopies, and fruit with thicker peel.

Indian cultivars possess denser canopy which leads to poor penetration of light, which is required for the protein synthesis in the leaves and the nutrients translocation to fruit (Sharma and Singh, 2006). Thus, poor light penetration may be associated with higher incidence of fruit pitting in Indian cultivars. With regards to nutritional deficiency, Ca was significantly lower in pitted fruit than normal fruit, indicating that Ca deficiency is related to this disorder.

Table 1: List of important physiological disorders and their relative cause in fruit crops

Relative Cause	Disorders	Affected fruit crop	Reference
Nutrient related disorders	Internal necrosis	Aonla	Ram *et al.*, 1976
	Cracking	Bael	Saini *et al.*, 2004
	Leaf scorch	Mango	Pandey and Sharma, 1979
	Gummosis	Mango	Bhargava *et al.*, 2011
Temperature related disorders	Scorching	Litchi	Bhargava *et al.*, 2011
	Brown or Black flesh	Pine apple	Paull and Reyes, 1996
	Unfruitfulness	Aonla	Bhargava *et al.*, 2011
	Spongy tissue	Mango	Katrodia *et al.*, 1988
	Purple spot	Loquat	Gariglio *et al.*, 2003
Water moisture related disorder	Premature defoliation	Grapes	Satyanarayana, 1982
	Granulation	Citrus	Zong *et al.*, 1979
	Fruit cracking	Litchi	Huang *et al.*, 2003
Harmful gases related disorder	Black tip	Mango	Zhang *et al.*, 1995
Disorder due to genetic factor	Fruit cracking	Ber	Bhargava *et al.*, 2011
Disorder due to genetic factor	Alternate bearing	Mango	Singh, 1990
Disorder due to lack of pollination	Jhumka in mango	Mango	Negi, 1999
	Fruit drop	Mango	Pandey, 1998
Disorder due to phenolic oxidation	Husk scald	Pomegranate	Defilippi *et al.*, 2006
	External browning	Pomegranate	Abd El-Rhman., 2010

Papaya

Skin Freckles

Skin freckles are disorder of an inorganic nature which occurs most intensely on fruit surfaces directly exposed to solar radiation, however, the exact cause of this malady is not well understood. Blemishes are visible on both unripe and ripe fruit; the freckles develop during the later stages of fruit maturations and not seen in young fruit. The disorder occurs with minor incidence on cv. Golden of the Solo group. It appears as superficial dark brown spots on the skin of the fruit and these spots increase in size and engulfs several smaller spots forming large circular areas with a corky aspect on the fruit skin, so it is called "frog skin" or "Skin Freckles." These discolorations are concentrated on the parts of the fruit most directly exposed to direct sunlight and are most frequently found in the midface of the fruit. The soil water status for different irrigation depths (Filho, 2008) or climatic factors such as rainfall, and solar intensity together with plant characteristics, such as transpiratory capacity and fruit development stage, determine the frequency of physiological skin freckles in papaya (Reyes *et al.*, 1994). Same researchers also observed the positive correlation between the occurrence of this disorder and the beginning of the rainy season. The genetic feature is predominant in the susceptibly to skin freckles (Oliveira *et al.*, 2005). The increase in internal pressure of the laticifers' or laticifer's cells could be associated with environmental factors such as excess water in the soil and/or high relative humidity in the air (Reyes *et al.*, 1994), low temperatures, or very high daily thermal amplitudes (Downton, 1981). Environmental factors alone, acting upon the fruit tissue, are not able to trigger skin freckle symptoms. There is also a greater predisposition of the tissue as a result of the higher number of the laticifer arms near the epidermis (Kaiser *et al.*, 1996) and higher latex soluble solids (Reyes *et al.*, 1994). All these factors, associated with the genetic characteristics of plant material, may increase the internal pressure of the laticifer cells and consequently increase the occurrence of physiological blemishing. (Eloisa *et al.*, 1994) noticed that wrapping of young fruits in white paper bags reduce freckle incidence.

Pulp Flesh Translucency

Pulp flesh translucency is characterized by a translucent jelly like appearance of the mesocarp (Campostrini *et al.*, 2010 and Schripsema *et al.*, 2010). The symptoms extend from the endocarp to the exocarp but there is no visible outward sign of their presence. The fruit becomes dense due to low quantities of water accumulation in the seed cavities. This malady appears from color breakers stage, to the later stages of fruit development while it stay on tree and not seen in mature green fruit (Oliveira *et al*., 2010). Typical characteristic of pulp flesh translucency in fruit is detachment of the skin and outer layer mesocarp from the rest of the pulp making it possible to remove the skin with hand. The Golden cultivar of the Solo group exhibits the pulp flesh translucency disorder. Pulp flesh translucency in papaya suggests low quantities of water fill in the intercellular spaces, resulting in soaking of the mesocarp tissues (Oliveira *et al*., 2010). Same researchers stated that the wilting state of the cells as well as the firmness of the pulp allow to differentiate between pulp flesh translucency and premature ripening of the tissue.

Hard Lumps

High temperature stress leads to inactivation of the degradation enzymes in the cell wall. These enzymes prohibit ethylene emission and alter the colour of the papaya skin and pulp (Paull, 1995). The disturbance is characterized by the formation of deeply marked areas that appear on the mesocarp where the tissue is much firmer than in the neighbouring areas. Although no external symptoms are observed to distinguish it from unaffected fruits. The thermo tolerance can be stimulated artificially (Paull & Chen, 1990) or result from naturally occurring conditions in the growing environment; i.e., from pre-harvest climatic conditions (Paull, 1995). One of the factors thought to cause thermo tolerance is the synthesis of more heat shock proteins (HSPs) which are low molecular weight proteins able to revert the aggregation of other proteins when thermal stress occurs (Queitsch *et al*., 2000). Fabi *et al*. (2010) showed that the genes related to the productions of heat shock proteins are the most expressed during ripening. Exposure of papaya fruit for three days in the field to minimum temperatures above 22.4°C found to be responsible for the acquisition of thermo tolerance in these fruit, preventing the softening process in the pulp induced by standard hydrothermal treatment (42°C for 30 min followed by 20 min at 49°C).

Pomegranate

Fruit Cracking

It is a most serious physiological disorder which hinders its cultivation to a great extent. In young fruits it may be due to boron deficiency but fully grown fruit crack due to moisture imbalances or due to extreme variations in day and night temperature. (Abd El-Rhman, 2010). Prolonged drought causes hardening of peel and if this is followed by heavy irrigation then the pulp grows and the peel cracks and if harvesting of the mature fruit is delayed for long time or there is attack of insect pests it leads to cracking (Hoda and Hoda, 2013). This problem can be overcome by maintaining soil moisture and, cultivation of tolerant varieties. The water retention capacity of the plants should be increased by the use of organic manures. The plants should be irrigated regularly during the entire fruit development stage. Early harvesting and spray of calcium hydroxide on leaves and on fruit set reduces the incidence of fruit cracking. Foliar application of boron reduced the extent of fruit cracking in pomegranate (Singh *et al*., 2003). GA is used for improving fruit set and also to control cracking in various fruits including pomegranate (Sepahi, 1986). In later years Lal *et al*. (2012) observed that application of GA3 @ 40 ppm in pomegranate reduced fruit cracking. Some varieties like Sur-Anar, Francis, Shirvan, Krasnyl *etc*., tolerant to fruit cracking (Singh *et al*., 2006) can be cultivate.

Internal breakdown is another serious disorder in pomegranate which leads to 50-60 % loss. This disorder is mostly occurs in ambe bahar. Softening of fruits occur 90 days after anthesis and fruits become creamy-browny to dark blackish-brown from outerside and became a severe, if matured fruits retain on the plants for 140 days onwards. So, to avoide this disorder 130-135 days old fruits should be harvested (Sharma, 2005b).

Citrus

Granulation

It is a serious threatens to citrus industry worldwide, firstly reported by Bartholomew (Bartholomew *et al*., 1934). This abnormality is initiated at the stem end of the fruit which gradually extends towards the stylar end. The affected juice sacs become hard assume a greyish colour and become somewhat enlarged. Granulated fruits contain less extractable juice as most of it turns into gelatinous mass. This results in more quantity of rag and thus low pulp/rag ratio (Zong *et al*., 1979). The terms granulation, crystallization and dry end are used to describe this disorder. It is much more prevalent in larger sized fruits than in small fruit, in young than in old trees and in humid than in dry areas. Almost all citrus fruits suffer from granulation, but sweet oranges and mandarins are more severely affected than other types of citrus (Singh, 2001, Sharma and Saxena, 2004). Several factors like luxuriant growth, rootstock and the variety, frequent irrigation, mineral constituents in plant tissue, time of harvest, exposure to sunlight, *etc*., are found to be associated with this malady. The vigorous rootstocks like rough lemon increase the incidence of granulation as compared to less vigorous rootstocks. The incidence of granulation could be reduced to 50% by applying two to three sprays of NAA @ 300 ppm in the months of August, September and October. Spraying of GA3 @ 15 ppm followed by NAA @ 300 ppm in October and November also reduces granulation. Three spray of GA3 @ 15 ppm applied during August- September and October decrease the incidence and degree of granulation by 50 to 60% (Singh and Singh 1981).

Citrus decline

Citrus decline is caused by various biotic and a biotic factors. It is a syndrome where citrus plant look unhealthy/sick after satisfactory performance for a few years. Sparse foliage, chlorotic leaves twig drying symptom are associated with it. These symptoms of the affected citrus trees have been attributed to die-back disease at first and later the syndrome is called decline. According to Kanwar *et al*. (1965) soil condition leads to citrus decline. Improper and inadequate nutrition in soil lead to decline in India. The declining tree has low level of nutrients and more incidence of pre-harvest fruit drop than the healthy tree (Saini *et al*., 1999) The preventive measures for citrus decline are proper site selection, use of disease free and healthy planting materials, integrated nutrient and water management, plant protection, elimination of the common host plant and application of the tetracycline are some other recommended practices.

Fruit cracking is also a serious physiological disorder of citrus mainly in lemons and limes. It cause due to sudden rains or irrigation followed by prolonged drought, fluctuating soil moisture level, high N, deficiency of B and Ca *etc*. Adequate and regular irrigation particularly in summer should be needed for avoidance of this malady. Spray of NAA @ 100 ppm or GA3 @ 100-120 ppm during fruit growth period can control this disorder. Frenching or foliocellosis or mottle leaf is a another disorder of citur mainly occur due to deficiency of Zn and which is controlled by foliar application of Zinc sulphate @ 0.5% (Sharma, 2005c).

Grape

Berry Shrivels

This physiological disorder of grapevine affects berry development and decreases yield and quality of the crop. The causes of berry shrivel are unknown and no treatment exists for prevention or cure. Symptoms associated with berry shrivel are turgor loss, lack of sugar accumulation, high acidity contents and disturbed colour development through delayed anthocyanin synthesis mainly occurs in red varieties while rachis and pedicels do not show any kind of necrosis (Krasnow *et al*., 2009). Death of cells in the rachis are postulated to be involved in symptom development in cv. Cabernet Sauvignon and disturbed assimilate transportation to the berries may explain the ceased sugar accumulation and the shrivelling of berries in addition to water loss (Hall *et al*., 2011).

Flower-bud, Flower and Berry Drop

This problem has been reported from the states of Punjab, Haryana and Rajasthan in North India. Inadequate 'N' application, improper fertilization, high temperature, heavy crop load, uneven ripening and endogenous auxin deficiency at a particular stage of berry development are reported to cause the malady. GA, 20 and 50 ppm and parachloro-phenoxy acetic acid 20 ppm applied at 18 days before anthesis reduce the flower bud drop significantly in 'Thompson seedless' grape (Jawanda *et al*., 1974).

Hen and chicken

This disorder is widely fond disorder in grape growing regions in different parts of the world. In this disorder, many shot berries surround a bold berry and it looking like a hen as a bold berry and chicken as shot berries hence, the name given hen and chicken disorder. It mainly happens to the deficiencies of zinc and boron micronutrients and improper fertilization. So, foliar application of zinc and boron lead to controlling this malady. Pink berries also a prevalent disorder found in Maharashtra region in 'Thompson Seedless grape, cultivar. It causes due to high temperature during ripening which turns berries pink colour before harvest. Application of adequate doses of potash, 25-30 days prio to berry softening and treatment of benzyl adenine @ 10 ppm at berry softening stage helps to minimize the incidence of pink berry development in grapes.

Aonla

Internal necrosis

This is the main disorder of aonla in sodic soil which is deficient in micro nutrients (mostly 'B'). It is mainly nutrient related disorder however some newly developed cultivars have are comparatively free from this 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 found to exhibit higher productivity and fruits are free from necrosis indicating their suitability for fruit processing (Pareek *et al.*, 2014). Cultivar 'Francis' and 'NA-9' are most affected by necrosis. Necrosis is a micro nutrient deficiency related disorder. Combined spray of zinc sulphate (0.4%) + copper sulphate (0.4%) and borax (0.4%) during September-October has been found effective. Spray of 0.5 to 0.6 % borax in the month of September-October. Resistant cvs. like 'Chakaiya', 'NA-6' & 'NA-7' should be planted in the orchard for avoidance of this disorder.

Off Season Flowering

Off season flowering is also a serious problem in aonla production. The study conducted by Rai *et al*. (2002) revealed that a complex of situation is responsible for this disorder. An economical loss of 30 to 40% due to off season flowering in aonla was estimated by them. The main reason of this disorder may be global warming or due to some alteration in the tree physiology due to externally governed internal mechanism which leads to absence of distinct phase of dormancy after fruit harvest. Plant comes in partial flowering with predominance of male flower which do not set fruit, exhaust the plant and disturb the physiology and thereby reduce the crop load in the main season crop. In any case if some fruit set they do not develop properly and drop 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 lead plant to enter into dormancy.

Litchi

Fruit cracking is one of the serious problem for litchi growers, mainly in early bearing cultivars (Singh, 1986). This malady mainly occurs due to low atmospheric humidity, high temperature and hot winds during fruit development and maturity stage. (Kumar and Kumar 2007) reported that fruit cracking in litchi occur when trees are subjected to drought just after fruit setting. Regular irrigation during fruit setting and development helps to maintain soil moisture and improves humidity which minimizes the fruit cracking incidence. Singh (1986) observed that mulching with farm residues and 3 irrigations significantly reduced the cracking in litchi cv. 'Shahi'. In addition, spraying with either 100 ppm NAA or 0.2% borax during the developing stage of the fruits has been found to be highly effective in checking the cracking. Fruit drop is also a major problem in litchi production in India as well as abroad. Several factors like, varietal diversity, soil conditions, moisture relation, nutritions and hormonal regulation, number of developing fruits *etc*. responsible for fruit drop. It can be reduce by application of NAA and 2, 4-D @ 10-20 ppm (Sharma, 2005d). (Menzel and Waite 2005) found that Increase in relative humidity due to high rainfall lead to reduce fruit drop in litchi.

Loquat

The "purple spot" a physiological disorder of loquat fruit is related to an alteration of water relationships between the flesh and the rind caused by the simultaneous occurrence at fruit colour break the period of high sugar accumulation in the flesh in addition to a high fruit growth rate. The dehydration process is enhanced by cultivation practices like thinning intensity, and environmental factors-low temperature and sunlight exposure which affect sugar and mineral assimilation and partitioning in favour of the flesh, increasing the gradient of solute concentration between both tissues (Gariglio *et al*., 2008). Low temperatures at colour break correlated with purple spot incidence and its incidence was reduced by increasing night temperatures in a greenhouse (Gariglio *et al*., 2003).

Conclusion

Comprehensive knowledge about the causes and management approach of different physiological disorders in tropical and subtropical fruits will not only aid the quality production to fruit growers , but also it will be useful for researchers to generate an innovative ideas to control these disorders through biotechnological interventions, breeding strategies or by understanding a physiological basis to overcome it. So, keeping in mind all this information, there is an urgent need to understand the factors responsible for occurrence of these disorders at physiological level which are hindering the quality production and export potential of our country and also a need to follow a different management approach as mentioned in this chapter to manage a particular disorder.

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