Progressive Research – An International Journal
Vol. 4 (Special Issue) : 415-421 (2009), ISSN : 0973-6417

Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) INDIA

KEY TO UNLOCK THE LOCK OF PHYSIOLOGICAL DISORDERS OF SOME IMPORTANT FRUITS CROPS – A REVIEW

Sangeeta Kumari, Rashmi Rai, Ranjit Kumar and Birendra Prasad*
Rajendra Agricultural University, Pusa, Samastipur, Bihar
***Corresponding author** (Birendra Prasad) **Email :** birendragbau@gmail.com*

ABSTRACT

Physiological disorders are one of the major threats to fruit industry causing economic losses world-wide .In general, the problem arise due to unfavourable environmental conditions and improper cultural practices which affect the normal plant growth and development is called as physiological disorder of plant. The productivity as well as the quality of fruit crops is affected to a greater extent due to various physiological disorders. The extremes of environmental variables like temperature, moisture, light, aeration, and nutritional imbalances result in disturbances in the plant metabolic activities leading to these disorders. In fruit crops, the deficiency of micronutrients causes many more disorders than that of macronutrients. These disorders have become widespread with diminishing use of organic manures, adoption of high density planting, use of root stocks for dwarfing, disease and salt tolerance, unbalanced NPK fertiliser application and extension of horticulture to marginal lands. To get high quality fruit and yields, micronutrient deficiencies have to be detected before visual symptoms are expressed. This article presents a critical review on cause and characteristics of physiological disorders in important fruit crops *viz.* litchi, guava, citrus, aonla, pomegranate, sapota, coconut, bael, ber and jackfruit, besides providing materials for researchable issues. This will also help in the formulation of management strategies, reducing the loss to a significant level.

Key words : *Physiological disorders, commercial fruit crops.*

India ranks second in fruit production in the world after China. Different types of perennial fruits are grown in India, among which litchi, guava, citrus, aonla, pomegranate, coconut, sapota, bael, ber, cashew, jackfruit having high economic values and alsoexport potential. They also provide livelihood security to the fruit growers and nutritional security at national level. Hence greater attention is required towards increasing the quantum and quality production by preventing the losses due to various factors. Approximately 70% of crop yield reduction due to abiotic factors (Acquaah 2007). Though, India is the second largest producer of fruits in the world, the productivity in India is dismally low. Reasons for low productivity of fruit crops in India are primarily physiological or stress related disorders such as alternate bearing, unfruitfulness, fruit drop, fruit cracking, sun-burn or scorching, malformation, wilt, granulation, deformities etc. rather than biotic and other related factors (Sharma 2006). Abiotic factors negatively affect the crop productivity worldwide, leading to a series of morphological, physiological and biochemical changes that adversely influence plant growth and development (Chattopadhyay 1994).This is further complicated by climate change scenario involving an array of ecological stress factors like increased atmospheric temperature and decreased soil osmotic potential caused due to uneven, irregular and unpredictable rainfall pattern. If we look at the production of these fruit crops, we find that the adverse climatic conditions singularly or in combination induce cellular damage and change in physiological processes in plant body ultimately affecting the fruit production. The plant architecture above the ground and the root system below interact with the environmental, edaphic and genetic factors causing physiological disorders.

Physiological disorders of some important fruit trees : Some important physiological disorders, their possible causes and suggested corrective measures for important commercial fruit crops are discussed here.

Litchi (*Litchi chinensis* Sonn.) : Litchi is affected by many physiological disorders like fruit cracking and splitting, flower and fruit drop, sunburn, retarded fruit development, irregular bearing and black tip etc. The incidence and severity of these physiological disorders vary with locality, season, cultivar and orchard management practices (Kumar and Kumar 2008).

Fruit cracking : This is the most important disorder occurring in almost all the important litchi growing

countries of the world causing losses as high as 5-70% (Menzel and Waite 2005). This disorder is associated with hot dry weather, drought and low calcium concentrations. It has been observed that early ripening cultivars under poor management practices are more susceptible to this disorder. The other nutrient element found to be associated with fruit cracking is boron (deficient soils). A high concentration of abscisic acid and low gibberellins has been found in the fruit pericarp, seed and aril of cracked fruits. Insects, hail, and the sun can damage the skin during cell expansion and induce cracking towards harvest. In general, it has been observed that fruit skin cracking often occurs when there is sudden change in soil moisture or there is drought soon after fruit set. Cell division is reduced and the fruit skin becomes inelastic, and often splits when the aril grows rapidly before harvest. This can occur after irrigation or heavy rain, or just after an increase in relative humidity. It has been reported that application of calcium @2ml/L liquid formulations and gibberellins @20 ppm reduced the activity of cellulose and thereby reduced cracking (Sinha *et al.* 1999, Peng *et al*. 2001, Kumar and Kumar 2008).Boron sprays in the form of borax or boric acid @ 2g/L at the initial stage of aril development in conjunction with sufficient soil moisture in the root zone prevented from fruit cracking significantly (Kumar and Kumar 2008). Constant moisture and appropriate humidity isneeded at the time of fruit maturity. Irrigation at 30-40% depletion of available soil moisture is quite helpful in reducing cracking of fruits. The soil moisture conservation in the root zone for prolonged period can be achieved by providing mulching beneath the canopy (Sharma 2006, Kumar and Kumar 2008).

Sunburn : Occurrence ofsunburn on fruits is a serious problem in litchi producing countries like India, South Africa, Australia and Thailand (Kanwar and Nijjar 1972, Sanyal *et al.* 1990, Menzel *et al*. 2002).The fruits in orchards having scanty irrigation during fruit development stage favour sunburn (Menzel and Waite 2005).In light and sandy soils, only light irrigation with increased frequency (4-5 days interval) is found to reduce the chances of sunburn in farmers field (Kumar and Kumar 2008).The trees provided with sufficient quantities of organic manures such as compost, FYM, cakes, green manure, vermicompost, and irrigation applied at regular interval during fruit development and ripening stage prevents fruits from sunburn. Raising wind break around the orchard have also been found to reduce sunburn problems.

Flower and fruit drop : Litchi trees suffer a heavy flower and fruit drop between flowering and fruit maturity. Only a small proportion of flower (2-18%) is carried up to maturity in different cultivars. The quantum of flower and fruit drop varies with variety, season and tree age.The fruit drop may occur due to failure of fertilization, embryo abortion, nutrition and hormonal imbalance and external factors like high temperature, low humidity and strong westerly winds (Chadha and Rajput 1969, Menzel 1984, Sharma and Ray 1987). Timely treatment of plants for strong and healthy shoot production delays flowering phase and increases the female flower ratio and finally the fruit-set. Visits of honey-bees in orchards ensure better pollination and fertilization which increases the fruit set and retention.

Irregular bearing : Irregular bearing is a serious problem in almost all litchi growing areas of the country and abroad (Mustard *et al.* 1956). It has been observed that capacity of litchi shoots to bear is cultivar dependent while some bearing terminals of current year are more productive (70-95%) in the next year. Faulty management practices include late application of manures and fertilizers (particularly nitrogenous fertilizers), high frequency and heavy irrigation just before the panicle emergence and flowering period. Late harvesting and severe pruning and training operations may lead to non bearing in that particular year of operation.Applying proper nutrition, irrigation and controlling insect-pest infestation can significantly reduce the intensity of this malady. The proper pruning and training operations (semicircular canopy) give rise to strong and healthy flush that bear fruits in ensuing season. Late pruning and training should be avoided (Kumar and Kumar 2008).

Retarded/underdeveloped fruits : This disorder is not well documented but cause considerable loss due to poor quality fruits (Kumar and Kumar 2008). Ensuring presence of pollinators in the bearing orchards during flowering to fruit set stage and spraying plain water in early morning hours of the day during the advanced stage of fruit growth and development have been found highly effective. An arrangement of sprinkler system of irrigation may be done to reducing this disorder (Kumar and Kumar 2008).

Black tip : The occurrence of black tip is not widespread in litchi as in case of mango. This symptom has been observed in plantation mainly in vicinity of urban areas and appears to be due to deleterious effect

of smoke fumes which contain SO_2, C_2H_2 and CO_2. A small etiolated area at the distal end of the fruit develop against the normal green colour of the fruit pericarp, which gradually spreads, turns nearly black and covers the distal end completely. In the affected fruits, there is poor development of aril, seed, size and colour (Kumar and Kumar 2008). Foliar spray of zinc ($ZnSO_4$ @ 0.2%) one month before panicle initiation and boron (borax @ 0.2%) during fruit growth phase have been found to prevent this disorder.

Chilling injury : Chilling injury to litchi fruits is mainly a post-harvest disorder which occurs when there is disturbance in maintaining cool chain during fruit storage and marketing. Both temperature and duration of exposure of fruit at low temperature are important. Cultivar and growing conditions are also responsible factors for this injury (Menzel and Waite 2005, Kumar and Kumar 2008).As remedial measures the harvesting of fruits in early morning and operations like sorting, grading and packaging should be done properly in pack-houses.Transportation in refrigerated vans without breaking the cool chain can avoid the occurrence of this injury on fruits.

Guava (*Psidium guajava* L.) :

Bronzing : Bronzing in guava is a complex nutritional disorder. This disorder is very common in marginal soils of Karnataka. It manifests as development of bronze or copper colour in the interveinal tissue of older leaves while terminal ones remain green. It is due to the deficiency of P, K and Zn elements. It is also attributed to poor management and low fertility of soils coupled with soil acidity. Total defoliation, brown coloured patterns on the fruits skin and reduced yield is noticed in severe cases. Bronzing in guava was more severe on Entisols, followed by Vertisol and Inceptisols. Avoiding guava plantation in acidic soils or soils with high water table along withgood cultural practices including balanced irrigation, soil pH and nutrition prevents from this disorder. Foliar application of 0.5% diammonium phosphate and Zinc sulphate in combination at weekly intervals for two months reduced bronzing in guava. Pre-flowering sprays with 0.4% boric acid and 0.3% zinc sulphate increased fruit yield and fruit size.

Fruit drop : Fruit drop is a serious concern in guava as it results in about 45-65% fruit loss which is attributed to environmental factors. This occurs due to poor fertility status of soil, poor moisture content in the rhizosphere during fruit growth, hormonal imbalance and attack of insect pest and diseases (Sharma 2006). Proper plant protection measures and spraying of GA_3 has been found to be effective in reducing fruit drop in guava.

Citrus (*Citrus* spp.) :

Granulation : Granulation is a serious problem of citrus, especially under North Indian conditions. This abnormality starts at the stem end of the fruit which gradually extends towards the stylar end. The affected juice sacs become hard and dry; fruits become grey in colour, enlarged in size, have flat and insipid taste and assume a granular texture. Granulated fruits contain less extractable juice as most of it turns into gelatinous mass (Srivastava and Singh 2005). Many factors have been associated with the development of granulation such as advanced fruit maturity, large fruit size, excessive tree vigour, severe mite infestation/damage, composition of the juice, cool dry and windy weather conditions. Tree water status and irrigation have also been reported as responsible causes. Changing cultural practices (i.e. fertilization and irrigation) and use of rootstocks that encourage vigorous tree growth may favour this disorder. Species and cultivars variability in this case has also been reported as sweet oranges are more prone than tangelos, grape fruit and mandarins (Sharma 2006).The incidence of granulation could be reduced by applying two to three sprays of NAA (300 ppm) in the months of August, September and October. Spraying of GA @15 ppm followed by NAA @300 ppm in October and November also reduce granulation.

Citrus decline : Citrus decline is not a specific disease but is an integrated expression of many disorders in a plant. The term decline actually signifies continuous dying of the twigs. Tree grows well for the first 5 to 6 years, but thereafter, they show retarded growth and become unproductive. In severe cases, they may wilt and die. The improper and inadequate nutrition as well as low organic matter, excess of Fe, higher uptake of Mn and non-availability of micronutrients like Zn, Cu, Mg and boron aggravate tree decline (Srivastava and Singh 2005 and 2008). Apart from these the excessive irrigation, water stagnation and use of saline water also lead to citrus decline. Pests such as citrus leaf miner, fruit sucking moth, lemon butterfly, aphid, psylla and mites damage the crop either by direct feeding or acting as vectors for transmission of viruses. The incidence of citrus nematode (*Tylenchulussemipenetrans*) and burrowing nematode (*Radopholussimilis*) also contribute towards citrus decline. Incidence of fungal

diseasessuch as *Colletotrichum gloeosporiodes*, and *Phytophthora* spp. (foot rot) are predominantly associated with dieback in most of the citrus orchards in India. In India, virus and virus like pathogens which have been associated with die back are crinkly leaf, infectious variegation, exocortis, leathery leaf, mosaic, tristeza, rubbery wood and greening (Sharma 2006).Due to the prevalence of soil salinity, viruses and nematode problems in different regions, it is highly desirable that rootstocks be thoroughly evaluated before use. Proper drainage, avoiding excessive irrigation and following clean cultivationis important to reduce the incidence of this disorder.

Fruit cracking or splitting: Cracking or splitting is common physiological disorder of citrus fruits which is especially related with limes and lemons. Lemons are more prone to fruit cracking than limes. Splitting may be radial (Longitudinal) or transverse, radial being more common. The split may be short and shallow or it may be deep and wide, exposing the segments of the juice vesicles. The cracked fruits become entry points for micro organisms making them unfit for human consumption.

Puffing : Puffing disorder of citrus fruits occurs before it reaches to maturity. The causes of this disorder have been related to the water exchange regulation through peel. Accordingly, high RH together with high temperatures at fruit colour break stage increases the appearance and intensity of puffing, particularly in the period of drought.

Aonla(*Embelica officinalis* Gaertn.) :

Internal necrosis : Internal necrosis has been observed in aonla fruits. Cultivar 'Francis' is highly susceptible followed by 'Banarsi'. The symptoms starts with browning of inner most part of mesocarpic tissue at the time of endocarp hardening in the 2ndor 3rd week of September which later extends towards the epicarp resulting into brownish black appearance of flesh. Internal fruit necrosis is associated with boron deficiency during the fruit development. Infection has not been noticed on other aonla cultivars like 'Chakiya', 'NA-6' and'NA-7' which need to be encouraged for commercial cultivation (Pathak *et al*. 2003). Combined spray of zinc sulphate (0.4%) + copper sulphate (0.4%) and borax (0.4%) during September-October has been found effective.

Fruit drop : It is a serious problem in aonla which influences the final yield of crop. There are phases (three waves) of flower and fruit drop, observed in aonla(Bajpai and Shukla 1990). In case of the first wave, more than 70% flowers drop within three weeks of flowering which is normally due to lack of pollination, while during the second wave the drop is that of young fruitlets at the time of dormancy break and in last i.e., third wave the drop of fruits is due to embryological and physiological factors and it is spread over the entire period of the fruit development. It starts from later half of August and continues up to harvest (Bajpai and Shukla 1990). Fruit drop results due to many factors such as dry spell, imbalance of hormones, improper nutrition, fluctuation in temperature, cultivars and age of tree, and number of developing fruits. Also delay in harvesting results in heavy fruit drop particularly in 'Banarasi' and 'Francis' cultivars (Shukla *et al*. 2000).

Pomegranate (*Punica granatum* L.) :

Fruit cracking : Fruit cracking is a serious problem of pomegranateparticularly in arid climate. Cracked fruits are sweet but unfit for long distance transportation. Incidence of cracked fruits varies from 10 to 70% depending upon the prevailing environmental conditions .Longitudinal or radial splitting of rind surface occurs. The longitudinal cracking is more prevalent where the crack originates at the navalor styler end while radial cracking originates between the ends. The cracked fruits are breeding grounds for insects, harmful bacteria and fungi making fruits unfit for marketing and consumption. The '*Mrigbahar'* crop is more susceptible to cracking than the crop of other *bahars*. Various factors are responsible for fruit cracking which include fluctuation in soil moisture regimes, climate, tree nutrition and cultivars. Young fruits cracks due to boron deficiency while fully developed fruits cracks due to variation in soil moisture content, atmospheric humidity and temperature. Prolonged drought causes hardening of peel and if this is followed by heavy irrigation or downpour than the pulp grows and the peel cracks). The intensity of fruit cracking varies with cultivars and season. Cultivars such as 'BedanaBosec', 'Khogand', 'Jalore Seedless' are comparatively crack tolerant whereas 'Guleshan', 'Khog', 'Kazaki', 'Sur-Anar', 'Francis', 'Shrivan', and'Krasnyl' are reportedly resistant to fruit cracking. Varietal features like rind thickness and texture determine the susceptibility to cracking.The management strategies include growing of resistant or tolerant cultivars, proper selection of '*bahar*', use of Pinolene (5%) as vapour guard, spraying GA_3 (120ppm), liquid paraffin (1%) at 15 days interval, twice

during June, application of borax (0.1%)or calcium hydroxide on leaves and fruits after fruit set. Adequate calcium and potassium levels as per soil test values need to be maintained (Singh *et al.* 2006, Sharma 2006). In hot dry period fruits should be covered with butter paper bags apply adequate and regular irrigation during fruiting season. The water retention capacity of the plants should be increased by the use of organic manures and then regular irrigation to maintain soil moisture is some of the measures which can reduce fruit cracking..

Sun scald : Surface skin of fruits facing afternoon sun turns brownish black due to scorching while underneath skin is normal.To avoid this disorder proper canopy architecture should be developed which prevent the direct exposure of fruits to sunlight. Spraying kaolin during the hot summer months is useful in reducing sunscald. First spray of 5% and subsequently 1 or 2 additional spray with kaolin @2.5% at 15 days interval reduce sunscald. Bagging the fruits with butter paper covers is useful in minimizing fruit spoilage due to sunscald. White colour bags are more effective in reflecting sunlight and protecting the growing fruits.

Aril browning : In many cases, the intensity of the disorder in mature ripe fruits could be more than 50% causing severe loss of quality. As the fruits affected by this disorder remain free from external symptoms, they cannot be separated out before being packed, thus posing serious problems in export. Aril breakdown or browning is characterized by soft, light creamy, brown, dark blackish or brown and slightly flattened arils which are deformed and possess an unpleasant odour when the fruit is cut open. This disorder is accompanied by desiccation, wrinkling and development of internal spaces in the arils. Experimental studies indicated that the juice and seed content of affected fruits have reduced level of TSS, acidity, ascorbic acid, reducing sugars, calcium, phosphorus, and enzyme catalase and increased level of non-reducing sugars, starch, tannins, nitrogen, potassium, magnesium, boron and enzyme polyphenol oxidase compared to healthy fruits.

Sapota (*Manilka razapota* L.) :

Fruit drop : Sapota has the problem of low fruit setting and shedding. Only about 10-12% of the total set fruits develops and retained till maturity. Most of the fruit-drop occurs immediately after fruit setting. Increase in fruit set and retention are possible by spraying NAA and GA_3 at 25 to 100 ppm during flowering and at 15-day interval.

Corky tissue : Corky tissue (CT) of sapota is characterized by hard lump in the pulp, slightly desiccated in nature and acidic to taste. This disorder shows no distinct external symptoms and becomes visible only when the fruit is cut open. Under severe conditions, corky skin eruptions are seen (Sulladmath 2005). CTis prevalent in the cultivar 'Cricket Ball' (up to 35%). Past studies have shown that the CT affected fruits have a lower concentration of sugars associated with the accumulation of starch as compared to healthy fruits. Being a climacteric fruit, sapota ripens rapidly under optimal environmental conditions after harvest. However, the CT fruits exhibit a lack of uniform ripening and the probable cause of such impaired ripening has been correlated by the changes in the rates of conversion of starch involving the activities of -amylase, starch phosphorylase and acid phosphatase enzymes.

Coconut (*Cocos nucifera* L.) :

Barren nuts : The occurrence of nuts without or with imperfectly developed kernel is known as barren nuts or seedless or imperfect nuts and it is a common phenomenon in coconut (Sharma 2006).The affected nuts are oblong in shape as compared to round shape of the normal nuts and the quantity of husk produced is less as compared to normal. The most common feature of the barren nut is frequent splitting of the shell during the period of development. The major causes attributed to this disorder are: the defective fertilization or poor pollination, nutritional deficiency such as K and B in the palm and increased production of palm in the tree. The production of barren nuts can be reduced to a greater extent by proper thinning of nuts with adequate application of P and B along with normal recommended dose of fertilizers (1 kg muriate of potash + 200 g of borax + RDF) (Sharma 2006). The general practice of applying common salt has also been found beneficial in reducing this malady.

Button shedding : Button shedding and premature nut fall are commonly observed disorder which results in considerable loss in nut yield. This phenomenon of shedding of buttons varies from 55-95% depending on conditions prevailing and on the cultivar of coconut. A large number of female flowers in the inflorescence fail to fertilize which do not develop into nuts and eventually shed. The female flowers or buttons shed after fertilization and some of the nuts fall prematurely after

setting. The fall of immature nuts at a later stage of development often causes considerable loss of crop. The shedding of buttons is comparatively heavier in the dwarf palms than in the tall ones .The occurrence of this malady can be managed by application of proper irrigation by avoiding drought. Maintaining good tilth by proper ploughing and better soil aeration. Thinning of bunch after two months by cutting away the nuts that are observed to lag behind in general development and those found crowded in the bunch reduces the incidence and provides sufficient space for development of remaining nuts. Root feeding of coconut with 40 ppm of NAA reduces the button shedding and increases nut yield. The effort of application of 2, 4- D @ 30 ppm one month after the opening of the spathe can be made for correcting the ill effect caused of lack of pollination (Janik and Paull 2006).

Bael (*Aegle marmelos*) :

Fruit cracking : Fruit cracking is an important physiological disorder found in some commercial cultivars of bael, which occurs just before the ripening stage. It is associated with sudden change in weather conditions such as temperature and humidity. Heavy irrigation or rainfall after prolonged drought is also one of the causes of this malady (Pandey *et al*. 2005).These can be managed by providing good irrigation facility, making wind breaks around the orchard and by spraying borax @ 0.1% twice at full bloom and after fruit set. The deficiency of nitrogen and zinc is common in bael orchards and can be corrected by soil application or foliar spray.

Fruit drop : The large number of flowers and fruits borne by trees are not carried to maturity and a portion of this drop during the course of development. Fruit drop is a serious problem in bael which occurs due to many factors such as strong winds, imbalance of soil moisture, improper nutrition and hormonal imbalance (Pandey *et al*. 2005). This malady can be managed by maintaining the appropriate soil moisture level during fruit development, spraying of growth regulators (2,4-D, GA_3 and 2,4,5-T at recommended concentrations) (Sharma 2006).

Ber (*Ziziphus mauritiana* Lamk.) :

Fruit drop : Fruit drop in ber tree may be due to any one or combination of many reasons as disintegration of ovules, shrivelling of fruits and high incidence of powdery mildew. Fruit drop depends on cultivar, maturity period of cultivar (early, mid or late) and extent of fruit set, and bearing of tree (Pareek 1983). Fruit drop has been found to be reduced byapplication of either 2,4-D (10-20 ppm) or 2,4-5-T (5-10 ppm) or GA_3 (25 ppm) in cultivars like 'Kaithali','Umran', by timely irrigation of trees after fruit set, by application of adequate quantity of organic manures fertilizers during fruit development (50 kg FYM, 250 g N + 50 g P_2O_5 + 50 g K_2O per tree after pruning and fruit set), by application of NAA @ 10ppm at fruit bloom (Singh and Singh 1976) and by foliar application of borax and zinc sulphate. Maximum fruit retention and minimum fruit drop was recorded in the trees sprayed with 1.5% potassium sulphate and 20 ppm NAA at fruit set stage by Singh and Bal (2006).

Jackfruit (*Artocarpus heterophyllus* L.) :

Irregular shape : The irregularly shaped jackfruit occurs due to boron deficiency in the fruit(Janik and Paull 2006). Nutrition plays a vital role and boron is the key to improved flowering, fruiting, and internal and external fruit quality in jackfruit.

Premature fruit drop : Premature fruit drop in jackfruit is often related to unfavourable environmental conditions, irregular watering, improper nutrition and hormonal imbalance (Ghosh 2000, Janik and Paull 2006). This causes huge economic loss to the growers every year. For mature tree watering must be done during dry period from blooming to throughout the growth and development period of fruit.

From the review it is clear that physiological disorders have become menace in many fruit crops resulting in huge losses to growers. There is a need for long-term quantitative documentation of tree phonological patterns in diverse climatic zones of India. Recent advances in physiology and genetics may help solve problems of perennial fruit tree production. Though molecular biology have greatly improved our understanding of plant responses to stresses in many important commercial horticultural crops, a lack of transcriptomic and genomic information hinders our understanding of the molecular mechanisms underlying fruit-set and fruit development. There is need for exhaustive studies to know the precise physiological significance of radiation effect in climatic fastidious fruit crops. Intelligent anticipatory management strategies and adaptation will be the critical components for successful and sustainable quality fruit production. Management aspects may include biophysical treatments including reclamation of deficiency and excess of nutrient elements by proper

fertility status maintenance, timely agronomical operations and input application. Location specific management strategies for important perennial fruit crops will require focused attention through multidisciplinary approach including adaptation and management.

REFERENCES

1. Acquaah G. 2007. Principles of plant genetics and breeding, Blackwell, Oxford, UK.
2. Bajpai P N and Shukla H S.1990. Aonla. *(In) Fruits: Tropical and Subtropical* pp 757-767. Bose T K and Mitra S K (Eds). *Naya Prakash Publishers*, Kolkata, India.
3. Chadha K L and Rajpoot M S. 1969. Studies on floral biology, fruit set and its retention and quality of some litchi varieties. *Indian Journal of Horticulture 26:* 124-129.
4. Chattopadhyay T K. 1994. A textbook on pomology Vol I: Fundamentals of fruit growing. *Kalyani Publishers*, New Delhi pp.144-185.
5. Ghosh S P. 2000. Status report on genetic resources of jackfruit in India and SE Asia. *IBPGRI South Asia Office*, New Delhi, India.
6. Janik J and Paull R E. 2006. The Encyclopaedia of Fruits and Nuts. *CABI Publications*, pp 107-118.
7. Kanwar J S and Nijjar G S. 1972. Fruit growth studies in litchi (*Litchi chinensis*Sonn.) at Gurudaspur (Punjab). *Punjab Horticulture Journal 12:* 146-151.
8. Kumar K K andKumarR. 2008. Managing physiological disorder in litchi. *Technical Bulletin-5, ICAR-NRC on Litchi.* Muzaffapur, Bihar, India.
9. Menzel C M and Waite G K. 2005. Litchi and Longan: Botany, Production and Uses. *CABI Publishing,* Wallingford, Oxfordshire, UK.
10. Menzel C M, Bagshaw J, Campbell T, Greer N, Noiler J, Olesan T and Waite G K. 2002. *Lychee Information Kit*. Queensland Department of Primary Industries. Nambour, Australia.
11. Menzel C M. 1984. The pattern and control of reproductive development in litchi: A review. *Scientia Horticulturae 22:* 333-345.
12. Mustard M J, Nelson R O and Goldweber S.1956. Exploratory study dealing with the effect of growth regulators and other factors on the fruit production on the lychee. *Proceedings of the Florida State Horticultural Association 3:* 33-38.
13. Pandey D, Shukla S K and Nath V. 2005. Diversity of bael (*Aegle marmelos* Correa) in Bihar and Uttar Pradesh. *Progressive Horticulture 31:* 359-62.
14. Pareek O P. 1983. *The Ber*. *ICAR Publication,* New Delhi.
15. Pathak R K, Pandey D, Haseeb M and Tandon D K. 2003. The Aonla. *Bulletin* CISH, Lucknow, India.
16. Peng J, Xi J B, Tang X D, Wang Y G, Si X M and Chen J S. 2001. Effect of $Ca(NO_3)$ and GA spray on leaves on the fruit cracking of 'Nuomici' litchi. *Acta Horticulturae Sinica 28:* 348-350.
17. Sanyal D, Ahsan A, Ghosh B and Mitra S K. 1990. Studies on sunburning and skin cracking in some varieties of litchi. *Indian Agriculturist 34(1):* 19-23.
18. Sharma R R. 2006. Physiological disorders in tropical and subtropical fruits: causes and control. *(In) Fruit Production-Problems and Solutions* pp 301-325. *International Book Distributing Co.,* Lucknow, UP, India.
19. Sharma S B and Ray P K. 1987. Fruit cracking in litchi-A review. *Haryana Journal of Horticultural Science 16:* 11-15.
20. Shukla A K, Pathak R K, Tewari R P and Nath V. 2000. Influence of irrigation and mulching on plant growth and leaf nutrient status of aonla under sodic soil. *Journal of Applied Horticulture 2(1):* 37-38.
21. Singh C and Bal J S. 2006. Effect of nutrients and growth regulators on fruit drop, size and yield of ber (*Zizyphusmauritiana*Lamk.) *International Journal of Agricultural Sciences 2(2):* 358-360.
22. Singh D B, Kingsley A R P and Jain R K. 2006. Controlling fruit cracking in pomegranate. *Indian Horticulture 51(1):* 14-32.
23. Sinha A K, Singh C and Jain B P. 1999. Effect of plant growth substances and micronutrients on fruit set, fruit drop, fruit retention and cracking of litchi cv. Purbi. *Indian Journal of Horticulture 56:* 309-311.
24. Srivastava A K and Singh S. 2005. Diagnosis of nutrient constraints in citrus orchards of humid tropical India. *Journal of Plant Nutrition 29(6):* 1061-1076.
25. Srivastava A K and Singh S. 2008. Citrus decline: soil fertility and plant nutrition. *Journal of Plant Nutrition 32(2):* 197-245.
26. Sulladmath V V. 2005. Studies on the pattern of mineral nutrient accumulation in developing sapota (*Manilkaraachras* (Mill.) Fosberg) fruit with special reference to internal breakdown, *Ph.D. Thesis, Dr.Bhimrao Ambedkar University*, Agra, Uttar Pradesh, India.