Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 6, 2021, Pages. 925-947
Received 25 April 2021; Accepted 08 May 2021.

FRUIT DROPS IN MANGO: A REVIEW

ASHOK KUMAR[1], B.D.BHUJ[2], C.P.SINGH[3],

[1] *Associate Professor, Department of Horticulture, SGT University, Gurugram,, Haryana, [NCR Delhi]*
[2] *Professor Horticulture, College of Agriculture, G.B.P.U.A &T- Pant Nagar, U.P., India*
[3] *Professor Horticulture, College of Agriculture, G.B.P.U.A &T- Pant Nagar, U.P., India*

Abstract

Mango (Mangifera indica L.), the sixth most important fruit crop worldwide, Mango produces an abundance of male and polygamous flowers, but only a small proportion of the latter group is successfully pollinated and has the potential for setting fruit. Numerous abiotic and biotic factors reduce pollen viability, the fertilization process of the flower, and embryo survival, which are all commonly associated with extensive fruit drop in early season. The gibberellin content in seed increased rapidly during early seed growth and declined as growth decreased. The seed was the major source of gibberellin in the fruit, the pericarp containing only traces. Cytokinins were present both in pericarp and seed. During the single period of rapid growth in fruit and seed, cytokinin concentrations increased rapidly at two periods. The first rapid increase in cytokinin concentrations preceds the period of rapid cell division and cell enlargement and the second increase coincide with the period of rapid cell enlargement only. The level of ABA-like inhibitor was high in the first 21 d preceding pollination which corresponded with the period of slow growth in fruit and heavy fruit drop. During the rapid period of fruit growth, the level of inhibitors decreased and that of promoters increased. However, in maturation and slow fruit growth period, the levels of both the growth promoters and inhibitors were low. The number of pollinators/panicle/minute increased as the average temperature increased to 19.5°C but decreased with further increase in temperature and with rains. Isolates of Trichoderma spp. (ACB-14, ACB-33, ACB-37, and ACB-40) and Bacillus subtilis (ACB-66, ACB-69, ACB-77, and ACB-83) were tested separately or in mixtures for suppression of postbloom fruit drop in citrus, caused by Colletotrichum acutatum.

Keywords: Fruit Retention; Intercropping; Irrigation; Mangifera Indica; Plant Growth Regulator

1. Introduction

Mango (*Mangifera indica* Linnaeus) is one of the most popular and earliest cultivated fruits of tropical and sub-tropical regions, and is grown in more than 100 countries. It is ranked the second most cultivated tropical fruit and sixth major fruit crop worldwide], and the fruit has a high cropping potential under climate change scenarios. Mango production in the country is estimated to lower by 4.36 per cent at 20.44 million tons (MT) in the crop year 2019-20 ending this month, the latest data from the agriculture ministry said on Tuesday. The output of mango, the king of fruits, stood at 21.37 MT during the 2018-19 crop year (July-June). The arrival of mangoes from the southern and western India has started, while the season in the northern states like Uttar Pradesh will begin from mid-June onwards. However, production of other summer fruits muskmelon and watermelon is estimated to be higher than the previous year, as per the second estimate of horticultural crop production released by the ministry for the crop year 2019-20. Therefore, mango fruit appears to be one of the critical food sources for the consistently growing world population. The genus *Mangifera* is one among the 73 genera belonging to the family Anacardiaceae in the order Sapindales. Mango (*Mangifera indica*) has been cultivated for more than 5000 years and a wide genetic diversity exist in this crop. The largest number of Mangifera species are found in the Malay Peninsula, the Indonesian archipelago, Thailand, Indo-China and the Philippines. Edible fruits are produced by at least 27 species in the genus.

The malady is one of the most serious and destructive diseases of mango in nature (Prakash and Srivastava, 1987; Kumar and Beniwal, 1992; Ploetz, 2001) because of economic losses faced every year vary between 5-30% (Srivastava, 1998) or as high as 80% (Ginai, 1965). Maximum loss in India due to this deformation is 86%, in South Africa 73% of the mango farms are affected and severity varies from 1-70% (Kumar et al., 1993). Distribution of mango malformation disease in the world: Mango malformation was first reported in India in 1891 by Kumar and Beninwal The worldwide production of mango (Mangifera indica L.) is frequently reduced by severe losses of fruit numbers throughout the growing season, a phenomenon that is referred to as premature fruit drop (Singh et al., 2005). Mango produces an abundance of male and polygamous flowers, but only a small proportion of the latter group is successfully pollinated and has the potential for setting fruit (Mukherjee, 1953; Singh et al., 1966). Numerous abiotic and biotic factors reduce pollen viability (Issarakraisila and Considine, 1994), the fertilization process of the flower, and embryo survival (Lakshminarayana and Aguilar, 1975), which are all commonly associated with extensive fruit drop in early season (Singh et al., 2005). Fruit that remains attracts a greater share of the available tree resources for continued growth and development. Subsequent fruit drop is induced by any factor reducing carbohydrate availability and thus the demand of the growing fruit is not sufficiently matched by its supply (Wünsche and Ferguson, 2005). This carbohydrate imbalance can occur, for example, by air temperatures below 13 °C or exceeding 36 °C as a result of heavily reduced leaf photosynthesis rates (Issarakraisila and Considine, 1994; Whiley et al., 1999; Yamada et al., 1996).

For mango, principal phenological growth stages are distinguished (Hernández Delgado et al., 2011) according to the general BBCH-scale (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie); however, fruit drop is only described in Stage 7 with “beginning and end of the physiological fruit drop” when fruits have attained 10% or 30% of final fruit size, respectively. The premature fruit drop stages have been named invariably and there is also no common agreement on the number of drop stages as well as the onset and duration of each. Dahshan and Habib (1985) originally described three distinct stages of premature fruit drop of mango and this classification was also used in the review of Singh et al. (2005). The first stage is referred to as “post-setting drop” and ceases 60 d after “fruit set” (BBCH-scale 619). The second stage is termed “mid-season drop,” characterized by duration of 15 d with lesser intensity than during the “post-setting drop.” The third stage is the “pre-harvest drop” with only moderate losses. These descriptions of premature fruit drop, commonly found in the literature, represent some considerable limitations. The onset of each fruit drop stage is based on a “fixed” number of days from “fruit set” as used for example in the review of Singh et al. (2005). Fruit set, however, is variably related to: 1) time after all flowers have dried out at the end of bloom (Malik and Singh, 2003); 2) 14 d after full bloom (DAFB) (Notodimedjo, 2000); or 3) size of fruitlets (Lam et al., 1985).

The flowering of mango is a very prolonged and sometimes non-synchronized process, especially in the tropics where erratic flowering is common but also in the subtropics flowering can occur from a few days of an individual flower, 1 to 2 weeks within a panicle to up to 1 month within a tree canopy (Goguey, 1997; Mukherjee, 1953; Verheij, 1986). Typically, panicles exhibit a hierarchical flowering pattern from distal to proximal with an overlapping continuum of flowering and fruit development (Mukherjee, 1953; Singh, 1954). The terms “full bloom” and “fruitlet size” are often subjectively assessed by scoring and variably defined and thus do not offer precise occurrences that justify a valid comparison of published fruit set data. The duration of each fruit drop stage is clearly dependent on seasonal, regional, and cultivar-specific variability and therefore the “fixed time after fruit set” definition might be useful for characterizing the annual drop pattern of a given cultivar in one location but is not appropriate when comparing multiple data sets. Consequently, the main objective of this study is to provide a new approach for interpreting and evaluating fruit drop data, attempting to overcome or at least to alleviate the limitations described. Consequently, fruit drop of two mango cultivars was monitored in largely different cropping and management systems over six seasons in the Province Sơn La in North Vietnam and data were tested and validated in a mathematical model. Unfavorable environmental cues, particularly when temperature extremes coincide with severe drought conditions (Elsheery et al., 2007), are thought to be key triggers for the extensive premature fruit drop patterns in this province. Huong (2010) further suggested poor orchard management, in particular insufficient pest management, as an additional cause of fruit drop for the local mango cultivars Hôi and Tròn predominantly cultivated in this region. Crop management strategies such as irrigation or plant growth regulator (PGR) applications may also offer opportunities for fruit drop prevention.

1.2. Mango in the World

Mango (Mangifera indica L.) belongs to the order Sapindales in the family of Anacardiacea which is a family of mainly tropical species, with a few representatives in temperate regions. Apart from mango, cashew, spondias and pistachio are other well-know crops of the family. The classification of Mangifera species comprise of 69 species according to Kostermans and Bompard (1993) which at least 26 of this species bear edible fruits primarily found in southeast Asia. Nowadays, mangos grow in over 100 countries from the equator to close to 36° latitudes, indicating both the great adaptability to different environments and cultural management techniques in the different producing countries (Sauco, 1997). Producing areas can be grouped in 6 main regions; (1) USA (Florida), (2) Mexico, (3) West Indies (Caribbean Islands), (4) South America, (5) Africa/Arabian Peninsula, and (6) Indian subcontinent and Indochina. However, by continents, Asia is the main producer with approximately 77% of the total world production, followed by America with nearly 14% and Africa with 9%, respectively (Sauco, 2004). According to FAO (2010) India, China, Thailand, Mexico, Pakistan, Brazil, Philippines, Indonesia, Nigeria and Vietnam are the leading producing countries. In fact, these ten countries cover 85% of the entire world production (Gunjate, 2009) but India accounts for 55% of the total mangoes produced worldwide (Naidu and Naidu, 2009).

2. Fruit abscission in Mango

2.1. Pollination and Fertilizations

The understanding of mango flowering in the tropics and subtropics is essential to efficiently utilize crop management systems which extend both the flowering and crop production season (Chacko, 1991; Whiley et al., 1991). Flowering and fruit set are the most critical events after establishing a tree crop. In nature, mango trees produce large numbers of flowers of which only a small proportion set fruit. There are two different kinds of flowers; male, which have one or more stamens and staminodes and a completely abortive or reduced pistil, and hermaphrodite flowers with one or more fertile stamens and functional female organs (Kostermans and Bompard, 1993).

Only perfect (hermaphrodite) flowers are able to set fruit, however, the number of perfect flowers per inflorescence varies between cultivars or is variable from year to year, depending on the location of the inflorescence in the tree (Singh and Arora, 1965; Singh, 1954; Singh, 2005). Mango flowers are small, 5-10 mm in diameter, and according to Mukherjee (1953) both male and hermaphrodite flowers offer nectar and pollen. Depending on the cultivar, fertilization occurs within 48 to 72 h after pollination (Davenport and Nunez-Elisea, 1997; Singh, 1997). However, a successful fruit set is dependent on the use of selective pollinizers (Ram et al., 1976) and pollen viability has been considered to be a major factor limiting yields in mango (Davenport and Nunez-Elisea, 1997). Cross-pollination increased fruit set and retention in most cases (Singh, 2005) because self-incompatibility has been reported for several mango cultivars, however, cross-incompatibility between certain cultivars was also described (Ram et al., 1976). According to Singh (2005) mango flowers are generally pollinated by insects, predominantly by diptera (Anderson et al., 1982; Singh, 1997). The efficiency of pollination and fertilization defines fruit set in mango; however, environmental cues, particularly air temperature, strongly determines timing and intensity of flowering and fruit set, and later on influences fruitlet abscission.

2.2. Air temperature

Mango trees are adapted to a wide range of subtropical and tropical climatic and edaphic conditions (Schaffer et al., 1994); however, favourable weather conditions are crucial for flowering and fruit retention (Chacko et al., 1970; Lakshminarayana and Aguilar, 1975; Sukhvibul et al., 2005). In particular, temperature extremes and strong winds during pollination and fruit set, are known to negatively affect the crop. Low temperatures during anthesis have been shown to reduce particularly the number of hermaphrodite flowers in mango (Sukhvibul et al., 1999a; Sukhvibul et al., 1999b) which was suggested earlier by Issarakraisila and Considine (1994). It was demonstrated that air temperatures below a critical threshold of 10°C during anthesis or at an early stage of fruit development might prevent fertilization or ovule development (Whiley et al., 1988). Additionally, according to Nunez Elisea and Davenport (1983), high temperatures throughout anthesis and early fruit set leads to embryo abortion. This was confirmed by observations of reduced pollen viability, within periods of higher temperature during the critical period of flowering (Issarakraisila and Considine, 1994). Fruit that set during periods of high temperature did not develop to maturity compared to those set during lower temperature periods (Chacko, 1984). For avocado it was shown that heat associated with dry winds has detrimental effects on pollination and fruit set (Wolstenholme, 2002). For mango grown in Western Australia hot, dry winds negatively affect fruit set (Johnson and Parr, 1999), which might be accelerated by periods of water deficiency.

2.3. Water Relations

Typical mango environments in the tropics and subtropics indicate extreme water deficits due to prolonged periods of droughts. Generally, plants with laticifers or resin ducts are adapted to drought by modulating the water status of the plant, thus reducing the loss of water by transpiration (Downton, 1981; Kallarackal et al., 1990). The differentiation, structure and distribution of resin ducts in trunks, shoots, leaves and fruit exocarp of mango have been reported to be in close association with the vascular tissue (Joel, 1980, 1981; Joel and Fahn, 1980). The mango tree can withstand considerable periods of water stress and is considered to be drought tolerant, however, during the reproductive phase a higher amount of water supports fruit set and fruit retention (Whiley and Schaffer, 1997). Although several studies indicate that irrigation increases yields in subtropical evergreen fruit trees there are conflicting reports about the need for irrigation in mango (Koo, 1979; Lahav and Kalmar, 1977, 1983; Nagle et al., 2010). It was also described that a water deficit at pre-flowering time might enhance flowering intensity, however, detrimental effects at the stage of flowering, pollination and fruit set were observed (Chacko, 1984; Gonzalez et al., 2004; Lu et al., 2000). It was reported that fruit abscission on trees under severe drought stress was enhanced (Schaffer et al., 1994). Fruit drop in mango at an early developmental stage is associated with low soil moisture and excessive loss can be prevented by adequate irrigation, particularly during flowering and the first six weeks after fruit set (Larson et al., 1989; Spreer et al., 2007). Irrigation also can increase individual fruit size and overall yield as described by Spreer et al., (2007) and Whiley and Schaffer (1997). However, mango orchards in Northern Vietnam generally are not irrigated properly (Gunjate, 2009), especially during the critical time of flowering and early fruit development, which takes place during the hot and dry season.

2.4. Hormonal Regulation

Hormonal regulation of fruit abscission has been observed in many fruit crops (Addicott, 1968; Roberts et al., 2002) and endogenous hormones play a major role in fruit growth and fruit drop in mango (Chattha et al., 1999). Generally, they function at relatively low ppmconcentrations in fruits to regulate the formation and activation of the abscission zone within the separation layer (Singh et al., 2005). Like in other fruit crops, fruit abscission in mango is regulated by a complex interaction of phytohormones, which protect the abscission zones or induct the separation process. The efficiency of various phytohormones and their synthetic analogs, called plant growth regulators (PGR) for the control of fruit drop in mango have been conducted in several studies (Chen, 1983; Notodimedjo, 2000; Oosthuyse, 1995; Ram et al., 1983).

2.4.1. Auxin

The major common auxin in plants is indole-3-acetic acid (IAA). IAA is one of the principal hormones that control plant growth and development. All natural auxins are found in plants either as free acids and/or in conjugated forms. IAA is synthesized from tryptophan or indole primarily in leaf primordia, young leaves and in developing seeds (Davies, 2004). In combination with other hormones, auxins are involved in the development of vascular tissue and regulation of plant growth primarily through control of cell division and elongation. (Abel and Theologies, 1996). Additionally, the hormone is involved in abscission process mainly by facilitating the separation of organs from plants (Osborne, 1979; Sexton and Roberts, 1982).

IAA is transported basipetally from cell to cell mainly in the vascular system in specialized phloem parenchyma cells which are in contact with vascular bundles (Ross, 1998). Higher fruit drop intensity is generally associated with periods of lower auxin concentration in mango fruits (Singh, 2005). Thus, continuous auxin synthesis and basipetal transport to the abscission zone is critical for maintenance of plant organs, including the fruit (Davenport et al., 1980; Roberts and Osborne, 1981). Activation of the abscission zones (AZ) of leaves, flowers and fruit appear to be governed by the interaction of auxin and ethylene (Gonzalez-Carranza et al., 1998). The synthetic auxins which have been most effective in reducing mango fruit drop are naphthaleneacetic acid (NAA) and 2,4-dichlorophenoxyacetic acid (2,4-D). Together with auxins, cytokinins is another group of plant hormones which regulate cell division and cell expansion.

2.4.2. Cytokinins

Cytokinins (CKs) are adenine derivates represented by kinetin, zeatin and 6- benzylaminopurine. The most common cytokinin in plants is zeatin (Davies, 2004). The majority of adenine-type cytokinins are synthesized in the roots tips, cambium and developing seeds (Davies, 2004). CKs are a class of plant hormones that promote cell division in plant roots and shoots. They are primarily involved in cell growth and differentiation; however also affect apical dominance, auxillary buds growth, and leaf senescence. CKs transport is via the xylem from roots to shoots. CKs play an important role in inducing fruit set of several plants (Letham, 1967; Skoog and Armstrong, 1970). Also in mango, cytokinins play a key role in cell division and cell enlargement and have been found in both pericarp and seed, respectively (Ram et al., 1983; Singh, 2005).

Low cytokinin concentrations in developing mango fruits have been correlated with fruit drop and cessation of fruit growth (Ram, 1983). The application of synthetic cytokinin has also demonstrated improved fruit set and retention, suggesting that cytokinins play a role in establishing relatively high crop loads. Particularly post-bloom treatments with CPPU plus gibberellins (GA3) at early stages of fruit growth promoted fruit set (Chen, 1983; Oosthuyse, 1995). Cytokinin is required for fruit development and retention, however, the role of cytokinin in abscission still remains inconclusive (Davenport and NunezElisea, 1997).

2.4.3. Gibberellins

Gibberellic acid (GAs) are a family of compounds based on the entgibberelline structure. GA3 was the first gibberellin to be structurally characterized. There a currently over 126 members identified and characterized from plants, fungus and bacteria (MacMillan, 2001). Biosynthesis of GAs takes place in seeds, young leaves, young shoots and also in roots and is probably transported in xylem and phloem to the target organs. In mango, major endogenous GAs have been reported in apical buds, leaves and vegetative shoots (Davenport et al., 2001). Beside from being involved in growth and development of fruit, the direct role of GAs to the onset of abscission is ambiguous (Chacko et al., 1970; Davenport and Nunez-Elisea, 1997; Ram, 1983). Several classes of plant growth retardants have been characterized to interfere with early and late gibberellin biosynthetic pathway (Rademacher, 2000) and have been therefore investigated to improve fruit retention in mango. However, the efficacy of exogenously applied GA3 to pre- and post-anthesis inflorescences to enhance fruit set and retention have been inconclusive (Oosthuyse, 1995; Singh et al., 2005).

2.4.4 Carbohydrate Deficiency

In fruit trees a reduced carbohydrate availability due to heavy and prolonged flowering, subsequently limits nutrition to satisfy the demand on fruit set and development (Goldschmidt, 1999; Whiley et al., 1996). Consequently, abscission of flowers and fruits at an early stage of development adjust fruit number to the capacity of carbohydrate supply which the tree can provide (Agusti et al., 1982; Gomez-Cadenas et al., 2000). In mango, carbohydrate storage capacity is one of the important factors that determine the number of fruit that the tree can nurture to maturity (Davie et al., 2000; Normand et al., 2009). However, competition for nutrient resources is also a factor for premature fruit abscission (Stephenson, 1981; Stephenson and Gallagher, 1986). Internal competition between vegetative growth, flowers and fruit have been proposed as a controlling factor in flower and fruit abscission (Kozlowski, 1992). In mango, the availability and distribution of photosynthates during fruit set and development was suggested (Davenport and Nunez-Elisea, 1997) as one of the reasons for fruit abscission and this is also reported for other fruit crops, such as apple (Berüter and Droz, 1991; Stopar, 1998).

2.4.5. Abscission Zone

2.4.5.1. Morphology

Abscission of plant organs occur at predetermined positions called abscission zones (AZs) (Gonzalez-Carranza et al., 1998; Sexton and Roberts, 1982; Taylor and Whitelaw, 2001) and previous microscopic studies of fruit AZs in several fruit crop species indicated, that cells affected by the separation process are morphologically distinguishable prior to abscission from neighboring cells (Pandita and Jindal, 1991; Rascio et al., 1985; Stösser et al., 1969a). In mango, the pedicel AZ exist from flowering stage to fruit maturity (Singh, 1961) and can often be ascertained externally as a thin circular groove at the pedicel close to fruit base (Baird and Webster, 1979; Barnell, 1939; Singh, 1961). Adventitious zones are defined as functional abscission zones (Addicott, 1982), and have been shown to form in stem, petiole, pedicel or phyllomorph tissue (Roberts et al., 2000). The terms “abscission zone” and “abscission layer” are used in accordance with the definition of Shiraishi and Yanagisawa (1988) and Gawadi and Avery (1950). Generally, “abscission zone” refers to the tissue region through which the “abscission layer” forms. The term “abscission layer” refers to one or two cell layers through which mechanical break occurs. “Abscission layer” and “separation layer” are synonymous terms (Roberts et al., 2000; Taylor and Whitelaw, 2001); however, in this study “separation layer” is used. The numbers of cell rows that comprise the AZ vary markedly with species, plant organ and the site of cell separation (Sexton and Roberts, 1982). Abscission zone in leaves e.g. of Phaseolus or Olea have 10 to 12 cell rows and Sambucus nigra have 20 to 30 cell rows (Osborne and Sargent, 1976), whilst AZ of tomato flower may consist of 5-10 rows of cells (Roberts et al., 1984). In peach AZ consists of two rows of cells (Bonghi et al., 2000) whilst Rascio et al,. (1985) indicated several rows of cells.

2.4.5.2. Abscission Process

Abscission of premature fruits in mango is a natural mechanism (Lam et al., 1985; Singh, 1960) which is particularly high (90% fruit shedding) during the first 3 to 4 weeks after pollination (Nunez-Elisea and Davenport, 1986; Singh, 1960). Fruit drop might be caused by several factors, such as nutrient deficiency, disturbances in embryogensis and/or embryo abortion, sink competition between fruits, and abiotic and biotic stressors (Chadha, 1993). Generally, the cell separation process does not involve the entire AZ. The cells within the AZ that. are involved in the abscission process by rapid reduction in cell integrity (Sexton and Roberts, 1982) have been identified as separation layer (Addicott, 1982; Roberts et al., 2000; Sexton, 1994). In mango, just the separation layer is mentioned to initiate fruit drop without precise information on how many cell rows are involved (Nunez-Elisea and Davenport, 1986); however, in cherry fruit and leaflet of olive 2 to 8 longitudinally rows of cells define the fracture line (Polito and Lavee, 1980; Stösser et al., 1969a).

2.4.5.3. Role of Phytohormones and Assimilates

The activation of the separation layer involves several mechanisms in physiological response to such as e.g. auxin (Addicott, 1970). The reduction of the basipedal IAA transport results in the abscission of the organ e.g. fruit and leaf (Bangerth, 1989), which may be mediated by low assimilate allocation to the fruit, which was found in several fruit tree species (Agusti et al., 2002; Berüter and Droz, 1991; Patrick, 1979; Stopar, 1998; Wertheim, 2000). Else et al., (2004) assumed that increased basipetal auxin transport at periods of rapid cell expansion might promote translocation of assimilates into the fruit during extensive growth phases (Blanusa et al., 2005). Indeed, this has been intensively studied in apple (Berüter and Droz, 1991), pistacchio (Nzima et al., 1999), cherry (Atkinson et al., 2002) and orange (Ruiz et al., 2001), however, starch content in the AZ of the pedicel is contradictorily discussed (Baird and Webster, 1979; Bornman et al., 1966; Shiraishi and Yanagisawa, 1988).

3. Types of Flower Drops

3.1 Light Flower Drop

This occurs during initial stage of the flowering. This is normal in all mango orchards. Cause are wind, temperature, rain, birds and sometime, insect. It is not possible to check this type of flower drop. The most common cause is infertile or the group of flowers which is not pollenized by the pollenizer insect.

3.2 Heavy Flower Drop

Heavy flower drop is a cause of heavy economical loss. The cause of heavy fruit drop can be a single factor for example- formation of abscission layer. Loss by heavy flower drop is sometime more than 90 to 99% (It is not an authentic data. It is based on our experiment.)

3.3 Time of Flower Drop

March and April. Light flower drop in march and heavy flower drop in April.

4. Mango Fruit Drops:

4.1 Types

1. Pin Head Drop
2. Post Setting Drop
3. May Drop

4.1.1 Pin Head Drop

Underdeveloped fruits can be seen fallen in an orchard. This type of fruit drop is serous problem due to heavy loss in production.

4.1.2 Post Setting Drop

Post setting drop is mostly caused by the abiotic factors. It becomes a headache for the growers. Control is difficult.

4.1.3 May Drop

It is the final stage of fruit drop. May drop is due to unfavorable conditions such as bad weather. Chemical control is not effective. After May drop, fruit starts to ripe in many varieties.

4.1.4. Reasons (Flower and Fruit Drop)

4.1.4.1. Biotic Reasons (Factors)

4.1.4.1.1. Insects

Insect-pests such as mango mealy bug, mango hoppers and red ants are major insect-pests of mango. Mango mealy bug sucks sap of panicle (tender portion of the panicle), which is a reason of drying up of panicle. Red ants weave their home using leaves which envelop the panicle. Mealy bug is an another sap sucking insect.

Figure 1: Insect-Pests such as Mango Mealy Bug, Mango Hoppers and Red Ants.

4.1.4.1.2. Birds

They cause normal loss.

4.1.4.1.3. Biotic Reasons (Factors)

Temperature: High temperature is harmful for newly emerged flowers. It supports the formation of abscission layer. New flowers dry up and fall from the tree. It cause significance loss in production.

A. Rain: Unwanted rains during flowering. Heavy rain cause serious damage. Rain can trigger mildew in panicals.

B. STORM

1. **Hail storm:** Hail storm damages panicals, severely.
2. **Sand storm:** A strong sand storm is strong enough to dislodge the flowers from the tree.
3. **Wind:** Very hot wind such as Loo is a cause of flower drop.

4.1.4.1.4. Control Measures: Management

4.2. Biological Management

a) Microorganisms

This study used four isolates of Bacillus subtilis (ACB-66, ACB-69, ACB-77, and ACB-83) from citrus flowers and leaves (Kupper & Gimenes-Fernandes, 2002), four isolates of Trichoderma spp., ACB-14 and ACB-40 (Trichoderma sp.), ACB-33 (T. aureoviride), and ACB37 (T. pseudokoningii) from citrus soil (Moretto et al., 2001). All the microorganisms studied are deposited in the collection of APTA Center Citros Sylvio Moreira/IAC, Cordeirópolis, São Paulo, Brazil.

b) Cultural Management Practice

Sanitary management practice should be applied in an orchard. Give adequate water per plant/tree using thala irrigation system.

4.3 Chemical Control Measures

2, 4-D is sprayed as a chemical control measure. 2, 4-D is a weedicide, but in low concentration it acts as a plant hormone. Applicable percentage is 2.

Figure 2: Fruit Drops in Mango at Pea Stage.

5. Explanation of Post Related Words

5.1. Physiological Disorders

Physiological disorders are the abnormalities in many species of plants in which a plant shows symptoms of a disease without the attack of a disease causing agent. hysiological disorders in mango are are- **1.** Black tip. **2.** Spongy tissue. **3.** Mango malformation and, **4.** Alternate bearing.

5.2. Fruit Drop

Fruit drop is serious problem in mango and cause great loss to the growers. A tree producing several thousand panicles yields only a few hundred fruits. Most of the flowers falling down after full bloom or at later stage of development. Only 0.1 to 0.25% perfect flowers or even less develop in to mature fruit. Fruits drop at all stages of maturity. Maximum fruit drop takes place in last week of April or first week of May depends upon favourable condition. The fruit drop can be divided in to three distinct phases eg., pin head drop, post setting drop and May drop. The flower drop as well as the fruit drop is primarily due to the formation of an abscission layer at the point of attachment of the fruit with the twig. Several factors have been considered responsible for the formation of abscission layer. **The causes can be divided in to two;**

Figure 3: Mango Tree Disease.

1. External causes:

- Unfavourable climatic conditions.
- High incidence of serious diseases like powery mildew and anthracnose and pests like hoppers and mealy bugs.

2. Internal causes:

- Poor soil
- Lack of pollination
- Low stigmatic receptivity
- Defective perfect flowers
- Poor pollen transference
- Occurrence and extent of self incompatibility.
- Abortion of embryo
- Degeneration of ovules.
- Competition between developing fruit lets.
- Drought / lack of irrigation.

5.3. Measures to Prevent Fruit Drop

1. Spraying of 2, 4-D @ 10 ppm or NAA @ 50 ppm at pea stage and at marble stage helps in preventing fruit drop.
2. Providing pollenisers for self incompatible types.
3. Maintaining sufficient soil moisture also prevents fruit drop and helps in increasing the size of the fruit.
4. Provision of wind beaks all around the orchards, which prevents drop due to high velocity winds at the time of fruit development.

6. Summary & Result

Mango production in Northern Vietnam is mainly organized in farmer-owned, small-scale orchard operations. However, the production is limited due to excessive fruit drop presumably caused by unfavourable climatic conditions in combination with plant stresses during the fruit set period. There is a general belief that this phenomenon is caused by different combinations of stressing factors which may vary between regions and sites. In the mountainous area of Northern Vietnam, fruit drop of two main local cultivars ‘Hôi’ and ‘Tròn’ may be caused by environmental cues occurring particulary during fruit set. Environemntal stress factors may include excessive air temperature, low relative humidity, strong prevailing winds and little rainfall. These multiple stressors are likely associated with a time dependent change of the endogenous plant hormone auxin (indole-3-acetic acid, IAA) exported from fruit and within the pedicel. Field trials revealed, that fruit shedding could be reduced by irrigation and plant growth regulator (PGR) application throughout the 3-year experiment study; however, it remains unclear how climatic conditons might induce hormonal response and thus enhance fruit shedding at different stages of fruit development.

7. Premature fruit drop induced by

7.1. Climatic factors

7.1.1. General climatic conditions

The effect of climatic conditions in Northern Vietnam on the intensity of premature fruit drop was analyzed throughout a 3-year experimental period. It seems to be evident that the variable flowering period of the cultivars Hôi and Tròn was based on the specific weather conditions within a given year. The dry season, occurring between November to April, generally begins with a cool period from November to end of January followed by a hot period from February and/or March to April (Phan, 2005). Furthermore, the hot period in February and March is typically accompanied with strong and dry prevailing southern winds, with less than 12% relative humidity (Do Anh, 2004).

The second phase of fruit drop between 18 to 46 dafb at 'pinhead' to 'marble-size' in 2007 is regarded as the premature fruit drop, induced by environmental cues. Similar patterns of fruit drop, most pronounced during 3 to 4 weeks after fruit set, have been reported for mango (Searle et al., 1995; Singh and Arora, 1965). In 2008 with delay in flowering and fruit set possibly caused by the cold weather conditions before and during the flowering period, premature fruit drop occurred at 11 to 46 dafb, whereas for 2009 period of flowering and fruit drop followed the season 2007. Fruit abscission intensity of both cultivars was remarkably different for all years, possibly due to environmental conditions and genotype interaction. It is known that many cultivars, e.g., 'Kensington', 'Tommy Atkins', and 'Haden' usually bear only one fruit per inflorescence to maturity, whereas 'Sensation', 'Irwin', and 'Nam Dok Mai' often carry two or more fruits per inflorescence; thus intensity of fruit drop seems to be influenced by genotype (Singh, 2005). According to Singh and Arora (1965), Krisanapook et al. (2000) and Searle et al. (1995), fruit drop is most pronounced during first 28 days after fruit set, whereas Guzman-Estrada (1996) timed the main fruit abscission period between 25 and 50 days after fruit set. Consequently, our results for 'Hôi' and 'Tròn' indicate a fruit drop period from 18 to 46 dafb which corresponds well with other studies of mango cultivars. Effect of air and fruit temperature on fruit drop: Poor fruit set in mango in the subtropics due to unfavourably cool temperatures during floral anthesis and fruit set was described previously (Whiley et al. 1988; Tsai et al. 1996). Generally, air temperatures of 15°C/5°C day/night cause damages of stigmas and ovaries in various mango cultivars, resulting in embryo abortion and fruit drop (Sukhvibul et al.,1999, Issarakraisila et al., 1992).

Moreover an increased susceptibility of generative organs to low air temperature of polyembryonic cultivars as compared to monoembryonic cultivars was reported (Sukhvibul et al., 2005; Sukhvibul et al., 1999b). Indeed, Sukhvibul et al. (1999) concluded that monoembryonic cultivars appeared to be more tolerant to low temperatures during flowering. Although 'Hôi' and 'Tròn' are polyembryonic and hence potentially at greater risk to unseasonably cool conditions occurring during anthesis, fruit samples at marble-stage in 2008 had fully developed seeds (data not shown). Generally, air temperatures above 30°C promote vegetative growth in mango (Whiley et al., 1989), and can negatively affect fruit development. However, several studies indicate different air temperatures detrimentally to mango fruit set and development (Issarakraisila and Considine, 1994; Lam et al., 1985; Nunez-Elisea and Davenport, 1983). In contrast to seasonal warm years in 2007 and 2009 with mean value of 17°C, 2008 had lowest air temperature in February, compared to 12-year climate records in Yen Chau. Fruit temperature is dependent on ambient air temperature but also on direct exposure to the sunlight (Ferguson et al., 1998; Wünsche et al., 2001). According to Ferguson et al. (1998) bulky organs such as fruit may act as heat sink, and flesh and skin temperatures vary distinctively to air temperature. The surface temperature of fruit from irrigated trees in 2007 and 2008 was randomly lower with 1.2°C compared to control trees, which might indicate an increased transpiration rate as mechanism for evaporative cooling. Moreover, high wind speed in 2007 might additionally decrease temperature at the fruit surface. Similar effect is reported by Thorpe (1974) in apple, where wind speed increase from 0.3 to 4.0 m s-1 resulted in temperature drop of 5°C at fruit surface. For 2009; however, this observation could not be confirmed and heat presumably induced closure of stomatal closure apertures (Wilson and Bunce, 1997) would reduce the rate of leaf transpiration (Bunce, 1996). High temperatures can also directly affect the photosynthetic processes in mango and thus reduce carbohydrate availability for supporting fruit growth processes (Yamada et al., 1996). Further, strong fruit abscission during hot and dry season could be a response to reduced leaf photosynthesis in mango (Chacko et al., 1995).

7.1.1.2. Premature Fruit Drop Alleviated by Irrigation and the Use of Plant Growth

Regulators Effect of environmental conditions: Throughout the 2-year study, the year 2008 indicated a delay in flowering and fruit set due to cold weather conditions before and during the onset of flowering. In contrast, the experimental year 2009 constitute mean warm air temperatures which facilitated timely onset of full bloom. However, fruit counting indicated differences in fruit drop pattern of 'Hôi' and 'Tròn', which is confirmed by other studies in mango, respectively (Guzman-Estrada, 1996; Singh, 1960). Abscission occurs from full bloom throughout all stages of fruit development (Krisanapook et al., 2000; Ram et al., 1983); however, is intensified during 2 to 4 weeks after full bloom (Bhuyan and Irabagon, 1993; Nunez-Elisea and Davenport, 1983) similar to results in our study. The total amount of precipitation differs significantly throughout the fruit drop period of each experimental year. According to 12-year climate records, the lack of precipitation during early fruit development associated with hot and dry winds which are common for the study area. With 0.6 mm precipitation from full bloom throughout the fruit drop period respectively, the year 2009 indicated lowest precipitation within the study period. However, the year 2008 marked a severe cold spell in February (maximum and minimum ambient temperature of 17°C and 11°C respectively) including a total amount of 154 mm precipitation within the period fruits abscised. Effect of irrigation: Mango is generally considered as a drought tolerant fruit crop (Chacko, 1984; Urban and Jannoyer, 2004), however, water requirements vary according to the phenological stage. Sufficient water supply is most critical during the first 6 weeks (Schaffer et al., 1994), and lack of precipitation might affect photosynthetic activity, pollination and fruit set (Gonzalez et al., 2004; Lu and Chako, 1997). Water deficiency during early stage of fruit development is assumed to induce fruit drop intensity (Spreer et al., 2007). It is recognized that the distribution of precipitation rather than the total quantity of water is a crucial factor for the productivity of fruit crops (Chalmers and Wilson, 1978; Lechaudel et al., 2004). Precipitations from 4 to 39 dafb in 2008 were abundant; while it was presumably sufficient in 2009 with only 0.6 mm rainfall to replenish soil moisture. Little rainfall during rapid fruit growth coincides with decreased water stress (Li et al., 1989a; Li et al., 1989b); moreover, decreased photosynthetic capacity in mango rapidly reverses due to irrigation (Damour et al., 2009). According to Spreer et al. (2009), in years with precipitation, well-irrigated trees indicate higher yields; contrarily, in dry years this effect is more pronounced to non-irrigated trees. Water application availability presumably increased fruit set in 2008 compared to control; however, compared to higher fruit set in 2009, additional precipitation might also detrimental affect flowering and early fruit set in both cultivars. Water stress may help to stimulate trees to flower but with complete emergence of inflorescences supplementary irrigation is recommended (Coelho and Borges, 2004).

8. Effect of PGR

Chemical application in each study year increased fruit set. It is well known in many fruit crops, including mango, that retention of a fruit e.g. the capacity of a fruit to prevent itself from being shed, relates positively of the fruit ability to produce growth promoting hormones (Berüter and Droz, 1991; Buban, 2000; Chen, 1983; Prakash and Ram, 1984). The applications of synthetic PRGs such as CPPU, GAs and NAA have been reported to enhance fruit retention in mango (Burondkar et al., 2009; Oosthuyse, 1995, 1997; Singh and Ram, 1983) and might suggest a correlation of deficiency or metabolic and or transformational alterations of natural occurring hormone values at early stages of fruit development with fruit drop in mango (Malik and Singh, 2003; Ram et al., 1983). Several studies in fruit crops such as apple, citrus, guave, macadamia, persimmon and mango (Black et al., 1995; Kassem et al., 2010; Masia et al., 1998; Oosthuyse, 1997; Ortola et al., 1998; Singh and Ram, 1983; Williams, 1980) indicated enhanced crop load by CPPU and NAA, respectively. In grapes combined effects of CPPU and GA3 were better than single chemical treatment (Han and Lee, 2004). In our study, however, single application of CPPU applied directly after full bloom promote mango fruit retention, with maximum of 3 fruits per inflorescence in 2008 and 3.4 fruits per inflorescence in 2009. This contradicts results by Oosthuyse (1997) where CPPU alone was not found to increase fruit retention in mango applied shortly after flowering. The specific role of carbohydrates in fruit abscission and phytohormones are not completely understood. It has been suggested that carbohydrates and hormones participate in a complex signal transduction system (Roitsch, 1999) and in citrus; abscission induced by carbohydrate shortage was triggered by increases in the levels of ABA, ACC as precursor of ethylene, respectively.

Auxins have been reported to promote variable effects (Agusti et al., 2002); however, capacity modifying fruit abscission has been described as well (Yuan et al., 2002). In mango, highest cytokinins levels were measured at 7 to 21 and 42 to 70 days of fruit growth, respectively (Ram et al., 1983); whereas Chen (1983) defined maximum concentration of cytokinins 5 to 10 days after full bloom, respectively which decrease rapidly thereafter. In kiwi the effect of CPPU might be explained by increased cell divisions reducing flower shedding, respectively (Iwahori et al., 1988). Thus, Oosthuyse (1995) concluded, that cytokinin is important during initial stages of fruit growth in mango; thereafter, increasing concentrations of auxin and gibberellins become significant. In view of the results in CPPU, spray application of NAA increased significantly fruit retention; however, the degree of efficiency depends on the kind of auxin used and the weather conditions of application time and additives (Agusti et al., 2000; Meland, 1998). The data show that when NAA was applied at marble stage, maximum increase over control with 3.5 fruits per inflorescence in 2008 and 3.7 fruits per inflorescence in 2009 for cultivar ‘Hôi’ whereas similar, however lower fruit retention were obtained in both years for ‘Tròn’ respectively. Therefore, the use of NAA to improve retention appears to be linked with developmental fruit stage. Indeed, similar studies mentioned inhibitory or delaying treatment effect of NAA on apple at late growth stage (Masia et al., 1998); however, for mango Naqvi et al. (1990) specified, spraying with NAA to premature fruit at pea size stage and two weeks after marble stage significantly increased fruit retention. Similar studies confirm; period of application; however, NAA concentration and application repetition might significantly enhance increasing fruit retention in mango, respectively (Naqvi et al., 1990; Oosthuyse, 1995, 1997).

8.1 Morpho-Physiological Changes in the Abscission Zone of Mango Fruit Pedicel

Abscission morphology and cellular changes: The morphology of the mango pedicel was similar to that described earlier by Barnell (1939); however, lignified pith cells proximal to the groove were not found in the present study. The grooves represent the site where the abscission process ultimately occurs (Barnell, 1939). Singh (1961) also reported lignified pedicel cells during late stages of fruit development; thus, sampling was discontinued prior to lignifications of the pedicel. No varietal difference could be observed in the shape of the grooves between ‘Hôi’ and ‘Tròn’; however, it was shown that ‘Hôi’ with a bigger fruit size, had an increased fruit pedicel thickness compared to ‘Tròn’, which represents a cultivar specific feature. This was also observed in several citrus cultivars, where pedicel diameter was also linked to fruit size (Bustan et al., 1995; El-Otmani et al., 1993; Stewart et al., 1952). The AZ of tightly packed small cell rows and the transition from AZ cortex cells (AZ-cc) to neighbouring tissue is clearly distinguishable. The smallest number of AZ-cc cell rows of investigated pedicels was 4 and ranged to a maximum of 16 at the broadest point of the AZ-cc. Throughout the sampling period, the number of rows of cells within the AZ steadily increased, whereby ‘Tròn’ tended to have more cell rows compared to ‘Hôi’. These observations may correspond with studies in plums where the ease of fruit detachment was positively correlated with the number of cell rows (Al-Jaru and Stösser, 1973).

The cultivar ‘Hôi’ indicates a larger AZ thickness; however, this did not result in enhanced fruit retention. According to Bonghi et al. (2000) AZ-cc in peach are grouped in cell units and transverse sections in our study on mango indicate similar cell formations. Moreover, sectioning through the AZ indicated that resin ducts are perforating the pedicel AZ. Resin ducts are non-uniformly arranged in fruits of various Anacardiaceae species (Grundwag, 1976; Joel, 1980; Joel and Fahn, 1980). The resin ducts occur both in the exocarp and the inner region of the mesocarp and the duct system enters the pedicel and also penetrates the abscission zone (Joel, 1980, 1981). It is unclear to what extent the incidence of resin duct systems in mango may contribute to the instability of the abscission zone; however, as shown in Figure 11D, it is obvious that resin ducts in the AZ reduce the area of cellular connection and may support indirectly the abscission process due to destabilization of the pedicel. Separation process: With a reduced amount of samples it might be suggested that fruit abscission in mango occurred fast. This is supported by several studies, reporting that the abscission of plant organs occur within hours after induction of the abscission process. Polito and Lavee (1980) and Brown (1997) indicated abscission of fruits and leaves typically within 12-60 h after AZ induction; however, for tomato, flower abscission was already found within 4 h (Roberts et al., 1984) or even 1 h (Abeles et al., 1971). In mango the beginning of abscission was first noticeable by cell separation occurring in the AZ-cc adjacent to vascular tissue and progressing to the periphery. Similarly, Baird and Webster (1979) described the abscission process of sour cherry, beginning in the central part of the AZ and progressing towards the periphery.

In apple it was shown that abscission starts at epidermis cells continuing through collenchyma, vascular tissue and sclerenchyma cells of the pith (McCown, 1943). However, according to Pandita and Jindal (1991) separation of cells in the AZ of apple commenced in the cortex and spread to the vascular tissue. This correlates with results on flower abscission in tomato, where cell separation occurred at the distal side of the AZ with parenchyma cells responding first (Roberts et al., 1984). Conversely, Polito and Lavee (1980) reported that the separation processes in olive leaves occurred first in abaxial cortical cells adjacent to the vascular tissue and progressing toward the epidermis. Stösser et al. (1969a) identified the AZlayer in cherry by its low affinity to haematoxylin, indicating that cell walls of different tissues showed different staining intensity. Further, he suggested low affinity through alteration of cell walls in the AZ-layer and degradation of cell-wall constituents such as polysaccharides and pectin (Stösser et al., 1969a). In mango, staining of cell walls of the separation layer could not be observed prior to abscission; however, pedicels indicated staining in AZ-cc after abscission differing from neighbouring tissue. The even fracture surface with rounded cells (Figure 11C) suggests that the cell separation is based on cell wall lysis due to middle lamella degradation and increased turgor of the AZ cells (Brown, 1997; 2002). Sexton (1979) stated that rounded cells are found at the edge of abscised tissue. Cell enlargement in association with abscission is considered as an important component of the abscission process (Osborne and Morgan, 1989; Rascio et al., 1987; Sexton and Redshaw, 1981). Brown and Addicott (1950) suggested leaflet abscission caused by shearing forces which presumably resulted in different tension and compression of vascular vessels in the AZ tissue, respectively. Similar was observed in apple, where mechanical rup-turing of the vascular strands enlarge the break in the separation layer leading to complete separation of the cells (Pandita and Jindal, 1991; Sexton and Redshaw, 1981).

8.2. Inducing Factor of Abscission Process

8.2.1. Indole-3-Acetic Acid (IAA)

March) likely excluded lack of pollination and embryo degeneration as potential causes of abscission (Chadha, 1993; Singh and Singh, 1995). Several reports suggest that IAA is reduced in about-to-abscise fruits due to suppression by a stronger auxin export from adjacent, more dominant fruit or shoot tips (Agusti et al., 2000; Bangerth, 1989). Conclusively, it has been postulated that, if the IAA flux through the AZ is maintained, cell separation is inhibited and thus abscission prevented (Berüter and Droz, 1991). Moreover, the balance model proposes induction of abscission depends on a complex interplay of IAA and ethylene concentration (Beyer and Morgan, 1971; Sexton, 1998; Taylor and Whitelaw, 2001). Although NunezElisea and Davenport (1986) suggested antagonistic relationship between ethylene and auxin is evident for abscission processes (Taylor and Whitelaw, 2001). In our study, ‘Hôi’ fruit exported more IAA compared to ‘Tròn’ fruit throughout the sampling period, which is correlated with greater fruit retention for ‘Hôi’. Higher IAA export from fruitlets might control the sensitivity of the AZ to ethylene and thus abscission susceptibility. IAA is postulated to have a direct effect on assimilate partitioning (Agusti et al., 2002; Patrick, 1979) i.e. the regulation of the flow of assimilates to developing fruits, thus might be an important factor in determining whether or not fruits are retained (Else et al., 2004).

8.2.2. Carbohydrate

It was shown that ‘Hôi’ had an increased fruit pedicel thickness compared to ‘Tròn’, which might be linked to bigger fruit size and represents a cultivar specific feature between both cultivars. Similarly, it was observed in several citrus cultivars, where pedicel diameter was also linked to fruit size (Bustan et al., 1995; El-Otmani et al., 1993; Stewart et al., 1952). Relationship between fruit set and carbohydrate availability are reported for several fruit trees, including mango (Chacko, 1991). A low carbohydrate level is often mentioned as one possible reason for premature fruit drop in mango (Davie et al., 2000; Ram et al., 1983). Generally, the photosynthetic capacity of the tree regulates the supply of carbohydrate with a high percentage of the accumulated photosynthates being primarily utilised for growth and development followed by the respiration process of the tree (Kozlowski, 1992). The surplus of carbohydrates is then stored, usually in the form of starch (Davie et al., 2000; Kozlowski, 1992; Normand et al., 2009). In our study, pedicels from irrigated trees indicated increased starch accumulation in AZ-cc; and starch grains were also found in cells of pith area, which was also reported for Citrus (Wilson and Hendershott, 1968). However, starch grains were not present in cells of the AZ separation layer itself, which was reported for tomato flower AZ (Roberts et al., 1984). In different species starch accumulation was found in cortical cells of the leaf abscission zone, as well as in flower pedicels (Gilliland et al., 1976; Roberts et al., 1984). However, there are ambiguous observations of abscission susceptibility which might be linked with low starch levels (Kozlowski, 1992; Scott et al., 1948).

Further, Shiraishi and Yanagisawa suggested (1988) that starch was hydrolyzed in cells of the distal parenchyma and resynthesized during AZ formation suggesting an increase of starch concentration, respectively. According to Davie and Stassen (1997) mango trees set very large numbers of fruits which the tree nurtures before natural fruitlet abscission reduces crop load to levels the tree is capable to support. Further, it was concluded, that slow-growing small fruits were prone to abscission possibly due to competition for photosynthates and lower production of endogenous hormones (Krisanapook et al., 2000). Referring to early stages of fruit growth in apple, a reduction of glucose below critical thresholds in the pedicel may induce the abscission process of fruits (Berüter and Droz, 1991). In this study, where the number of starch grains decreased in the AZ and the adjacent tissue an increased susceptibility of mangos to abscise might be linked to lack of energy source.

8.2. 3. Water Relations

According to Bally et al. (2000) water is the crucial factor, affecting flowering, fruit set, fruit size and total yield in mango, which is also supported in studies on apple (Berüter and Droz, 1991) and peach (Chalmers and Wilson, 1978; Li et al., 1989b). Initial fruit growth within the first 6 weeks following full bloom represents a critical phase in mango fruit development when water deficiency might strongly affect crop load (Coelho and Borges, 2004). Further, fruit transpiration and the water movement through the pedicel affect the fruit water content (Jones and Higgs, 1982). However control and treated trees of both cultivars indicated fruit abscission, water deficiency of control trees might affect negatively pedicel growth, respectively. Similar is confirmed in citrus by increased vascularisation of the pedicel due to transport of water and photosynthates to vigorously growing fruitlets (GarciaLuis et al., 2002). Generally, drought stress and related water deficits have been reported to cause abscission processes (Apelbaum and Yang, 1981; Taylor and Whitelaw, 2001). Further, plant water deficits associated by rehydration and shrinking of plant organs generating wound ethylene (McMichael et al., 1972; Morgan et al., 1990; Taylor and Whitelaw, 2001) have been linked to abscission and determine the IAA biosynthesis and metabolism thus inducing abscission process.

9. Conclusion and Outlook

Fruit drop can be regarded as one of the most serious problems for mango production in Northern Vietnam which affects the performance of the two main local cultivars ‘Hôi’ and ‘Tròn’. Both mango cultivars respond with enhanced fruit shedding during fruit set and early fruit development which falls into the dry season with low humidity and excessively high ambient temperatures. Irrigation during flowering and early fruit growth stages improved final fruit retention and irrigated trees had higher crop load per inflorescence close to harvest compared to nonirrigated trees. Additionally, morphological changes in AZ tissue in mango showed, that irrigation had a positive effect on fruit retention in both cultivars, which might be influenced by increased pedicel thickness thus increased nutritional status of the fruit during critical environmental periods. However, in northern Vietnam water resources especially on the hillside plantations are increasingly scarce resource and irrigation systems are costly investments for local farmer. As an alternative to reduce stress-induced fruit drop in mango, application of plant growth regulators at specific stages of fruit development are studied. In considering reducing fruit drop all chemical treatment indicated increased fruit retention. However, as shown in this study, single spray application of NAA and CPPU can effectively reduce fruit drop when sprayed shortly after flowering and ‘marble’-stage fruit size. Further, with low concentration and one-time application, PGR treatments indicate an economic viability and ease of handling for farmers. However, we assume that shortage of carbohydrate may be associated with hormonal changes as signals triggering the abscission process. Here, more studies will be needed to elucidate the abscission process in mango, particularly the interplay between activation of the AZ, hormonal changes and carbohydrate reserves

10. References

1. Abel, S., Theologies, A., 1996. Early genes and auxin action. Plant Physiol. 111, 9-17.
2. Abeles, F.B., Leather, G.R., Forrence, L.E., Craker, L.E., 1971. Abscission: Regulation of senescence, protein synthesis and enzyme secretion by ethylene. Hort Science 6, 371-376.
3. Addicott, F.T., 1968. Environmental factors in the physiology of abscission. Plant Physiol. 43, 1471-1479.
4. Addicott, F.T., 1970. Plant hormones in the control of abscission. Biol. Rev. 45, 485-524.
5. Addicott, F.T., 1982. Abscission. University of California Press, Berkeley, USA.
6. AGROINFO, 2008. Vietnam's agriculture report on development in 2007 and prospects for 2008. Information Center for Agriculture and Rural Development, Hanoi, Vietnam, pp. 1-189.
7. Agusti, M., Garcia-Mari, F., Guardiola, J.L., 1982. The influence of flowering intensity on the shedding of reproductive structures in sweet orange. Scientia Hortic. 17, 343-352.
8. Agusti, M., Juan, M., Almela, V., Gariglio, N., 2000. Loquat fruit size is increased through the thinning effect of naphthaleneacetic acid. Plant Growth Reg 31, 167-171.
9. Agusti, M., Zaragoza, S., Iglesias, D.J., Almela, V., Primo-Millo, E., Talon, M., 2002. The synthetic auxin 3,5,6-TPA stimulates carbohydrate accumulation and growth in citrus fruit. Plant Growth Reg . 36, 141-147.
10. Ahmed, A.; Khalil, M.; Abd El-Rahman, A.; Nadia, A. 2012. Effect of zinc, tryptophan, and indole acetic acid on growth, yield and chemical composition of Valencia orange trees. J. Appl. Sci. Res., 8, 901–914.
11. Al-Jaru, S., Stösser, R., 1973. Der Einfluss von ethtel und cycloheximid auf die trenngewebeausbildung und die reduktion der haltekräfte bei zwetschen und mirabellen. Der Erwerbsobstbau , 15, 171-174.
12. Allen, R.G., Pereira, L.S., Raes, D., Smith, M., 1998. Crop evapotranspiration: Guidelines for computing crop water requirements (Irrigation and Drainage Paper No. 56). Food Agriculture Organization of the United Nations (FAO), Rome, Italy.
13. Alloway, B. 2009. Soil factors associated with zinc deficiency in crops and humans. Environ. Geochem. Health, 31, 537–548.
14. Anderson, D.L., Sedgley, M., Short, J.R.T., Allwood, A.J., 1982. Insect pollination of mango in northern Australia. Aust. J. Agric. Res. 33, 541-548.
15. Antúnez-Ocampo, O.M.; Sandoval-Villa, M.; Alcántar-González, G.; Alvarado-López, J.; Sabino-López, J.E. 2016. Flowering and fructification of Physalis peruviana L. By ammonium and nitrate application, vigour and plant age. Agrociencia, 50, 603–615.
16. Apelbaum, A., Yang, S.F., 1981. Biosynthesis of stress ethylene induced by water deficit. Plant Physiol. 68, 594-596.
17. Arauz, L.F., 2000. Mango anthracnose: Economic impact and current options for integrated management. Plant Dis. 84, 600-611.
18. Asif, M., Usman, M., Fatima, B., Laskani, M.I. & Khan, M.M. 2002. Fruit set and drop behaviour of three commercial cultivars of mango. Pak. J. Agr. Sci. 39 129 131
19. Atkinson, C.J., Else, M.A., Stankiewicz, A., Webster, A.D., 2002. The effects of phloem girdling on the abscission of Prunus avium L. fruits. J. Hortic. Sci. Biotechnol. 77, 22-27.
20. Baird, L.A.M., Webster, B.D., 1979. The anatomy and histochemistry of fruit abscission. Hortic. Rev. 1, 172-203.

21. Baldwin, E.A.; Bai, J.; Plotto, A.; Dea, S. 2011. Electronic noses and tongues: Applications for the food and pharmaceutical industries. Sensors, 11, 4744–4766.
22. Bally, I.S.E., Harris, M., Whiley, A.W., 2000. Effect of water stress on flowering and yield of 'Kensington pride' mango (Mangifera indica L.). Acta Hort. 509, 277-282.
23. Bangerth, F., 1989. Dominance among fruits/sinks and the search for a correlative signal. Physiol. Plantarum 76, 608-614.
24. Bangerth, F., 2000. Abscission and thinning of young fruit and their regulation by plant hormones and bioregulators. Plant Growth Reg 31, 43-59.
25. Bariya, H.; Bagtharia, S.; Patel, A. Boron: A promising nutrient for increasing growth and yield of plants. In Nutrient Use Efficiency in Plants; Kopriva, S., Ed.; Springer: Basel, Switzerland, 2014; pp. 153–170.
26. Barnell, E., 1939. Studies in tropical fruits. V. Some anatomical aspects of fruit-fall in two tropical arboreal plants. Ann. Bot. 3, 77-89.
27. Benjawan, C., Chutichudet, P. & Chanaboon, T. 2006. Effect of gibberellin (GA3) on fruit yield and quality of Kaew mango (Mangifera indica L.) cv. Srisaket 007 in Northeast Thailand Pak. J. Biol. Sci. 9 1542 1546
28. Berüter, J., Droz, P., 1991. Studies on locating the signal for fruit abscission in the apple tree. Scientia Hortic. 46, 201-214.
29. Beyer, E.M., Jr., Morgan, P.W., 1971. Abscission: The role of ethylene modification of auxin transport. Plant Physiol. 48, 208-212.
30. Beyschlag, W., Pfanz, H., Ryel, R.J., 1992. Stomatal patchiness in Mediterranean evergreen sclerophylls. Planta 187, 546-553.
31. Bhuyan, M.A.J. & Irabagon, J.A. 1993. Effect of fertilizer, potassium nitrate and irrigation on fruit drop of ‘Carabao’ mango South Indian Hort. 41 315 321
32. Bhuyan, M.A.J., Irabagon, J.A., 1993. Effect of fertilizer, potassium nitrate and irrigation on fruit drop of carabao mango. S. Ind. Hortic. 41, 315-321.

33. Black, B.L., Bukovac, M.J., Hull, J., 1995. Effect of spray volume and time of NAA application on fruit size and cropping of Redchief 'Delicious' apple. Scientia Hortic. 64, 253-264.
34. Blanusa, T., Else, M.A., Atkinson, C.J., Davies, W.J., 2005. The regulation of sweet cherry fruit abscission by polar auxin transport. Plant Growth Reg 45, 189-198.
35. Bohner, J., Bangerth, F., 1988. Effects of fruit set sequence and defoliation on cell number, cell size and hormone levels of tomato fruits (Lycopersicon esculentum Mill.) within a truss. Plant Growth Reg 7, 141-155.
36. Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. & White, J.-S.S. 2009. Generalized linear mixed models: A practical guide for ecology and evolution Trends Ecol. Evol. 24 127 135
37. Bonghi, C., Tonutti, P., Ramina, A., 2000. Biochemical and molecular aspects of fruitlet abscission. Plant Growth Reg. 31, 35-42.
38. Bornman, C.H., Addicott, F.T., Spurr, A.R., 1966. Auxin and gibberellin effects on cell growth and starch during abscission in cotton. Plant Physiol. 41, 871-876.
39. Brown, H.S., Addicott, F.T., 1950. The anatomy of experimental leaflet abscission in Phaseolus vulgaris. Amer. J. Bot. 37, 650-656.
40. Brown, K.M., 1997. Ethylene and abscission. Physiol. Plantarum. 100, 567-576.
41. Bunce, J.A., 1996. Does transpiration control stomatal responses to water vapour pressure deficit? Plant Cell Environ. 20, 131-135.
42. Burondkar, M.M., Jadhav, B.B. & Chetti, M.B. 2009. Post-flowering morpho-physiological behavior of Alphonso mango as influenced by plant growth regulators, polyamine and nutrients under rainfed conditions. Acta Hort. 820, 425 432
43. Burondkar, M.M., Rajput, J.C., Waghmare, G.M., Jamadagni, B.M., Chavan, S.A., 2000. Recurrent flowering: A new physiological disorder in 'Alphonso' mango. Acta Hort. 509, 669- 674.
44. Bustan, A., Erner, Y., Goldschmidt, E.E., 1995. Interactions between developing citrus fruits and their supportive vascular system. Ann. Bot. 76, 657-666.
45. Chacko, E.K., 1991. Mango flowering- still an enigma! Acta Hort 291, 12-21.
46. Chacko, E.K., Kachru, R.B., Singh, R.N., 1970. Changes in levels of acidic and neutral growth promotes during fruit development in 'Dashehari' mango (Mangifera indica L.). J. Hort. Sci. 45, 341-349.
47. Chacko, E.K., Lu, P., Kohli, R.R., 1995. Photoassimilate production and distribution in relation to productivity in mango (Mangifera indica), Mango 2000- Marketing seminar and production workshop proceedings. Queensland Dept. of Primary Ind., Brisbaine, pp. 109-124.

48. Chadha, K.L., 1993. Fruit drop in mango. Advanc. Horti. 3, 1131-1166.
49. Chalmers, D.J., Wilson, I.B., 1978. Productivity of peach trees: tree growth and water stress in relation to fruit growth and assimilate demand. Ann. Bot. 42, 285-294.
50. Chattha, G.A., Anjum, M.A. & Hussain, A. 1999 Effect of various growth regulators on reducing fruit drop on mango (Mangifera indica L.) Intl. J. Agr. Biol. 1 288 289
51. Chattha, G.A., Anjum, M.A., Hussain, A., 1999. Effect of various growth regulators on reducing fruit drop in mango (Mangifera indica L.). International Journal of Agriculture & Biology, 288-289.
52. Chen, W.-S. 1983 Cytokinins of the developing mango fruit: Isolation, identification, and changes in levels during maturation Plant Physiol. 71 356 361
53. Chen, W.-S., 1983. Cytokinins of the developing mango fruit : isolation, identification, and changes in levels during maturation. Plant Physiol. 71, 356-361.
54. Clemens, G., Fiedler, S., Cong, N.D., Van Dung, N., Schuler, U. & Stahr, K. 2010 Soil fertility affected by land use history, relief position, and parent material under a tropical climate in NW-Vietnam Catena 81 87 96
55. Coelho, E.F. & Borges, A.L. 2004 Irrigation and fertirrigation of mango Acta Hort. 645 119 128
56. Coelho, E.F., Borges, A.L., 2004. Irrigation and fertirrigation of mango. Acta Hort 645, 119- 128.
57. Costa, G., Dal Cin, V., Ramina, A., 2006. Physiological, molecular and practical aspects of fruit abscission. Acta Hort 727, 301-310.
58. Dahshan, D.I. & Habib, S. 1985. Seasonal changes in endogenous auxin like substances in relation to fruit drop in mango Proc. Egypt. Bot. Soc. 4 769 780
59. DaMatta, F.M.; Grandis, A.; Arenque, B.C.; Buckeridge, M.S. Impacts of climate changes on crop physiology and food quality. Food Res. Int. 2010, 43, 1814–1823.
60. Damour, G., Vandame, M. & Urban, L. 2009 Long-term drought results in a reversible decline in photosynthetic capacity in mango leaves, not just a decrease in stomatal conductance Tree Physiol. 29 675 684

61. Damour, G., Vandame, M., Urban, L., 2009. Long-term drought results in a reversible decline in photosynthetic capacity in mango leaves, not just a decrease in stomatal conductance Tree Physiol. 29, 675-684.
62. Davenport, T.L. 2006 Pruning strategies to maximize tropical mango production from the time of planting to restoration of old orchards HortScience 41 544 548
63. Davenport, T.L., Morgan, P.W., Jordan, W.R., 1980. Reduction of auxin transport capacity with age and internal water deficits in cotton petioles. Plant Physiol. 65, 1023-1025.
64. Davenport, T.L., Nunez-Elisea, R., 1997. Reproductive Physiology., In: Litz, R.E., (editor.), The mango: botany, production and uses. Wallingford Oxon, UK: CAB International. p 69– 146. (Ed.).
65. Davenport, T.L., Pearce, D.W., Rood, S.B., 2001. Correlation of endogenous gibberellic acid with initiation of mango shoot growth. J Plant Growth Regul 20, 308-315.
66. Davie, S.J., Stassen, P.J.C., 1997. The effect of fruit thinning and tree pruning on tree starch reserves and fruit retention of 'Sensation' mango trees. Acta Hort 455, 160-166.
67. Davie, S.J., Stassen, P.J.C., Grove, H.G., 2000. Starch reserves in the mango tree. Acta Hort 509, 335-346.
68. Davies, P.J., 2004. The plant hormones: Their nature, occurrence, and functions, Plant Hormones. Springer Netherlands, pp. 1-15.
69. Dhanalakshmi, R., Prasad, T.G. & Udayakumar, M. 2003 Is auxin a diffusible signal mediating abscission of recessive sinks? Plant Sci. 164 689 696
70. Do Anh, T., 2004. Family resources and their impact on living standard and food security of farmers in the mountainous farming systems in northwest Vietnam, Institute for Farming and Rural Systems Economics. University Hohenheim, Stuttgart, Germany, pp. 1-164.
71. Domingo, R., Ruiz-Sanchez, M.C., Sanchez-Blanco, M.J., Torrecillas, A., 1996. Water relations, growth and yield of Fino lemon trees under regulated deficit irrigation. Irrig Sci. 16, 115-123.
72. Dos-Santos, J.B.; Marenco-Centeno, C.R.; de-Azevedo, C.A.V.; Raj-Gheyi, H.; de-Lima, G.S.; de-Lira, V.M. Sunflower (Helianthus annuus L.) growth depending on irrigation with saline water and nitrogen fertilization. Agrociencia 2017, 51, 649–660.
73. Downton, W.J.S., 1981. Water relations of laticifers in Nerium oleander. Aust. J. Plant Physiol. 8, 329-334.
74. El-Otmani, M., Agusti, M., Aznar, M., Almela, V., 1993. Improving the size of 'Fortune' mandarin fruits by the auxin 2,4-DP. Scientia Hortic. 55, 283-290.
75. Else, M.A., Stankiewicz-Davies, A.P., Crisp, C.M., Atkinson, C.J., 2004. The role of polar auxin transport through pedicels of Prunus avium L. in relation to fruit development and retention. J. Exper.

Bot. 55, 2099-2109.

76. Elsheery, N.I., Wilske, B., Zhang, J.-L. & Cao, K.-F. 2007 Seasonal variations in gas exchange and chlorophyll fluorescence in the leaves of five mango cultivars in southern Yunnan, China J. Hort. Sci. Biotechnol. 82 855 862
77. English, R., Badcock, J., 1998. A community nutrition project in Viet Nam: effects on child morbidity. Food, Nutrition and Agriculture 22, 15-21.
78. Estrada, A.B., Dodd, J.C., Jeffries, P., 2000. Effect of humidity and temperature on conidial germination and appressorium development of two Philippine isolates of the mango anthracnose pathogen Colletotrichum gloeosporioides. Plant Pathol. 49, 608-618.
79. Estrada-Herrera, I.R.; Hidalgo-Moreno, C.; Guzmán-Plazola, R.; Suárez, J.J.A.; Navarro-Garza, H.; Etchevers-Barra, J.D. 2017. Soil quality indicators to evaluate soil fertility. Agrociencia, 51, 813–831.
80. Ferguson, I.B.; Boyd, L.M. Inorganic Nutrients and Fruit Quality; CRC Press: Boca Raton, FL, USA, 2002.
81. Galán Saúco, V. 1997 Horticultural practices of mango Acta Hort. 455 391 400
82. Garcia-Luis, A., Oliveira, M.E.M., Bordon, Y., Siqueira, D.L., Tominaga, S., Guardiola, J.L., 2002. Dry matter accumulation in citrus fruit is not limited by transport capacity of the pedicel. Ann. Bot. 90, 755-764.
83. Gawadi, A.G., Avery, G.S., 1950. Leaf abscission and the so-called "abscission layer". Amer. J. Bot. 37, 172-180.
84. George, A.P., Nissen, R.J., Howitt, C., 1990. Effects of environmental variables and cropping on leaf conductance of custard apple (Annona cherimola × Annona squamosa) `African Pride'. Scientia Hortic. 45, 137-147.
85. Gholap, A.; Bandyopadhyay, C.; Nadkarni, G. Aroma development in mango fruit. J. Food Biochem. 1986, 10, 217–229.
86. Gilliland, M.G., Bornman, C.H., Addicott, F.T., 1976. Ultrastructure and acid phosphatase in pedicel abscission of Hibiscus. Amer. J. Bot. 63, 925-935.

87. Goguey, T. 1997 Architectural approach of the mechanisms of canopy growth and flowering of mango trees Acta Hort. 455 124 131
88. Goldschmidt, E.E., 1999. Carbohydrate supply as a critical factor for citrus fruit development and productivity. HortScience 34, 1020-1024.
89. Gomez-Cadenas, A., Mehouachi, J., Tadeo, F.R., Primo-Millo, E., Talon, M., 2000. Hormonal regulation of fruitlet abscission induced by carbohydrate shortage in citrus. Planta 210, 636-643.
90. González, A., Lu, P. & Müller, W. 2004. Effect of pre-flowering irrigation on leaf photosynthesis, whole-tree water use and fruit yield of mango trees receiving two flowering treatments, Sci. Hort. 102, 189- 211
91. Gonzalez, A., Ping, L., Müller, W., 2004. Effect of pre-flowering irrigation on leaf photosynthesis, whole-tree water use and fruit yield of mango trees receiving two flowering treatments. Scientia Hortic. 102, 189-211.
92. Henderson, J., Davies, H.A., Heyes, S.J., Osborne, D.J., 2001. The study of a monocotyledon abscission zone using microscopic, chemical, enzymatic and solid state 13C CP/MAS NMR analyses. Phytochemistry 56, 131-139.
93. Hermanns, W., Schulz, L.C., 1981. Enzyme histochemical demonstration of certain cell populations in synovium using plastic-embedded whole rat joints, In: Deicher, H., Schulz, L.C. (Eds.), Arthritis. Models and mechanisms. Springer, Berlin Heidelberg New York, pp. 137- 143.
94. Hernández Delgado, P.M., Aranguren, M., Reig, C., Fernández Galván, D., Mesejo, C., Martínez Fuentes, A., Galán Saúco, V. & Agusti, M. 2011 Phenological growth stages of mango (Mangifera indica L.) according to the BBCH scale Sci. Hort. 130 536 540
95. Higuchi, H., Sakuratani, T., Utsunomiya, N., 1999. Photosynthesis, leaf morphology, and shoot growth as affected by temperatures in cherimoya (Annona cherimola Mill.) trees. Scientia Hortic. 80, 91-104.
96. IFPRI, 2001. Fruits and vegetables in Vietnam: Adding value from farmer to consumer. International Food Policy Research Institute (IFPRI) Washington DC., pp. 1-297.
97. Issarakraisila, M. & Considine, J.A. 1994 Effects of temperature on pollen viability in mango cv. ‘Kensington’ Ann. Bot. (Lond.) 73 231 240
98. Issarakraisila, M., Considine, J.A., 1994. Effects of temperature on pollen viability in mango cv. 'Kensington'. Ann. Bot. 73, 231-240.
99. Joel, D.M., Fahn, A., 1980. Ultrastructure of the resin ducts of Mangifera indica L. (Anacardiaceae). 1. Differentiation and senescence of the shoot ducts. Ann. Bot. 46, 225-233.
100. Johnson, P.R., Parr, D., 1999. Mango growing in Western Australia. Government of Western Australia-Department of Agriculture and Food Bulletin 4348, 1-29.

101.Jones, H.G., Higgs, K.H., 1982. Surface conductance and water balance of developing apple (Malus pumila Mill.) fruits. J. Exper. Bot. 33, 67-77.
102.Kallarackal, J., Milburn, J.A., Baker, D.A., 1990. Water relations of the banana. III. effects of controlled water stress on water potential, transpiration, photosynthesis and leaf growth. Aust. J. Plant Physiol. 17, 79-90.
103.Kassem, H.A., El-Kobbia, A.M., Marzouk, H.A., El-Sebaiey, M.M., 2010. Effect of foliar sprays on fruit retention, quality and yield of Costata persimmon trees. Emir. J. Food Agric. 22, 259-274.
104.Khadka, B.; Munir, T.M.; Strack, M. Dissolved organic carbon in a constructed and natural fens in the Athabasca oil sands region, Alberta, Canada. Sci. Total Environ. 2016, 557, 579–589.
105.Khan, A.S.; Ullah, W.; Malik, A.U.; Ahmad, R.; Saleem, B.A.; Rajwana, I.A. Exogenous applications of boron and zinc influence leaf nutrient status, tree growth and fruit quality of Futrell’s early (citrus Reticulata Blanco). Pak. J. Agric. Sci. 2012, 49, 113–119.
106.Khoi, B.X., Tri, M.V., 2003. Fertilizer recommendations for sustainable production of orchard fruit in the South of Vietnam. Food and Fertilizer Technology Center (FFTC), Taipei.
107.Khorsandi, F.; Yazdi, F.A.; Vazifehshenas, M.R. Foliar zinc fertilization improves marketable fruit yield and quality attributes of pomegranate. Int. J. Agric. Biol. 2009, 11, 766–770.
108.Lahav, E., Kalmar, D., 1983. Determination of the irrigation regimen for an avocado plantation in spring and autumn. Aust. J. Agric. Res. 34, 717-724.
109.Lakshminarayana, S. & Aguilar, P.H. 1975 Effect of orchard heating in reducing parthenocarpic fruit in ‘Haden’ mango Proc. Fl. St. Hort. Soc. 88 502 505
110.Lakshminarayana, S., Aguilar, P.H., 1975. Effect of orchard heating in reducing parthenocarpic fruit in 'Haden' mango. Proc. Fla. State Hort. Soc. 88, 502-505.
111.Lam, P.F., Ng, K.H., Omar, D. & Talib, Y. 1985 Fruit-drop and growth, respiration and chemical changes in ‘Golek’ mango Malaysian Agr. Res. Dev. Inst. Bul. Penyelidikan. 13 8 14
112.Lam, P.F., Ng, K.H., Omar, D., Talib, Y., 1985. Fruit-drop and growth, respiration and chemical changes in 'Golek' mango. Bul. Penyel. Mardi 13, 8-14.

113.Lange, O.L., Lösch, R., Schulze, E.D., Kappen, L., 1971. Responses of stomata to changes in humidity. Planta 100, 76-86.
114.Larson, K.D., Schaffer, B. & Davies, F.S. 1989. Effect of irrigation on leaf water potential, growth and yield of mango trees Proc. Fl. St. Hort. Soc. 102 226 228
115.Larson, K.D., Schaffer, B., Davies, F.S., 1989. Effect of irrigation on leaf water potential, growth and yield of mango trees. Proc. Fla. State Hort. Soc. 102, 226-228.
116.Lechaudel, M., Jannoyer, M., Genard, M., 2004. Effects of the leaf:fruit ratio on growth and partitioning of water and dry matter in mango fruit. Acta Hort 645, 429-433.
117.Letham, D.S., 1967. Chemistry and physiology of kinetin-like compounds, pp. 349-364.
118.Leuschner, C., 2002. Air humidity as an ecological factor for woodland herbs: leaf water status, nutrient uptake, leaf anatomy, and productivity of eight species grown at low or high VPD levels. Flora 197, 262-274.
119.Li, C.-J., Bangerth, F., 1999. Autoinhibition of indoleacetic acid transport in the shoots of two-branched pea (Pisum sativum) plants and its relationship to correlative dominance. Physiol. Plantarum 106, 415-420.
120.Li, S.-H., Huguet, J.-G., Bussi, C., 1989a. Irrigation scheduling in a mature peach orchard using tensiometers and dendrometers. Irrigation and Drainage Systems 3, 1-12.
121.Li, S.-H., Huguet, J.-G., Schoch, P.G., Orlando, P., 1989b. Response of peach tree growth and cropping to soil water deficit at various phenological stages of fruit development. J. Hort. Sci. 64, 541-552.
122.Lovatt, C.J., 1997. Pollination biology and fruit set in avocado, Proceeding from Conference '97: Searching for Quality, Joint Meeting of the Australian Avocado Growers Federation, Inc. and NZ Avocado Growers Association, Inc., 23-26 September 1997, pp. 98-105.
123.Lu, P., Chako, E.K., 1997. Flowering behavior and subsequent productivity in mango. Annual Report. Aciar Project No. 9012. Australian Centre for International Agricultural Research, ACIAR, Canberra, 34.
124.Lu, P., Müller, W.J., Chacko, E.K., 2000. Spatial variations in xylem sap flux density in the trunk of orchard-grown, mature mango trees under changing soil water conditions. Tree Physiol. 20, 683-692.
125.MacMillan, J., 2001. Occurrence of gibberellins in vascular plants, fungi, and bacteria. J Plant Growth Regul 20, 387-442.
126.Malik, A.U. & Singh, Z. 2003 Abscission of mango fruitlets as influenced by biosynthesis of polyamines J. Hort. Sci. Biotechnol. 78 721 727
127.Malik, A.U., Singh, Z., 2003. Abscission of mango fruitlets as influenced by biosynthsis of polyamines. J. Hortic. Sci. Biotechnol. 78, 721-727.

128. Masia, A., Ventura, M., Gemma, H., Sansavini, S., 1998. Effect of some plant growth regulator treatments on apple fruit ripening. Plant Growth Reg 25, 127-134.
129. Meland, M., 1998. Thinning apples and pears in a nordic climate. III. The effect of NAA, ethephon and lime sulfur on fruit set, yield and return bloom of three apple cultivars. Acta Hort 463, 517-525.
130. Menzel, C.M., Simpson, D.R., 1986. Effect of temperature on growth and flowering of Litchi (Litchi Chinensis Sonn.) cultivars. J. Hort. Sci. 63, 349-360.
131. Mok, D.W.S. & Mok, M.C. 2001 Cytokinin metabolism and action Annu. Rev. Plant Physiol. Mol. Biol. 52 89 118
132. Monteith, J.L., 1995. A reinterpretation of stomatal responses to humidity. Plant Cell Environ. 18, 357-364.
133. Montoya-García, C.O.; Volke-Haller, V.H.; Trinidad-Santos, A.; Villanueva-Verduzco, C. Nutrient concentration of purslane (Portulaca oleracea L.) in response to NPK fertilization. Agrociencia 2018, 52, 241–254.
134. Morgan, P.W., He, C.-J., De Greef, J.A., De Proft, M.P., 1990. Does water deficit stress promote ethylene synthesis by intact plants? Plant Physiol. 94, 1616-1624.
135. Mukherjee, S. 1953 The mango—Its botany, cultivation, uses and future improvement, especially as observed in India Econ. Bot. 7 130 162
136. Mukherjee, S., 1953. The mango-its botany, cultivation, uses and future improvement, especially as observed in India. Economic Botany 7, 130-162.
137. Munir, T.M.; Khadka, B.; Xu, B.; Strack, M. Mineral nitrogen and phosphorus pools affected by water table lowering and warming in a boreal forested peatland. Ecohydrology 2017, 10, 1–15.
138. Musvoto, C. & Campbell, B. 1995 Mango trees as components of agroforestry systems in Mangwende, Zimbabwe Agrofor. Syst. 32 247 260
139. Notodimedjo, S. 2000 Effect of GA3, NAA and CPPU on fruit retention, yield and quality of mango (cv. Arumanis) in East Java Acta Hort. 509 587 600
140. Notodimedjo, S., 2000. Effect of GA3, NAA and CPPU on fruit retention, yield and quality of mango (cv. 'Arumanis') in east java. Acta Hort 509, 587-600.
141. Oosthuyse, S.A. 1993. Effect of spray application of KNO3, urea and growth regulators on the yield of ‘Tommy Atkins’ mango South African Mango Grow. Assn Yrbk. 13 58 62
142. Oosthuyse, S.A. 1995. Effect of post-bloom aqueous spray application of GA3, NAA, and CPPU on fruit retention, fruit size and yield in Tommy Atkins and Heidi mango South African Mango Grow. Assn. Yrbk. 15 31 33
143. Oosthuyse, S.A., 1995. Effect of post-bloom aqueous spray application of GA3, NAA, and CPPU on fruit retention, fruit size and yield in Tommy Atkins and Heidi mango. S.A. Mango Growers' Assoc. Yearbook 15, 31-33.
144. Oosthuyse, S.A., 1997. Effect of KNO3 sprays to flowering mango trees on fruit retention, fruit size, tree yield, and fruit quality. Acta Hort 455, 359-366.
145. Ortola, A.G., Monerri, C., Guardiola, J.L., 1998. Fruitlet age and inflorescence characteristics affect the thinning and the increase in fruitlet growth rate induced by auxin applications in citrus. Acta Hort 463, 501-508.
146. Patrick, J.W., 1979. Auxin-promoted transport of metabolites in stems of Phaseolus vulgaris L.: Further studies on effects remote from the site of hormone application. J. Exper. Bot. 30, 1-13.
147. Pavel, E.W., de Villiers, A.J., 2004. Responses of mango trees to reduced irrigation regimes. Acta Hort 646, 63-68.
148. Pena, J., Mohyuddin, A., Wysoki, M., 1998. A review of the pest management situation in mango agroecosystems. Phytoparasitica 26, 129-148.
149. Pesis, E. Induction of fruit aroma and quality by post-harvest application of natural metabolites or anaerobic conditions. In Fruit Analysis; Springer: New York City, NY, USA, 1996; pp. 19–35. Plants 2018, 7, 97 11 of 11
150. Phan, M.V., 2005. Characterization of barren hills and perspectives for rehabilitation in Northern Vietnam, Institute for Plant Production and Agroecology in the Tropics and Subtropics. University Hohenheim, Stuttgart, Germany, pp. 1-149.
151. Polito, V.S., Lavee, S., 1980. Anatomical and histochemical aspects of ethephon-induced leaf abscission in Olive (Olea europaea L.). Bot. Gaz. 141, 413-417.
152. Prenger, J., Ling, P., 2000. Greenhouse condensation control: understanding and using vapor pressure deficit (VPD), Fact Sheet (Series) AEX-804-01, Columbus, OH. p. 4. http://ohioline.osu.edu/aex-fact/0804.html, date accessed: January 12, 2010.
153. Rademacher, W., 2000. Growth retardants: effects on gibberellin biosynthesis and other metabolic pathways. Ann. Rev. Plant Physiol. 51, 501-531.
154. Ram, S. 1983. Hormonal control of fruit growth and fruit drop in mango cv. ‘Dashehari’ Acta Hort.

134 169 178
155. Ram, S., 1983. Hormonal control of fruit growth and fruit drop in mango cv. Dashehari. Acta Hort 134, 169-178.
156. Ram, S., Bist, L.D., Lakhanpal, S.C., Jamwal, I.S., 1976. Search for suitable pollinizers for mango cultivars. Acta Hort 57, 253-263.
157. Ram, S., Sirohi, S.C., Rathore, V.S., 1983. Naturally occurring cytokinins in mango (Mangifera indica L.) fruit. Aust. J. Plant Physiol. 10, 65-73.
158. Razzaq, K.; Khan, A.; Malik, A.; Shahid, M.; Ullah, S. Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of ‘kinnow’mandarin. J. Plant Nutr. 2013, 36, 1479–1495.
159. Ribeiro, S.M.R., Barbosa, L.C.A., Queiroz, J.H., Knödler, M., Schieber, A., 2008. Phenolic compounds and antioxidant capacity of Brazilian mango (Mangifera indica L.) varieties. Food Chemistry 110, 620-626.
160. Richards, E.L. The Mango—Botany, Production and Uses, 2nd ed.; CABI: Oxford, UK, 2009; p. 680.
161. Roberts, J.A., Elliott, K.A., Gonzalez-Carranza, Z.H., 2002. Abscission, dehiscence, and other cell separation processes. Annual Review of Plant Biology 53, 131-158.
162. Roberts, J.A., Osborne, D.J., 1981. Auxin and the control of ethylene production during the development and senescence of leaves and fruits. J. Exper. Bot. 32, 875-887.
163. Roberts, J.A., Schindler, C.B., Tucker, G.A., 1984. Ethylene-promoted tomato flower abscission and the possible involvement of an inhibitor. Planta 160, 159-163.
164. Roberts, J.A., Whitelaw, C.A., Gonzalez-Carranza, Z.H., McManus, M.T., 2000. Cell separation processes in plants- models, mechanisms and manipulation. Ann. Bot. 86, 223-235.
165. Roberts-Nkrumah, L.B. 2000 The establishment and growth of young mango trees in on-farm hillside trials in Trinidad, W.I Acta Hort. 509 705 712
166. Ruddell, C.L., 1967b. Hydroxyethyl methacrylate combined with polyethylene glycol 400 and water; an embedding medium for routine 1-2 micron sectioning. Stain Tech. 42, 119-123.

167. Ruiz, R., García-Luis, A., Monerri, C. & Guardiola, J.L. 2001. Carbohydrate availability in relation to fruitlet abscission in citrus Ann. Bot. (Lond.) 87 805 812
168. Ruiz, R., Garcia-Luis, A., Monerri, C., Guardiola, J.L., 2001. Carbohydrate availability in relation to fruitlet abscission in Citrus. Ann. Bot. 87, 805-812.
169. Ryan, J.; Estefan, G.; Rashid, A. Soil and Plant Analysis Laboratory Manual; ICARDA: Aleppo, Syria, 2007.
170. Santoso, P., 2000. Mango production and industry in Indonesia. Acta Hort 509, 51-58.
171. Sauco, V., 1997. Horticultural practices of Mango. Acta Hort 455, 391-400.
172. Sauco, V., 2004. Mango production and world market: current situation and future prospects. Acta Hort 645, 107-116.
173. Schaffer, B., Whiley, A.W., Crane, J.H., 1994. Mango. In: Schaffer, B., Andersen, P.C. (Eds.), Handbook of environmental physiology of fruit crops subtropical and tropical crops, Vol. II. CRC Press, Boca Raton, FL.
174. Scott, F.M., Schroeder, M.R., Turrell, F.M., 1948. Development, cell shape, suberization of internal surface, and abscission in the leaf of the 'Valencia' orange, Citrus sinensis. Bot. Gaz. 109, 381-411.
175. Searle, C., Whiley, A.W., Simpson, D.R., Saranah, J.B., 1995. A preliminary phenophysiological model for 'Kensington' mango in subtropical Australia. In: Mango 2000- Marketing Seminar and Production Workshop Proceedings. Queensland Dept. of Primary Ind., Brisbane, 127-135.
176. Sexton, R. & Roberts, J.A. 1982. Cell biology of abscission Annu. Rev. Plant Physiol. 33 133 162
177. Sexton, R., 1979. Spatial and temporal aspects of cell separation in the foliar abscission zones of Impatiens sultani Hook. Protoplasma 99, 53-66.
178. Sexton, R., 1994. Abscission. In: Pessarakli M (ed) Handbook of Plant and Crop Physiology. Dekker, New York, USA.
179. Sexton, R., 1998. The role of ethylene and auxin in abscission. Acta Hort 463, 435-444.
180. Sexton, R., Redshaw, A.J., 1981. The role of cell expansion in the abscission of Impatiens sultani leaves. Ann. Bot. 48, 745-756.
181. Sexton, R., Roberts, J.A., 1982. Cell biology of abscission. Ann. Rev. Plant Physiol. 33, 133- 162.
182. Sharma, R.; Singh, R. The fruit pitting disorder—A physiological anomaly in mango (Mangifera indicia L.) due to deficiency of calcium and boron. Sci. Hortic. 2009, 119, 388–391.
183. Shaw, G.J.; Ellingham, P.J.; Birch, E.J. Volatile constituents of feijoa—Headspace analysis of intact fruit. J. Sci. Food Agric. 1983, 34, 743–747.
184. Shiraishi, M., Yanagisawa, T., 1988. Anatomical and histochemical studies of starch distribution during abscission in filaments and petals of Wase satsuma Mandarin. J. Japan. Soc. Hort. Sci. 56, 365-

374.
185. Singh, G., 1997. Pollination, pollinators and fruit setting in mango. Acta Hort 455, 116-123.
186. Singh, R., Arora, K.S., 1965. Some factors affecting fruit drop in mango (Mangifera indica L.). Ind. J. Agric. Sci. 35, 196-205.
187. Singh, R.N. & Arora, K.S. 1965. Some factors affecting fruit drop in mango (Mangifera indica L.) Indian J. Hort. 35 196 205
188. Singh, R.N. 1954. Studies on the floral biology and subsequent developments of fruits in the mango (Mangifera indica L.) varieties of Dashehari and Langra Indian J. Hort. 11 69 88
189. Singh, R.N., 1954. Studies in floral biology and subsequent developments of fruits in the mango (Mangifera indica L.) varieties of Dashehari and Langra. Ind. J. Hortic. 11, 69-88.
190. Singh, R.N., Majumdar, P.K. & Sharma, D.K. 1966. Sex-expression in mango (Mangifera indica L.) with reference to prevailing temperature Proc. Amer. Soc. Hort. Sci. 89 228 229
191. Singh, R.S., Ram, S., 1983. Studies on the use of plant growth substances for fruit retention in mango cv. 'Dashehari'. Ind. J. Hortic. 40, 188-194.
192. Singh, U.R., 1960. Studies in the fruit drop of mango (Mangifera indica L.). II. Nature and extent of fruit drop. Hortic. Adv. 4, 142-154.
193. Singh, U.R., 1961. Studies in the fruit drop of mango. IV. Embryo development, its degeneration and studies on fruit-pedicel and abscission zone. Hort. Adv. Sahar. 5, 218-227.
194. Singh, Z. 2009. Gibberellin type and time of application influence fruit set and retention in mango Acta Hort. 820 407 412
195. Singh, Z., 2005. Embryo abortion in relation to fruit size, quality, and concentrations of nutrients in skin and pulp of mango. Journal of Plant Nutrition 28, 1723 - 1737.
196. Singh, Z., Malik, A. & Davenport, T.L. 2005. Fruit drop in mango Hort. Rev. 31 111 153
197. Singh, Z., Malik, A.U., Davenport, T.L., 2005. Fruit drop in mango. Hortic. Rev. 31, 111-153.
198. Singh, Z., Singh, L., 1995. Increased fruit set and retention in mango with exogenous application of polyamines. J. Hort. Sci. 70, 271-277.

199. Singh, Z.; Malik, A.U.; Davenport, T.L. Fruit drop in mango. In Horticultural Reviews; Janick, J., Ed.; John Wiley & Sons, Inc.: New York City, NY, USA, 2010; Volume 31, pp. 111–153.
200. Skoog, F., Armstrong, D., 1970. Cytokinins. Ann. Rev. Plant Physiol. 21, 359-384.
201. Snyder, R.L., Paw, U.K.T., 2002. Measuring vapour pressure deficit in the field. Regents of the University of California, http://biomet.ucdavis.edu/biomet/VPD/vpd.htm, date accessed: January 6, 2010.
202. Souza, M.P.; Vaz, A.F.; Cerqueira, M.A.; Texeira, J.A.; Vicente, A.A.; Carneiro-da-Cunha, M.G. Effect of an edible nano multilayer coating by electrostatic self-assembly on the shelf life of fresh-cut mangoes. Food Bioprocess Technol. 2015, 8, 647–654.
203. Spreer, W., Nagle, M., Neidhart, S., Carle, R., Ongprasert, S., Müller, J., 2007. Effect of regulated deficit irrigation and partial rootzone drying on the quality of mango fruits (Mangifera indica L., cv. 'Chok Anan'). Agric. Water Manage. 88, 173-180.
204. Spreer, W., Ongprasert, S., Hegele, M., Wünsche, J.N. & Müller, J. 2009. Yield and fruit development in mango (Mangifera indica L. cv. Chok Anan) under different irrigation regimes Agr. Water Mgt. 96 574 584
205. Spreer, W., Ongprasert, S., Hegele, M., Wünsche, J.N., Müller, J., 2009. Yield and fruit development in mango (Mangifera indica L. cv. Chok Anan) under different irrigation regimes. Agric. Water Manage. 96, 574-584.
206. Stephenson, A.G., 1981. Flower and fruit abortion: proximate causes and ultimate functions. Ann. Rev. Ecol Syst. 12, 253-279.
207. Stephenson, R.A., Gallagher, E.C., 1986. Effects of temperature during latter stages of nut development on growth and quality of macadamia nuts. Scientia Hortic. 30, 219-225.
208. Stewart, W.S., Hield, H.Z., Brannaman, B.L., 1952. Effects of 2,4-D and related substances on fruit drop, yield, size and quality of 'Valencia' oranges. Hilgardia 21, 301-309.
209. Stino, R.G., El-Wahab, S.A.M.A., Habashy, S.A. & Kelani, R.A. 2011. Productivity and fruit quality of three mango cultivars in relation to foliar sprays of calcium, zinc, boron or potassium J. Hort. Sci. Ornam. Plant. 3 91 98
210. Stopar, M., 1998. Apple fruitlet thinning and photosynthate supply. The Journal of Horticultural Science & Biotechnology 73, 461-466.
211. Stösser, R., Rasmussen, H.P., Bukovac, M.J., 1969a. Histochemical changes in the developing abscission layer in fruits of Prunus cerasus L. Planta 86, 151-164.
212. Stösser, R., Rasmussen, H.P., Bukovac, M.J., 1969b. A histological study of abscission layer formation in cherry fruits during maturation. J. Amer. Soc. Hort. Sci. 94, 239-243.

213. Sukhvibul, N., Whiley, A.W., Smith, M.K. & Hetherington, S.E. 2000. Susceptibility of mango (Mangifera indica L.) to cold-induced photoinhibition and recovery at different temperatures Austral. J. Agr. Res. 51 503 513
214. Sukhvibul, N., Whiley, A.W., Smith, M.K., 2005. Effect of temperature on seed and fruit development in three mango (Mangifera indica L.) cultivars. Scientia Hortic. 105, 467-474.
215. Sukhvibul, N., Whiley, A.W., Smith, M.K., Hetherington, S.E., Vithanage, V., 1999a. Effect of temperature on inflorescence and floral development in four mango (Mangifera indica L.) cultivars. Scientia Hortic. 82, 67-84.
216. Sukhvibul, N., Whiley, A.W., Smith, M.K., Hetherington, S.E., Vithanage, V., 1999b. Effect of temperature on inflorescence development and sex expression of mono- and polyembryonic mango (Mangifera indica L.) cultivars J. Hortic. Sci. Biotechnol. 74 (1), 64-68.
217. Taylor, J.E., Whitelaw, C.A., 2001. Signals in abscission. New Phytol. 151, 323-340.
218. Thimmappaiah, & Suman, C.L. 1987 Sex ratio in relation to fruit-set and fruit yield in mango Punjab Hort. J. 27 8 11
219. Thorpe, M.R., 1974. Radiant heating of apples. J. Appl. Ecol. 11, 755-760.
220. Treharne, K.J., Quinlan, J.D., Knight, J.N., Ward, D.A., 1985. Hormonal regulation of fruit development in apple: 'A mini-review'. Plant Growth Reg 3, 125-132.
221. Urban, L., Jannoyer, M., 2004. Functioning and role of stomata in mango leaves. Acta Hort 645, 441-446.
222. Verdú, A.M.; Mas, M.T. Mulching as an alternative technique for weed management in mandarin orchard tree rows. Agron. Sustain. Dev. 2007, 27, 367–375.
223. Verghese, A., Nagaraju, D.K., Kamala Jayanthi, P.D., Madhura, H.S., 2005. Association of mango stone weevil, Sternochetus mangiferae (Fabricius) (Coleoptera: Curculionidae) with fruit drop in mango. Crop Protection 24, 479-481.
224. Wertheim, S.J., 2000. Developments in the chemical thinning of apple and pear. Plant Growth Reg 31, 85-100.
225. Verheij, E.W.M. 1986. Towards a classification of tropical fruit trees Acta Hort. 175 137 150
226. Westerling, A.L., Cayan, D.R., Brown, T.J., Hall, B.L., Riddle, L.G., 2004. Climate, Santa Ana winds and autumn wildfires in Southern California. Eos 85, 289-300.
227. Whiley, A.W., Rasmussan, T.S., Saranah, J.B., Wolstenholme, B.N., 1989. Effect of temperature on growth, dry matter production and starch accumulation in ten mango (Mangifera indica L.) cultivars. J. Hort. Sci. 64, 753–765.
228. Whiley, A.W., Rasmussen, T.S., Saranah, J.B., Wolstenholme, B.N., 1996. Delayed harvest effects on yield, fruit size and starch cycling in avocado (Persea americana Mill.) in subtropical environments. II. The late-maturing cv. Hass. Scientia Hortic. 66, 35-49.
229. Whiley, A.W., Rasmussen, T.S., Wolstenholme, B.N., Saranah, J.B., Cull, B.W., 1991. Interpretation of growth responses of some mango sultivars grown under controlled temperatures. Acta Hort 291, 22-31.
230. Whiley, A.W., Saranah, J.B., Rasmussen, T.S., Winston, E.C. & Wolstenholme, B.N. 1988. Effect of temperature on growth of ten cultivars of mango with relevance to production in Australia. Proc. 4th Austral. Conf. Tree and Nut Crops. p. 176–185
231. Whiley, A.W., Saranah, J.B., Rasmussen, T.S., Winston, E.C., Wolstenholme, B.N., 1988. Effect of temperature on growth of 10 mango cultivars with relevance to production in Australia, in: Batten, D. (Ed.), Proceedings of the 4th Australasian Conference on Tree and Nut Crops, Lismore, pp. 176–185.
232. Whiley, A.W., Schaffer, B., 1997. Stress Physiology, In: Litz, R.E. (Ed.), The Mango-Botany, Production and Uses. CAB International, Oxon, UK, pp. 147–173.
233. Whiley, W.A., Searle, C., Schaffer, B. & Wolstenholme, N.B. 1999. Cool orchard temperatures or growing trees in containers can inhibit leaf gas exchange of avocado and mango J. Amer. Soc. Hort. Sci. 124, 46 51.
234. Williams, R.R., 1980. Control of premature fruit drop in Macadamia integrifolia: effects of naphthalene acetic acid application, cincturing, and shoot-tip removal. Aust. J. Exp. Agric. Anim. Husb . 20, 740-742.
235. Wilson, A.D.; Baietto, M. 2009. Applications and advances in electronic-nose technologies. Sensors, 9, 5099–5148.
236. Wilson, K.B., Bunce, J.A., 1997. Effects of carbon dioxide concentration on the interactive effects of temperature and water vapour on stomatal conductance in soybean. Plant Cell Environ. 20, 230-238.
237. Wilson, W.C., Hendershott, C.H., 1968. Anatomical and histochemical studies of abscission of oranges. Proc. Am. Soc. Hortic. Sci. 92, 203-210.
238. Witney, G.W., Bender, G.S., 1992. Water Conservation Strategies for California Groves, Proceeding of Second World Avocado Congress, USA, pp. 349-355.

239. Wolstenholme, B.N., 2002. Ecology: Climate and the edaphic environment. In: Whiley A.W, Schaffer B, Wolstenholme B.N (Eds) The Avocado: Botany, Production and Uses. CABI Publishing, Wallingford UK.
240. Wünsche, J.N. & Ferguson, I.B. 2005 Crop load interactions in apple. Hort. Rev. 31 231- 290
241. Wünsche, J.N., Greer, D.H., Palmer, J.W., Lang, A., McGhie, T., 2001. Sunburn- the cost of a high light environment. Acta Hort. 557, 349-356.
242. Yamada, F., Fukamachi, H. & Hidaka, T. 1996. Photosynthesis in longan and mango as influenced by high temperatures under high irradiance J. Jpn. Soc. Hort. Sci. 64, 749 756
243. Yamada, F., Fukamachi, H., Hidaka, T., 1996. Photosynthesis in longan and mango as influenced by high temperatures under high irradiance. J. Japan. Soc. Hort. Sci. 64, 749-756.
244. Yan, Z.; Sousa-Gallagher, M.J.; Oliveira, F.A. Shrinkage and porosity of banana, pineapple and mango slices during air-drying. J. Food Eng. 2008, 84, 430–440.
245. Yen Chau, 2008. Statistical Data of Yen Chau District. Statistical Department, unpublished. Yuan, R., Huang, H., 1988. Litchi fruit abscission: its patterns, effect of shading and relation to endogenous abscisic acid. Scientia Hortic. 36, 281-292.
246. Young, A. 1989. Agroforestry for soil conservation. CAB International, Wallingford, UK
247. Yuan, R. & Huang, H. 1988. Litchi fruit abscission: Its patterns, effect of shading and relation to endogenous abscisic acid Sci. Hort. 36, 281 292
248. Yuan, R.C., Hartmond, U., Kender, W.J., 2002. Naphthalene acetic acid and 2,3,5-triiodobenzoic acid affect the response of mature orange fruit to abscission chemicals. Hort Science, 37, 348–352.
249. Zia, M.H.; Ahmad, R.; Khaliq, I.; Ahmad, A.; Irshad, M. 2006. Micronutrients status and management in orchards soils: Applied Aspects. Soil Environ., 25, 6–16.
250. Zucconi, F., Monselise, S.P. & Goren, R. 1978. Growth abscission relationships in developing orange fruit Sci. Hort. 9, 137 146
251. Sharma, M. O. H. I. T., and A. D. I. T. I. Mathur. "Boosting mango exports with gap adoption: challenges and prospects." IMPACT: International Journal of Research in Business Management (IMPACT: IJRBM) 4.5 (2016): 35-44.
252. Nair, Vaishnavi. "Market Potential Of Agrochemicals Used In Mango And Okra From Valsad And Surat Districts." IMPACT: International Journal of Research in Business Management (IMPACT: IJRBM) 6.7 (2018) 37-42
253. Shende, Deepika, Awani Shrivastav, and Ashis Kumar Datta. "Effect of Mango Puree Thickness on Refractance Window Drying For Making Mango Leather." IMPACT: International Journal of Research in Engineering & Technology 7.5 (2019) 41-54
254. Amulya, P. R., et al. "Effect of Edible Wax Coating and Map on the Quality of Mango During Storage." International Journal of Agricultural Science and Research (IJASR) 6.4 (2016): 13-18.
255. Karkera, Anusha, Kiran Kamalakar Mirajkar, and Renuka Sudarshan Patil. "Antioxidative Enzymes and Biochemical Responses Of Mango (Mangifera Indica L.) Genotypes To Mango Leafhopper Infestation." International Journal of Agricultural Science and Research (IJASR) 6.5 (2016) 59-74
256. Micah, JOHN A., and EMMANUEL W. Inkoom. "Overcoming Constraints in Mango Production in Ghana." International Journal of Agricultural Science and Research (IJASR) 6.5 (2016): 147-154.