CHAPTER II

REVIEW OF LITERATURE

The severity of fruit cracking prior to their harvest attracted the attention of a number of workers to analyse this malady. Excellent contribution on the various attributes related with the fruit cracking in temperate fruits was made by Foster (1937), Louw (1948), and Knoppen (1949) in cherry, Frazier (1936), Frazier and Bowers (1947) in tomato, and Louw (1948), Fritzsche (1950), and Nilsson and Bjurman (1960) in apple. Cheema et al. (1954) and Randhawa et al. (1958) reported this malady in pomegranate, limes and lemons, respectively. The severity with which this malady occurs in pomegranate and lime necessitated a thorough survey of literature on the causes and controls of cracking in these fruits, thus, enabling to understand the nature of the problem in order to overcome this malady.

1. Extent of cracking

The intensity of fruit cracking differs with the type of fruit and also among varieties of the same type depending on the atmospheric conditions, physico-chemical and anatomical characters. The earliest account of cracking in fruits was given by
Rixford (1918) in fig and the damage was reported to the extent of 25 per cent. Foster (1937) recorded fruit cracking as high as 90 per cent in cherry. On the contrary, Knoppian (1949) and Louw (1948) experimenting on the same fruit recorded only 28.5 per cent cracking. The latter, in apple observed cracking to the extent of 63 per cent. Randhawa et al. (1958) in citrus reported great variations in the intensity of fruit cracking in different varieties of lemons and oranges. The highest incidence of (31.87%) of fruit cracking was recorded in Italian lemon, while it was least in variety Genoa (6.9%). Pomegranate crop is also severely damaged by this malady as pointed out by Hayes (1960). The damage sometimes exceeded 50 per cent of the crop (Cheema et al., 1954).

II. Nature of fruit cracking

Frazier (1936) reported that the incidence of cracking in tomato exhibited variations from plant to plant, as well as, among the fruits on adjacent plants. It was further reported in tomato that certain individual plants within the variety were more resistant to fruit cracking than others (Frazier and Bowers, 1947). Coit (1919) related the incidence of fruit cracking on a single
plant to the position of the fruits on the tree. He observed in citrus that the fruits borne on outer twigs and exposed to adverse atmospheric conditions were likely to be damaged more by cracking than those protected inside the foliage of the tree.

A study of nature of cracking further revealed that radial splitting was frequent in citrus fruits and always initiated from the stylar end, transverse splitting was also reported but was less common (Fawcett, 1936, Randhawa et al., 1958).

III. Factors affecting fruit cracking

A. Weather

Atmospheric conditions viz, temperature rain and humidity etc. have long been known to influence growth or development of the fruits, having a pronounced effect upon fruit cracking. It is a general conviction among the orchardist that a climate marked by severe weather conditions, i.e., intense hot and dry season followed by wet and high humid conditions is unsuitable for growing some of the fruits due to their susceptibility to cracking under these conditions. The observations of Levin et al. (1959) in cherries, were also similar. Cracking, thus, appears to be influenced more by the interactions of various climatological attributes than through
their individual effects.

Both, drought and rain bring about profuse fruit cracking, especially when the former precedes the latter. Coit (1919) reported that in Navel orange fruits, continued drought in the early season checked growth, resulted in inelastic nature of the peel and consequently, the rains later on caused splitting. Findings of Hartman and Bullis (1929), and Powers and Bollen (1947) were similar. They noted that heavy cracking in cherries and grapes was due to excessive rain at the time of fruit maturity. Sawada (1934) in cherries, show that cracking was directly linked with the effect of rain water on the fruit. Randhawa et al. (1958), however, opined that splitting in lemon fruits was due to sudden change in weather conditions especially when dry season preceded heavy rains and period of high humidity. They further reported that hot and dry winds caused desiccation of tissues in the fruit rind, inactivated them and obstructed their further growth. Singh and Singh (1954) ascribed cracking in litchi to hot winds blowing at the time of maturity of fruits. Similar observations were recorded in cherries, apple and citrus (Powers and Bollen, 1947., Luchetti and Maccanti, 1950., Wyss Dunant, 1950). High temperature with low humidity was reported to enhance fruit cracking in tomatoes (Cotter et al., 1961). The fluctuation in atmospheric humidity has
also been reported to influence cracking of fruits. Rixon, as early as 1918, reported cracking in fruits to accompany high atmospheric humidity during the ripening period even though there were no rains. Gardner et al. (1952) reported that excessive atmospheric humidity during certain seasons of the year induced cracking in fruits of apple, cherries and pear. Johnston (1953), however, believed that humidity alone was not enough to cause cracking in Naval orange fruits but the wide fluctuation in humidity was responsible for bringing about this disorder. Fritzschke (1950) observed in apple fruits that skin cracking was due to cessation of fruit growth during drought period followed by rapid development during rainy season.

Gerritsen (1948) reported that in apple, intensity of fruit cracking exhibited variation on account of seasonal fluctuations. This was also confirmed by Vyvyan (1949) in cherries and plums. The citrus fruits were also found to be affected by cracking during wet season (Nauriyal, 1955).

B. Physico-chemical characteristics of fruits

Fruit cracking was mostly found at the weakest point in the rind of tomato fruits (Frazier and Bowers, 1947). Preston (1946) noticed
that cracks had developed opposite the carpel of apple fruits. In Navel oranges, fruit splitting commonly originated from the navel and the rind being thinnest in this portion (Taylor et al., 1968). Resistance to cracking in other oranges was, however, due to thickness of the rind at the navel end (Johnston, 1953).

Kertesz and Nebel (1936) reported that cracking in cherries was due to high percentage of soluble solids in juice, which affected splitting through excessive absorption of water by the fruits. Frazier and Bowers (1947) on the other hand, attributed cracking in tomatoes to increase sugar contents during long drought which resulted in increased intake of moisture by fruits during rains. The internal pressure was too much for the peel to withstand stress and, thus, splitting occurred. Luchetti and Maccanti (1950) in apple reported that variation in sugar percentage at the time of maturity led to cracking. They pointed out that cracking was not necessarily initiated at the place of highest osmotic pressure but generally at the point of least mechanical resistance of tissues. Hartman and Bullis (1929), however, observed in cherries that high osmotic pressure, as a result of increase in soluble solids and sugars, caused excessive absorption of moisture through the roots or through the epidermis
of the fruit itself and resulted in fruit cracking. Rixford (1918) found that in fig, damp weather enhanced the cell sap circulation which gorged the cells with juice causing an excessive internal pressure and rupturing the skin.

C. Fruit peel permeability

Excessive absorption of water either through the roots or from the humid atmosphere generally caused fruit cracking. This was found to be the common cause of cracking in cherry fruits (Levin et al., 1950), but findings of Verner and Blodgett (1931) have shown that cracking in sweet cherries was also due to absorption of water through the skin of the fruit. This is directly influenced by the skin of the fruit and skin permeability. Hartman and Bullis (1929), Kertesz and Nebel (1935), and Frazier (1935) reported that water intake in fruits caused swelling and induced fruit cracking. Verner (1957) established a relationship between the water intake and cracking in cherry fruits. Submergence of cherries in water caused profuse cracking in them (Powers and Bollen, 1947).

D. Histology of cell affecting fruit cracking

The histological changes during
fruit cracking and the bearing of the anatomical structure on the resistance to cracking has been investigated by many workers so as to establish a relationship between anatomy of fruit rind and cracking of fruits (Tetley, 1930., Kertesz and Nebel, 1935., Verner, 1938., and Milicic, 1956). It was a common belief among the previous investigators that weakening of the peel was closely linked with the structure and the arrangement of the cells. Tetley (1930), however, reported that cracking in apple was caused when cold dry period was followed by warm and wet season. This produced comparatively thick and inelastic type of cuticular cells, especially on the exposed side of the fruits. Thus, epidermis was unable to check the rapid swelling of the cells and the consequent cracking thereof. Kertesz and Nebel (1935) working on cherries and Verner (1938) on apple fruits found that cracking was chiefly on account of premature cessation of growth in the hypodermal layers, whereas the cortex continued to grow and thus cells of both the zones separated from each other and were exposed to cracking. In tomato, Milicic (1956) reported that the cuticular layer was quite thick and in the lateral walls intercellular ribs were well developed. He held the view that break up of cutinized part of epidermal layer might, therefore, be only due to tension in
the epicarp of mature fruit. The outer cracks produced in the cuticle and cuticular layers were open and the inner cracks were caused by breaking of cuticular ribs.

IV. Control measures

A review of the various attributes related to the incidence of fruit cracking established that primarily the climatological, physico-chemical and anatomical factors provided basis for bringing about the necessary conditions leading to cracking in fruits. Little can be done to modify the climate but influence can certainly be minimised and in turn the effective control can be devised by regulating the cultural practices and modifying the physiological conditions with the help of chemicals and growth promoting substances.

It was pointed out by Verner (1938) that the susceptibility of fruits to cracking might be due to difference in the rate of water absorption and also on account of unequal capacities for expansion of the peripheral tissues to accommodate the increased fruit volume resulted due to water absorption; any treatment that led to decrease the rate of water intake, increased the capacity of the fruit tissues to stretch without rupturing and thus reduced the susceptibility of fruits to
cracking. He advocated that cherries having slow rate of water absorption and large capacity for expansion tend to be immune to fruit cracking. He further believed that degree of permeability of the fruit skin and the elasticity of the peripheral tissues might be subjected to modifications.

Foster (1937) reported successful use of copper sprays in checking fruit cracking in cherries. He attributed reduced cracking to less absorption of water due to change in skin permeability. Evidences showed that fruit cracking was reduced to 1 per cent with copper sulphate spray in cherries (Powers and Bollen, 1947). Knoppien (1949) employed a number of chemical sprays and found copper sulphate to be the most effective for controlling cracking of fruits in cherries. Similar results were reported by Bullock (1952).

Besides copper sulphate and calcium hydroxide, boron and aluminium sulphate were also tried successfully in reducing fruit cracking (Powers and Bollen, 1947), Bullock, 1952). Boron influenced the elasticity of cell membranes and thus brought down percentage of fruit cracking in cherries (Powers and Bollen, 1947). Bullock (1952) checked cracking in cherries to the extent of 50 per cent with boron sprays. Bullock (1952) and
Anonymous (1966) also reported effectiveness of aluminium sulphate as a spray for controlling fruit cracking in cherry.

Recently the role of plant regulators in modifying the physiological functions of the plant have been demonstrated. These growth regulators inhibit or accelerate the metabolic functions of the plant parts. Among the various plant regulators used, 2, 4-D has been successfully employed against rind disorders (Klots et al., 1966) and fruit cracking (Stewart and Klotz, 1947).

Sudden fluctuation in soil moisture is known to induce fruit cracking by creating enormous pressure inside the fruit due to increased intake of water. This pressure if exceeds to an extent where further expansion of the rind is not possible, cracking of the fruit wall takes place. In order to check this excessive intake of water during the rainy season following a dry period, maintenance of soil moisture level is most essential. Fawcett (1936) suggesting preventive measures for controlling cracking in citrus, emphasized on keeping adequate moisture in the soil during periods of stress. Meynhardt (1957) reported that berry cracking in grapes could be reduced by maintaining regular supply of water to the plants through irrigations. Wilson (1957) advocated uniform supply of soil
moisture for remedying fruit cracking in tomatoes. Randhawa et al. (1958) also recommended frequent and light irrigations during hot months for overcoming cracking disorder in citrus fruits.

Fruit bagging is also an effective measure against cracking due to keeping away hot sun, dry hot wind and excessive humidity from the fruits. Montgomery (1959) reported that the apple fruits covered with polythene bags were free from cracks, while the uncovered fruits showed cracking.

The foregoing review on the causes and control of fruit cracking has brought to light the various attributes contributing to this malady. The previous studies have, however, inadequately covered fruits growing in different regions viz, temperate, tropical and sub-tropical. Only a few instances have been reported so far where such investigations were extended to tropical and sub-tropical fruits. The control measures though reported in an inadequate number have also not been fully explored to the extent of finding out a satisfactory solution of the above disorder.

Consequently, the present investigations were taken up with a view to understand the problem of fruit cracking in lime and pomegranate and to devise suitable preventive measures for checking this malady.