Literature review

I. The Growth of Fleshy Fruit

1. Fleshy fruit

A fruit is the product of determinate growth from an angiospermous flower or influorescence. The word 'fruit' derives from the Latin 'fructus' to enjoy, produce. The fleshy fruit means the edible product of a plant or tree with or without accessory structures and/or seeds and latter become juicy and pulpy.

The fleshy fruit can devided to two types which result from the development of a number of ovaries and flowers.

a) Simple fruit

The fruits which develop from a single overy, for example, peach, orange, mango, pear, apple etc.

b) Compound fruit

The fruit which develop from several ovaries.

- Aggregate fruits, develop from one flower, for example, strawberry, raspherry.
- Multiple fruits, develop from several flowers, for example, pineapple, fig.

For simple fleshy fruits, there are two basic types which classified by the characteristic of development of the endocarp, berry and drupe.

- Berry, the endocarp remains membraneous.
- Drupe, the endocap remains thickens and hardens.

In some fruits, the fruit flesh, edible part, develop from structures other than the gynaecium. They are aceessory fruits.

Apple is a pome which is one kind of accessory fruits and develop from tissue of either the receptacle or possibly the base of perianth.

2. Fruit growth pattern

Growth of fruits can be followed by measuring size (diameter, volume etc.) or/and weight (fresh and dry weight) of fruits sample at intervals during the period of growth.

The two basic characteristic of curve of fruit growth pattern is

1) single sigmoid curve and
2) double sigmoid curve.

For single sigmoid curve, there is three phases of growth curve. (see fig.1)

Phase I Initial phase, a period of slow increase.

Phase II Acceleration period, a period of rapid exponential increase.

Phase III Deceleration period, a period of declining rate of growth.

Fruits having a single sigmoid curve are banana, avocado, strawberry, orange, tomato, melon, pineapple etc..

Double signoid curve, there are two rapid growth periods as phase I and III and between these phases, phase II, has little or no growth occurs (see fig.2). Some of fruits having a double sigmoid are : all stone fruits, fig, grape and olive etc.. In the three growth phases, the components of the fruit (mesocarp, endocarp and seed) do not develop simultaneously.

Phase I : During this initial phase of rapid growth the pericarp and seed increase in size and weight. In the pericarp there is usually a period of cell devision which is followed by rapid cell enlargement. In this phase the endocarp and seed reach almost full size. The development of embryo occurs little.

Phase II : In the second phase, there is a retardation in mesocarp growth but there is initially rapid hardening of the endocarp. The embryo develops rapidly and may, depending on species, reach maximum size during this period.

Phase III : Again in the rapid growth like phase I. There is usually an increase in both cell size and amount of intercellular space in the flesh.

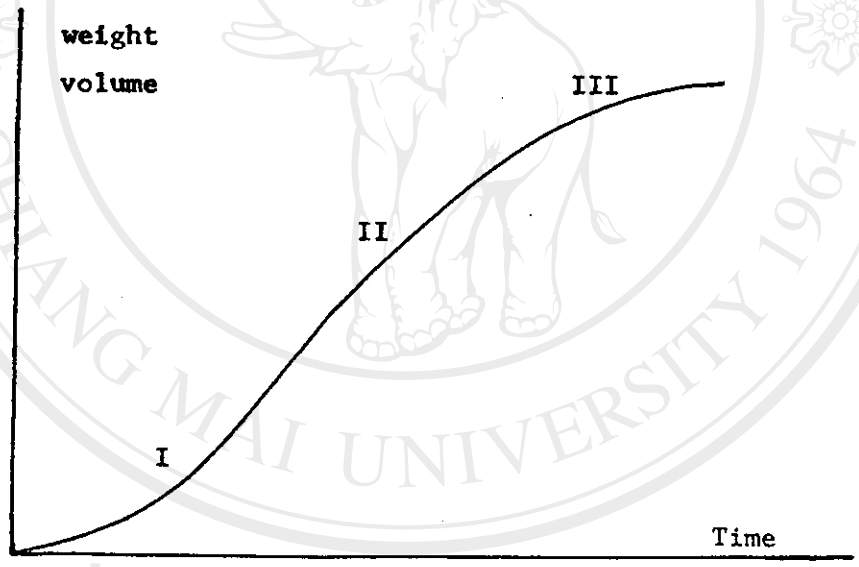

Fig.1 The schematic of a single sigmoid growth curve of fruit.

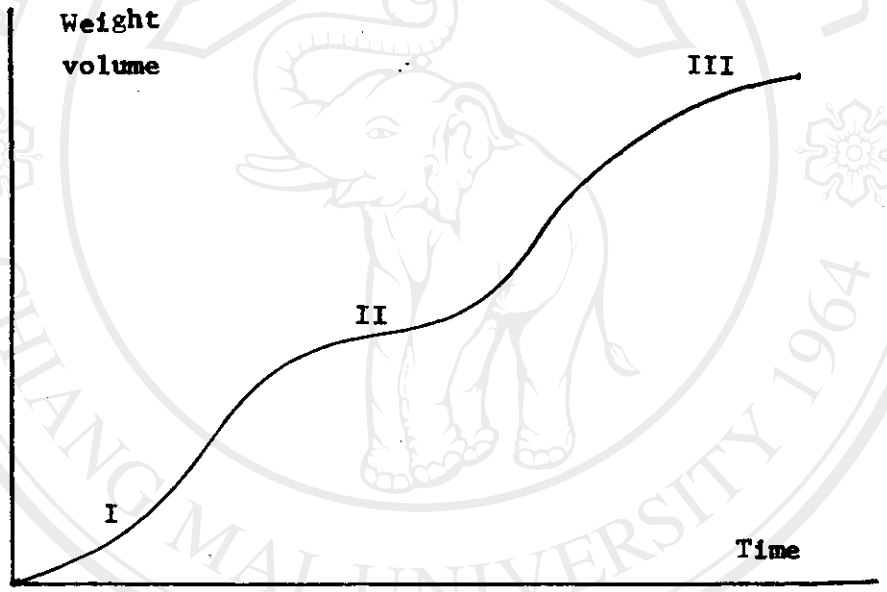

Fig.2 The schematic of a double sigmoid growth curve of fruit.

The major factors of fruit growth are a number of cell before anthesis and cell expansion after anthesis and small contributions result from cell division after anthesis.

The growth of apple fruit.

The growth pattern of various varieties of apple in weight (Bain and Robertson, 1951 ; Smith, 1950), volume (Bain and Robertson, 1951 ; Tukey and Yong, 1942) and tranverse diameters (Tukey and Young, 1942) are shown in fig.3, 4, 5 and 6.

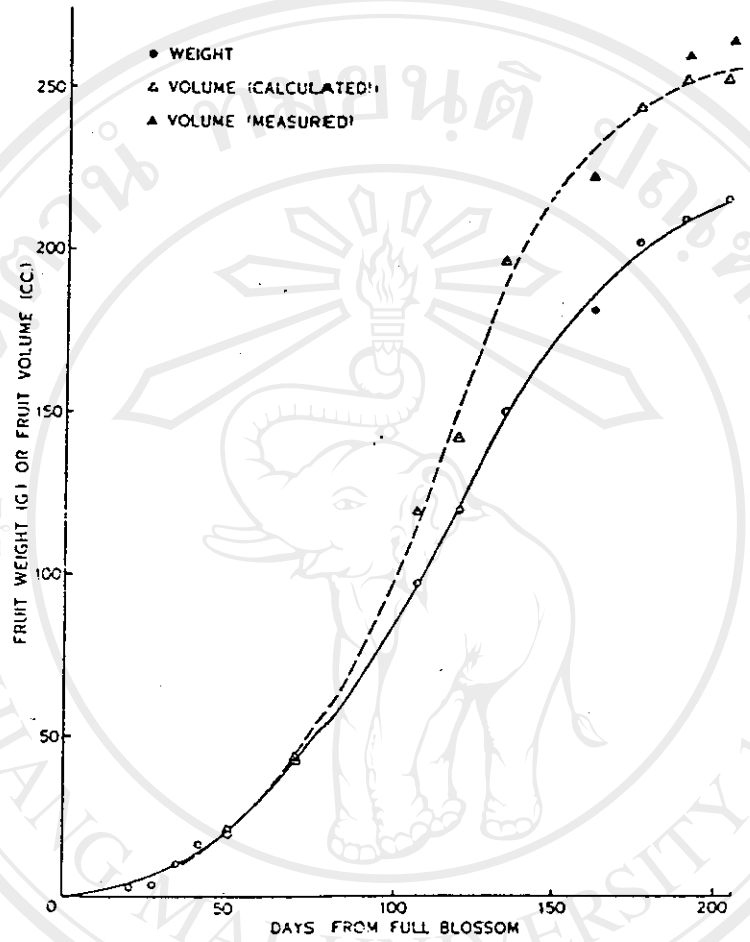

Fig.3 Increase in mean weights and volume of fruits with time. Calculated fruit "volumes" are included for comparison with the measured volumes of two samples.

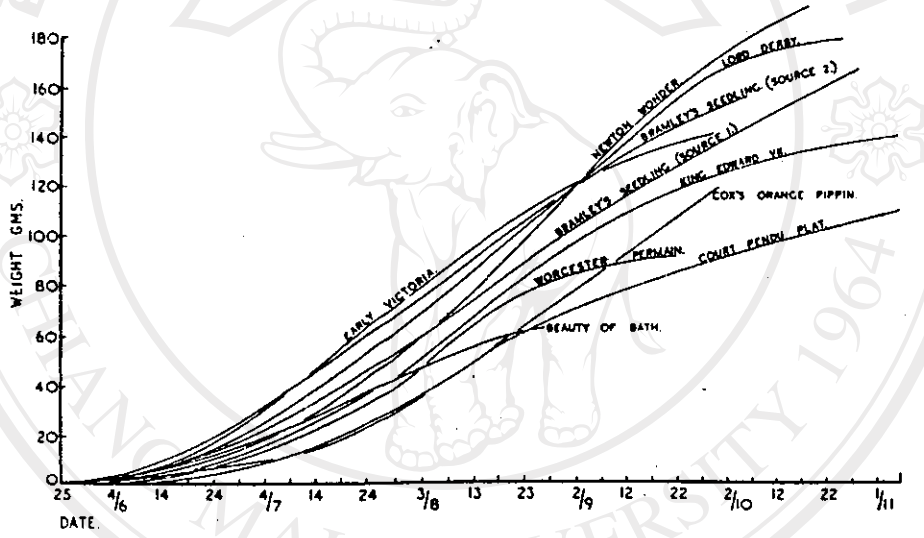

Fig.4 Increase of fruit-weight during development of varieties of apple.

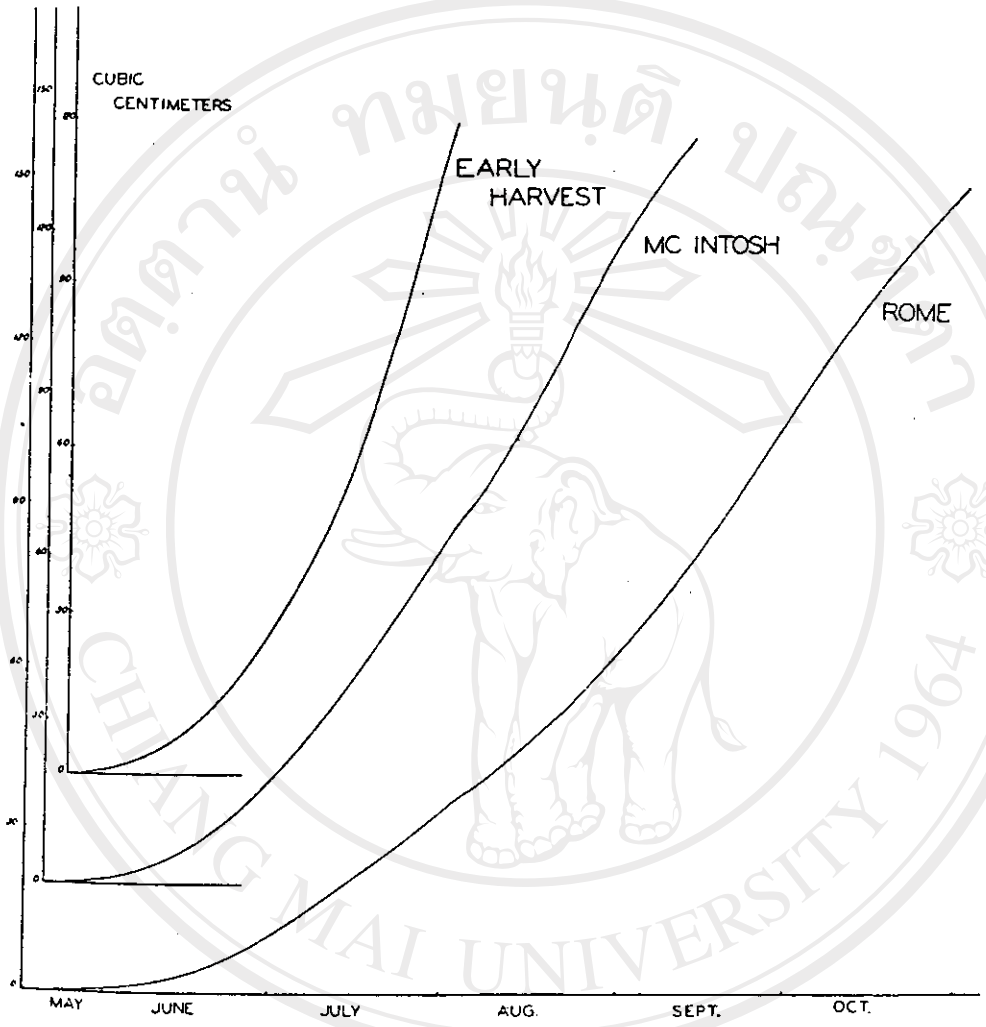

Fig.5 Increase in volume of fruit of Early Harvest, McIntosh, and Rome apples from full bloom to fruit ripening (water displacement method).

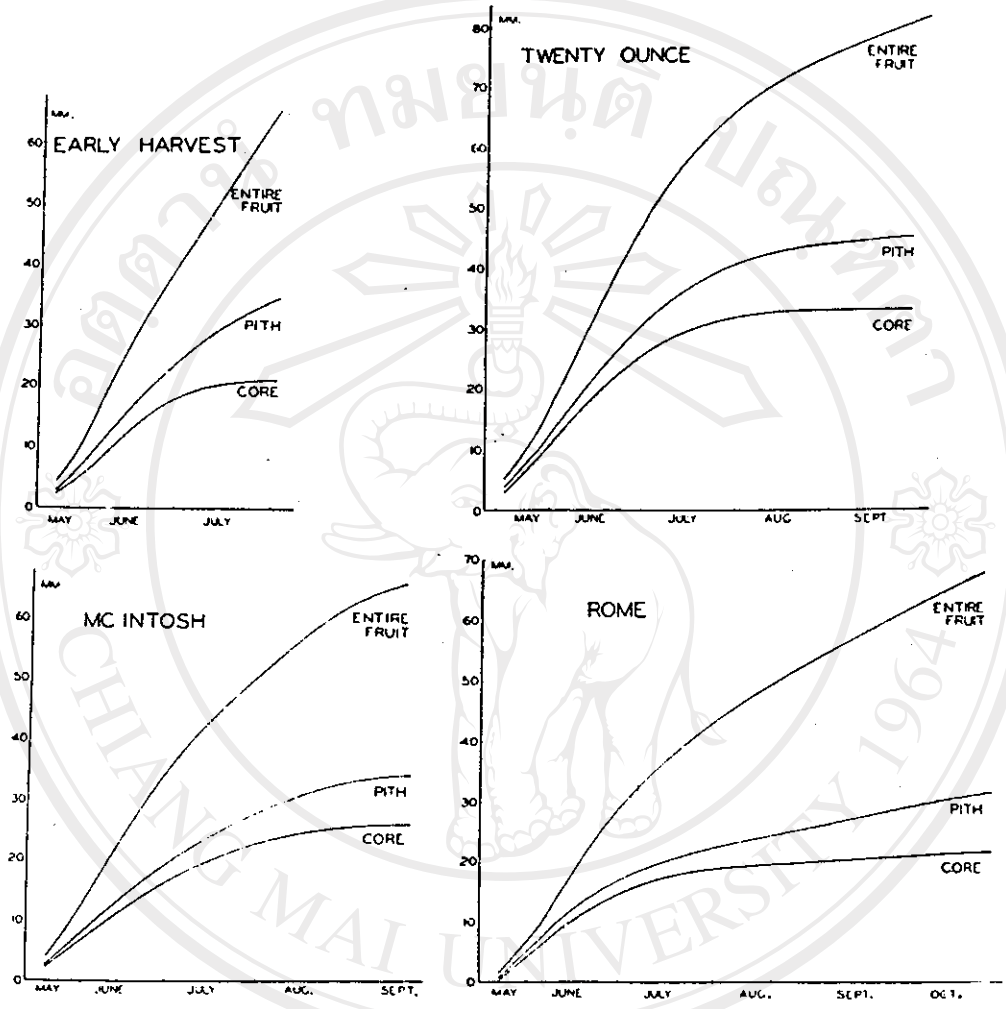

Fig.6 Increase in tranverse diameters of entire fruit, pith, and core or outer boundary of pericarp of Early Harvest, McIntosh, Twenty Ounce, and Rome apples from full bloom to fruit ripening.

Hulmes and Rhodes (1970) stated that during the first few weeks after pollination a phase of rapid cell division occurs. The lenght of this period varies considerably with the variety and the growing conditions. For Cox's Orange Pipin apples grown in England, cell division ceases about 30-40 days from full blossom and this phase coincides with the period of exponential growth of the whole fruit with the Australian apple, Granny Smith, cell division ceases about 4 weeks after full blossom although this variety has a long overall growing period. The major period of growth of the fruit is almost exclusively dependent on cell expansion wich occurs after the period of cell division. During this period the meristematic cells differentiate into the various tissues of the fruit.

General characteristic of fruits

Starch

Starch is commonly found in many young friuts, for example, mango, banana, tomato, pear and apple. During maturation starch usually decrease (Whiting, 1970).

Easu (1965) cited to Miller (1958) that in apple, starch accumulates during ripening but later disappears, whereas sucrose increase in amount.

Sugar

Sugar are present highly in the most fruits at maturity. The main sugars present in fruit are sucrose, glucose and fructose. The predominant sugar varies in different fruits (Wills, et al., 1981). (See table 1).

Table 1 Sugar content of some ripe fruits (From Wills, et al., 1981)

Fruit	Sugar (g/100 g fresh weight)		
	Glucose	Fructose	Sucrose
Apple	2	6	4
Banana	6	4	7
Cherry	5	7	0
date	32	24	8

Table 1 (cont.)

Fruit	Sugar 1 g/100 g fresh weight)		
	Glucose	Fructose	Sucrose
Grape	8	8	0
Orange (juice)	2	2	5
Peach	1	1	7
Pear	2	7	1
Pineapple	2	1	8
Tomato	2	1	0

There is no consistent pattern of changes in sugars (either sucrose and reducing sugars-glucose, fructose) during growth and maturation. In climacteric fruits, for example, apricot, peach mango and passion fruit, show a high sucrose content at maturity. While in apricot and peach sucrose increase during maturation, but in passion fruit it shows a slight decrease. Other climacteric fruits show very little or no sucrose during growth and maturation, e.g. tomato, while plum has none at the immature stage but show a rapidly increasing content near the ripe stage. In non-climacteric fruits, immature oranges have high

sucrose content but slight decrease during maturation. In the cherry, sucrose is absent throughout growth and maturation. Reducing sugars often increase steadily throughout growth and maturation in both climacteric and non-climacteric fruits. The proportion of glucose to fructose differ with various fruits (Mapson, 1970).

Acid

There are several organic acids in fruit, for example, citric, malic, tartaric, oxalic acid. Most fruits often have one dominant acid, for example, malic acid in pip fruits, citric acid in citrus and tartaric acid in grapes. These are generally stored in vacuole. During growth and maturation most fruits show characteristic fluctuations in acid content, usually, the initial level is low, it increases steadily with growth reaching a maximum some time in mid-season, and then steadily declines as the fruit matures. The flavor of fruit is contibuted by the level of acids. Thus sour lemon (Citrus limon) fruit contains 4-9 % of organic acids while sweet lemon (C. limettiodies) contains less than 1 % (Bollard, 1970).

Vitamins

Fruits, together with vegetable, are a good sources of vitamin for human being. Several fruits are sources of

carotene (pro-vitamin A), e.g. apricots, peaches, melons and cherries. Many fruits contain moderate amounts of biotin, pantothenic acid (apricots, citrus fruits). Nicotic acid, folic acid, thiamine and viboflavin also occur little. The greater important vitamin that man obtain from fruit and vegetable, about 90 %, is vitamin C (ascobic acid). The ascobic acid content in some fruits are shown in table 2 (Mapson, 1970).

Table 2 Average ascorbic acid content of fruits. (edible protions). (From Mapson, 1970).

Fruit	Ascobic acid mg/100 g fresh weight
Apple	2-10
Apricot	7-10
Avocado	15-20
Banana	10-30
Cherry	5-8
Guava	300
Lemon	50
Lime	25
Orange	50
Peach	7
Pear	4

For apple, both reducing sugar and sucrose rise throughout the period of growth while starch rises to a peak before harvest. The time of the peak in starch is variable but the decline does not appear to be directly related to the onset of the respiration climacteric. Malate accumulates in the fruit during the early stages of growth on the tree and then slowly declines. (Hulme and Rhodes, 1970).

II. Harvest Indices

Harvest indices are some characteristics of fruits showing the proper stage of maturation that can be picked. Good quality is obtained when harvesting is done at proper stage of maturation. Immature fruits when harvested will give poor quality and erratic ripening.

Pantastico et al., (1975) concluded the determination of maturity as follows :

1. visual means : skin color, size, persistence of a part of style, presence of dried outer mature leaves, drying of the plant body and fullness of fruit ;

2. physical means : ease of seperation or abscission, firmness, and specific gravity ;

3. chemical means : solids, acids, solid-to-acid ratio, and starch content ;

4. computation : days from bloom in relation to date of bloom, and heat units ; and

5. physiological means : respiration.

Harvest indices of apple

Apples harvested too early may be small and not ripen to satisfactory eating quality after storage, whereas apples picked too late may lack firmness and be more susceptible to breakdown and rotting during storage (Wilkinson and Sharples, 1967).

The indices of harvest maturity of apples, "readiness for harvest", are based largly on color (external and internal), flesh firmness, composition (starch, sugar, and acid), mechanical properties (yield force, rupture force, modulus of elasticity, etc.), ease of separation from spurs, and day elapsed from bloom to harvest (Ryall and Pentzer, 1974 ; and Salunkhe and Desai, 1984).

Ryall and Pentzer (1974) cited to Magness et al.,(1926) ; Haller and Smith (1950) ; Rollins and Mathus (1963) ; and Schomer (1965) and concluded that the number of days from bloom to harvest is probably the single most reliable guide to "readiness for harvest". The studies which compare production areas, seasons and cultivars show that the elapsed period is fairly consistent for each cultivar. Results of elapsed period from bloom to harvest studies with several cultivars are shown in Fig.7.

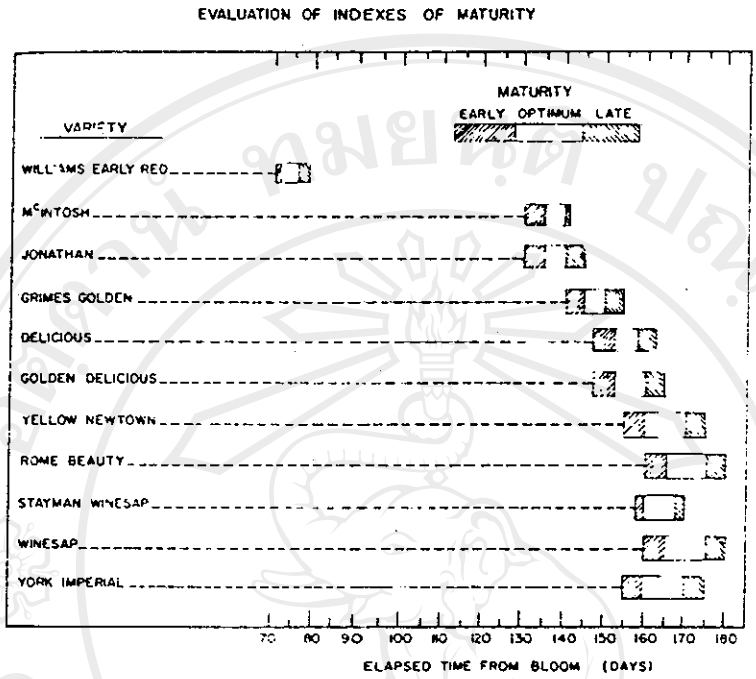

Fig.7 Days from full bloom to harvest maturity of apples. (From Haller and Smith, 1950 ; quoted by Ryall and Penzer, 1974)

Ryall and Pentzer (1974) stated that the Delicious cultivar which now provides a major part of United States production and an increasing proportion of world production. It's divided permissible harvest into three phases as follow ;

1. Early maturity, 135 to 140 days from full bloom ; these satisfy and early market demand, ripen with fair desert quality, and are not highly susceptible to shrivel and scald.

2. Optimum maturity, 140 to 150 days from full bloom ; these are ideal for prolonged storage and ripen with good quality.

3. Late maturity period, more than 150 days from full bloom ; these soften faster than fruit picked earlier, often have some water core at harvest, and are suitible only for brift storage.

Childers (1976) has suggested that ease of separation of fruit from spur can be used for and indication of picking time. When an apple is ready to pick, it can be separated from the spur easily. There are popular varieties, such as McIntosh and Delicious, which may loosen and drop before maturity as a result of various factors. On the other hand, there are certain varieties, as Jonathan and Stayman Winesap, which may retain their fruit until it is overmature. Thus, ease of separation of fruit from the spur is not necessary an indication of proper maturity to harvest, but it may indicate the picking time to save the crop. If no sound fruit is dropping, it is considered that the apples are still attached to the tree, and if a few sound apples are dropping and also fruits can be easily separated from the tree it is the time to pick the crop.

A "Maturity Commitee", the system used in Washington State seem to function effectively and fairly for Delicious

apples. Elapsed period from full bloom, flesh firmness, sugar content and general agreement among the commitee based on experience are criteria used (Ryall and Pentzer, 1974 ; and Childers, 1976).

Judgement of the optimum maturity for harvesting apples with maximum storage potential and desirable fruit quality after storage is one of the most difficult decisions to be made by orchardist. The measurements of total soluble solids, titratable acidity, sugar to acid ratio, starch and soluble pectin contents, flesh firmness, fruit skin and seed coat color, day from full bloom in a given locality, heat units during growing season, and rate of respiration and ethylene production have been suggested to be maturity indices to determine picking date. However, they are not indicative of fruit maturity because of the complications due to variations in microclimates, soil and tree factors,orchard nutrition and management, and seasonal effects. For certain cultivars grown in regions with a ressonably predictable climate, some of these measurement are useful (Fidler et al., 1973 ; quoted by Lau, 1980).