

# Mango Production in Pakistan



**M. H. PANHWAR**

# **MANGO PRODUCTION IN PAKISTAN**

**BY**

**M. H. PANHWAR**

Published by:

M. H. Panhwar Trust  
157-C Unit No. 2  
Latifabad, Hyderabad

<b>Chapter No</b>	<b>Description</b>	
1.	Mango (Magnifera Indica) Origin and Spread of Mango.	4
2.	Botany. .. .. .	9
3.	Climate .. .. .	13
4.	Suitability of Climate of Sindh for Raising Mango Fruit Crop.	25
5.	Soils for Commercial Production of Mango .. ..	28
6.	Mango Varieties or Cultivars .. .. .	30
7.	Breeding of Mango .. .. .	52
8.	How Extend Mango Season From 1 <sup>st</sup> May To 15 <sup>th</sup> September in Shortest Possible Time .. .. .	58
9.	Propagation. .. .. .	61
10.	Field Mango Spacing. .. .. .	69
11.	Field Planting of Mango Seedlings or Grafted Plant ..	73
12.	Macronutrients in Mango Production .. .. .	75
13.	Micro-Nutrient in Mango Production .. .. .	85
14.	Foliar Feeding of Nutrients to Mango .. .. .	92
15.	Foliar Feed to Mango, Based on Past 10 Years Experience by Authors'. .. .. .	100
16.	Growth Regulators and Mango .. .. .	103
17.	Irrigation of Mango. .. .. .	109
18.	Flowering how it takes Place and Flowering Models. ..	118
19.	Biennially In Mango .. .. .	121
20.	How to Change Biennially In Mango .. .. .	126

21.	Causes of Fruit Drop	..	..	..	..	..	..	131
22.	Wind Breaks	..	..	..	..	..	..	135
23.	Training of Tree and Pruning for Maximum Health and Production	..	..	..	..	..	..	138
24.	Weed Control	..	..	..	..	..	..	148
25.	Mulching	..	..	..	..	..	..	150
26.	Bagging of Mango	..	..	..	..	..	..	156
27.	Harvesting	..	..	..	..	..	..	157
28.	Yield	..	..	..	..	..	..	163
29.	Packing of Mango for Market.	..	..	..	..	..	..	167
30.	Post Harvest Treatments to Mango	..	..	..	..	..	..	171
31.	Mango Diseases.	..	..	..	..	..	..	186
32.	Insects Pests of Mango and their Control	..	..	..	..	..	..	211
33.	Mango Processing and Production.	..	..	..	..	..	..	221
34.	Uses of Mango	..	..	..	..	..	..	231
35.	Economics of Mango Production	..	..	..	..	..	..	233

## CHAPTER. 1

### MANGO (MAGNIFERA INDICA) ORIGIN AND SPREAD OF MANGO.

#### Mango family.

Mango belongs to Anacardiaceae family.

Other members of same family are:

- Cashew.
- Pistachio.
- Umbrella or spondiascytherae (South East Asia)
- Gandaria or Bouea macrophella (South East Asia).
- Hogolum (spondias mombin) from tropical Central America.
- Jamaican plum (spondias purpurea).
- Kuwini (Mangifera ordera)

Of above cashew can grown in Ghorabari-Keti Bander area and Amarella in whole Sindh. Ambarella (spondia cytherea), has better potential than all others in Sindh. It comes from South East Asia (Thailand, Indonesia, Philippines etc. Fruit size: dia 4" long, propagated cutting or by budding. It is excellent for jams and preservatives. It is planted at 25 x 25 feet (7.6 x 7.6 meters) with 70 trees per acre. It bears continuously if irrigated or rainfall occurs year around.

#### Mango (Mangifera) edible species.

The 45 species of magnifera are distributed from India to Philippines of them fourteen are edible, but only four are grown on large scale. The four main species (Indica, foelida, odorlia and caesia widely cultivated and their geographical distributors is given in table below along with 9 others which are grown on limited scale in some countries and three more numbers 14, 15, and 16 ,17 are grown though are not very popular.

Name of species	Geographical distribution
1. M.altissima Blenca	Phillippines.
2. M.caesia Jack	Malaysia, Sunda Isles, Bali, Boreneo.
3. M.cochinchinensia	Thailand, vietnam.
4. M.foetida Lour	Surma, Thailand, Laos, Cambodia, Vitenam.
5. M.giffithii	Philippines.
6. M.indica.	India, Sri Lanka, Burma, Thailand, Laos, Combodia, Vietnam, Sunda Isles, New Guinea, Moluccas, Celebes,

	Borneo.
7. <i>M.isgenifera</i> Griff	Thailand, Laos, Cambodia, Vietnam, Malay paninsula.
8. <i>M.macrocarpa</i> 81	Laos, Cambodia, Vietnam, Malaysia, Borneo, Sunda Isles.
9. <i>M.odoreta</i> Griff	Laos, Cambodia, Vietnam, Malaysia, Sunda Isles, Borneo, Celebes.
10. <i>M.pajang</i> Kastern.	Thailand to Malay peninsula.
11. <i>M.pentendra</i>	
12. <i>M.sylvatica</i> Roxb	India, Burma, Thailand, Laos, Cambodia, Vietnam, Malaysia.
13. <i>M.zaylanica</i>	Sri Lanka
14. <i>M.oblongifolia</i>	Thailand, Laos, cambodia, Vietnam, Malay peninsula.
15. <i>M.kemanga</i> 81	Malaysia, Sunda Isles.
16. <i>M.rumphil</i>	Malaysia, Moluccas.

It is not possible to describe all 45 mango relatives but figures of some are given for general information of readers.

#### **Origin of mangifera indica.**

Mango has more than 45 relatives discovered so far mostly in South East Asia and of the researchers the last century's important work was that of Duchman Andre J. G. Kostermom published by Linnean Society London in 1993. This and many other works put origin of mango family million of year back, but the new method of DNA testing may throw some new light of its origin and spread at present. It is generally believed that ancestors of present popular mango first evolved on Assam-Burma border and from there spread to South East and South Asia. The first grown up adjusted to climate of South Asia and there from came to Sindh some Millenia back. The second group spread to South East Asia. The difference between the two is that South Asian group is monoembryonic and South East Asian polyembryonics.

#### **Spread of mango.**

There are two major sites of evolution of mango. The first is mild sub-tropical northern Indian-Burmese region, where it is cultivated for 4000 years. The region has produced varieties having great tolerance to low temperatures and all are monoembryonic varieties. The other is south-East Asia producing polyembryonic varieties. They are acclimated to high temperatures and do not stand cold weather. They have been cultivated for 2000 years. Long lived orchard over 40 years old have tendency to be biennial.

#### **General characteristic**

It is supposed to be native of South and South-East Asia from Assam-Burmese border to Indo .China. Mango tap root goes about 6 meter (20 feet) deep it there is no water logging or rock underneath the surface soil, the horizontal roots of mature tree usually have about 6 meter (20 feet) radius or 12 meters (40 feet)

diameter. About 60-75% of horizontal feeder roots usually are concentrated in the top 45-50 cms (16-20 inches) and the balance below this depth. They are tolerant of drying out, so they can regain rapidly when soil is re-watered. Varieties differ in their horizontal root spread and root spread also changes during the year. It is a large tree height from 5-25 meters, 5-15 meters wide with dome shaped canopy. It has a large number of varieties. Trees if properly looked after can fruit for a hundred years or more. Its popular use is eating fresh as dessert, but other uses are juice, milk shake, jams, chutney, preserved slices, sherbets etc.

Mughal emperor Akbar planted a large orchard of 100,000 trees in northern India in last quarter of sixteenth century and some trees were still fruiting in mid eighteenth century.

It was being grown at 50 x 50 feet (15 x 15 meters) in nineteenth century leaving large space for intercultivation field crops. In mid twentieth century, usually 40 x 40 feet (12 x 12 meters) was recommended in India and Pakistan and by 1980 it was realized that these trees did not meet even in 15 years and another tree at center of square was planted. Today it is considered too primitive for costly land, water and management costs and new spacing are much closure.

It can grow on many soils types, with pH varying from 5.5 to 8.5 and in later case with well drained non saline soils. It accepts tropical and low latitude sub tropical climate from South and South East Asia it has spread to large areas of world within above climatic zones. Of thousands of varieties each country had developed the best one as their national varieties. These are being replaced inter-cultivation in South Asia fast due to international trade. Its root distribution is affected by continuous

Results from Venezuela on root distribution of different cultivars show the following pattern.

<b>Cultivar</b>	<b>Depth of Roots and Percentage</b>	<b>Horizontal spread diameter</b>
Haden.	0-40 cms, 61	6 meters
Diplomatico.	0-40 cms, 63	6 meters
Kent.	0-40 cms, 73	6 meters

The trees were planted at 6x6 meters and no intercultivation was done. In the South-Asia trees acre planted at 50x50 or 40x40 feet and inter crops of wheat, cotton and fodder are planted year around. Ploughing for intercrops and inter-cultivation is common. In these case horizontal roots spread is limited to about 8 to 8.5 feet (2.5 meters). Yields invariably are poor. Height of mango can be 75 to 90 feet or 25-30 meters in South-Asian, as against these commercial orchards in USA have height limited to 3.5 to 4.5 meters. This kind of dwarf tree was produced in the past 40 years, with assistance of Dwarf Tree Association

established in 1964. Long lived orchards over 40 years old in South Asia have tendency to be biennial and very low yielders.

### **Mango production in 7 leading countries of the world 10 years ago.**

1.	India.	10,000,000 tons.
2	China.	1,180,000 tons.
3	Mexico.	1,090,000 tons.
4	Pakistan.	800,000 tons
5	Indonesia.	779,000 tons
6	Thailand.	630,000 tons
7	Nigeria.	500,000 tons

Now the position has changed Australian horticulturist working since 1989, are taking advantage of their climate and geographical position in Southern Hemisphere to introduce high technology to produce and export mangoes to Europe. In expertise, they are already well advanced and are expected to exceed Pakistan in or before 2010.

### **Mango in Brazil.**

#### **General.**

Average yield for that country is 6 tons per acre. This is double that of Pakistan. Mango is grown between 24° S to 2° N, but most of it is close to 24° S having low temperatures and with annual mean of 21° C, against our mean of 27° C in Sindh. Tolerant root stocks are used for control of diseases. This aspect is neither known nor properly invested in South Asia. Malformation causes heavy loss even in Brazil.

#### **Pakistan mango position.**

Pakistan production is 8% of India's and ranks as the fourth largest producer after India, China and Mexico with Brazil and Australia producing more, Pakistan may be pushed back to number six.

#### **Florida mangoes and impact on world industry.**

Mulgoba was only mango which survived a long journey from India to Florida in 1889 .It was pink skinned monoembryonic mango which in next 60 years produced more than 100 outstanding off springs, a type of selection unknown before.

Haden was produced by open pollination between Tarpendine and Mulgoa and Haden became parent of Eldon, Glenn, Lippen, Osteen, Parvin, Smith, Springfield Tommy Aitkin and Zill. Lippen is parent of Irwin. Which is parent of Pope of Hawaii and Tahar of Israel, Keitt and Tommy Aitkin are resistant to some diseases but not to anthracnose and latter is slightly prone to anthracnose



than the former M. Laurinas a poly-embryonic could be good mango relative for breeding and anthracnose resistance.

### **Mango Expansion in the Western Hemisphere.**

Mango expanded due to migrations of South Asian to South-East Asia in the sixth century. The recent century's expansion was brought by the Portuguese, who took mango from Goa to East Africa and from there to West Africa and thence to Brazil. The Spanish expanded it to Central America. It was available in Barbados in 1742, Rio de Janeiro in 1768 and Jamaica 1782, where a plant captured from a French ship by the British was taken to Mexico, and where it was available in 19 century.

## CHAPTER. 2

### BOTANY.

#### **Botanical characteristics of mango.**

The mango tree is large, with spreading branches, 6-15m, high, though in dense jungle, it often attain gigantic sizes of 30 meters or more. Leaves are alternately inserted all along the branches, but are apt to be more dense near the ends of the same, and are rather stiff in texture and shiny, 12-30cm.long, 3 to 9 cm, broad, more or less lance-head in shape, tapering a both to the apex and base, the edges somewhat wavy; the leaf stalks or petioles are 1 to 5 cm .long .Flowers are small and inconspicuous taken singly, but they appear in large branched yellowish inflorescence panicles at the end of the branches. Sepals are small, concave, yellowish green, slightly hairy on the outside; petals yellowish green with a touch of pick or purple at base and sides, oblong; stamen 4 to 5, unequal, one of them much larger and fertile, the rest usually sterile and reduced to mere stalk. The fertile stamen consists of a long filament or stalk and purplish anther. The whole flower is only about 6-8 mm. across when fully opened, and at times has a rather disagreeable odour. The fruit is technically called a drupe, that is to say, it is a fleshy fruit with a large stone in the middle; the quality of the mango depends on the flavour of the flesh; and the absence of fibres; in shape the mango is generally heart-shaped, but in practice most varieties have their own shape and size. Most unripe fruits possess a strong flavour or turpentine, which disappears in the ripe fruit of the better varieties.

#### **Mango Yield n tropics and sub-tropics.**

The following are some characteristics of mango yield.

- Mango yield is poor when compared to other tree crops due to irregular flowering in tropics and failure to set fruit in sub-tropics.
- Yield is also poor due to excessive fruit drop.
- Hermophrodite percentage contributes to reduced production.
- Low winter temperatures of 10-15° C promote growth check and enhance flower initiation, but low temperatures of 5° C can result in to totally male flower inflorescence.
- Photo-inhibiting of photo-synthesis is a process by which excessive light radiation, which is absorbed by leaves, results in to inactivation and / or impairment of chlorophyll-containing reaction centers of chloroplasts, thus inhibiting photosynthesis.
- Chilly nights re-markedly enhance-photo damage, which develops in sun exposed mango leaves on the following day.
- The photo-inhibitory damage gradually accumulates during repetitive cycles of chilly nights and sunny days. This effect occurs in mango,

papaya and banana, but to a lesser extent in citrus and not at all in peach in tropics and sub-tropics.

### Mango tree architecture.

Mango tree architecture is controlled by:

- Genotypes or parentage.
- Grafting height (recommended height for veneer grafting is 8-10cm from ground level.)
- Root-stock type: (the work still is in infancy), but root stocks have definite effect on tree size and spread.
- Planting density: Low density accelerates tree height and spread.
- Training in prunings. Proper pruning produces well shaped tree, sunlight in the limbs and more yield.
- Regularity of bearing: Flowers and fruit have dwarfing effect.
- Intercrop: Intercrops like pulses or leguminous crops may promote growth and some others retard it.
- Fruit set is mostly at distal end.
- Flavour is an account of levels of terpinolene in the fruit pulp. Such flavour is turpentine like and is present in many South-Asian varieties. Terpinolene levels are low in Australian R2E2. Keitt of Florida has lower terpinolene but higher levels of eucalyptol.

### Mango phenological cycle in subtropics.

Item	Time	Dates for Hyderabad Sindh
Flower bud development.	60 days.	1/11 to 31/1
Flower and fruit-set.	40 days.	1/2 to 10/3
Fruit growth.	90 days.	1/3 to 10/6
Vegetative growth.	75 days.	15/7 to 30/9 with peak on 31/8
Root development.	120 days.	1/9 to 31/1 with peak on 1/11
<b>Total</b>	<b>385 days.</b>	

**Note:** Root development overlaps vegetative growth and flowering.

The following is general vegetative growth, flower and fruit development, root flush cycle, as applied to Sindh.

S. No.	Phenological cycle	Timing at Hyderabad (all months inclusive)
1	Flowering and fruit set.	January to March with peak at end February.
2	Premature fruit drop.	March-April
3	Unwanted vegetative growth.	February to April
4	Fruit development to	March to Mid July

	harvest.	
5	Post harvest vegetative flush.	End July to mid Oct with peak at end of Aug.
6	Root development.	September to end December, with peak in early to end November, but continuous up to early January.
7	Vegetative dormancy.	Early or November to end January with no peak.
8	Flower bud development.	December to February with peak, in early February.

### **Tree growth and development and its influence of productivity.**

Following factors determine tree productivity.

- About 30-50 leaves are required to support one fruit in most local varieties but some important locally developed varieties need as low as 10 leaves per fruit.
- The leaves are long lived and have hard leathery texture that minimizes water loss when dry and supports efficient photosynthesis, when conditions are good.
- Large amounts of carbohydrates reserves are required to be stored in tree's permanent structures (roots, trunk, and branches) to enable fruit to utilize these reserves during fruit development.
- A lot of energy is wasted by the trees in retaining excess fruits too long before abscising them. This inhibits tree growth and consequently future yield. The fruit load should be reduced at optimum time by thinning if practical. Tree is able to adjust its crop load through heavy fruit drop, by this it is to directing energy from fruit production in to survival mechanism of tree.
- More numbers of flowers per flower shoot result in to longer period of anthesis in that shoot and this may increase probability of fruit set.
- Larger the tree more energy is wasted to swing in the wind and yield of trees in reduced.

### **Environmental effects.**

In tropical conditions mango has four flushes a year, whereas in sub-tropics one minor one non bearing and one major flush occurs on all panicles, after harvest. The varieties which have lower growth flushes a year are better yielders and regular bears. Tree has resin duct system that helps to maintain water balance during long periods, of drought. Sap that spurts out from fruit in picking, is part of this resin system.

### **Root Activity.**

Root activity of mango was noted by radio-tracer and results were as follows.

- i. In February highest absorption was close to trunk within the diameter of 48 (inches) (1.2 meters) and depth of 6 inches (152mm).

- ii. In February another zone of absorption, was near the periphery.
- iii. Absorption decreased with increased depth of soil.
- iv. Absorption in February was 84% up to depth of 12 inches.
- v. Absorption in October was 77.4% up to a depth of 12 inches.

### **Colour**

Colour of fruit is green and with development it turns yellow and orange. Red and pink colours appear on the shoulders and extend to exposed side of fruits.

### **Flushing of leaves.**

Tree can have one to four flushes annually. New leaves are often red, purple, or light green and change to green on maturity. The length of flush depends on tree health, vigour, crop load and temperature. Varieties determine number of flushes. Flushes occur about 6 weeks after harvest. Adequate fertilizing for two weeks before harvest or immediately after harvest can ensure flushing at the same time. New flush in October can be attacked by leaf minors. This needs control.

### **Dormancy.**

There are two dormancy periods during mango growth cycle. The first dormancy is about 4-8 weeks after harvest. Removal of panicle manually or chemically can reduce this period to about 4 weeks. The second dormancy is caused by cool weather before induction of flowers.

### **Fruit Characteristics**

Shape, size, colour, seed size and fibres from seed into pulp vary from variety to variety and have genetical back ground. Seed is monoembryonic or polyembryonic. The latter produces tree true to mother. In case of the latter 3-4 plants grow from single seed. They can be carefully separated or the dominant, seedling can dominate eliminating all others.

## CHAPTER-3

### CLIMATE

#### **General.**

For any crop, there are optimum climatic conditions for the highest returns. These include location of place i.e. latitude and some times longitude, temperatures before and during flowering, after fruit set to harvest and after harvest to onset of dormancy. Besides rains, humidity, dew, sun light, day length, winds, frost, hail and water stress, all affect the crop cycle, quality, yield and returns to farmer. These are discussed in paragraphs below.

There is yet another factor, the temperatures prevailing in different areas caused by local topography, nearness or remoteness from coast, solar insolation, continentality and cloud lines, all of which cause local micro-climates, which govern the flowering season and effect the crop up to harvest.

#### **a) Suitable Latitudes For Commercial Mango Production.**

Although mango grows in both tropics and sub-tropics, its commercial production is more successful in the low latitude sub-tropics, where there are distinct periods of summer and winter seasons. Winter chill induces heavy flowering and high summer temperatures impart its fruit high levels of sugars, large size, better flavour, higher yields and greater market prices.

Mango grows from 0° - 30° north and south latitudes, but some times is extended to warmer areas upto 37° N as in Spain, along the Mediterranean coast in a special micro-climatic zone. Beyond 28°N and S, there are problems specially of bienniality, frost damages and poor post-harvest growth. Fruit size reduces as at high summer temperatures development of fruit is retarded.

For every 125m increase in height, flowering is delayed by 4 days and for every degree of north of south latitude, it is delayed by another 4 days and some times even to 7 days, depending upon micro-climate of locality. In Australia Kensington pride matures one week later for each degree of latitude south from Bowen to Brisbane in Queensland. Tando Jam near Hyderabad, is 25° 28' N, and Multan is 30° 10' N, and the difference of 5 weeks in harvest is common. It would therefore be safe to assume 7 days delay in harvest for each degree of latitude N or S in most areas of Pakistan.

In the Low land tropics, mango fruits more regularly, at 2000 feet (600 M) elevation or a little higher, than at low elevations, as it gets its chilling requirement of less than 200 chill units earlier, unless at low levels, there is dry period causing stress, to induce blossoming.

### **Optimum Temperature Range For Mango Growing.**

Its growth is optimum where there are no frosts, annual mean temperatures range between 25-26° C (12.6° F) or within about the optimum limits and is suitable for raising mango. Diurnal temperature range is also within 7-15° C though out the year, except 10 to 15 rainy days in July and August. For the best results, mean monthly temperatures during fruit growing period should be above 27° C (81° F), but not exceeding 36° C (96.8° F).

Below temperatures 10° and above 50° C its vegetative growth stops altogether. The maximum temperature at which growth is retarded is 42° C (108°F), but even above this temperature, fruit on the trees keeps maturing, meeting its growth requirements from energy stored in the tree. This condition is fully met in Sindh and Southern Punjab except that the lower limit of 10°C is met only near Hyderabad, Mirpurkhas and down south to coast.

Micro-climate of Hyderabad only 17km miles west of Tando Jam is 1 to 2°C higher, where mango ripens earlier by 3 weeks, as it has higher night temperatures due to urban living and industrial heat, during the fruit development period. Flowering and fruit set is also earlier by two weeks.

High temperatures up to 36° C (97° C) result into vigorous plants. High temperature above 42° C cause leaf scorch, seed abortion and fruit fall. It is called sun-stroke. High temperatures, over 45°C at Tando Jam in 1988 for about 2-3 weeks produced early maturity of fruit by about 7-12 days but fruit drop was heavy. Long term effect of high heat on tree is not known. Mild temperatures, blow 36°C from mid May to mid July, ripened fruit, on the tree very fast causing glut in the market.

Mature mango trees can withstand 4° C (25° F) for a few hours, with minor injury to every young branches and leaves, but young trees can get killed even at 0° C (32° F). Before opening up of Sukkur Barrage in 1932, there were two to five frosty nights each year in Dadu District. Perennial canal irrigation has reduced frosts in that area to once in 10 years. Extension of irrigation in whole Sindh under two more barrages Kotri and Guddu have reduced frost damage to mango. Vegetative growth occurs only when mean monthly temperature is over 15° C. Inflorescence occurs when mean monthly temperature is between 12° -17° C. Flush of flowering ends when mean monthly temperature rises to above 17° C.

Probability of flowering in terminal shoot occurs; if shoot has under-gone a period of one or two vegetative flushes and has under gone sufficient chill before flowering. There is positive co-relation between shoot vigour and size of inflorescence. Vegetative growth after harvest has strong role in fruiting next year. The percentage of fruit set depends on vigour of vegetative flushes (one to three) in the season, before exposure to chill and then flowering.



Number of terminal shoots in canopy rises with tree age; however as tree ages, proportion of new shoots decreases. The starch accumulation is almost three times at 15-10°C day and night temperatures, than at 30-25° C. The purpose of chill units is to enhance starch accumulation and promote flowering.

### **Temperatures at Tando Jam and Flowering Patterns.**

Average January temperatures of the coldest month at Tando Jam. (Near authors orchard) are:

Maximum.	22.5 °C
Minimum.	8.5 °C
Mean.	15.5 °C

Average February temperatures when full bloom occurs at Tando Jam are:

Maximum.	28.5 °C
Minimum.	10.65 °C
Mean.	19.5 °C

This shows that flowering at Tando Jam will start in January (Average temperature greater than 12° C) and will end in February (with average temperature above 17° C). However there is year to year variation by 10-15 days and variety to variety and this data can be considered as indicator only.

### **Low Temperature During Flowering.**

Low temperatures during flowering can effect sex expression of flowers giving pre-dominance of males. Night temperatures around 10°C cause pollination failure in Floridan varieties like, Haden and Glenn, but Irwin can tolerate these temperatures. The effect of temperatures on mango cultivators in South-Asia has not been studied fully. Temperature below 12° C during flowering affects pollination and result in to fruit without seed which drops.

### **Temperatures For Dormancy And Flower Induction.**

Low night temperatures below 10°C before flowering, induce heavy flowering and maturing new growth, but temperatures must rise to 12-15°C for flowering. Moderate November-December temperatures induce flowering in early to mid January. If these are followed by low temperatures a few degrees above freezing at end the January or early February another late bloom is also induced.

Embryo of flowers and even small fruit-lets may be killed at 4.4°C (40°C). if these temperature occur after flowering. This can happen in Tando Jam once in five years in varieties which flower partly in late November and December the area. In 1983, low temperatures of 10°C for 3 hours after full bloom on 23<sup>rd</sup> February killed total inflorescence of the cultivar Banganpali, but not other cultivars. Flowers of most cultivars are tenderer and can be damaged, even much above freezing temperatures, say around 4.4°C or (40°C).



### **Flowering and Temperatures.**

Temperature regime is the single factor in during flowering. In tropics for flowering, dry period of 3-4 months is essential. This will not only check vegetative growth but will mature it and induce the flower flush, but in subtropics stress caused by cold temperatures of winter, has the same effect as stopping water. In subtropics in addition to cold temperature stress, if water stress is produced, flowering is early and profuse, but most of early flowers are males and fruit drop is excessive.

There are no standards, laid down for number of chill hours needed to induce flowering in different mango cultivars, however effective chill hours for mango are considered as hours below 12° C (53. 6° C) they vary from cultivar to cultivar. In general if 150 hours of chill below 7°C occur at Tando Jam in any year, flowering in all varieties is adequate. Even near Karachi and coastal areas having 100 chill hours, flowering is adequate in most cultivars and seedling trees.

It is observed that low night temperatures of 10-15°C days and day temperatures below 27°C can induce flowering, but fruit will be small and seedless and may fall before ripening. In some varieties flowers are damaged at low temperatures of even at 10°C, if such temperatures occur at full bloom. This was experienced in tropical variety Baganpali of south India, grown on 25° 28' at authors farm, Carboa, Peach, Haden, Sabre and Ruby are also sensitive likewise.

Dormant period of 2-3 months is needed for profuse flowering. It means low autumn and winter temperatures. At temperatures below 10° C, pollen viability and number of hermaphrodite flowers are reduced with poor fruit set. Unusually low and high temperature fluctuations during flowering effect yield.

If minimum temperatures are low, mangoes can flower in December, as it happens in high altitudes of the peninsular India, but where cold winter continues in January and February i.e. in Bengal, Bihar, U.P and Punjab of India, more mangoes flower in February. In the northern parts of Punjab due to continuing cold, flowering occurs in March, but in Sindh flowering starts around 15 January and is completed by 20 February, except in very late cultivars or when low temperatures continue beyond middle of February.

Drop in temperatures below 15.5° C (60° F) stops growth of pollen tube in mango. Due to temperature fluctuations, there may occur two or three flushes of blossoms, making flowering more stable and giving high female to male ratio. This usually happens in local cultivar Sindhri, Florida cultivars Keitt Glenn and Irwin. But in majority other cultivars, it is not so common.

The exact chill requirement optimum temperature for initiation of vegetative growth and flower induction of mango has not been critically examined; these are different for various cultivars. For perfect flowers higher temperatures in the range of 20-27° C are needed. At temperatures below 12° C (53° C) and below

there is cessation of pollen tube growth, fertilization and embryo, development. If this happens flower pruning can induce re-growth of flowers, when temperature rises, but if flower pruning is done after full bloom, tree will not flower again during the year. Best time to prune flowers is when about 30-40% flowers have come out but in this case, the night temperature should be between 10-15°C for 6 weeks to induce reflowering. One snag in pruning flowers in Sindh is that, for re-flowering after pruning, a period of 6 weeks is needed and after this period, temperatures may not be a low enough for second flowering. Removal of initial flowers induces new flower development, provided temperatures are optimum. In general this reduces the final flowering and yield.

If after flowering, average temperatures remain low, say below 20° C or in ranges where growth rate is low, the fruit will mature late. Year to year changes in temperatures, affect the time of flowering and harvesting of mango in a locality.

Blossoming and fruit ripening on same tree may continue for longer period in hotter regions than in less hotter areas. One Indian Punjab variety may set its main crop, in mid summer and ripens it in midwinter, but in such case, yield is poor and quality is marred because for sugar content, summer heat is must.

Flowering does not occur if temperatures are 20-15° C day and night but they occur when night temperatures come down to 10-12° C.

#### **Effect of Low Night and High Day Temperature during Transition from Meiosis to Prevacuolate Stage.**

Monoembryonic and polyembryonic varieties having evolved in difficult environments i.e. the first in north east parts of India and second in South-East Asia, the first were conditioned in low temperature 15-10°C during flowering and the second at high temperature and their growth after winter.

#### **Alphonso, Glenn and Iriwin**

Less than one flush at 15/10°C

#### **Alphonso, Glenn, Irwin, and Nom Doc Mai.**

More than one flush at 20/15°C

#### **Carabao, Kensington, and Nom Doc Mai.**

One flush. 25/20°C

#### **Alphonso, Glenn and Irwin**

Nearly two flushes at 25/20°C.

And 2 to 4 flushes at 30/20°C

This opens new chapter in flowering. The information on mono embryonic varieties is well documented and is discussed below:

Germination and tube growth of mature pollen is reduced by cool temperatures and completely inhibited at temperatures below 15° C. The percentage of viable pollen rises from 19 to 80% as night temperature during meiosis increases from 7°-15° C. At 8° C night temperature pollen viability is less than 25%. At 10° C night temperature pollen viability is 50%. At 10° C - 12° C pollen viability is still low. For pollination viability night temperature has to exceed 17°C. Pollen viability increases to 85% when temperatures reach 20°-25° C. Night temperature of 20° C is not a limiting factor, but if day temperature rises beyond 33° C, viability falls from 85% to 60%. If pollen viability is less than 50% there is low fruit set. In general if night temperatures are lower than 10° C, for more than 10 days after flowering, the pollen viability may be less than 50%. For good yield night temperatures more than 10° for consecutive nights are essential. In some varieties flowering starts at temperature above 12° C. Inflorescence occurs on mature shoots when temperatures exceed 12° , but it turns into vegetative flush when temperature rise above 17° C. Due to cold stress flowering in sub-tropics is regular but yield is disappointing, due to failures in pollination and fertilization. Orchard heated to 10° C during flowering will have more percentage of normal fruits.

#### **Temperature And Fruit Development From Fruit Set To Harvest:**

If temperatures are high winds are dry, tree growth is hampered, leaf drop occurs and the fruit yield suffers. In Israel 44° C day temperatures and 15% R.H., have caused fruit drop and poor seed formation. In Sindh maximum temperatures during May range between 45 - 49° C, but due to moderate humidity (40-50%) average harvest are obtained though fruit drop is continuous problem. In northern Sindh above Dadu-Moro to Jacobabad in May and early June, every year temperatures hit 48-50° C. (118.4-122° F.), but humidity is around 50% and less damage occurs, except sun burn of fruit on the western side. Flowers and fruit lets are killed of 4.4° C. (40° F.) even for a short time. Mango grows at temperature up to 48° C in Sukkur and Larkana area. The excess heat causes excess fruit drop. The loss due to fruit drop and premature ripening on the tree may be 33% or more as observed. Mango develops high percentage of sugar, and flavour due to high temperature 43-46° C. (110-115° F.) Sindhri the most popular cultivar in Pakistan does not do so well in Tamil Nado, where from it originated, due to low summer temperature during ripening. Blotches on trunks and branches of mango are caused by excessive temperatures and excess heat penetrating the tree, due to thin leaf canopy. They are not harmful, but affect cosmetic appearance of tree. Diurnal temperature range 10-20° C during fruit development is acceptable, although 5-10° C. is considered moderate. Sindh being surrounded by deserts has high diurnal range. It may be a cause of fruit drop and low yield, but this has not been investigated. Vegetative inductive temperatures are 30° / .25° C, day and night.

#### **Post-Harvest Temperatures and Flower Induction.**

Leaves becomes responsive to cold temperatures when seven weeks old. Apical buds of stems in which the distal leaves when clipped, initiate inflorescence

morphogenesis after three weeks, earlier than non-clipped shoots. Non clipped shoots need seven weeks to 18<sup>0</sup>-10<sup>0</sup> C days and night temperatures to flower. Initiation of inflorescence is delayed by leaves at distal end. The above phenomenon occurs only in sub-tropical latitudes.

### **Fruit Drop.**

Too much summer heat (Over 44<sup>0</sup> C reaching 50<sup>0</sup> C.) causes heavy fruit drop by stem-end rot (SER), bacterial black spot (BBS) and anthracnose. In Sindh in the month of May-June, 25-30% fruit falls down from the trees. This is caused by high temperatures BBS, SER, anthracnose and other fungal diseases, as well as competition for nutrients and water. Summer water requirement reaches 140% of pan evaporation.

### **Temperatures, fruit weight and quality.**

Climate has effect not only maturity dates of mango, but also on the fruit size for example Sindhri has average weight of 350 grams at Hyderabad, 300 grams at Naushero Feroz 210 Km (125 miles) further north and 250 grams at Multan some (400 miles) 666 kms north. It has thin peelable skin at Hyderabad and thick one at Multan. In hotter regions the time between flowering and ripening is shorter due to earlier heat summation discussed below.

### **Heat Summation.**

It is Heat Degree Days for fruit maturity from full bloom are calculated by formula:

- $H = n(t-17.9)$ : where:
- $H$  = Heat summation.
- $t$  = mean monthly temperature.
- $n$  = number of days of relevant months.

Oppenheimer (1974) considered heat summation of 1000 degree days above 17.9<sup>0</sup> C (64.22<sup>0</sup> F) in tropics and 1700 degree days in subtropics, as a good indication for fruit maturity. This does not apply all cultivars. In general for 3 main varieties of Sindh, the summation of degree days above 17.9<sup>0</sup> C from full bloom to earliest dates for harvest at Hyderabad are:

- Sindhri. 1230 Degree Days.
- Baganpali. 1525 Degree Days
- Sawarnarika. 1580 Degree Days.

### **Should Water Be Stopped To Induce Flowering.**

Mango came to Sindh from South-India where they stop water to induce flowering. Stopping water creates stress and restoring it brings flowering. This is being done in Sindh but has negative influence.

The observations In Sindh are, early and profuse flowering but the negative effects are:

- (i) Early flowering which produces male flowers rather than females or hermaphrodites and therefore fruit formation is less, though flowering is profuse.
- (ii) Heavy fruit-left drop during mustard, pea, bean and marble stages.
- (iii) Fruit drop continues until harvest.
- (iv) Fruit size becomes small, due to stress.
- (v) Yield is reduced.

Alternative to water stress is winter chill. Sindh has adequate winter chill in nine out of ten years, that normal flowering takes place without stopping water. Mango requires about 100-150 chill units (total hours when temperatures are below 7<sup>o</sup> C) and whole Sindh has this amount of chill except coast near Keti Bundar and Shah Bundar and this chill causes stress and normal flowering, even if water is not stopped, but flowering is delayed till 100-150 chill units are completed. This means late flowering and the results are that late flowers are females and hermaphrodites and there is more fruit formation. Less fruit drops from flowering to harvest and much larger size fruit if post flowering irrigation, is adequate more returns per kg of fruit and per acre compared to trees, water of which is stopped before flowering. The chill hour model has gone changes and even temperatures between 10-12<sup>o</sup>C contribute chill units in mango.

#### **General Effect of environments on mango production.**

Early flowering induces malformation. A dry season of minimum 3 months is needed for flowering and a wet season of maximum 7 months for vegetative growth, in rain fed tropical areas. Water deficiency and there by water stress, is an alternative to winter chilling. In Sindh and the Punjab, there is enough water chill accumulation that stopping water is not needed and its negative effect produces more male flowerets, weakening the tree and inducing fruit drop.

#### **Flowering and water stress.**

Water stress works if day and night temperatures fall within 28-17 or lower. It does not work at 30-20<sup>o</sup> C.

#### **Pollen Viability in mango**

There is linear negative corelationship between percent pollen viability and number of days in which mean night temperature is lower than 10<sup>o</sup> C, from meiosis to early nature stage. If number of the days having mean night temperature lower than 10<sup>o</sup> C is greater than 10 , pollen viability is reduced to less than 50%.If night temperature are below 12.8<sup>o</sup> C, position is negative.

#### **Effect of Chill, Frost, Rain and Hail Storm on Flowering.**

Hail storm, frost and chilly weather; adversely affect fruit set, due to poor insect activities. Long chilling weather kills pollinating flies and insects and so does the

frost. Hail storm shatters flowers and fruits. Frost kills young trees. Spray of calcium chloride during frosty night over, head irrigation and even irrigation of fields have saved trees against frost, if it does not last for long hours. Some times kerosene burners too have helped. Temperatures below 4.5<sup>o</sup> C will kill flowers in most cultivars. Temperatures below 15.5<sup>o</sup> C, will kill pollen tubes.

### **Rainfall and dew deposit**

Rainfall in mango areas varies from 100 mm to 2500 mm. In low rainfall areas, supplemental irrigation is very necessary. Rains or irrigation starting in the months of March, when fruit is of marble size to July, the time of harvest are helpful in increasing size of fruit, but they will promote diseases besides heavy rains can cause nutrient loss from the leaves, if water wets leaves and dribbles. Heavy rains during flowering, reduce pollination and thereby fruit setting. Rains increase mildew and anthracnose problem. Rains during fruit ripening causes splitting of fruit on the tree. Rains during fruit maturity also cause anthracnose, bacterial black spot and other fungal problems. In desert climate of Sindh, through data for dew are not collected, but some times, it can be as high as 3 mm. If weather is cloudy and its evaporation takes more than a few hours, dew can cause mildew problems and probably promote anthracnose.

### **Humidity and Mango.**

Bad weather i.e., cloudiness, rains, fog, and dew at the time of flowering, cause heavy annual fluctuations in yield due to high humidity.

### **Humidity, dry weather and dew:**

Heavy rains and high humidity before flowering induce vegetative growth in tropical areas of India, Sri-Lanka, Malaysia and Brazil. Rains in Sindh in December or February hardly exceed 5-10mm. They have never caused vegetative growth as winter chill is already at work. Dry season (rain-less) for 3 months prior to flowering, favours mango production by slowing down growth and inducing bloom in tropics. Dry season discourages anthracnose on bloom and helps in development of fruit. Anthracnose is less severe near coast than inland, as there is air movement which evaporates dew quicker, by coastal winds. High temperatures, during flowering are help-full against diseases, but if humidity falls to 15% this may damage fruit or fruit formation due to dehydration.

### **Coastal areas of Sindh**

They usually produce poor crop due to lack of winter chill and severe insect problems. Varieties suiting this climate have not been investigated and introduced, though many low chill cultivars exist in other countries.

### **Temperature and starch accumulation in trunk and roots**

Temperature effects starch accumulation. In the woody roots, at temperatures of 15<sup>o</sup>-10<sup>o</sup>C day and night for 20 weeks, starch concentration was 15.9% of dry weight, where as at 30<sup>o</sup>-20<sup>o</sup> for the same period it was 4.8% or the lowest. Lower the temperature more is starch accumulation by roots. Starch concentration in the



trunk increases sharply as temperature rise from 15<sup>o</sup>-10<sup>o</sup> C day and night to 20<sup>o</sup>-10<sup>o</sup> C and within 2 weeks it becomes 3 times that at 15-10<sup>o</sup> C. In another 12 weeks it increases 6 times compared to the trees held at 30<sup>o</sup>-20<sup>o</sup> C. It is the medium temperatures at which starch accumulates in the trunk. At temperatures higher than these, it decreases. Starch concentration in the roots, trunk and leaves in tropics and subtropics, are more closely related to flowering intensity, fruit set and retention. Temperature control and starch concentrations are closely retarded. Starch accumulation temperature varies differently with different cultivars. In cultivar Irwin accumulation of starch has been found to be highest at higher temperature, but all cultivars have not been studied.

### **Sun light**

Of all climate factors sunlight is foremost in crop production, as it provides energy to photosynthesis, various ingredients in air, soil and water into useful products for tree or crop growth. Sunlight is responsible for photosynthesis and thereby for tree productivity. Brighter green leaves do most rapid photosynthesis. There is no photosynthesis done by new leaves before they turn light green. Again after they turn dark green, there is less photosynthesis. Chlorophyll content of leaves at Hyderabad is highest in March-April and keeps decreasing until September. Trees exposed to sunlight during growing season (March-July) are larger, have more percentage of pulp. TSS and sugar to acid ratio is greater. In every hot sub-tropical area like Sindh, sun-burn of fruit is a common feature. Shading of tree reduces light in the tree and consequently, number of new shoots, their weight width and length reduces, and so does leaf weight and thickness, per unit area, It increases fruit drop, reduces fruit size, percentage of dry matter, fruit bud formation, even in the following year if shading is removed. Mango is sun loving tree and entry of sunlight in the canopy is to be managed with proper pruning maximum light can enter tree canopy and increase yield.

### **Wind and Pollination in fruit.**

Mango pollen can be transferred by wind. Mango pollination is largely promoted by wind and less by insects, but wasps and flies also play their role .Winds circulate air through the tree canopy and thereby reduces insects pests and diseases, provide fresh air for photosynthesis. Mango drop for various reasons continues through out the season but wind is considered as an important factor. There is more fruit-fall of heavy bearers than light bearers and in "On" years than "Off" years. The proportion of fruit drop to final yield is the same for heavy or light crops. It is not sure how much percentage of fruit fall is caused by winds and how many of those fruit would not drop, if high winds do not occur. Average winds at 18 km.p.h. (11 m.p.h) and gust winds at 30 km p.h. (18 m.p.h) show that fruits, which fall a few days prior to harvest, are usually smaller and usually about 40% or fewer in diameter compared to harvested crop. Peak drop is 3 weeks after flowering and declines in another 2 weeks. It does not seem to be wind induced. Where flowering is less, fruit drop is less. Fruit drop is directly proportional to flowering intensity and is caused by water stress, diseases, lack of

nutrition, low carbon reserves and inadequate pollination. These are irrespective of winds. Fallen fruit re-directs carbohydrates to other fruit, before fruit fall and it has low carbohydrates but high percentage of Ca, Mg and other ingredients. However in wind induced fruit drop, carbohydrate and other macro and micro ingredients are not re-directed. There is always maximum crop load, a tree can bear. The rest falls down even if there is no wind. The surplus fruit will not be carried through to harvest.

Cyclonic winds are different story. To this class belong winds with speeds of 80-200 km.p.h (50-120 m.p.h). They cause damage disproportionate to annual fruit fall. The 1999 cyclone caused 50% fruit drop at Tando Jam, though it was only at periphery of cyclone. Wind damage results into skin blemishes and also is cause of many bacterial diseases including bacterial block spot. Wind is not desirable during flowering, fruiting and maturing of mango. Hot winds may cause marginal leaf necrosis (death of leaf edge). If wind breaks are not provided, wind damage to the following degrees can occur.

- Flowers. 50%
- Leaves. 50%
- Fruits. 70%

#### **Winds as pollinator.**

Winds helps pollination of tree to a limited extent, but it also reduces insect activity and thereby reduces pollination. Thus winds during full bloom may reduce fruit setting.

#### **Hot wind**

Hot winds reduce flower and fruit setting. They Winds also cause fruit drop. Cyclones damage crop heavily.

#### **Wind Speed in Sindh.**

In winter winds blow at an average of 13.3 kms or 8 miles per hour in the upper Sindh and 6 miles (10 kilometers) per hour, in the lower Sindh. In summer winds blow at about of 10-16 kms (6-10 miles) per hour in upper Sindh and hit 40 kms (24 miles) in the lower Sindh, though they are about 26.6 kms (16 miles ) per hour most of the time in low Sindh.

#### **Wind damage in the Southern Sindh.**

In Hyderabad and Karachi Divisions, below the line passing through Sann and Nawabshah, South-Western winds blow from April to September for about 10 hours a day and 7-13 miles (11.20 kms) for another 10 hours. There is damage on South-Western side of foliage of tree and it bends north-east-wards. No reliable data on extent of damage is available, but present writers personal observations show that in these orchards the first crop is delayed by about two or three years and yield is affected in the earlier years to some extent. In the fruiting young tree i.e. 5 to 10 years old, the limb breakage occurs at wind speeds of over 20 miles (32



kms) per hour. Even a heavy wind for a few minutes, breaks limbs of bent trees, much more than the upright trees, not grown under wind break condition. The limb breakage is severe if limbs are not pruned and trained during the first 3 years or when foliage is too thick and branches are upright rather than at wide angles. Plants under water stress have their limbs severed more than those not under water stress.

### **Wind borne dust in the Southern Sindh**

Southern Kohistan about 30 miles or 50km on both sides of super high way, is badly damaged by off-load vehicles during the past 35 years. Soil having a virtual carpet of grasses and shrubs, has become loose and is blown in the atmosphere up to line passing east to west of Sann-Nawabshah. The whole area has thick inverted layer of dust above it, which could be considered as inverted bowl of dust from Karachi to Jodhpur. This dust intercepts solar heat and maximum temperatures fall down during the day, being lower at Hyderabad than at Nawabshah, Pad Idan, Rohri and Jacobabad (45° C against 47, 48, 49 and 50° C respectively at other places.

Reverse is effect at night when the same dust bowl does not allow hot ground radiation to pass through it and Hyderabad is warmer than other four places. The total heat makes Hyderabad town, the hottest place in Sindh, in terms of annual heat accumulation.

### **Summary**

Climate controls number of flushes. Climate of Sindh with adequate light, less cloud cover, favourable temperatures produces vigorous trees. By proper management tools, climate can be used for high yields.

## CHAPTER - 4

### SUITABILITY OF CLIMATE OF SINDH FOR RAISING MANGO FRUIT CROP.

Agro-meteorological data on Sindh have not been compiled in a meaningful form and therefore the present writers have and made an attempt to collect the meteorological data for different areas of Sindh from a number of sources for years 1904-2004. Based on these an agro-climate map of Sindh has been constructed. Two new but very important factors which have been evaluated for various areas of Sindh are, the total accumulated heat or heat index, and chill units under which most of the plants flower, grow, mature and produce fruit and fibre. These two determine the completion of winter dormancy and dates of flowering. The two factors also determine if any fruit crop or its cultivars can grow in a particular locally.

The internationally accepted criteria for heat indices is the total degree-days i.e., temperatures prevalent between 13<sup>0</sup> to 37<sup>0</sup>C. Below or above these two limits of temperatures, most sub-tropical plants stop vegetative growth.

Annual rainfall has become unimportant in the irrigated plains of Sindh, where assured canal water is available. Rainfall is important for Thar and Kohistan of Sindh to the east and west of the central alluvial plains. Which depend totally upon rain.

Aridity has been categorized as difference in evaporation and rain-fall and from this point, the whole Sindh is arid, except small south-eastern tip of Nagar Parkar and Mithi Talukas, which is semi-arid. Aridity becomes redundant where assured irrigation water is available.

Besides heat accumulation or total heat indices, total winter chill, called chill units is another important criteria for preparation of climatic maps. The winter chill is the total annual hours below 7.2<sup>0</sup> C, and above 0<sup>0</sup>C. Chill units determine breaking of winter dormancy of plants and on completion of it, plants re-grow. Chill units influence flowering, fruiting and yield of many fruits and many vegetables which need winter chill to flower.

In order to build a climatic map of Sindh, the present writers had made use of many years climatic data of 18 stations in Sindh, including one at Karachi (Saddar) and has worked-out winter chill units between November and February and summer heat indices between March and October, ignoring the negating influence of chill units and heat indices by adverse factors for some crop.

From this data an agro-climatic map of Sindh has been constructed, dividing it into zones. The map thus has eleven agro meteorogological zones.

## **Agroclimatic zones of Pakistan.**

**Zone I.** It consists of western Jacobabad district embracing Jacobabad, Ghari Khairo, Talukas and also Shikarpur, Ghari yesin, Taluka. It has 4969 Heat Indices between March and October and 420 Chill Units accumulated in cold months. It is hottest area in terms of maximum summer temperatures but not the coldest area. Temperature hit 49°C each year but in some years even hit 51°C

**Zone II.** It embraces eastern parts of Jacobabad district Thul, Taluka and Kandhkot, Ghotkei districts, and Sukkur and Rohri Talukas. It has 4575 Heat Indices and 420 Chill Units.

**Zone III.** It consists of Shahdad Kot, Lakarna and Dadu districts and Sehwan Taluka of Jamshoro district. It also includes an area 30-40 kms wide area on east of the river Indus in Khairpur and Naushohro district and parts of Nawabshah districts right up to Daultpur. It has 4500 Heat Indices in summer and 550 Chill Units. It is coldest area of Sindh because of trapping of air between western Khairthar hills, which make a right angle turn in south along Manchar lake to Sehwan.

**Zone IV.** This consists of eastern parts of Khairpur and Nawshero district and has 4450 Heat Indices but is less hot than Jacobabad and accumulates 450 Chill Units. Its main meteorological station Pad Idan records only 1°C less than Jacobabad.

**Zone V.** It consists of Nawabshah district and eastern part of Khairpur district also parts of Sanghar district. It has 4400 Heat Indices of 360 winter Chill Units. In this zone summer comes earlier and recedes late.

**Zone VI.** This consists of Tando Adam, Khipro, Tandojam, Hala, Matriari, Tando Allahyar, Mirpurkhas and Ummarkot Talukas. It has 4200 Heat Indices and 225+5 Chill Units. Day and night temperatures of 15° C are common. High velocity wind blows in this area from SW to NE carrying dust from April to September. Because of this dust the atmosphere, the zone is cooler during the day than northern parts and is warmer at night, but by only 2-3° C

**Zone VII.** It consists of eastern part of what is known as Nagar Parkar district, whole Kotri Barrage area of Badin and Thatta districts, but small area near the coast bound by Mirpur Sakaro, Ghorabari, Sujawal and Jati. It has 150 Chill Units and 4100 Heat Indices.

**Zone VIII.** It is area bounded by Sakro, Keti Bander, Jati and Sujawal. It has lower day and night temperatures than Zone VII and there is no danger of frost and low day temperature which allows many crops, to grow, which otherwise do not grow in zones I to VII. It is suitable for crops like coconut, palm oil, cashew,

macadamia and many other fruit nuts and industrial crops. It has 3222 Heat Indices and about 100 Chill Indices.

**Zone IX.** It is coastal belt ground water is saline, soils are also saline to various degrees, but sandy soils are less saline due to drainability and annual rain fall is about 12 inches, which makes sheet flow over the soils and salts are away, but sea tides too bring salts back in some area. The area is most suitable for saline crops. It has about 75-100 Chill Units and about 2500 Heat Indices.

**Zone X.** It is hilly area of the western Sindh. It is very warm, annual evaporation is 120 inches or even more, temperature on the rock surface can exceed 75°C at times. Winter chill can reach over 1000 units on hill tops and 550 at foot hill, heat units can exceed 5000 at foot hills but on hill tops can be very low.

**Zone XI.** Hyderabad city, Jamshoro university and surroundings have due to city traffic, hills its north and west and city itself getting hot winds from the west in summer and, Hyderabad remains warm from March 1 to November 1 and even November and February in some years are warm. Total heat accumulated in the year is more than Jacobabad and winter cold is 150 Chill Units or less.

With regards to mango most of zone can grow it except coastal area where chill units are less than 100 and water has to be stopped to create some stress. In all other areas there will be heavy fruit drop to May and June when temperatures exceed over 40°C. The drop may account for as much as 25%. The overall yield will be for in zones I to VI where maximum temperature of over 40°C remain for two months. In case of late varieties of August and September fruit drop may not be heavy as due to heat stress it is fruit in later stages of maturity which drops.

From the above discussions it can be concluded that the whole Sindh area is suitable for raising many types of fruit crop.

## CHAPTER 5

### SOILS FOR COMMERCIAL PRODUCTION OF MANGO

Mango tap root can go about 6 meters deep but feeding roots are limited to top 0.5 meters (20 inches), with maximum concentration in top 50 mm (10 inches). Mango can grow on any type of soils, but for the commercial production proper and shallow soils are preferable, as in these soils mango trees will stay dwarf, be more manageable and desired fruit blush is more common. Soils two meters deep, well drained and if acidic, are the best, but soils with in pH range 5.5 to 7.5 are also acceptable. Soils of Sindh having pH, 8.5 grow mangoes, but not without nutrient deficiency problems and low yields. . In silty soils of arid areas and the Indus river alluvium seedlings grow more vigorously than in clayey soils. This is general is the case in Sindh, but high water table at 12 feet depth causes serious problems with seeding trees in early 1980s. In clay soils mangoes do better, probably as vigour is less and therefore, trees bear more fruit, but soils should not be too heavy and impermeable. In rain fed areas, if soils are heavy the root system have difficulty to establish, due to lack of aeration and drainage. Mounding of soil around tree growth and yield due to additional root. In irrigated conditions it will work only with sprinkler system. Mounds around small trees will help in water not touching the tree trunk and causes no damage to trunk.

Heavy soils may be cross ripped or pits 4x4x4 feet (1.2 x 1.2 x 1.2 meters) dug, to break hard pan and provide suitable conditions for root penetration and good growth for first few years. Hard pan will be formed again, but if roots penetrate the strata before it re-forming, these roots will help in drainage. Acid soils (granite, siliceous sand stone) are suitable for mango. Sandy loam with 15-25% clay is also ideal for mango, but tree will be very vigorous and for high yield growth is to be controlled. Sandy soils are not suitable, as fruit will be test-less, watery and inferior, due to lack of ability to maintain soil moisture, at field capacity. Calcareous soils containing more than 15% calcium are unsuitable for mangoes. As exchangeable calcium to magnesium ratio of 5:1 seems to be suitable for mango growth and yield. Total soluble salts in mango orchard soils, should be less than 0.2% i.e.,2,000 ppm. High pH soils are alkaline due to excess of sodium and therefore impermeable. Potash status of soil should be 80-200 ppm.

#### **Mango and soils of Sindh**

Soils of Sindh show good lime-magnesium ratio varying from 8:1 to 16: 1 under such soils there will be no calcium and magnesium deficiency. Their water holding capacity is low varying from 40-55%. Good drainage to about 2 to 2.5 m depth is essential and if it is less than this soil is not suitable for mango. Through on Sindh, there is hard pan at depth at 30-44 inches (0.75-1.1 meters) and this needs breaking through. Water table should be minimum at 250 cms or 100 inch

depth. Hydrosopic coefficient of soil has to be a low of 15-20% .ie., Sodium carbonate containing more than . 0.5% of total soluble salts or 5000 parts per million parts is not desirable. NaCO<sub>3</sub> is most injurious salt in Kalar lands frequently found in Sindh.

**Salinity stress tolerance:**

It varies with cultivars. Some can tolerate high level and others not. Root-stock. 13/1 has high salt tolerance and is used in saline soils of Israel. Effects of high salt concentrates are; reduced transpiration, reduced growth, reduced uptake of sulphates and increased up take of chlorides. Increase in leaf area too is reduced.

**Physiological and morphological factors and growth response to flooding.**

Flooding results in to less carbon dioxide assimilation during sunlight. It reduces, root growth. A fortnight of flooding needs two months to recover to pre-flooding level, if properly taken care of with macro and micro nutrients. Mortality of flooded trees for a fortnight, can reach 45% in young plants of less than 10 years age. Mango possesses certain adaptation to flooded conditions. Flooding of large mature trees can be less harmful if land is well drained, quickly dries up and is supplied with macro and micro-nutrients immediately.

**Soil Analysis**

One sample for every 10 acres is adequate Soil sample for 0-6 inches or 0-150 mm is enough for most soils of Sindh, which usually are 4.5 to 6.0 meter (15-20 feet) deep. Sometimes second sample up to depth into 6-12 inches (150-308 mm) is to taken, to ensure that lower layers are also uniform and similar to upper layer.

## CHAPTER - 6

### MANGO VARIETIES OR CULTIVARS

#### Leading mango varieties of the World.

Many countries have their own mango cultivars, which they consider as the top ones, but due to recent international trade, these barriers have been broken and foreign varieties are being introduced. Here are some examples:

*Table show important cultivars of mango of some countries and new cultivars introductions.*

Country	Local popular Mango	New Introduction
Brazil	Itamarka Bourban	Haden, Tommy Atiking, Kitt.
Columbia	Chanclelo	Haden, Tommy Atikin, Kett, Kentt.
Cuba	Corazon	Haden super Haden.
Florida	Tommy Aitkin, Keitt, Kent	Irwin, Palmer, Brooks, Zillate, Van dyke, Earlygold.
Haiti	Madam Franis	
Jamica	Julie (Juhil)	Haden, Tommy Atikin
West Indies	Julie	Amelie, Peter
Mexico	Manzanillo	Julie, Coraboa, Manila, Florida varieties.
Hawaii	Gouveia, Pope	Ah Ping, Hardins, OK Rong, Rapoza.
Purito Rico	Julie	Tommy Aitkin, Haden, Keitt
Peru	Chuluanas	Haden, Rosica, Presidente.
Venezuela	Criollo	Haden, Kent, Keitt, Smith.
Indonesia	Asumania, Gulets	Manalagi.
Kenya	Barido	Apple, Ngowe.
Philippines	Caraboa, Pico	Pope, AhiPing, Fair child
Australian	Kensigton	Haden, Glenn. Irwin, Edward (before 1980) and after 1989, Pulmor, Kent, Keitt, besides R2E2, Celebration
Sudan	Kitchner	Totapuri (Abusmaka), Alphonso
Sindh	Sindhri, Baganpali, Swarnarika	Chaunsa late, Neelum, Totapuri
Punjab	Chauna late	Sensation (Lal-Badshah)
South Asia	Peach, Rosa .Sabre (root stock)	
Malaysia	Sri Jaya.	



### Some mango cultivars and their possible harvest dates in Hyderabad (Sindh)

<b>Mango</b>	<b>Harvest date</b>	<b>Weights gm</b>	<b>Remarks</b>
Banana Calo	May 1	225	Yellow
Glenn	15 May	350	Good quality, yellow orange
Early gold	15 May	280-400	Less than Glenn quality, yellow
Sindhri	25 May	250-400	Yellow, anthracnose, very serious
Kensington Pride	5 June	450	Yellow, oranges, pink
Tommy Aitkein	5 June	450	Yellow with red blush
Edward	10 June	450	Yellow with crimson blush, good quality
Haden	15 June	450-670	Yellow with crimson blush, good quality
R <sub>2</sub> E <sub>2</sub>	1 July to 20 July	675-1000	Orange with red blush
Palmer	10 July	500	Dull bronze red blush
Keitt	1 August to 30 August	675	Dull bronzy red blush
Florigin	8 June	350	Yellow with pink blush
Van Dyke	30 June	500	Orange with red blush
Anna (Haden)	1 July	350	Good taster, heavy bearer
Malika Perk	1 July	700	Highly red coloured
Davis Haden	1 July	500	Dark crimson yellow
Kent	15 July	500	Dark crimson yellow
Smith	15 July	360-660	Greenish yellow, crimson blush
Nam Dock Mai	End August	250	Yellow but very good quality
Sensation	1 <sup>st</sup> August to 15	300	Not good taste, Red blush
Julie	1 <sup>st</sup> August	160-170	Dark Green with red tinge
Plamer	10 <sup>th</sup> August	700	Orange yellow
Keitt	1 August-1 September	600	Green with red blush, good quality
Neelum	7-15 August	250	Not to good taste, yellow
Osteen	1 August-1 September	500-700	Pink, fair quality
ONO	10 September	300-500	Pink, fair quality
Brooks	15-30 September	700	Yellow, good, latest.

### Description of some important Mango varieties of World, based on harvest dates in Hyderabad Sindh.

In general mono embryonic cultivars of Indian origin are more suitable for desert purposes and they seem to do better in desert areas.



**1. Alphano**-India, Mono-embryonic, late mid season, irregular and poor bearer, heavy to light in different locations, not suitable for sub-tropics, yellow, low fibre, Brix 17.9°, good taste.

**2. Amelie**, West African, mono-embryonic, green to yellow skin , pulp deep orange, 300-600 grams, juicy, melting, good taste, resembles Julie and very popular in France.

**3. Arumani, or Hrumanis**, Indonesia, both yellow and red, poly-embryonic, poor external colour, Brix 19.4°, very sweet, slightly turpentine, slightly susceptible to 15%, anthracnose (25% stem end rot, 80% premature ripening and 33% of seed weevil).

**4. Banana Calo**, similar to Awnar-Ratol in size and shape, from Australia, poly-embryonic, dwarf, 150 trees per acre, 15 April to 1 May, yield 8 tons per acre, skin yellow, fibreless, 200 grams, flesh recovery 67 % against 45% of Anwar Ratol, Brix 15°, taste good , anthracnose 27% and seed weevil 71%.

**5. Banganpali**, South India, Mono-embryonic, medium skin, mid late season, skin primrose yellow, pulp maize yellow, fiberless 500-800 g, ovulate to oblong, skin very thin, juicy pleasant, very sweet, highly susceptible to fruit fly, hoppers , ants anthracnose.

**6. Bourban**, Brazil, poly-embryonic, medium size, bears fruit throughout the year, skin greenish yellow, fibre long and diffused, 900 grams, oval, stone medium, sub acid, and juicy.

**7. Brooks late**, Florida mono-embryonic, seedlings of Totapuri, medium size, some what dwarf, very late, 15 September to 10 October, can become alternating unless flush is forced, heavy bearer, yellow with red blush, fibreless, 650 grams, oval oblong and plane. Large stone, pulp 57%, taste fair to good, resistant to anthracnose, stem end rot and bacterial black spot problem, hopper, flying fox and scales other problems, highly in demand due to lateness

**8. Carabo**, Philippines, poly-embryonic, large tree, early mid season, heavy bearer , tendency to alternate, yellow skin, pulp lemon yellow, 270-440 grams, papery stone but , large seed, Brix 19.2°, thin skin, good ,slightly acidic, sweet, mild aroma, important in export to Japan, susceptible to anthracnose, bacterial black spot, hoppers, shoot borers and scales.

### **9. Celebration**

Northern territory Australia, has potential, can superseed Tommy Aitkin, less fibre, good taste and mild flavour, sap burn negligible.

**10. Chausa Summer Bihst**, India, mono-embryonic, harvest July-August, alternate bearing, skin yellow, oblong with prominent beak, Brix 19°, sweet full of aroma, soft nose through out the season, juice has some amount of tannin.

**11. Crimson Blush**, Australia, early mid May, regular, pale or orange yellow skin, fair quality, anthracnose resistant.

**12. Desheri**, India, mid season, poor yield, light yellow, 160 grams, Brix 18.7°, highly resistant to powdery mildew, soft nose, jelly seed but highly susceptible to malformation, and fruit rot takes place by softening of whole pulp.

**13. Earlygold**, Florida (1948), medium size tree, harvest 15 May, , heavy bearer, fruit in clusters, yellow but some times red blush, pulp yellow to white, fibreless, 50 grams, in Florida, 250g at Hyderabad, Brix 15.2°, good to excellent taste, juicy, high premature ripening 42%, anthracnose resistant (5%), susceptible to stem end rot, resistant to powdery mildew, softnose, a problem sap burn mild, fruit splitting problem, seed weevil 35%, sunburn, medium size, irregular maturing, acceptable due to earliness.

**14. Edward**, Florida (1943), mono-embryonic, (Haden x carabao), vigorous, tall, compact, dense, 1 July, 8 tons per acre, highly coloured, pink red, if in sun, pulp dark yellow orange, 450-650 grams, stone thin pappery and easily removed, Brix 17.5°, best flavour, spicy, juicy, sweet, sunburn a problem, seed weevil 17%, anthracnose 15%.

**15. Glenn**, Florida, A Haden seedling, mono-embryonic, moderately vigorous, small to medium tree, spacing 25 x 10 feet, 177 trees per acre, to be reduced to 88 in year 10, first fruiting 3-4 years, 20 May, alternate bearing, yield 6-7 tons per acres, yellow skin with red blush, pulp blight yellow, fibre nil, 400-650 grams, stone to whole fruit 7%, flesh recovery 77%, Brix 15-16°, taste good to excellent, pleasant aroma, mildly resistant to anthracnose 12%, stem end rot 18%.

**16. Haden**, Florida 1910, mono-embryonic, seedling of Mulgoba, vigorous, alternating, yield high in Florida, low in Israel, but 6 tons per acre at Hyderabad, skin crimson blush, pulp deep yellow, 400-650 grams, high incidence of nubbin , flesh recovery 65-75%, Brix 14.7° in Florida ,19° and 17° at Hyderabad, taste good to excellent with sub acids, juicy , slightly turpentine near skin, highly susceptible to premature repining 17%, mildly susceptible to anthracnose, bacterial black spot, jelly seed, soft nose and sap burning, susceptible to fruit fly, internal break down, scales shoot borers, pink wax scale and mild to moderate sunburn.

**17. Irwin**, Lippens seedling from Florida (1945), moderately vigorous, but open canopy low height 16.6 feet in 6 years, 20 x 13.3 feet can give 164 trees per acre. fruit in clusters, regular, medium bearer due to earliness, 10 tons per acre, easily possible in year 8, skin yellow with red blush, highly colored, pulp lemon yellow, 300-450 grams, stone paper thin, Brix 19.5° in USA, 14.5% in Australia, 16.5° in

Hyderabad juicy pleasant aroma, highly susceptible to anthracnose and fruit fly, susceptible to stem end rot, soft nose, sun burn moderate,

**18. Itamarka**, Brazil, poly-embryonic, dwarf, non -vigorous, late, can give winter crop, skin greenish yellow, pulp golden yellow, fibreless, taste good with very little turpentine.

**19. Jakata**, Indonesia, early 5 June, very attractive, good flavour, susceptible to stem end rot.

**20. Julie**, West Indies, mono-embryonic, very dwarf, 218-264 trees per acre, late, off season, regular, yield medium, crimson blush and yellow, pulp orange, fibre less, 80-280 grams, small seed paper thin, pulp 67%, Brix 17°, unique and excellent taste, melting, juicy, spicy, highly susceptible to anthracnose 10%, seed weevil 14%.

**21. Keitt**, Florida (1945), seedling of Mulgoba, mono-embryonic, dwarf height 6.6 to 16.6 feet at age of 6 year, pruned to 13.3 feet and maintained at that height, canopy diameter 7.5-10 feet, 216-264 trees per acre, even 444 trees a possibility. Harvest 1st August to 10th September, regular to dependable yield, bearing in clusters, yield per tree for size and per acre highest of all varieties. At 7-8 years 10 tons per acre, though 6 tons possible, skin greenish yellow with rosy pink blush, pulp deep yellow, fibreless, 450-850 grams ( can be 500-2000 grams, stone 7-8.5%, flesh recovery 75-80%, Brix 15-15.6°, taste excellent, juicy, sweet, lavender smell, takes 15 days to soften at room temperature and can be stored at room temperature, for another 15 days or so, can be shipped to Europe by sea in 15 days or so, acceptable in international market, resistant to anthracnose, premature ripening, stem end rot, powdery mildew, jelly seed and hoppers and this makes it one of the most desirable mangoes, but is highly susceptible to bacterial black spot, sunburn in Sindh and Western Australia, though not in Florida.

It is not without serious defects as 56% fruit is reported to be marketable; rest is lost due to sun burn, fruit fly and internal breakdown caused by high nitrogen, low calcium, magnesium and boron. It can be left on tree for four weeks but seed germination is a problem. Internal break down and large size controlled by reduction of nitrogen, but consequently yield goes down. Parrots usually damage ripening fruit; sun burn can some time be more than 50% in Sindh. Internal break down common in young trees of age 4-8 years. Bagging controls sunburn, but bags promote scales only way to keep in productive is pruning at every harvest, since flowering takes place over 10-12 weeks (December to March,), 3-4 harvests are need ,and small fruit left on tree gains size.

## **22. Kensington Pride.**

Australia's main variety since 1966, poly-embryonic, vigorous, spreading, dense canopy, tall, 40 trees per acre, but some plantation have 70, first fruiting in mid

season, grafted second year, seedling fourth year , irregular bearing, alternating, yield 4-6 tons per acre under Australian management ,but erratic in warm tropics, skin yellow with average red blush, pulp deep yellow, small fibre, 300-600 grams, pulp recovery 65-70%, taste good to excellent, Brix 16.3°, anthracnose susceptible, premature ripening less than 10%, malformation , bacterial black spot, powdery mildew, jelly seed, fruit rot, sap burn, fruit fly and hoppers problems ,scales, tip borers, and thrips can easily kill the tree. Sunburn moderate to high, this National Australian mango is being replaced by R2E2, Keitt, Irwin, Celebration and many other new varieties very fast, since 1989.

### **23. Kent.**

Florida, mono-embryonic, seedling of Brooks (1940), large vigorous dense upright, harvest July 10 , late mid season, bearing 5-6 tons per acre in Florida, skin yellow with dark red blush, pulp deep yellow eye appeal very attractive, no fibre, 600-700 grams , stone 9% of whole fruit, Brix 18°, taste excellent, flavour sweet, melting, juicy and one of best taste of any mangoes, premature ripening only 6%, susceptible to anthracnose, powdery mildew, sap burn, internal disorders, seems to be suitable to dry climate of Sindh, as in Mexico.

### **24. Langra**

South Asian variety 18<sup>th</sup> to 19<sup>th</sup> centuries , mono-embryonic, vigorous, dense canopy, midseason, heavy bearer 10 tons per acre if heavily fertilized, other wise alternating, skin greenish yellow, pulp lemon yellow, fibreless or soft fibers, very sweet, very juicy, good taste suitable for canning.

### **25. Late Sindhri.**

Sindhri seedling, but large fruit 750-1000 grams, end July.

### **26. Malika.**

Inida, monoembryoic, (Neelem x Deshri), dwarf, but dense canopy, 1 July, heavy bearer but irregular , skin bright yellow, pulp deep yellow, no fibre, 280-450 grams, oblong with rounded base, Brix 19.2°, taste good to excellent, juicy , sweet sunburn moderate, sapburn susceptible.

### **27. Manzilo Numez**

Mexico, mono-embryonic, medium size, early but harvest extends to 2 months, regular, 300 kg yield in year 8, yellow aroma with red blush on 75% fruit, fibreless 600-700 grams, stone 6%, Brix 15°, slightly acidic but pleasant, long shelf life , sun burn moderate problem.

### **28. Maya**

Israel, mono-embryonic, tall tree, very early in Israel, not commercial outside Israel, skin yellow with red blush, fruit size 300-40 grams, good eating quality, but does not store well and has heavy internal break downs.

### **29. Neelum.**

South Asia ,18<sup>th</sup> and 19<sup>th</sup> century, mono-embryonic, dwarf, heavy bearer but compact canopy, greenish yellow skin, pulp deep yellow, no fibre, 230-300 grams, taste tolerable, not so good as other mangoes, resistant to antracnose and powdery mildew, very late end September in Sindh and therefore fetches good prices.

### **30. Nom doc Mai**

Thailand, polyembryonic, vigorous, upright, 20 feet in 6 years, 75-100 trees per acre, .fruiting at 30 months age in grafted and seedling 6 years , late end July to mid August, heavy bearer, biennial tendency, 5-6 tons per acre, green coloured skin, pulp lemon white, 250-400 grams in Thailand, but 350-500 grams in Florida, flesh recovery 70-75%, Brix 19.7°, excellent eating quality, juicy, rich spicy pleasant aroma, susceptible to premature ripening 44%, anthracnose 30%, stem end rot, powdery mildew, fruit fly, soft nose and sap burn problems, other common insects attacking it are; scales, shoot caterpillars, tip borers and hoppers.Can be eaten green when 75% full size

### **31. Nuwunchan-Nan Klangwan etc.**

Thailand, poly-embryonic, medium size, dense canopy, moderately vigorous, early, regular, greenish yellow with red blush in some years, not in Hyderabad Sindh), 300-500 grams, pale yellow, pulp long and slender with flatend base, good quality, sweet, juicy, pleasant aroma.

### **32. ONO**

Hawaii, poly-embryonic, moderately vigorous, upright, open canopy, mid season reguar, may yeild 5-6 tons per acre, skin yellow with red tone, pulp deep yellow, fruit small 160-200 grams, flesh recovery 66%, Brix 18°, good eating quality, very sweet, juicy, susceptible to anthracnose 20%, jelly seed 7%, sunburn moderate, small size a problem, though has good quality.

### **33. Osteen**

Florida, Haden seedling, favorable for new plantation in South Africa, mono-embryonic, vigorous, dense canopy, medium size, late, August, 1-15 , regular , skin yellow orange with purplish blush, pulp lemon yellow, fibre less, 500-750 grams , Brix 15.6-18.0°, sweet good quality, juicy, pleasant aroma.

### **34. Palmer**

Florida, parentage unknown, mono-embryonic, semi dwarf, but tight canopy, upright, spacing 20 x 13 or 23 x 16.6 feet, 114-163 trees per acre, late, August 1-10 in Hyderabad Sindh, regular bearer, but 3-5 pickings needed for harvest, yield can be 8-9 tons per acre, skin orange yellow with red blush all over, pulp orange, fibre less, 500-900 grams, pulp 75%, Brix 15°, eating quality good, sweet, juicy, subtle scent, mild aroma , melting, susceptible to premature ripening 20% and fruit fly, but resistant to powdery mildew, jelly seed, soft nose, also susceptible to

hoppers, tip borers and scales. It has been superseded by Palmer seedling, which has not yet fruited in Hyderabad Sindh.

### **35. R2E2**

Australian, poly-embryonic though seedling of Kent. Seedling can be 66% poly-embryonic and 33% mono-embryonic, medium vigor, but fruiting growth is limited, 20 feet high in 6 years, with 16 feet canopy, spacing can be 20 x 20 feet or 6 x 6 meters with 108 trees per acre, harvest July 1 to 10, regular, yields 6 tons per acres, yellow with red blush in some years, pulp lemon yellow and very attractive, 600-1000 grams and some times 2,000 grams, pulp 77%, Brix 16-17°, long shelf life at ambient temperature or under heat treatment or under cold storage or under modified atmosphere, picked when nose shows sign of yellowing, ships well, popular for export, anthracnose medium resistant, susceptible to bacterial black spot, boron deficiency serious, susceptible to fruit fly, hoppers, tip borers and scales, sun burn moderate to high

### **36. Sawarnarka**

South Asia, tall and slender tree, heavy bearer with tendency to alternating, skin cadmium yellow, pulp yellow, fibreless, juicy, pleasant aroma, slightly turpentine resistant to powdery mildew, harvest July 20 in Hyderabad, 450-500 grams, anthracnose a problem, greenish yellow skin not acceptable for export.

### **37. Sensation**

Florida 1940, mono-embryonic, open canopy, dwarf, harvest August 1-10, heavily alternating, cluster are so heavy that it gets diseased before maturing, skin yellow with red blush, fibreless, 280-340 grams, medium juicy, weak aroma, lacks flavors, premature ripening, highly susceptible to premature ripening 11%, anthracnose, bacterial black spot, internal breakdowns, fruit fly and sap burn, not commercial any where, except in Pakistan.

### **38. Sindhu**

It has nothing to do with Sindh. It was bred at Venguria Research station District Sindhudurg Maharashtra and Sindhu came from name of district. Tree characteristic are: dwarf, fruit 215-250 grams, yellow with pink blush giving it good eye appeal, seed is 6.72 grams i.e. 3 to 3.5% of weight of fruit and is known seedless, seed stone is cotyledon free. It is extraordinary sweet melting with Brix of 21.11° making it one of the sweetest mangoes of the World.

### **39. (13/1)**

Origin Egypt, it is poly-embryonic seed obtained by Israel from Egypt and used as root stock on high pH, calcareous soil and even saline water. Size medium to large, somewhat kidney shaped, yellow skin, but large stone with fibrous coat. Its important application in Pakistan would be root stock in saline, calcareous and high pH soils, besides fruit itself is reasonably large size and sweet in taste.



#### **40. Tommy Aitkin.**

Florida (1926), mono-embryonic, Haden, seedling, dwarf, 218 trees per acre, first fruiting in year 4-5, mid season June 10, regular, dependable, heavy bearer in clusters, skin dark red blush, pulp dark or orange, good eye appeal, abundant fibre, 450-700 grams in USA, 500 grams in Israel, stone 6-8%, pulp recovery 70%, Brix 15.6°, sweet fair to good quality, medium juicy, internal breakdown serious with excess fertilizing and irrigation, long shelf life at ambient temperature, under heat treatment, cold storage or controlled atmosphere ships well, stands handling damage, highly resistant to anthracnose, but premature ripening 46%, jelly seed 42%, fruit rot due to internal breakdown serious, moderate sunburn.

#### **41. Turpentine.**

West Indies, poly-embryonic, vigorous, large spreading tree, used as root stock, early to late midseason, fruits in clusters, high yield, skin yellow with red blush, abundant coarse fiber, big seed, poor quality but rich aroma, popular root stock, but superseded by 13/1, Sabre and others.

#### **42. Van Dyke.**

Florida, mono-embryonic, late mid season, July 10 fruit in clusters, heavy cropper, 6 tons per acre, 280-500 grams, pulp recovery 65%, Brix 17.9°, good to excellent taste, sweet juicy, pleasant aroma, most acceptable in Europe, premature ripening 15%, anthracnose susceptible 20%, stem end rot 38%, soft nose 48%, sun burn moderate to high in Sindh.

#### **43. Winters.**

Florida 1959, seedling of Ono, poly-embryonic, mid season, heavy but irregular bearer, taste wise only next to Van Dyke, 400 grams, flavour fair to poor, susceptible to anthracnose, but resistant to soft nose.

#### **44. Zill**

Florida (1930), seedling of Haden, vigorous open canopy, late (early August), regular bearer, skin dark red or yellow, pulp pale yellow, no fibre, 356-450 grams, seed 8% of fruit, Brix 17.4°, good to excellent, taste, can be halved like avocado, premature ripening 37%, fruit fly very severe, sun burn high.

#### **45. Zillate.**

Florida, mono-embryonic, late September-October in Sindh, but low yielded about 3 tons per acre, regular bearer, skin purple with red blush, attractive, Brix 17.8°, average eating quality, slightly turpentine, susceptible to premature ripening, stem end rot and bacterial black spot, sunburn low to moderate, has future, due to lateness.

In addition to above Israel is progressing with Naomi and Lily (similar to Irwin), South African Manzliano, Jon and Osteen. Dutch and French markets are importing new varieties namely; Atalifa and Champagne (deviation of Manila (already forward in USA)

There is also demand for Edward, Heidi, Otts and Zill as they can be halved like Sindhri or avocado.

There is preference among growers for varieties producing fruit in clusters .There are many such mango varieties some of them are R2E2, Keitt, Irwin, Earlygold, Brooks, Tommy Aitkin, Van Dyke, Deshri, Bourban of Brazil, Espado (Brazil), Haden, Kent, Malika, Nam Doc Mai, Ono, Osteen, Pervin, Sensation (but alternating ), Turpentine, Celebration, Sindhu etc. Those of some merit have already been described above but few more need attention.

We have selected a number of varieties from seedlings over 25 years and have named them PS-1, PS-2, PS-4, RD-1, ZL,PO etc. They all are worth trying PS-1 is earliest (April 25), PS-2 flowers in November but its fruits are killed by cold. Heating tree on cold night by keeping Hurricane lantern under tree or two kerosene wick lumps saved fruit which was harvested on 15 April. The flowers killed by January re-emerged in February and harvested July 5-10. RD-4 is slender, longer, but looks like Sindhri and harvested on July 5 when Sindhri is no longer available in Sindh and fetches high price. ZL is full of juice when ripe and by puncturing juice can be extracted directly in a glass slightly squeezing .PO weights 2 kgs and has small seed , many such varieties which are being released to the farmers .Their harvest dates is April 15 to October 1.

#### **Pakistan varieties.**

Where do we stand with our own varieties in the international market. We have not checked defects in our varieties and accept due to good eating quality only Sindhri and Chausa. Both are low yielders with serious problems discussed in table below and we have to decide, whether to introduce new varieties? We have a lesson to learn from Florida. They imported mango from India in 1889 and by 1949 in 60 years selected more than 100 varieties of mango from seedlings. These are now being exported from South America, Mexico, Florida, West Indies, Israel, Australia and South Africa.

#### **Can existing Pakistan mango varieties presently for local use, be leaders in export in the developed countries?**

The answer is no. The two main exportable varieties of Pakistan are Sindhri and Chausa. Both have troubles from harvest to sophisticated export markets, as shown in table below:

#### **Unsuitability of Sindhri for export**

<b>Factors</b>	<b>Quality</b>
Yield	Low, 3 tons per acre at 15-20 years age.
Bearing regularity	Alternating, variable year to year, in every 5 years one good crop, two poor crops and two average crops.
Skin colour	Yellow acceptable in South East Asia, but less preferred to pink skin in Europe, Australia, South Africa and Western



	Hemisphere.
Jelly seed	Common in large or late harvested fruits and spoils eating quality.
Stem end rot	10% fruit
Shelf life	Very short, 2 days after softening
Anthracnose	Serious skin blemishes, spoils soft fruit in 36 hours.
Sap burn	Serious , quality reduced due to skin blemishes
Skin blemishes	Excessive due to anthracnose, stem end rot, sap burn and market-chain browning.
Bacterial black spot	10% fruit
Taste	Very good within 24 hours of ripening, then quality deteriorates.

### Unsuitability of Chausa for export.

Factors	Quality
Bearing regularity	Highly alternating.
Yield	Not high, average, less than 3 tons per acre
Skin colour	Yellow, acceptable in South-East-Asia, pink preferred in Europe.
Softnose and internal breakdown	Severe, almost every fruit has softnose sponge like cavities.
Sweetness	Too sweet for European taste, pulp leaves taste of molasses or guar, probably due to tannin in pulp.
Seed	Large, low pulp ratio to whole fruit
Pulp to fruit weight ratio	Low 60% against 75-80% of good varieties
Size for export	Marginal, 250-300 grams against 400-650 grams preferred for export.

### Desired characteristics of mango varieties of export to Europe and other sophisticated markets.

Characteristics	Acceptable for export
Colour	Pink blush
Pulp weight to whole fruit	Plus 80%
Seed ratio to weight	Less than 10% although 6% is ideal
Size of normal fruit	400-650 grams
Size of exotic fruit for export	600-2000 grams
Post harvest life	15-20 days from harvest to consumption

### Root stocks

In South Asia there has been limited work on plant growth, fruit yield, nutritional status in mango as influenced by root stock.

In northern India and Pakistan root stocks used are mono-embryonic i.e., seed is different from same mango and is hybrid in its own right. Seeds are collected as house hold waste by sweepers, damped in piles and sold in lots in gunny bags. 4-6 weeks after they were consumed. These seed invariably are attacked by fungus, bacteria, insects and disease and germination rate is very poor. Usually planted in September they do not develop pencil thick size in February-March. In advanced nurseries of developed countries these are considered sick plants and are destroyed.

In South Asia they are maintained for August grafting, majority of them are sick and grafts on them are weak, unhealthy and are usually transplanted in February-March, 18-20 months after seed planting. Unlike 8-9 months of developed countries field mortality of these plants is very high and sick plants give troubles through out their life. Besides it is common observation that scions of any variety grafted on seedlings available, has different tree sizes, shapes and even yield varies from tree to tree. Leaf analysis of these trees too differs to some extent. Knowing that this is due to scion-root stock influence, we tried Sindhri on Sindhri seedlings, but the size differed from tree to tree and in all 50 trees per acre. It was clear to us that each Sindhri stone or seed was a hybrid and variable and not true to the mother. We concluded that problem will persist, if we use mono-embryonic seedling as root stock. Poly-embryonic seedling is an answer, but even seedlings of different root stock give different characteristic to scion tree. An interesting recent study by Spanish workers V.H.D, Zuozo, J.A. Ruiz and A.M.Raya on mango reported in international Journal of fruit science Vol 5. No. 4, 2005, proves that their trials on two different root stock for same scion of Osteen mango, showed that fruit yield was greater in one type of root stocks than the other, but second root stock produced heavier type diameter and more nutritious fruit.

This now opens a new venue for root stock-scion relations of the known polyembryonic root stocks. We can try a few in Pakistan for initial results of uniformity of size of tree to begin with and then work on yield size and quality of same scion on different root stocks. There is great scope for research on polyembryonic root stocks as well on mango relatives of South-East Asia, but they are all tropical and some of them may not survive cold weather, even in coastal Sindh.

### **Why dwarf trees, their characteristics advantages and problems?**

Credit for promotion of dwarf fruit trees goes to Professor, Harold Bradford Tukey, who wrote a book on the subject it in 1964 at East Lansing Michigan and it has been printed a number of times. The book limits itself to temperate zone fruit trees. Later on International Dwarf Tree Association was established in 1968, but since majority of its members were from temperate zone, their work was limited

to apples, peaches, plum, cherry etc .However some workers in California and Florida applied this technology to citrus successfully and many workers in Homestead Florida and Fairchild Garden Miami, worked on mango and other fruits, prominent among them were Professor Robert Knight and Dr. Carl Cambell. Israeli students have also worked on dwarfing of mango with good results. Two Israeli consultants are working near Salton, Sea (California) on 500 acres dwarf mango orchard, but no visitors are allowed. We have introduced dwarf mango varieties and have planted not to allow their height to exceed 4.5 meters and diameter 3 to 3.5 meters and technology is being applied to lychee, peach, apple, grape fruit and pomegranates grown on authors farm. In brief the advantages are as under:

- Early first fruiting due to trees occupying at least 75% of area in 4-5 years.
- Low cost per unit production.
- Less man power.
- Harvesting from ground rather than climbing tree or using costly equipment.
- Easy and economical orchard management.
- Low cost of pruning and thinning per unit.
- Easier and cheaper control of pest and diseases and less use of pesticides.
- Less loss of trees from wind storm.
- Large percentage of quality fruits, less sub-standard or rejectability, higher market prices, and more income.
- Early returns on investment, early first fruiting, early break even period, early pay back period on investment.
- In high density planting number of trees can be 150-435 per acre and loss of one tree will be less than 0.66% where as in low density of 25-40 trees, loss can be 2.5-4.0%
- Planting cost is more with high density planting but this extra cost of planting and maintenance can be paid back by first good crop in year 4-5.
- Large trees need large spray machine and high pressure to penetrate through the whole cross -section and more water and total pesticides due large tree but dwarf trees do not waste pesticide and can work at low pressure. This is important as new management may need twelve sprayings annually against about three under old technology.
- Micro climate created by large number of trees reduces summer temperatures and can even face turbulent frost winds on lee ward side of wind break and make pest control easier.
- Pruning and thinning will be easy as small branchlets have to be removed against large limbs of large trees.
- High density planting suppresses growth of weeds between trees and tree rows where as it is serious problem in low density scattered trees with large size. When turbulence between tree is common.
- In dwarf tree mango orchard harvesting is done by crew, while walking around the trees and in case of large trees, the crew has to climb tree or use

costly equipment. The labor requirement is reduced to 25-30% and there is saving of about 30% on harvesting costs.

- Old unprofitable trees can be rejuvenated by top working at height of about 2 meters. It is known that young trees (rejuvenated) produce high quality fruit and mango trees more than 30 years old, may prove to become liability.
- New mango varieties have potential of 10 tons per acre or more, against 3 tons of old varieties.
- Colour of young dwarf trees will be better than old tall varieties due to shading of fruit by large canopy, size also can be uniform.
- Dwarf trees have disadvantage of small root spread and could suffer from drought. Mulching tree guarantees against drought which is applied water every 12 day against 7 days in conventional method as practiced in Sindh.
- Wind damage in large trees is more as the large branches have to bend and return back, In Hyderabad area 21 feet wind mill generates 0.75 KW for about 33% annual hours, A large tree about 40 feet height and 40 feet canopy will with stand 3.0 KW power. The tree metabolism has to generate this extra energy at cost of fruit production. Small dwarf trees wont face this problem which will also be handled by moderate size wind breaks.

#### **How can a tree be dwarfend.**

The above paragraph explains how large limbs and wood in large tree is not only non productive but counter productive, in winds, shading lower limbs, drying their wood, and affecting not only colour of fruit, but also yield.

New trend is that branches should be thin and be replaced by pruning. Our normal practice is to have 3 branches per tree at height of about 0.75 meters and when these branches are 45 cms tall, they are tipped to produce 6 branches which again are pruned at 45 cm to produce 12 branches and from of each which 32 fruiting branches are produced in 2 years by tipping them when 18 inches (45 cms) tall .After first four years 25% of those 12 original branches are cut down and allowed grow again and produce 32 fruiting tips. All branches are cut down this way in 4 years remains dwarf. After harvest the fruiting branchlet is cut 8 inches (20 cms behind the point where flowering started. In the season they grow 8 inches and re-flower. Size of tree has thus remained the same year after year .It is labour intensive, but tree interior open up, yield is more, and fruit is without blemishes, with large size and pays back.

#### **Permanent bed cropping of fruits nuts and some perennial tree crops.**

Permanent bed cropping for annuals or non perennial crops is being promoted for the past 10-15 years in South East Asia and Australia .Its advantages are that soil is not being compacted and weeds and stubbles of crop are being used as mulch. It is an efficient system but need training to farmers and these is limitation to type of crops.

We have successfully used permanent beds for various crops including fruit crops and spacing of rows varies between 2.5 meters for grapes 4 meters for citrus, 4.5 meters of peaches, plums, and pomegranate, and 6 meters for mango, lychee and logan .The beds are 2 meters wide, 25-31 cm high, except 1.2 meters for grapes. These allow for rows 2.4m for grapes, 4.5 m for citrus, 4.5 for peach, plums, pomegranates and 6meters for mango lychee and longan. The furrows are irrigated to produce weeds, which are cut and dumped on ridges as mulch, described in separate chapter .It is after couple of years that real advantages of permanent beds, furrow, mulching and saving of water are seen and realized almost as magic.

### **Bees as pollinators.**

Although bees plays significant role in pollination of mango but they pollinate many other crops near an orchard and their protection is more duty of every growers .Bees are killed by many chemicals and other agents on the farm and these have to be understood by all growers.

### **Bee poisoning and control**

1. Insecticides used on crops during flowering.
2. Drift of toxic sprays into adjoining crops
3. Contaminated water drunk by bees
4. Contaminated pollen or nectar collected by bees.

### **Pesticides which affect bees.**

1. Miticides
2. Organic phosphours compound
3. Carbantes
4. Organo chlorides
5. Prethroids
6. Rotenone
7. Sulfur dust or lime sulfur
8. Petroleum oil
9. Herbicides
10. Defoliantes
11. Desicants
12. Pyrazophos fungicides (other fungicides)

Grower can control drift of the chemicals to adjoining lands and not to contaminate water flowing to his or other land.

### **Young mango tree care and training**

Young mangoes have same leaf, stem and root diseases as to mature tree and in South Asia the mortality is very high as plants are available from rural and primitive nursery men, who use diseased stones for seedlings which take about a year to be ready to graft instead of 6-7 months.

The growers are also advised to locally non-technical people cover the plants against hot summer winds and direct sunlight and so the growers make a small conical hut must covering it and leaving a small opening to the North. No sunlight fall on leaves, photosynthesis is reduced and mortality can hit 25%. However water is applied weekly.

When winter comes to save trees from cold winds of north, trees are covered the same way leaving a small opening to the south the mortality can hit another 25%.

We have developed a method of putting mulch consisting of weeds, grasses etc, around the young trees about one foot (30 cms) around the stem and 18 inches (45 cms) high, leaving only leaves outside and even on frosty nights the mortality reduced to less than one percent. The mulch actually raises ground temperature by about 5° C and roots do not get damaged. As regards fertilizing of different countries have been using different disease and none of them are in agreement. For young trees recommendation similarly vary. Many years experience have shown us that small monthly ground doses of NPK every month of from February to end October in all 9 times a year gives good growth and also weakly sprays with 1% urea have enhanced growth. In addition we have been using urea 1% triple super phosphate, 10% and potash 1.33 percent along with 250 grams each of copper and zinc, 125 grams of manganese every month along with pesticide or fungicides every month and also 250 grams of boron once a year. These plants remain very healthy and have fruited in 3 years a commercial crop in year 5 and maximum yield with year seven.

We allow trees to grow on single stem until about 40-48 inches (1.0-1.2 meters) tall, then cut off top 3-4 inches (7.5-10 cms) and 3-4 branches grow from below the point of cut. If they are less a second cut one or two inches below this point will give at least 4 branches. They can be bent to form about 45° angle with the main stem or trunk by spacers or by using soft plastic strips. When these four branches became a 18 inches (45 cms) long they are tipped to produce two branches. This process is repeated or three years when each original four branches produce 32 branchlets. These could produce fruits in year four but it is better to allow them to grow a little more and flowers are removed to get first commercial crop in year five.

**Table showing the fertilizer doses per month from year 1 to 5 years per tree in a high density planting.**

Year	Urea grms	TSP or DSP	Potassium Sulphate	Total annual doses.
1	10	10	10	8 to 9
2	20	20	20	8 to 9
3	30	30	30	8 to 9
4	40	40	40	8 to 9
5	50	50	50	8 to 9



Our experience shows that even this dose is very high, but growth rate had been satisfactory and a large number of plants had flowered at age of 3 years and all of them at age of 4 years. With 150-200 trees per acre annual dose of nitrogen in year 5 when plants occupied 75% of allocated space was about 90 kgs per acre, but depending yield dose can be doubled, when in year 5 to 8 or when maximum yield is achieved.

#### **Pruning non bearing trees.**

- i) Ideal tree should have 3 or maximum four branches and not more.
- ii) Tree height should not exceed 6 meters, so that future harvest takes plants from ground.
- iii) Pruning is carried out with purpose of
  - a) Shaping trees
  - b) Opening center
  - c) Allowing free movement of air in the tree.
  - d) Allowing sun light to enter the trees.
- iv) The trees may be allowed to grow to one meter height, then cut back to 0.6 or 0.7 meters .The cut is to be given just below a ring of buds .If cut is given above whorl of leaves or bud 7-8 branches will develop and even when thinned to 2 branch-lets, this will be a week point. If cut is given just below whorl or leaves there would be only 2-3 shoots and all well spaced and strong. These shoots may be allowed to grow 1.0 meter and cut back below the whorl at length of 0.6 meters or even 0.5 meters.

#### **Layout of HW Disinfecting Machine Along With Weight Size.**

This simple drawing shows how to disinfect mangoes against fruit fly. Baskets of mango at required temperature of water say 46°C move from one end to other in 60-75 minutes .Their movement is controlled by speed of conveyor. Fresh rinse is to remove any sap or dirt. Fungicide application will enhance post harvest life as well as cosmetic look of fruit, but its use will depend on the acceptance of importing country. Sorting table will be for removal of unwanted fruit. Weight size will grade fruit in different sizes including under weight rejectable pieces. To protect fruit from re-infection by fruit fly the whole premises from desaping to end of packing has to be protected by proper sieves and even box holes covered with screens allowing air and moisture movements. Mango season temperatures in Pakistan hit maximum 42-49°C.It will be economical to hold water in an over head metallic tank to save cost of heating in the boiler. The temperature control over in the hot water tank has to be maintained accurately by sensors.

#### **Technological aspects of producing mango products.**

Mango is produced almost in every tropical and low latitude subtropical country. The edible pulp varies between 60-75 in most of commonly popular mangoes, but in some cultivars it reaches 80-85% by weight. It contains 83% water about 15% sugars mostly sucrose, vitamin A of 30 mg, citric acid per 100 grams of pulp.



These also contain glycolic, oxalic, mallic, tartaric acid. It contain amino acid namely glutamic acid, allanine, glycine, serine and alpha -amino butyric acid. Juice and all kinds of preserves can be made from it .Pickles and chutney are made from unripe fruit. Mango slices, pulp and juice are canned and bottled. In canning slices ,softening is a problem, which can be overcome by firming agents like calcium chloride and calcium lactate since mango season is limited and prices fall down during mango glut, this is time to procure raw material and ripen it to good quality and hold it in cold store it .For processing further. Mango make delicious jams and mango latex .they can be canned by two method called open kettle and cold pressure methods.

In open kettle method mangoes are washed, skin peeled, sliced to endocarp or seed, slices put in 60% syrup, cooked for 10 minutes, and citric acid or lemon juice added. This hot mixture is put in to cans or bottles and sealed and finally product is cold stored. The product is sweet to begin with but after several weeks' storage become more satisfactory. .Cold pack of 60% syrup is made, slices put in and filling syrup poured over them and allowed to exhaust for 5 minutes before processing for 15 minutes at 34.5 x10<sup>3</sup> (psi) pressure and sealed before putting in cold storage. All above requires specialized equipment and without that quantity can not be maintained for long storage and export.

### **Mango powder.**

Unripe mangoes are used for making powder which is added to various dishes. Mango are peeled and sliced and dried in sun. Slices are very small and pass for powder.

### **Bam Paph**

It virtually means dried slices. Pulp is squeeze out from ripe soft mango, spread on some kind of mats, sprinkled with sugar and allowed to dry under sun. When first layer has dried second layer is laid above it for drying process to repeatable till be layer or slab become ½ to 1' thick .Lot of dust will collect in South Asia environment, a nearer of fungus and insects will attack it. Philippines have been selling mango slices of good quality by drying the same under proper sanitation and scientific methods, eliminating all insects, pests, fungus and bacteria and hermetically. There is great scope for mango slices.

### **Mango pickles.**

This is common product of South Asia. Mangoes which are fully developed sliced longitudinally with stainless knife and slices are kept in 2-3% brine to prevent blackening of cut surface .Then they are processed by adding following spices.

<b>Spices</b>	<b>Weight</b>
Mango slices	20kgs
Salt powder	5 kgs
Metne ground coursly	2.5 kgs
Kalaunji	600 grams

Turmeric	600 grams
Red chilli powder	600 grams
Black paper	600 grams
Saunf (Ani seed)	600 grams

The mixture is usually put in glazed pot and kept under sun for 4-5 days for slices to turn pale yellow; some times rape seed oil is also added.

### **Sun drying yards**

It is practically impossible to avoid dust, sand and other liter like collecting over the fruit being dried and more so to remove this material from the fruit at later stage .In Southern half of Sindh below Nawabshah high velocity wind blows from south west to north east from April to September and is loaded with dust. On other hand machine drying at 60° C (140° F) will cost on fuel. There are single piece drying ovens occupying one small room with air inlet and exhaust, which can dry many tons of fruit every 48-72 hours. The clean product they produce will be more than compensated by high export price.

### **Sulfuring room**

It is another requirement, that fruit being dried is first exposed to sulfuring process, so that it maintains its colour. Again sulfur dioxide is irritating and shocking gas to human beings, sulfur dioxide also attacks iron, zinc and untreated iron and special care is needed for selection of materials for fumigation. Fumigation tarpaulin can eliminate building sulfur house, but disadvantage is that though strong and decay resistant, it is easily cut by sharp edges of tools, trolleys and trays and in general can not stand rough handling.

### **Jams**

Lot of care is required in handling jams. It is not house hold industry but is large scale production if aimed at local and foreign markets. It needs the following items to be carefully selected, protected, experimented and samples, tested almost on a day to day basis:

- Use of right equipment, jelly kettles, deep fat thermometers, jelly bags for extracting juice from fruit containers that can be sealed air tight with fresh lids.
- Use of right ingredients, good flavour, and fruit with good color, sugar proper amount of pectin and citric acid and lemon juice added if needed.
- Filling and sealing jars properly which are kept in hot water untril used.

### **Cold storage**

Processing jars is done in hot water bath at 87.7° C (190° F), for 5 minutes to ensure vacuum seal.

### **Jellies**

Making jelly from juice either by short boil method or no cook method or even long boiling method, all of which need equipment, testing for pectin, acid and adding sugar if needed, cooking juice and testing for jelling point.

### **Mango butter**

Half ripe mangoes are peeled sliced. About 16-33% volume of sliced mango is added to water and cooked until it soft enough to mash. Fruit can be blended for flavour and colour, white or brown sugar added for darker butter and more for pronounced flavour, even species or lemon juice is added.

### **No sugar Jam and jellies.**

In this process even existing sugars in juice are reduced, and no sugar is added.

### **Economics of Mango Production**

In Pakistan there is land and water shortage, land hunger and owning even small piece of land a prestige, consequently land prices have risen multifold and presently if capital cost of land and infra structures at the site is included ,no orchard or field crop will ever pay back its cost. The high density orchard can pay back all other costs in at least 12-13 years, though break in period i.e., owner no longer has to put his own money except returns from land, will be year 7-8.

With conventional low density planting of 25-40 trees per acre, break in period can be atleast 10 years and pay back period 20 years. Of course in both cases capital cost of land or interest on it is not included. The reason for this is suppression of prices of agriculture commodities for the past 60 years to feed rural and urban poor. In the year 2006 mango growers were getting Rs 7.00 to 8.00 per kg for their mango sent to whole sale markets where as far the same commodity price in Australia, South Africa, Florida and Israel was 10 times. This indirectly has affected the growers ability to spend on improvements like better tools, deep well turbine tube wells instead of conventional pump in the pit, precision land leveling, better spray , equipment , better mango harvesters, better packing and packing facilities, better pest control etc.

### **Factors to be considered in economic analysis.**

These are as under:

#### **1) Capital cost**

- a) Land, shed and workshop, fencing
- b) Tube well, irrigation, tractors, implements, utility equipment, packing shade and stores
- c) Tree planting and maintenance up to end of year 5
- d) Vehicles
- e) Total cost up to end of year five.

#### **2. Major production costs.**

- a) Weed control
- b) Pest and diseases control

- c) Fertilizers.
- d) Irrigation (running cost )
- e) Slashing, and pruning labour and maintenance
- f) Picking and packing or harvest costs including labour , boxes, packing materials.
- g) Freight to market , taxes en-route, loading and unloading
- h) Agent's commission.

### **3. Owners/Contractors personal supervision charges**

This includes transport, correspondence, interest on borrowed money, supervisory staff, guards, power, telephone etc

### **4 Total cost.**

It would be sum of 1, 2 and 3 above

### **5. Returns from crop and residual value of equipment and capital goods.**

General maintenance, office costs, accountant's costs, government taxes, insurance and cost of market visits.

- 6. The above will give net profit or loss from year to year, but if interest on cost of land if purchased from borrowed money is included, the annual losses will keep increasing and orchards will never pay back

### **7. Our experience of internal rate of return during past 40 years.**

Our experience of Internal rate of return shows that with high density planting, dwarfing trees by proper pruning, optimum inputs, mulching around the year optimum irrigation pest and disease control, the IRR at high yields and high prices can be 30-40 %. At medium yields of 3-5 tons per acre it can be around 10% and at low yields of less than 3 tons per acres it can be -5 to + 5%

### **8. Mango profitability.**

- i) Internal rate of return should not be less than government loan rate + inflation ( as determined by price of gold)
- ii) Break even period should not exceed 7-8 years
- iii) Peak debit, should reduce after year five.
- v) Payback period is time required for accurate cash returns to equal the accumulated cash cost and best period should be year 9-10, though year 12-13 is acceptable for medium management.
- vi) Payback period beyond year 20 may never pay back and most of Pakistan mango orchards belong to this category.

### **Origin of mango**

1. Mango has more than 45 relatives discovered so far mostly in South East Asia and worked done by the Dutch in Indonesia, of whom last century's important work was that of Andre J.G. Kostermom published by Linnean Society London in 1993. This and many other works put origin of mango family million of year back,

but the new method of DNA testing may throw some new light of its origin and spread at present. It is generally believed that ancestors of present popular mango first evolved on Assam-Burma border and from there spread to South East and South Asia. The first growth partly adjusted to climate of South Asia and then climate of Sindh.

2. South East Asian poly-embryonic mango basically is humidity tolerant and resistant to mildew attacks on new growth, flowers and fruit let's damaging 50-90% of crop, but some mono-embryonic varieties are mildew resistant. Although South Asian mango is mono-embryonic but does not tolerate humidity and mildew. Tap root descends to 20 feet, in deep soils and wide spreading roots also send down may anchor roots which penetrate several feet. Panicles get up to 2000 minute flowers, which have volatile substance, causing allergies reactions and respiratory problems for some people.

3. South Asian cultivars are more suitable for desert areas due to dry climate.

- Powdery mildew is promoted by wet weather and frequent fog. It attacks leaves first.
- Powdered kelp spray controls mildew, as does sodium bicarbonate, but synthetic fungicide are common due to promotion by pesticide companies.
- Anthracnose can be controlled by bimonthly application of copper. During flowering captan can be used.
- Digging, and disking causes feeder root loss productive tree can lose lot of yield by frequent digging with harrow.
- Soft nose is problem of excessive nitrogen in the soil.
- Commercial marketability requires 13% TSS.
- Fruit ripens best if kept with stem end down and covered with dampened cloth to avoid shriveling.

4. Some cultivars have flower scar at apex and in some cultivars bugs from fruit.

5. Skin of all mangoes and its relatives is inedible.

6. If irrigation water is hard, there will be more fibre. Excess fertilizers can produce excess fibre. While planting seeds, husk is removed and seed planted with hump close to ground level.

7. Multiple poly-embryonic seedling have to be carefully separated, as soon as they have sprouted so that they do not lose cotyledons. Plastic bag with a few drops of water improves chances of graft being successful. Grafts are most successful if two leaves are allowed below the grafts, but suckers are removed.

## CHAPTER - 7

### BREEDING OF MANGO

#### **Desirable Characteristic in Mango Trees for breeding.**

For breeding and selection of mango ,following should be its desirable qualities.

- It should bear good crop each year and be high yielding.
- It should have good skin colour with good eye appeal.
- It should have high percentage of perfect flowers, good fruit set and high yield.
- Fruit should have market acceptable size, excellent flavour and texture.
- It should be a small tree, to have large population of trees per acre.
- It should be dwarf to facilitate harvesting from ground.
- With heavy bearing tree, large number of trees per acre, the yield per acre price per Kg, gross and net returns per acre should be very high.
- It should have high retention of fruit, i.e., minimum two fruits per cluster, though more than two is preferable.
- First fruiting should be at an early age, besides fruit should have a long shelf life. It should have resistance to diseases like; anthracnose stem end rot, bacterial black spot, mildew and many other pre and post harvest diseases.
- It should be earlier or later than mid season mango glute period, to gain price advantage and out of season flowering can lead to earlier or late harvest.
- Flowers and trees should have frost resistance.
- At ambient temperature storage during post-harvest, it should ripen or soften, 10-15 days after harvest, so that there is adequate time for marketing channels, to carry fruit to the retailers or pass through export channel.
- It should have full or maximum resistance to sapburn.
- While introducing new cultivars in Florida (USA), these factors were kept in view and among their mango cultivars, Zill, Irwin, Keitt, Kent Earlygold, Brooks and Palmer meet these requirements. Earlygold comes in Florida in May, Brooks in September - October and others in between, so that season is extended over five months.

Although mango breeding programme was started in India, in 1913-15 by Burn and Prayay, the Indian Council for Agricultural Research established in 1935, started a planned breeding programme. In 1908 Agriculture Research Mirpurkhas imported some mango varieties from Coimbatore (South India), but their nomenclature got mixed up and same cultivars were imported again in 1936-37 from the same source, and , of them Sindhri Baganpli, and Swarparika suited climate and environment of Sindh. But since then there is stagnancy of and all these varieties belong to 19<sup>th</sup> century and here Sindhri did very well, every farmer interested in this variety and market price here reduced to less than 50% in the past 6 years.



## Breeding Problems

The breeding problems are:

- a) There is extreme alternate bearing, in many mango cultivars.
- b) The percentage of fruit drop in is 99.9%.
- c) Seedlings fruit in 8-10 years and take another 4 to 5 years, before the yield data can be recorded with certainty.
- d) Self incompatibility to various cultivars has not been fully investigated.
- e) Hand pollination has given low rate of success for seed production.
- f) Erratic cropping behavior is most of common in many cultivars.
- g) Biennial bearing behaviour of many high yielders is common.
- h) Lack of information on mango tree behavior in different climates and environments.
- i) Lack of information on photoperiodism and thermoperiodism.
- j) Latent infections affecting post harvest diseases.
- k) Development of disease resistance varieties against anthracnose, mildew, bacterial black spot, malformation, softnose, jelly seed, stem and rot etc is to be determined.
- l) Southern and Eastern sides of tree flower earlier and have a lower percentage of hermaphrodites than shady northern side.
- m) Off season flowering in areas close to equator, for example June in Peninsular India and December in Malelane of South Africa, shows that; photoperiodism-light intensity has quantitative effect on certain phases of reproductory behaviour. This needs to be understood fully.
- n) Basic tree structure to ensure freedom for poor crotch angle, which is inherent in some cultivars.
- o) Tree health and growth rate also depends on the root-stock rather than totally on scion. In other words the mother plant raised from stones, and used for budding and grafting, should produce fast growing and well rooting off-springs.
- p) The sickly plants grow slowly, have stunt growth are prone to diseases and yield less, in spite of same amount of inputs and same life. It can thus be imagined that life span of these trees will be less. However a grower in Israel has used these apparently sick plants for dwarfing tree with well known success.
- q) Recent researches by Kosterman and Bombard in Indonesia have lead to a large number of mango relatives, which may be used as root-stock. This new venue is to be tapped

## Self incompatibility and advantage to breeding.

Self incompatibility of some varieties presents good possibility for breeding. Indians have done lot of work. Langra, Deshri, Chaunsa, Himsagar, Neelum and Bombay Green are self incompatible. Self-pollinated fruitlets of above varieties fall down after four weeks. It is suggested that hybridisation can be achieved by top working the desired parents, with another variety, covering, the tree by polythene or cellophane bags and introducing cultural house flies. Deshri and



Chaunsa are biennial and their crosses may be biennial. Neelum a dwarf and prolific bearer, if left long enough, becomes bigger in size and is a very late variety of Sindh. It could be used for breeding. One result of such breeding in India was Malika, which is regular bearer with average weight of 307 g, against 170 grams of Neelum and 158 grams of Deshri, its parents. It also has better keeping quality.

Many countries have crossed and developed a number of cultivars and some of them reported in various journals are mentioned below.

### **Israel's breeding programme**

Israel's research is based on seeding of high quality and high performing of some seedlings of prominent varieties. Over 30,000 seedlings had been planted in the past 20 years of which 10,000 are still under observation. Israel has selected 7 new varieties in the past 5 years addition to hybrids produced earlier. They have 15 acres (6 hectares) under high density spacing 2 x 4m or 1250 trees per hectare or 506 trees per acre and each occupying 86 squares feet or nearly 8 square meters. Each year 1500-2000 new seedlings are planted and trees are not kept for more than 6 years. Each year about 1000 or more seedlings are discarded.

### **Brazil**

Brazil depends on selection of self infertile cultivars and grafting them on other varieties self infertile varieties. This would finitely produce new varieties but there is more scope in Israel's methods and some chance seedlings can be outstanding .Brazil has produced following hybrids.

Ametisla x Zill, Ametisla x M20/222, Ametis x Edward., Edward x Zill, Eiden x Kent, Keitt x Zill, M20/222 x Edward, Santa Alexandria x M 20/222, St. Alexandria x Kent, St. Alexandria x Tommy Aitkin, Tommy Aitkin x Zill, Tommy Aithin x M20/222

### **Florida.**

In Florida breeding work has been most outstanding that from one tree in 60 years. They produced more than 100 new cultivars including identifying self sterile females and crossing them and following new cultivars have been developed.

Simond.	=	Indian x Indo Chinese.
Edward.	=	Indian x Indo Chinese.
Fascell.	=	Brooks x Haden.
Pico	=	Indo Chinese x Edward.
X?	=	Edward x Kent.
Y?	=	Edward x Spring field.
Z?	=	Edward x Pico

Their selection method now has history of more than a century.

## **India**

A Large number of new hybrid are developed by self sterile varieties and hybrids produced at various research staliens are listed.

### **Kodhur Research Station:**

Au Rumani (Rumani x Mulgoa).

### **Fruit Research Station, Pariakulam, (Tamil Nadu)**

RKM-I (Chinnasuvarnarekha x Neelum)

RKM-2 (Neelum x Mulgoa)

### **Central Institute for Subtropical Horticulture Resarch Station Lucknow (Uttar paradesah)**

CISH M-I (Amarpail x Janardan Pasand).

### **Andhra Pradesh Fruit Research Station, Sangraddy.**

Majeera (Rumani x Red Mulgoa). 450 grams.

### **Indian Council for Agriculture Research head office New Dehli**

#### **Malika**

Neelum x Deshri, 300 g, apricot yellow, pulp 75%, Brix x 24<sup>0</sup>.

#### **Neelgoa:**

Neelum x Yarramulgoa. Large tree but good exportable fruit, medium yield, regular.

#### **Arka Puneet.**

Alphonso x Baneshan, 20<sup>0</sup>-22<sup>0</sup> Brix, regular, prolific ,225 g, red skin, 75% pulp.

#### **Arkha Aruna.**

Baneshan x Alphonso, 500-700 g, regular, small tree spacing 6 x 4 meters or about 166 trees per acre, red flesh red skin, 78% pulps.

#### **Cherukkurasam.**

Disease resistant, heavy bearer, fruit in clusters, good shelf life.

#### **Panakalla.**

Sucking variety, heavy yielder.

#### **Amarpaili .**

(Dashri x Neelum), dwarf, 600-800 trees per acre, yellow skin, 200g. yield 22 tons per acre in 11<sup>th</sup> year.

#### **Niranian.**

Off Season, Flowers in June, harvest in October, Yellow, 163 gram ,67% pulp, Brix 18<sup>0</sup> ,acid 0.8%.

### **Gujarat Fruit Research Station Paria.**

Neelphonso (Neelum x Alphonso)

Neeleswari (Neelum x Desheri)

Neelshan (Neelum x Baneshan)

### **Sindhu Mango of Maharashtra India.**

This is new Indian hybrid, (Ratna x Alphonso), Brix 19-21<sup>0</sup>. Red skin colour Ratna itself is hybrid of Neelum x Alphonso.

It was developed in Maharashtra at Regional Fruit Research Station, Vengurla, Maharashtra and is named as seedless Sindhu after the name of local district.

The Characteristic of this outstanding variety are:

- Pulp. 90%
- Weight. 215 grams.
- Pulp to stone ratio. 26:1. It is called seedless mango.
- Stone thin, small. 6.7 grams.
- Skin colour, Deep orange (82%) with red blush
- Fibre. Fibreless.
- Pulp Colour. Orange
- Ascorbic acid. 52,22 mg/100g.
- B-crotene. 11850 mg/100g.
- Cotyledone free stone. 3.1%
- Except for the size, it appears to be excellent.

### **Cardozo Mankurd Mangoes of Goa (India)**

It is descendent of popular variety Majurd, but superior to it in following respects:

- Regular instead of alternating.
- Heavy yielder instead of medium yielder.
- Growing season early.
- Fruit weight 320g, against 270 grams.
- Brix. 22<sup>0</sup>- 25<sup>0</sup>
- Flesh. 78.79%

### **Aim of Breeding In India In terms of Yield.**

Yield 10-14 tons per acre. This is less than our projected possible target of 25 tons per acre a target of 10-16 tons per acre is possible and is less than 50% of potential of some cultivar.

### **High density plantation in India.**

Amarpali at 10 x 8.3 feet (3.0 X 2.5 meters) and 533 trees per acre gave 4.5 tons per acre in year seven eleven tons per acre in year nine and 22 tons in year 11. It was 14 times yield of old plantations at 28 trees (12x12m) acre. It was developed in early 1980s.

High Density planting expansion in very slow in India as most of growers stick to old method of interactivation in between wide spaced trees

### South African hybrids.

South Africa has developed seven new hybrids.

**Table-giving the performance of seven new hybrids of South Africa.**

SELECTION	WEIGHT	SEASON	TASTE
Heidi	375	Late	Excellent
Joa	350	Early mid	Very good
Neldica	375	Early/Mid	Acceptable.
Chene.	375	Early.	Very good.
E10-13-14	450	Early	Very good
E10-4/11	400	Mid-Late	Good.
E-4/12	450	Very Early	Good.

### Australia

Australia has developed an outstanding variety R2H2 (Kent (mother) x Kensington.). Australia has developed other varieties namely:

- Celboration (Northora Territory.)
- Kenesignton Red (Queensland)
- Honey gold (Queensland.)
- Poarl (Queensland)
- B 74 (Queensland)
- These five are under pattend rights.

### Future breeding research lines.

- There is fast progress in breeding of new varieties and it is not easy to predict or project but following are lines on which breeders are expected to work.
- New varieties of better quality, acceptable weight, long shelf life. Shipping quality, attractive colour.
- Cultivars covering long harvest season.
- Dwarfing root stocks.
- Root stock resistance to adverse conditions.
- Flowering physiology and ease of manipulation.
- Pest control (fruit fly and other insect resistance)
- Disease resistance (powdery mildew, bacterial black spot, stem end rot, anthracose).
- Physiological problems (malformation, internal fruit break down and softnose.)
- Long post harvest life.
- Ability of cultivars which can be transported by sea to Europe, without elaborate methods of post harvest treatment like modified atmosphere etc.

## CHAPTER NO - 8

### HOW EXTEND MANGO SEASON FROM 1<sup>ST</sup> MAY TO 15<sup>TH</sup> SEPTEMBER IN SHORTEST POSSIBLE TIME:

#### **Expansion of Sindhri variety and consequence.**

Sindhri mango proved to be most successful in Sindh since fifties of the last century and the Queen Elizabeth was presented with it, on her official Coronation in 1953. When mango cultivation was promoted in mid-sixties every body started growing Sindhri, due to high price and good eating quality. Season of harvest of Sindhri, is 20 May to 20 June. It becomes rare after about 15<sup>th</sup> June and after 5 tone develops jelly seed almost in every fruit which mars its quality. During these 30 days, there is total glut of this variety in the market and prices dwindle and become so low that growers can not cover cost of their annual inputs on fertilizers, pests and disease control, labour for maintenance, irrigation, harvest, packing and transporting, market commission and government taxes like water charges and income tax etc.

In recent years grower has cut down inputs like fertilizers and plant protection to make both ends meet, but this in turn has affected health of trees and yield. The vicious cycle is dwindling the industry. Many years ago, we understood the shape and fate of industry and over the past thirty five years have tried different mangoes varieties kept their yield and market price records, per tree, tree size and thereby the maximum number of trees per acre and projected final income, per acre for each variety. Such data has never been collected and analyzed and therefore, grower has never been properly educated, guided and be saved from ruin.

The top class mango varieties of the present Pakistan came either from northern India (Uttar Pradesh and Bihar) or from South-India. The two are distinct in the way, that in the first case it is winter chill that induces flowering and in the second case it is drought, which causes similar stress as winter chill does. There is however one distinction, the south Indian varieties are regular bearers and early (April to June) and north Indian varieties are late (July-August) and many alternate because after harvest the latter have no time to put on new vegetative flush for flowering next years. These two factors were never reviewed for recommendations to farmers. These varieties had originated from chance seedlings on the farms of jagirdars, for whom it was prestigious not to allow multiplication. No scientific investigations had backed this selection other than taste

The Punjab cannot grow South-India low chill varieties, which will have their flowers killed in late winter, but Sindh could grow both varieties. However South-Indian late season varieties (Baganpali and Swarnarika) become alternating in Sindh and early varieties (Sindhri and Bombay Green) becomes

poor bearer to earliness. All early varieties are so. Langra is the only variety that is consistently regular and heavy bearer. Its yield per tree can be three four times per acre than of Sindhri and Chausa, Langra has no export potential due to green skin and turpentine smell.

The selection of varieties in India was based on their taste rather than on yield and economy. This factor alone eliminates the top class mangoes as economically viable. Comparing two crates of 15 kgs per tree for Anwar Ratol, eight to ten crates for Chausa in alternative years, and thirty crates for Langra every year, in spite of prices per crate, economics are clear, but the farmer was neither informed or any data were available, to inform him of these aspects at all. Having thus brought ruin to the grower, by wrong recommendations based on hearsay and no data, it is essential to lay down some guidelines for the grower. Over the past 35 years, we have tried many varieties of mangoes some of them from our own selection programme of seedlings and some imported from abroad and have finally selected those, which have the following general characteristics:

- a) Dwarf trees giving 100-200 trees per acre.
- b) Early first bearing (year 3 to 4)
- c) Early occupation of allotted area by trees (year 6 to 8)
- d) Early maturity of orchard to full production (year 10)
- e) Early break-even period (year 7)
- f) Pay back period (year 10)
- g) Resistance to mildew, anthracnose, stem end rot, bacterial black spot, jelly seed, internal softening and internal rots at least in 4 out of above 7.
- h) Market acceptability, i.e., size 300-750 grams, yellow skin but preferably with red blush colour, lack of turpentine smell, sugar content around 15%, long keeping quality, softening period not less than one week, resistance to packing and transportation stress etc and internal rots.
- i) High market prices.

We have selected some mango varieties which will meet above criteria and shall be harvested from 1 May to 15 September, each at 15 days interval, so that some 10 varieties covers the entire period, though it can be 20 varieties. Each grower has his choice to make. It is possible to top work the existing mango varieties. Top worked trees produce fruit in 2-3 years. The growers can make a programme to top work the whole orchard in six years. Many growers will not top work, so Sindhuri glut will take years, to come to an end, but diversification to new varieties will give growers better returns. New varieties being introduced are all dwarfs. This means growers has to plant one or two additional trees, in between the existing ones, the very year, he decides to top work.

In our top working programme, mango varieties and priority wise removal of varieties is as under. Anwar Ratol (poor bearer) Sufeda (Poor quality fruit) all

types of Stiolis (mostly alternating). Fajri (shy bearer) collector (poor quality), and finally Sindhri and Chausa .To top work tree, one branch having 20% of leaves of the whole tree is allowed to stand, so that it supplies energy to roots and new grafts. Experience shows that this branch gives 40% fruit of the whole tree next year. Growers can maintain it for one or two years to compensate themselves, but the branch left becomes the central leader and does allow good growth to new branches and grafts. We found it useful to remove it, soon after new grafts turn green.

There is a separate chapter on top working and rejuvenation of mango and which gives more details of this technology.



## CHAPTER NO - 9

### PROPAGATION.

#### **Source of Seed.**

Best sources of seed are, Turpentine, Common Sabre and 13/1 as the plants grafted on them are uniform in size and performance. 13/1 has tolerance to a saline soils and saline ground water is commonly used in Israel, where desert soils are saline Multiple poly-embryonic seedling have to be carefully separated, as soon as they have sprouted so that they do not lose cotyledons. Plastic bag with a few drops of water improves chances of graft being successful.

#### **Seed Planting**

Selected stones from a very healthy mother if above root stocks are not available should be field planted in July and August and budding of grafting done to 7-8 month later, provided that only seedlings which have achieved their stem size to thickness of pencil or 6mm. The rest of plants may be considered sick and should be eliminated. Nursery men of Pakistan usually graft these rejectable plants in July-August, when about one year old. The healthy plants produced in February-March in the above manner can be transplanted in the field of July-August, when the mother plants are about one year old and have been grafted 3-5 months earlier.

The sick stock may even not be transplantable in February-March of the following year (When about twenty months old) and many times are used by nursery men and transplanted in July-September, when root stock is 24-26 months old. This is an un-healthy and unhygienic practice and may be done away with.

#### **Nursery bed spacing.**

The beds are 40 inches (one meter) apart and seeds are planted at 16 inches (41cms) within rows allowing 10,000 plants per acre. After germination seeds should preferable be planted in bags 6 to 8 inches (15-20 cms) deep and about 5 inches (12.5 cms) diameter.

#### **Seedlings versus grafted trees**

Seedlings require 6-10 years for first fruiting against 3-4 years for grafted plants to fruit. They will not be true to the parent and invariably will be a poor in eating quality and will fetch low prices. Trees will be tall, un-manageable and prone to malformation and other diseases. Grafting produces uniform fruit type. Polyembryonic varieties, produce true to the type in 93 percent cases, but they fruit later by 2-3 years against grafts on them.

### **Endocarp removal of seed**

A new method of propagation is to remove endocarp of stone to hasten germination and grafting is done while plant still is in red or brown stage and then is placed in polythene tubes or bags. Success is 71-96%

### **Optimum Conditions for seed germination**

Seeds lose viability within 4-5 weeks and must be planted within a week of their extraction. Seed should be fresh and not dry at time of planting. De-husked seed is better than husked and is planted with concave side up. Un-de-husked seed germinates within 3-6 weeks, with only 10-30 success and de-husked seed in less than 20 days with 100% germination. Extracted de-husked seed is dried in shade for 1-2 days before planting. Removal seed coat can eliminate many diseases. Its embryo can also be examined for diseases. For best results, the cleaned seed with husk may be given hot water treatment at 50°C for 20 minutes, husk removed and planted with convex side up at a surface level of ground. Hot water treatment kills fungi, bacteria, insects, and their eggs. Seed stored in polythene bags with charcoal showed 37% viability after 100 days, but only 17.5% without charcoal. This method is used for import of seeds from abroad, un-de-husked seed germination occurs between 15 to 50°C, but optimum temperature in 25-30°C. Temperatures below 15°C, can cause chilling injury to young seedlings. If below the seed bed there is concrete slab or iron sheet, it stops tap root growth and promotes fibrous roots development. This allows young seedlings to be lifted easily. Fresh dehusked mango stones give over 90% germination and produce tallest plants with largest number of leaves within first two months. They easily achieve a height of 21 cms before on set of winter. Poly-embryonic seed may give 1 to 12 seedlings of which the strongest is retained and the rest removed. Seedlings should not be grown under old mango trees, as there is danger of spread of diseases to the young plants. Many fungal and bacterial disease are present in soil and environment of old trees. In nursery, stone planted within one month of harvest give 85 percent germination.

After 40 days seed germination is reduced to 48% and after 70 days to 12% only. In Pakistan stones are collected from house holds and market cleaners, who dump them in piles in anaerobic conditions and when planted in lots of a few hundreds, germination is less than 5%. As seedlings grow they are attacked by small and large tip borers, leaf miners and thrips. In general, all insects of mature mango, are present in the Pakistan nursery. We are the only party using fresh, husked mango for nursery purposes, much to surprise of our own nursery men. Transplanting in nurseries of planter bags, may be done 4-8 weeks after germination, when young pink leaves turn green. Seed is best planted 3-5 cms deep in night soil, damp or old weathered saw dust. Composed saw dust mixed with sand in 1:1 ratio has give good success.

Farm yard manure in seed bed gives, vigor to the plant, but does not effect rate of germination. Poly-embryonic linres are generally mass sown and extra suckers removed at 2 to 8 leaf stage. Seedlings show better growth in small containers of

80 mm diameter and bags of say 6 inches diameter and 18 inches deep. Pot bound roots appear to regenerate a good root system following field plantation. Mono-embryonic seed has originated from fertilized egg and each seed will produce a different tree. Seed can also be, planted in 30mm (12 inches) saw dust and when it germinates, it could be transplanted in plastic bags.

### **Time for grafting.**

Root-stock when 18 to 20 inches (450-500mm) tall and 1 cm thickness at height of about 10" (250mm), is ready for grafting. Graft scion should be 50-90mm (2 to 3.5 inches) long. Newly grafted plants may be kept in 50% shade. Grafting under shade is 60-95% success. In open sun the success is less. Best months for successful grafting in Sindh are February-March, and July, August & September. Graft is prone to winter kill. We have tried grafting from February to mid October with 90% success by putting graft wood on northern side. In the coastal Sindh, grafting all year around is possible, under shade. For top working we graft year around by covering the grafted branch with No 200 plastic bag, which allows air to pass through the bag but stops moisture to get out and maintaining humidity at more than 90 percent.

### **Root-Stocks Characteristics at the Time of Grafting.**

Excellent results are achieved on 4-5 months old root stocks and only 20 cm high. Even 3 months old root stock gives 80% success against 88% of the 9 months old root stalk. Scion wood is to have same diameter as root stock. Most common root stocks are 7-9 months old and 50-60 cms (20-24 inches) tall. Directly field planted stone-stocks are suitable after about 12 months against those planted in saw dust, composted saw dust, compost, and soil mixtures in polythene bags, which may be ready for grafting after 6 months. Seedlings of mono-embryonic mangoes vary considerably in their vigour, disease resistance and fruiting characteristics. Seedlings of Turpentine a polyembryonic is used in Florida as root stalk because of its sturdiness and bearing good crops. Common root stock is used in Caribbean and 13/1 in Israel. Sabre is used in South Africa.. Trials may show which of the grafted mono-embryonic varieties give good results on these three root stocks.

### **Root Stock and Scion Growth Stage.**

Graft height should be 20-30 cm above ground level. Thickness of root stock should be, about that of a pencil or 6mm or ¼ inch. Bark of root stock should be green. There should be at least 5 leaves on root-stock below the point of grafting and these leaves should be retained till grafts is successfully established, as they ensure movement of nutrients to and from root to the graft.

### **Grafting methods to be used.**

Cleft or wedge grafting gives more union area and stronger tree, but is little difficult to perform. Cleft grafting produces ideal tree. Approach grafting is now out-dated for mango, but still used for some crops. Bark Grafting is better on established tree. It is also called Veneer bark grafting. If 3 or 4 side shoots are

needed to develop, cleft or whip and tongue graft can be used. Grafting can be done by whip, whip and tongue, wedge or side budding or patch if it needed. At least 12 months training to present nursery men is needed to pick up all these methods of grafting.

### **Dwarfing Root stocks.**

Dwarfing rootstock are not known with authenticity, but following have been reported. It has found that poly-embryonic seed produces smaller trees than mono embryonic. Totapuri, Red small, Neelum and Bangalore of South Asia are reported to produce dwarfing rootstock. Velleai-Kolamsan, Olour, Mylepatium Ambelavi also impart dwarfness to scion. Turpentine Common, and polyembryonic 13/11 are also have dwarfing effect. Common rootstock is used in the Western Hemisphere as seedlings are sturdy and trees have high yield. Sabre root stock is popular in South Africa and also in Israel. It is believed to have dwarfing effect on scion. The other stocks reported to impart dwarfness are Kishen Bhog (India) and Munkrathan (Thailand). In Pakistan they do not use dwarfing or any other standard rootstock.

### **Inter stocks**

They probably do not produce dwarf trees as it happens in citrus but the results in mango are inconsistent. Authentic data and dwarfing capacity of trees are lacking. It is not known if inter stocks impart some degree of precocity and dwarfness. Dwarfing by inter-stocks is worth investigation. Little is known of the effect of root stock or scion on each other, for selection or high yielding trees. Mono-embryonic seed if used should have its weak seedlings removed. Israel is using poly-embryonic cultivar 13-1 as root-stock and Maya as one of the varieties for calcareous soils, containing 20% lime. They are alright for calcareous soils, but dwarfing effect needs reconfirmation, as claims are scientifically unverified.

### **Polyembryonic Root Stocks.**

The following poly-embryonic root stock were used in some countries up to 1990. Goa, Bappakai and Pahutan (India), Golek and Arumani (Indonesia), Pico and Carabao (Phillippines), Carolee and Maison-rough (Re-Union), Sabre Israel and South Africa Common USA and No. 13/1 (Israel).

### **Rootstock Research in Australia.**

- i. Australian have tried 96 rootstocks specially Turpentine and Sabre. They give the following characteristics to the tree.
- ii. They increase marketable yield.
- iii. Tree efficiency (kg fruit per circumference of trunk increases.)
- iv. Fruit appearance improves.
- v. Flesh dry wet increases.
- vi. Dwarf tree size, reduced spacing and increased number of tree per acre.
- vii. Improved blush, fullness, overall attractiveness, visual quality of fruit.

This needs further investigation in other countries.

### **Scion Wood.**

Tip wood is best grafting material for mango most suitable tips are those which have prominent eyes or buds. If scion wood behind its tip is used, success rate is very low. Suitable length for scion wood is 10 cms (4 inches) Pre-condition for success of scion is that it should be sufficiently mature.

### **How to ship scion wood.**

Scion wood should be three months old, 8-10 cms long and sufficiently advanced for sprouting stage. It should be wrapped in moist absorbent paper and sealed in polyethylene bag. It can last transit for 6 days.

### **Some Important Facts for Successful Grafting.**

For preparing scion for grafting, the leaves of scion are clipped to half about two weeks before removing these shoots for grafting. The resulting scion has better chance of survival as tip will swell and new buds appear. In the same way if these scion shoots are ringed one week earlier, the results will still be better. For grafting 3-6 months old scion shoots give better results than older branches. Grafting in partial shade prevents grafts from over heating. If shoots of root-stock which is grafted, has its top portion cut off, after grafting, the joint is stronger and better. To prevent desiccation of scion, fresh graft is enclosed in a plastic bag containing two leaves of root stock. For successful graft at least five leaves are to be left below the point of joint on root stocks and these leaves are retained till graft is firmly established.

### **Modified methods of grafting**

Six weeks old seedlings, with roots in peat moss and wrapped in polythene, are tied to scion shoots and approach grafted, union is complete 4 weeks, when they are severed and potted up for another month. They are ready for transplanting 3 month after sowing seed. Success rate is 90-100 percent. The other method is that 3-4 month old seedlings are successfully budded 3-4 inches above ground level and after 21 days the polyethelene wrapping removed.

### **Size of scion and grafting success.**

Scion wood of 2.0 to 6 inches (51-162 mm) of Deshri shows the following percentage of success;

<b>Length mm</b>	<b>Percentage of Success</b>
- (51)	20
- (102)	80
- (152)	40

The local belief that grafts should be taken from young plants rather than old ones has not been examined. After grafting lopping or topping 5-10 cms above graft union leads to high percentage of success. If lopping is done 10 days after grafting, plants are ready to transplant after 90 days .Grafting at low height

produces spreading tree, while high up on the stock produces non-spreading tree.

### **Recommended Height for Veneer Grafting.**

Recommended height is 20-25 cms above the ground. Scions for grafting, if bought from out-side, should be placed in moist, (not wet) sphagnum moss or saw dust. In some parts of Pakistan graft wood is taken from a four years old tree, kept specifically for that purpose and finally it is bleed to death. No graft is taken from a productive plant.

### **Grafting methods.**

- i. The various grafting techniques commonly used are:
- ii. Veneer grafting or chip budding.
- iii. Side wedge or side grafting.
- iv. Side veneer grafting
- v. Side tongue grafting.
- vi. Side tongue and whip grafting.
- vii. Inarching.
- viii. Tip grafting is getting more common.
- ix. Splice grafting has been used successfully in top working of many species including citrus, mango and sapodilla (chiku).
- x. Graft joint on tree in the Northern-Hemisphere should preferably be to the north to over come drying effects of sunlight.

### **Grafting Of Young Plants with Young Shoots.**

These methods are neither known nor tried in Pakistan but they produce transplantable tree in a few months. In this method 5, 10 and 15 days old seedling root-stock are grafted with 1, 2 and 4 months old scion shoots. Five days old root-stock and one month old scion give the highest take when scion is 4 inches (102mm) long. Best results are obtained by grafting at 5 cms height followed by at 2 or 7 cms above root-stock collar. The other combinations i.e., 10 days and 15 days and one month old scions are also successful.

### **Grafting Under Fifty percent Shade.**

Maximum bud sprouts are found in 9 months old stock. Bud sprouting is increased by partial ringing of root stock 3 inch (76mm) above point of insertion of buds. 3-4 months old seedlings are successfully budded 3-4 inches (75-101mm) above ground level and after 21 days polythene wrapping is removed.

### **Budding of mango.**

For budding the best material is 8-9 months old plant, and 5-10 cms from the ground, without any leaves below the point of grafting or budding. Budding allows use of much younger root stock. Buds can be prepared in advance by removing leaves of terminal wood, which in turn destroys apical dominance and allows auxiliary buds to swell in 1-2 weeks.



### **Veneer Grafting.**

Veneer grafting on 3 months old stock gives about 80% success, while that on nine months old stock gives some what more, but earlier grafting gives trees, ready to be planted in about 6 months. Veneer grafts of mango dipped in IBA at 1,000 ppm gives better grafting joint and better size. About 5-6 inches (127-152mm) long shoots having 4-5 buds are used for grafting. T-grafting is best for bigger size trees. T-Grafting has proved better than veneer grafting as rate of growth is much faster. Planting bags or pots have to be 9 litre capacity or about 6 inches diameter and is inches (150 mm) deep. Pots should be placed in 50% shade and not over watered. Tapes should be removed in 6 weeks. Plants can be transplanted in another 6 weeks.

### **Top working.**

Top working of inferior mangoes can be done, to produce superior varieties or old trees can be restored to full production. In this case the tree branches are dehorned within a foot of main trunk of tree, in early spring and usually two or some times three shoots emerging are top worked and rest removed. Cleft, whip and side veneer grafting are preferred in top working of old inferior varieties. The various steps in top working are:

- (a) Trunk 1-8 inch (25 to 202mm) diameter can be veneer grafted 1 to 2 feet (300-600 mm) from ground.
- (b) If trunk is too large, grafting may be used on two or more of lower most branches at height of 1.0 to 1.5 meters (40 to 60 inches).
- (c) Branches having 6-8 inches (15-20 cms) diameter is just above main trunk are cut about meter or two from the crotch.
- (d) Cut surface may be painted with peraffin, water emulsion, Asphalt, or white latex paint. Trunk can be white washed with lime or plastic to keep it from and new grafts till they are fully developed and then these may be removed. It involves grafting; best time for top working is March to September in Sindh.
- (e) Extra precaution against sun burn is to put grass in crotches and allowed to decay there.
- (f) For top working most satisfactory method is grafting or budding on new growth. Top worked re-growth is much faster. Grafting at 20 inches (50cms) or three points 12 to 18 inches apart can give a good canopy in short time.
- (g) Vigorous new shoots may be pinched at 18" (45 cms) to form branches and after a year they be pruned to form vase shaped tree.
- (h) New growth is removed periodically. It will persist for two years.
- (i) Seedling mango trees when top worked, yield fruit after 2 years.
- (j) Feeder branches are removed as soon as new grafts have formed canopy.
- (k) Top worked graft can be covered with brown paper to protect it from sun burn till growth has taken place.



- (1) The branches are pinched at every 18" to produce two new shoots and these shoots are again pruned to produce third set of shoots until each branch has 32 shoots.

#### **Propagation of Cutting.**

IBA can help in establishment of mango from cutting 20-25 cm long, with 14 upper leaves, by dipping in IBA 2500 ppm solution, for half an hour. Success rate of 50-75% has been achieved. Dipping cuttings in IBA can be raise chances of rooting from 31-93%. Since this is a difficult and costly method, it is not used commercially any more.

#### **Weedicides Used In Mango Nursery.**

Indian experience shows that pre planting application of weedicides gave weed control for 30-40 days after germination and seed was not affected. The weedicides used were, Diuron, Terbacil, Sencor or Melribuzin, But a Chlore, Fluch larelin, Oxy Fluurfan, Granoxane, Fernoxone (Dich) or prop) and Illoxin (dielofop-methyl.)Next chapter on mango nursery management will give new tips for establishment of healthy nursery. There is another chapter Rejuvenation of old mango orchards which elaborates further information on top working.

## CHAPTER - 10

### FIELD MANGO SPACING.

Narrow tree spacing and high density plantation is a secret of high yield per unit area, evolved in the past forty years. Commercial mango orchards in Pakistan yield an average at 3000 kgs fruit per acre at maturity i.e., at an age of 15-20 years. American, Australian, South African, Israeli and Mexican commercial mango orchards produce about 6000 kgs of fruit per acre in the sixth year and 10,000 to 15,000 kgs at maturity. Our spacing is too wide and therefore low density and low yield. Genetically our trees are also not high yielding. Selection has been made on taste rather than yield. Tree size and tree members per unit area of mango growing needs revolutionary changes.

Our mango varieties produce first crop in the fifth to 7<sup>th</sup> Year, depending cultural practices and weed control. Floridian mangoes produce the first crop usually in the 3<sup>rd</sup> year and heavy crop in the 5<sup>th</sup> year. At maturity their yield is two to three times that of fifth year. Mangoes in high density are planted at 100 to 200 trees per acre. Usually plants crowd after 10 year, when they are pruned back heavily to the size, they had attained in the fifth year. There is no fruit in the 11<sup>th</sup> year but 12-16 year crop is heavy. Again in the 16 year after harvest, heavy pruning is resorted to. This is just one of the methods; annual pruning is another advancement to produce a dwarf compact tree.

Our wide space recommendation combined with low yielding varieties produce un-economic crops even in the 10 years. At our plant spacing of 35x35 feet (10.66 x 10.66m), we have 35 trees per acre and trees do not meet in 10 years. By planting another tree at the center of 35x35 feet square, the number of tree has been increased to 70 trees per acre. The diagonal distance in the square is 24.7 feet and yet some trees do not meet until in year 25 i.e., when original trees were 25 years old and new trees 15 years old. If we use early American spacing of 25x25 feet in hexagonal pattern, we will have 80 plants per acre. The rows will be 43 feet apart with center row at 21.5 feet. This is better than our 35x35 feet with one tree in the center of square. Spacing is to be determined by the size of tree at maturity and pruning programme. Neelum can be planted at 15x15 feet (4.5x4.5m) i.e. 194 plants per acre. Amarpali can be planted at 2.5x2.5 meters (8.33x8.33 feet) i.e. 640 plants acre.

Tables below gives spacing under various systems in some developed countries:

#### Spacing Per Acre in Florida.

Variety	Spacing in metres	Trees per acre.
Keitt	6 x 33 m	216
Keitt	5 x 3 m	264

Palmer	5 x 3 m	264
Kent	5 x 3 m	264
Tommy Aitkin	5 x 4 m	200
Maya	6 x 6 m	108
Haden	6 x 6 m	108

### Yield Per Acre Under Above Spacing.

Keitt.	8 to 11 tons
Tommy.	5 to 7 tons
Maya	4 to 7 tons.
Kent.	4 to 10 tons
Haden.	2 to 9 tons

**Table showing trend toward high density planting in some developed countries during past 57 years**

Recommendation	Year	Spacing		Tree per acre	Remarks
		Meters	Feet		
Florida	1960	7.6	25x25 Square	70	
Florida	1970		25x25 Hexagonal	80	
Florida		6x6	20x20	108	For early yield
		10x6	32.8x20	72	Hedgerow.
		8x5	26.6x16.4	100	Hedgerow.
Australia for Kensington	1980	7x7	23.66x23. 66	80	Vigorous tree.
Australia for Kent and Irwin	1980	5.66x5.6 6	19x19	120	Less Vigorous trees.
Robert Knight (Florida)	1980	3x3	10x10	430	
Robert Knight (Florida)	1995	5x5	16.6 x 16.6	160	If tree is not more than 6 meters (20 feet) tall
Robert Knight (Florida)	1995		13.5 x 20		
Robert Knight (Florida)	1995			166	
Robert Knight (Florida)		8x4	26.6 x 13.3	133	Hedgerow with pruning.
South Asia	1980	12x12	40x40	27	
	1990	9x9	30x30	48	
South Africa	After 1990	8x8	27x27	60	

South Africa	After 1990	10x5	33x16.5	97	
South Africa and Australia	1990	4.5x4.5	15x15	188	Central tree is to be removed when plants touch.
Kuunurra (W. Australian)	1985	3x2	10x66.5	666	For Tatura Trellis under trials
Chapman KR Recommendation for Sindh	1995	5x5	17x17	160	Four dwarf varieties to
Chapman KR Recommendations for Sindh	1995	8x4	26.6x13.3	132	be thinned to 66 in 10 years.

### High Density Plantation of mango in India.

Amarpali at 640 plants per acre produced 4.5 tons in year 4 and 8.8 tons in year 9 against 3.5 tons per acre as national average for mature trees, in India. Malika is dwarf like Desheri and is planted at 20x20 feet (6x6 meters) and 100 plant per acre.

### High density and yields.

High density gives 10 times more yield than conventional densities in the first 10 years.

### Mango Spacing Trials.

While re-allocating mango spacing, the present authors have tried 15x15 feet (4.5 x 4.5 meters) spacing with Neelum Trees. They did not meet in 10 years. Spacing of 20x20 feet was tried for Semi-vigorous varieties. They did not meet in 11 years. A New spacing of 20x10 feet is being tried to produce 218 plants per acre. Narrow spacing have given early crops with reasonably high yields. To keep tree dwarf 25% fruiting branches. After harvest will branches are cut back by 8 inches (200 mm) after harvest and 1/4th of all branches are cut down about one foot from the trunk. Tree remains dwarf and yield remains the same. Other branches are cut back by 8 inches, the expected growth rate after the harvest. The observation on high density planting with selective pruning shows that with 20x20 feet (6x6 meters) spacing, total yield in first 10-12 years was at least trees times that at 40 x 40 feet. The purpose of high density planting is to fill total space in orchard under tree canopy as early as possible. In high density planting trees should have small space between them or they should only touch each other, branches should not intrude in other trees but not. Shaded area should be about 75-80%.

### Mango Spacing:

Variety	Row Spacing Meters	Trees Spacing in meters.	No. of Trees per acre
Kensington	9-10	6-9	44-74

R2E2	7-9	4-6	74-145
Keitt	6-8	3-6	83-218
Palmer	7-9	4-6	74-145
Kent	7-10	4-8	50-145
Nom Doc Nai.	9	4-8	70-111

## CHAPTER - 11

### FIELD PLANTING OF MANGO SEEDLINGS OR GRAFTED PLANT

#### **Establishment and Management of mango orchards.**

Conventional method of planting is to dig pit about 2x2x2 feet (61x61x61cm) deep for plants and fill them with farm yard manure and earth from hole ratio of 25 to 75 or more. If farm yard manure is not well rotted it causes plant damage and even a death. There are better methods not commonly known and are discussed here. If deep rippers are available for breaking hard soil pan, they may be used to rip soil to a depth of 42 inches or about out 107cm. It is preferable to pre-irrigate the plot, so that roots of nursery plants do not dry up. If planting hole is dry, the plants get set-back, which they recovers only after several months.

Trees showing young immature leaves, usually are not transplanted until leaves become mature. If plants show mature leaves and evidence of well swollen buds, they may be transplanted at any time. Newly transplanted plants should be watered at least twice a week in warm season, though irrigation every second day for first month followed by every third day for another month until plant put on new growth, is guarantee of its success.

#### **Transplanting Mango Trees**

Old method of transplanting was making basins 1.2x 1.2m or 4 x 4 feet, for planting mango but under new method it can be planted on a ridge 1.5 meters wide and 25-30 cms high. Ridges have to run north to south and are about 6 meters (20 feet) wide running parallel of each other from east to west. Phosphate about 2-3 kgs, could be added to the soil, in each mango pit. It then will not need only phosphate for many years.

#### **Economic Crop of Mango.**

Mango produces some crop in 3 to 4 years after planting but is not economical to harvest South Asian or South East Asian varieties with densities of 25-50 tree per acre in a great need to change to varieties which are dwarf, accept high density planting and are better and early producers, but it needs strong technical support for many decades to switch over to new varieties.

#### **Staking**

After planting tree it is staked at 45<sup>0</sup>C with 40 inches long and 1 inch diameter stakes. It will ensure vertical growing of tree. This is possible in rain fed areas but in irrigated areas planting single stake of Jantor or Dhaincha (*Sesbania Dispinosa* and *S. Sebari*) can serve this purpose for even 3-4 years. One has to ensure that leaves of these two plants are cut down with regularity to remove any shade above mango plant.

**Raising Mangoes in Pots.**

Concrete pipe 3.66 feet diameter and 4.66 feet high are used for experimental as well as for portable plants at Homestead (Florida).

**Young Mango plant Care.**

Young mango plant would need good care till it fruits. The care would involve regular irrigation protection from adverse climate i.e. frost and high summer temperature over 40<sup>0</sup> C (104<sup>0</sup> F) and winds, fertilizing weed control, by chemicals or IPM, flower forcing and fruiting tree architecture management etc and conversion from juvenile to productive stage.



## CHAPTER - 12

### MACRONUTRIENTS IN MANGO PRODUCTION

#### General.

Nutrients are needed for tree growth, flowering and fruiting. For centuries it had been a guess work. Technologies developed in later half of twentieth century have changed old concepts and practices. The management approach is to monitor nutrients, by prevalent soil and leaf analysis and regular soil analysis of bearing trees.

#### Nutrient Removal by Mango Crop Per Hectare or Acre

A yield of 16 tons of mango per hectare per year, removes approximately the year following quantities of nutrients from field as give in Table below. The quantities can be adjusted according to yield. They will vary from farm to farm and area to area according to soil and climate.

**Table showing nutrients demand from the tree for yield of 16 tons of mango fruit per hectare or 6.4 tons per acre.**

Nutrient	Quantity removed per hectare with 16 tons yield in kgs and grams	Quantity removed per acre with 6.4 tons yield in kgs and grams.
- Nitrogen	105 kgs	42 kgs
- Phosphorus (P <sub>2</sub> O <sub>5</sub> )	12.5 kgs	5 kgs
- Potash (K <sub>2</sub> O)	100 kgs	40 kgs
- Calcium (ca)	90 kgs	36 kgs
- Magnesium (Mg)	45 kgs	18 kgs
- Iron (fe)	1000 g	400 g
- Manganese (Mn)	875 g	350 g
- Boron (B)	175 g	70 g
- Zinc (Zn)	175 g	150 g
- Copper.	375 g	150 g
- Molybednum	10 g	4 g

Of these elements nitrogen, phosphorus, potash, calcium and magnesium are called macronutrients and the rest are micronutrients. All these have to be incorporated in soil, but some of them like iron, copper, manganese get fixed to our high pH soils and became unavailable to the plant Solution is simple, as they can be supplied as foliar feed for quick results within days or weeks. For high yields, the various ingredients should be well balanced and be applied after

annual soil and leaf tissue analysis of all these ingredients. Excess of any ingredient even nitrogen, phosphorous and potash does not increase the yield. Unless all ingredients shown in table are available to the plant in proper proportions, shortage of any one of above ten ingredients will reduce over all yield, to its own availability. Since some of micronutrients get fixed to high pH soils of Sindh, application of micronutrients foliarly over two years automatically increases yield by 20 to 30% in the third year. In Pakistan only a few well organized and highly educated growers use micronutrients at all. The other do not use or balance even the first three and result it is low and uneconomic yields.

### Leaf analysis

A new tool in fertilization is leaf analysis. It indicates availability of various ingredients during the time of leaf sampling and is considered a guideline for fertilizing, though type of soil and availability of moisture determine, whether plant would uptake the various ingredients.

**Table-II showing optimum leaf levels of nutrients for mango.**

Element	Percentage or Parts per million Parts
- Nitrogen.	1.0 to 1.8%
- Phosphorus	0.09 to 0.15%
- Potassium	0.8 to 1.5 %
- Calcium	1.5 to 3.0%
- Magnesium	0.25 to 0.80%
- Zinc	20 to 150 ppm.
- Copper	10 to 20 ppm.
- Boron.	30 to 100 ppm
- Manganese	60 to 500 ppm.
- Iron	50 to 100 ppm.

Demand for nutrient is most intense during the first 20-50 days of growth of fruit i.e. 20 March to 10 May in Sindh. The demand starts 20 days after fruit set, but continues for next 50 days, when it drops gradually at end May in Sindhri. The demand for late varieties droplate and about 1 week before peak of harvest.

### Mango tree nutrients.

Application of fertilizers should be closely linked with phonological cycle. Application of nitrogen during early fruit development period will increase production. Application of nitrogen just prior to harvest will also benefit, as it replenishes carbohydrates consumed in fruit growth and becomes readily available to the leaves for post-harvest vegetative growth. Another application of one third dose of nitrogen after period of vegetative growth is to promote flowering, by increasing easily assimilated reserves in addition to induction potentiating effect of nitrogen itself. In general for Hyderabad Sindh area timing is March, June for early and August for late varieties and December in three equal doses of nitrogen.

In Sindh hitherto tree nutrition recommendations have been based guess work, rather than on any scientific investigations. Usually farm yard manure (FYM) is recommended and application rate varies from nil to 200 kgs per tree. The chemical composition of FYM depends upon type of animals and their daily feed, and varies from place to place and day after day. Recommendations also include 5-100 kgs of urea, in addition to farm yard manure per acre per year. This also has no scientific basis. These recommendations are like folk medicines, prescriptions of which contain many herbal ingredients in different proportions, not known even to the original prescribers of them, but the proud folk doctor has good excuse of boasting about it. In the whole South-Asia, farmers over fertilize and make show of their affordability. They know little of the adverse effects of over fertilizing on the yield. It has been proved that excess fertilization can produce excess fibre in mango fruit and excess nitrogen is responsible for pulp disorders like jelly seed, internal breakdown and possibly soft nose.

### **Farm Yard Manure (FYM)**

The ancients in South-Asia knew the value of farm yard manure as fertilizer and in addition to cattle by-products, animal excrete was also considered excellent for many human ills. It was never wasted and every bit of it was utilized including the ash. In recent years demand for it has sky-rocketed. The prices in terms of actual ingredients in it are much higher than fertilizers, micronutrients and foliar feed. Labour involved in its application and distribution makes it totally uneconomical. The organic matter in it, helps plants to uptake micro-nutrients from it, as well as the soil and has some amount of control over nematodes too. Farmers do not know that composted FYM can enhance its effectiveness four times and ingredients in it will be readily available to plant. By piling FYM in heaps exposed to Sun and rain a substantial percentage of nitrogen volatilizes and nitrogen along with other ingredients leaches down. Farmers have also not learnt to store it in shed. Animals browse on wild growth around villages in Sindh. FYM contains seed of these wild plants, which germinate on application to crops and weeds compete for nutrients and moisture. There are enough weedy grasses growing between trees in irrigated agriculture in Sindh. These could be cut down and spread under trees by cheap labour and this would be much better and cheaper substitute than FYM. They will also help in control of weeds and nematodes.

### **Recommendation for farm yard manure application in Sindh**

The present recommendation of Agriculture Extension in Sindh is as under:

Mature tree may be given 100 kgs of FYM and young ones from 10-40 kgs each year. With 100 kgs of FYM, ½ kg of actual nitrogen may be applied in December – January period, before flowering, in addition. About 3 kgs fish manure containing ½ kg of N<sub>2</sub> and be applied in March. One Kg N<sub>2</sub> in form of fish manure be applied in August. The whole programme is unscientific and very costly. Nitrogen, phosphates and potash contents of various organic manure in

percentage of dry weight basis as found in developed countries, where animals get rich and balanced feed are given in table below:

**Table-III Showing NPK (Nitrogen, Phosphorus and Potash) content of various organic material in developed countries.**

Organic Manure	N(Nitrogen)	P(Phosphorous)	K (Potassium)
Cattle manure.	0.5	0.21	0.16
Poultry Droppings	1.0	0.	0.4
Sewerage waste solids	0.9	1.1	--
Fish Meal.	7.0	15.0	--
Slaughter house blood	6.0	--	--

In Sindh cattle manure is the only organic matter used in mango orchards. FYM is collected daily dumped under sky and pile is allowed to grow till orchard owners buy it. In this process some manure remain fresh one at the bottom of pile is digested anaerobically. The ingredients NPK are not uniformly distributed and large quantities of nitrogen volatilize as ammonia.

#### **Fertilizer recommendation by the Agriculture Extension Punjab**

Their recommendations look simple and are 45 kgs FYM + 4.5 kgs bone meal + 7 kgs ash per tree per year. Bearing tree in addition to above may be given, 1.3 kgs N<sub>2</sub>, 0.75 kgs P<sub>2</sub>O<sub>5</sub> and 0.75 kgs K<sub>2</sub>O (Note: it has been found that ash increases pH level for a few weeks and this may cause fixation of phosphorus, iron, copper, zinc, manganese and boron to the soil.) FYM is to be applied 1-2 month before flowering. It would be November-December for Sindh. The recommendations for the state that 50% of annual N<sub>2</sub> dose to be applied before flowering i.e., at the beginning of January (for Sindh) along with full dose of K<sub>2</sub>O and P<sub>2</sub>O<sub>5</sub>. Balance 50% N<sub>2</sub> in mid March after fruit attains pea size. N<sub>2</sub> may preferably be applied after fruit harvest. In these recommendation the ratio of nitrogen: phosphates: potash is not properly balanced and is either too excessive or too small.

#### **Punjab recommendations for young mangoes during first 5 years.**

**Table-IV. Showing Punjab recommendations for young trees in first 5 years.**

Year Life	Farm Yard Manure	Ammonium Nitrate (NH <sub>4</sub> NO <sub>3</sub> ) in grams
1 <sup>st</sup>	20 kgs in pit.	-
2 <sup>nd</sup>	10 kgs	0.5 kgs
3 <sup>rd</sup>	15 kgs	0.75 kg or 100-125 g every month from April to September. Like mature tree
4 <sup>th</sup>	20 kgs	1.0 kg
5 <sup>th</sup>	25 kgs	1.33kgs. kgs.

Note: Area to which fertilizers are to be applied is the whole area within whole circumference of tree and in addition one foot (308 mm) strip around the

periphery out side the tree, FYM also applied in November-December .Chemical fertilizers are applied 15 days before flowering. The Punjab also recommends green manuring after harvest in fall. As before said the recommendation is unscientific and guess work.

### **NPK doses in different countries of the world.**

Fertilizer doses are not uniform through out the World and below are some of them.

#### **Florida (USA)**

1.25 to 1.5 kgs N<sub>2</sub> per tree

1.25 to 1.5 K per tree

#### **French Antilles.**

60g N, 75g P, 90g K per tree, per year per year age, until age of 12.

720g N , 900g P and 1100 g K for tree after age of 12 years.

#### **Venezuela**

Venezuela experiments showed that applying following doses of fertilizer increased yield by 30% on alluvial soils.

N<sub>2</sub> 32 kgs per acre ,per year.

P<sub>2</sub>O<sub>5</sub> 12 kgs per acre ,per year.

K<sub>2</sub>O 12 kgs per acre, per year.

These experiments also showed that production of 6000 kgs fruit per acre, removed about 40 kgs N<sub>2</sub>; 5 kgs P; 40 kgs K<sub>2</sub>O; 36 kgs Ca; 15 kgs Mg; 350 grams Mn; 70 grams B; 150 grams Zn; 200 grams Cu and 400 grams Fe, from the soil. This shows that application rates should be about 2.5 times the ingredients removed. Best results in Venezuela were obtained by 50% NPK before flowering and 50%after harvest. Fertilizer applied is young trees at 15 days interval was found better than if applied after 1,2,3 6 or 12 months intervals. For mature tree dividing the dose in 3 or 4 applications was found better than single dose. Application of phosphates and potash in one dose in December was found better, as observed by roots which were in active growth at this time of year.

#### **India**

Indian Council of agriculture research recommendation

N. 730g per tree, per year.

P 185g per tree, per year.

K 680g per tree, per year.

#### **Israel.**

Young trees are fertilized (fertigated) with every irrigation at same ratio as for adults i.e. 12:12:8 as N:P:K. They apply zinc sulphate at 1% once or twice a year and also (KNO<sub>3</sub>) at same rate. Iron sulphate in Ferrous form is applied at 0.4% four times annually, along with surfacant titron 100 at 0.025%.The total N<sub>2</sub> applied annually per acre is about 100 kg and other proportionately.

### U.S.A Recommendations

N<sub>2</sub> above 90kgs/ per acre will reduce fruit quality, cause excessive vegetative growth, increase internal break down in mango. Source of micro-nutrients used are sulphates of Cu, Zn, Mn and Fe.

### French West Indies.

In French West Indies 0.5 kg of N to 12 year old tree and N:P:K Mg, 12:15:18:5 at 6 kgs per tree year is applied. This makes N:P:K Mg as 720, 900, 100, 300 grams per tree respectively.

The above simply shows that rates fertilizing in different countries are not the same and depend on local experience and environment. We think that Nitrogen at 100kgs, Potash at 140 kgs and Phosphours at 25 kgs should give best results of 8-10 tons per acre.

### Various Ingredients Inorganic Fertilizers.

Fertilizer.	Percentage of Main ingredient.
• Urea.	46% N
• Ammonium Sulphate.	21% N
• Ammonium Nitrate.	35% N (In Sindh ammonium nitrate has 26% Nitrogen)
• Triple super Phosphate.	45% P <sub>2</sub> O <sub>5</sub>
• Single super Phosphate.	21% P <sub>2</sub> O <sub>5</sub>
• Double Super phosphate	
• Triple Super Phosphate.	
• Potassium Sulphate. (KSO <sub>4</sub> )	48% K <sub>2</sub> O
• Murate of Potash (KCl)	60% K <sub>2</sub> O

Note: P<sub>2</sub>O<sub>5</sub> multiplied by 0.436 gives P (Phosphors) and K<sub>2</sub>O multiplied by 0.83 gives K (Potash)

### Role of Nutrition in Mango.

Mango trees respond to nitrogen fertilization by increased rate of growth and specially growth of leaves will be better, tree will be healthy and will produce better inflorescence, provided nitrogen is not excessive. A young tree must get 500 grams N<sub>2</sub> for 25 kgs fruit production. Mature tree should get 100-150 grams for every additional 25 kgs of mango production. Urea quickly breaks in to ammonia gas and should only be used if immediately after application. it is ploughed in to soils, as it is acidic and will improve soils pH. The same will not happen with ammonium nitrate as it neutral, but ammonia and urea kill earth worms, Nitrogen is observed in the form of ammonia as the maximum rate. Guano, manure and sludge are not justified on deep soils, but only on light soils. Nitrogen can improve colour of coloured mangoes and even turn green mangoes to dark green colour.

### Phosphorus.

Phosphorus is essential for fruit set and vegetative growth. High level of it will increase fruit set. It increases storage life and is needed in small quantities. It can even be eliminated for several years in areas, where it has been applied year after year.

### **Potassium K**

It is essential for healthy tree growth and fruit size. It also helps in increasing yield.

### **Potassium Chloride versus Potassium Sulfate.**

Murate of potash or Potash chloride costs about 75%, as much as potassium sulfate ( $K_2SO_4$ ), but should be avoided in alkaline soils of Sindh. It could however be used as spray. Potassium is needed as it leaches down. It can increase yields on alkaline soils by 25%, but its heavy applications can build up salt damage.  $K_2O$  also lowers intake of calcium and magnesium. Both phosphate and potash do not increase yield unless nitrogen is also applied.

### **Adverse effects of fertilizers.**

#### **Softnose.**

It is caused by excess nitrogen applied after April (March Hyderabad Sindh) area, but it is also hereditary, as in Chausa.

#### **Die back or Burning of leaf tips.**

Die back or burn of leaves at tips and along margins is caused by over fertilization or salt toxicity, or soil contamination can cause it, irrigation doses can leach down contamination including of fertilizers.

Excess fertilizers can cause excess vegetative growth, lower yields and produce poor quality fruit with poor colour.

### **Seasonal uptake of various macronutrients by mango.**

Phosphate level is highest in February and March in all parts of tree and most suitable time to apply it in autumn, when last vegetative growth has started maturing and root system has started its growth

#### **Potash.**

Potash content in roots and wood decreases during flowering. Best time to apply it is February or a month before harvest.

### **Season of nitrogen uptake by mango trees.**

Maximum nitrogen demand in mango is in October at Hyderabad (Sindh) and continues up to December. It is also high at time of flowering but excess nitrogen may induce vegetative growth and may cause fruit abscission, though shortage of  $N_2$  can affect flowering and fruit development

The compromise is:

- 1/3<sup>rd</sup> Nitrogen at end December.
- 1/3<sup>rd</sup> in March.



- 1/3<sup>rd</sup> in June-July, about 2-4 weeks before harvest of a particle variety.

This is one recommendation and not the final, but appears probably a good compromise. The other recommendations have been discussed before.

### **Fertilizing Timing by different scientist.**

These differ so much that they need full review as noted below.

- (a) Some authorities suggested that best time to apply fertilizers is post flowering and immediately after harvest. Others think fertilizing at full bloom and 4 weeks before harvest. Still others think that 1/3<sup>rd</sup> one month after full bloom and 1/3<sup>rd</sup> 2-4 weeks before harvest.
- (b) It has also been recommended that half dose of nitrogen and full dose of phosphates and potash be applied 15 days before flowering and balance half in March. March dose may be omitted if crop is light.
- (c) In alkaline soils use of ammonium sulphate instead of urea is preferable, as it will improve pH of soil.
- (d) Leaching losses can be reduced by applying fertilizers in three or more split doses.
- (e) Potash is for root development and can be applied in October in Sindh, when the vegetative growth has ceased and has started maturing.
- (f) Demand for potash is at peak just before harvest. Since it leaches very slowly, it can be applied any time during the year, or before harvest. Nitrogen must be applied latest by about a month before harvest, to induce a good flush after harvest and no N<sub>2</sub> after that until after flowering. Our experience shows that vegetative flush in October does not mature to differentiate into flowers and one or two urea sprays in October or early November, is mature leaves and lead to flowering.
- (g) Nitrogen if applied a few weeks before fruit maturity, can increase incidence of soft-nose, but early harvest can over-come the problem, though this may affect market prices due to mango glut.
- (h) Application of nitrogen about 2-4 weeks before harvest will ensure that there are one or two vegetative flushes before dormancy and these flushes differentiate into flower buds.
- (i) If nutrients are imbalance, yields can reduce dramatically,
- (j) Excessive vegetative flush at wrong time i.e. when fruit is developing in April and in can reduce fruit size and quality.
- (k) Quality reduction can be green skinned mango, jelly seed and internal break down.
- (l) If soft-nose is not a problem nitrogen doses can be divided in three equal amounts and for Hyderabad these are at end December, early March and one month before harvest. December dose will probably be the best. The December dose definitely helps in flower induction, if post harvest growth in mature.
- (m) Nitrogen can be applied at rate 750 to 1500 grams per mature tree per year. Maturity varies High density dwarf trees are mature at age of 5 years, where

as low density South Asian varieties Sindhri, Chausa and Langra mature at age of 10 years rather and attain maximum yield at 15 years. The fertilizers have to be jousted to maturity and production, rather than the age.

- (n) Potash in leaves is higher in "Off" years than in "On" years.
- (o) Root system covers the whole canopy and to about one meter of soil depth, fertilizing should take care of it.
- (p) Feeder root density (FRD) is maximum midway around the canopy. In upper layers FRD is greater in April (active growing season) than in October (near to dormancy). It is greater in high yielding trees and lower in poor yielders. There is a positive co-relation between nitrogen and FRD. There are limited feeder roots within the first four feet radius of mango trees.
- (q) Phosphate should be about ¼ of nitrogen, and can be eliminated for some year, if it has been applied in previous years. Potash can be 40% more than nitrogen.
- (r) Translocation of Phosphorus may be involved in controlling alternate bearing.
- (s) NPK at per and one Kg each of urea, DSP (Double Super phosphate) and potassium sulphate per tree can give: greatest shoot growth, greatest leaf and flower number, greatest fruit set and retention, greatest fruit size, maximum percentage of TSS, ascorbic acid and sugar content, but lowest total fruit acidity.
- (t) Fertilizing at 15 days intervals, has given 100% flower bud differentiation, as compared to 3,6, and 12 months intervals. An interval of 7 and 30 days is better than larger intervals. There was no difference in flowering at 6 and 12 months intervals. The yield could increase by 80-90% by frequent application of fertilizers. Young non bearing trees can be fertilized every fortnight or month. We usually spray 1-3 years old trees with all there NPK every week and with NPK and micronutrient and every month. Tree, usually fruit in 3<sup>rd</sup> year and most of the time in 4<sup>th</sup> year.
- (u) Potash in large quantity can decrease yield
- (v) Magnesium can be about 50% of potash in acid soils
- (w) Manganese, copper, iron and zinc are also needed. Alternate applications of mancozeb and copper oxychloride sprays will be useful for anthracnose control during bloom and after words.
- (x) Iron can be applied in chelated form, if soil is deficient in it ,but at the present it is not cost effective in Pakistan. Spray with ferrous sulfate 3-4 time year or mulching will over come the problem of iron deficiency.
- (y) Manganese, copper, iron, zinc boron and molybdenum are micro nutrients and are discussed separately in next chapter.

### **Annual Monitoring Of Soil and Leaf Analysis.**

Records of annual application of fertilizers have to be maintained and if analysis shows some items in excess, they have to be reduced and those in shortage have to be applied. Imbalance of fertilizing can reduce yields. This also applied to micronutrients.

### **Spray time for nutrients (both macro and micro)**

Best time for spray of nutrients should be on new growth which would be in September and October for late varieties. It is also time for leaf minor attack two or three fortnightly sprays can control leaf minor and supply nutrients. In order not to burn leaves follow low doses are used in 200 litres of water (standard drum of 45 imperial gallons.). Zinc,  $\frac{1}{4}$ , Cu,  $\frac{1}{4}$  kg. Mn,  $\frac{1}{8}$  kg. Iron,  $\frac{1}{4}$  kg. Boron, 150 grams. Urea, 2 kgs. Phosphate, 1 kgs. Potash, 1.0 k.

Total load will be 5 kgs. If burns leaves, urea, potash and phosphate can be reduced to three quarter or half.

## CHAPTER - 13

### MICRO-NUTRIENT IN MANGO PRODUCTION

The trace elements have an important role in fruit production. The various trace elements are: zinc, copper, manganese, iron, boron, molybdenum and cobalt and need to be applied to tree for maximizing production.

#### **Micro-Nutrient in leaves of mango leaves at various stage of growth.**

Micro-Nutrient levels at different ages and stages of leaf growth are as under:

- Iron level remains the same year around.
- Copper levels are low from 1 to 5 months old leaf. It increases from 6-8 months and declines from 9-12 months.
- Manganese reaches its peak at 10 month age of leaf boron, reaches peak at 4 months age of leaf.
- Leaves grow year around and small quantities and micro-nutrients applied a number of times during the year specially to new foliage as it ember gas give best results.

#### **Effect of Leaf Age on Nutrient Composition**

Table below gives the percentage of various ingredients for macro and ppm (parts per million parts) for micro elements.

**Table.1.giving amount of macro and micro nutrients in percentage or ppm.**

Leaf age (months)	N %	P %	K %	Ca %	Mg ppm	Zn ppm	Cu ppm	Mn ppm	B ppm	Fe ppm
2-3	1.38	0.13	1.17	1.99	0.22	73	21	56	21	45
10-11	1.20	0.09	0.82	3.44	0.21	141	47	117	34	79
15-16	1.19	0.08	0.83	3.51	0.22	183	34	115	25	78

Source. Young and Koo (1971).

#### **SEASONAL VARIATION IN PHOSPHORUS AND IRON CONTENT IN LEAVES ,STEMS AND ROOTS OF MANGO CV. LANGRA**

Table II below gives the changes in percentage and ppm for macro and micro elements.

Month	Leaves	Stems	Roots
-------	--------	-------	-------

	P (%)	FE (ppm)	O (%)	Fe (ppm)	P (%)	Fe (ppm)
July	0.11	381.62	0.14	260.67	0.08	260.33
August	0.13	219.33	0.17	120.66	0.08	239.00
September	0.08	180.00	0.12	122.33	0.05	301.33
October	0.12	2451.33	0.15	120.33	0.05	280.33
November	0.09	438.67	0.11	120.33	0.07	398.67
December	0.15	201.00	0.22	79.00	0.07	220.66
January	0.14	301.00	0.24	120.00	0.06	239.00
February	0.11	275.00	0.13	280.33	0.074	478.67
March	0.08	319.33	0.10	201.00	0.06	438.33
April	0.10	300.66	0.18	106.33	0.08	399.00
May	0.12	278.00	0.17	180.66	0.08	259.33
June	0.11	197.33	0.14	100.67	0.09	139.00

Source. Reddy et al. (1982), Reddy (1984)

### Range And Mean Values Of Various Elements In Development Parts Of Mango Leaves

Table. III below gives the percentage or ppm various ingredient in leaves of mango.

Element	Whole Leaf		Leaf Blade		Petiole	
	Range	Mean	Range	Mean	Range	Mean
Nitrogen (%)	0.94-1.45	1.23	0.60-1.25	1.00	0.36-0.60	0.46
Phosphorus (%)	0.040-0.117	0.060	0.60-1.25	1.00	0.35-0.60	0.148
Potassium (%)	0.450-0.775	0.539	0.100-0.500	0.338	0.525-1.200	0.852
Calcium (%)	1.16-2.30	1.71	1.16-2.32	1.76	1.78-3.48	2.82
Magnesium (%)	0.54-1.25	0.91	0.43-0.73	1.20	0.70-1.33	1.07
Sulphur (%)	0.064-0.156	0.121	0.060-0.150	0.106	0.56-0.184	0.111
Zinc (ppm)	0-233	166	166-383	141	300-900	481
Copper (ppm)	1-33	12	1-8	3	1-15	4
Manganese (ppm)	30-10	66	40-130	77	20-100	48
Iron (ppm)	67-333	171	83-533	207	17-167	86

Source. Chadha et al. (1976)

### Optimum leaf nutrient ranges for bearing mango trees.

Table IV below gives the optimum nutrient longer for mature mango trees.

Nutrient	Optimum range
Nitrogen	1.5-1.5%
Phosphorus	0.08-0.18 %
Potassium	0.3-1.2 %

Calcium	2.0-3.5%
Magnesium	0.15-0.4%
Sulphure	0.2-0.6%
Iron	70-200 ppm
Manganese	60-500 ppm
Zinc	20-150 ppm
Copper	10-20 ppm
Boron	50-80 ppm
Sodium	0.20 %
Chloride	0.25%

### Procedure for taking leaves for analysis.

Each sample is to consist of 30 to 60 leaves for a summer or autumn flush, when they are 4-7 months old. From a block of 4 acres 30 leaves are enough. Samples should be taken along periphery of area taking two leaves per tree, from a height of about 5-7 feet. The leaves number 4 and 5 from base of stems are taken from mix-shoots, avoiding terminal leaf. Sample should be taken before fertilization. Leaves should then be washed in distilled water and air dried. If iron deficiency has to be found, soap water or detergent may be used and samples washed, at least 5 times with very clean or distilled water. If crops have been sprayed for copper, zinc, manganese and iron deficiency, analysis will not show the correct picture and wait period of eight weeks may be considered.

### Leaf analysis ranges for mango.

Mango leaf analysis should fall between the ranges in the table V below the deficient levels, yields go down considerably and do not bring economic returns.

**Table V Critical level of Macro nutrients in mango leaves:**

Nutrient	Range (%)	Slight deficiency (%)	Severe deficiency (%)
Nitrogen	1.0-2.2	0.90	0.67
Phosphours	0.08-0.175	0.08	0.03
Potassium	0.3-1.0	0.53	0.25
Calcium	2.0-3.5	1.5	0.81
Mgnesium	0.15-0.4	0.18	0.09
Sulfur	0.74-1.5	0.52	0.32

### Mango decline and micronutrients.

Nutrient deficiencies are connected with mango decline and manganese and iron are the two chief elements in short supply in old trees. Phosphorus also has negative effect and excess of it causes mango decline. Mango decline can be overcome by micronutrient application and pruning. Yellowing between leaf veins shows manganese and zinc deficiency. Poor leaf size, depicts zinc deficiency. Sindh soils in general are zinc deficient.

### Zinc Deficiency Symptoms

Successive new flushes of growth with smaller leaves short stems and leaves curved or curled (like sickle), and leathery leaves, show zinc deficiency. On leaf analysis, minimum zinc content of leaf should be 35.2 ppm in a healthy trees. Restricted shoot growth and terminal stoppage, shows zinc and copper deficiency. Sindh soils are deficient in zinc and its deficiency can retard terminal growth, curved leaves.

### **Copper Deficiency Symptoms**

Whitening and speckling of leaves shows copper deficiency. Copper requirement can be met by routine copper sprays in spring and autumn for fungal disease control. For mango it can be January, March and September.

### **Iron Deficiency Symptoms**

Pale green small leaves with crinkled margins or burning of margins show iron deficiency. Shortened stems and die-back of succeeding growth are also symptoms of iron deficiency. This typical iron deficiency is not uncommon in mangoes on calcareous soil of Sindh.

### **Foliar application**

#### **Zinc**

Its source are: Mancozeb (containing manganese and zinc), Ziram (contains zinc) zinc oxide, zinc sulphate. Zinc oxide being insoluble is less effective, as found recently. Spraying with at 0.2 to 0.4% zinc sulphate will remove symptoms of deficiency. At this dose, trees have produced new, flushes of leaves free of any deficiency symptoms. Zinc sulphate can be used for soil application too.

### **Soil Application of Zinc**

Zinc sulphate at 30 kgs per hectares or 12 kgs per acre in to soil, can over come the problem, but next seasons leaf analysis will be a guide lines if higher or lower dose is needed. Zinc level is more in "Off" years and less in "On" years. It is more in September than in December. Zinc level improvement can help in regular bearing. Foliar application of zinc gives quick results and quantity needed in less than ground dose.

### **Copper**

Copper compounds are used as micro-nutrients as well as fungicides. Combination of copper, zinc and manganese just before leaf fall in winter or copper in January, mancozeb in February and copper oxychloride in April and again in September will help in over coming micronutrient deficiencies of these ingredients. This has to be in addition to ground applications in acidic soils. In alkaline soils of pH over 7.0 copper gets fixed Mixture also gives good results, if used in split doses 2-3 times in a 9 years.

### **Boron**

Boric acid sprayed at 0.2 to 0.8% solution, increases leaf growth, pollination, fruit development and nitrogen content of leaf. Boric acid 0.8% spray increases fruiting. Timing is at 60% flower opening or by soil drench.



## Iron

Sequestrene 138 iron chelate is applied at 50-100 grams per trees, through soil or via irrigation system. Foliar sprays of 0.2% ferrous sulfate solution or 0.2% ferrous nitrate solution, along with wetting agent have removed deficiency, but effects of foliar feed with inorganic iron compounds are short lived and effect lasts for 3-4 months. It is to be applied at least 3 times a year. It is essential for chlorophyll formation. It can even be applied at 2% but probably 0.5 kgs in 3 to 4 spray applications in 200 litre drum would be better. Though foliar sprays and ground application with chelated iron have given good results, but the product is very costly and not economical under Pakistan conditions. There was a claim that iron chelate (Fe-Sequestrene-138) reduces mango malformation. Similar claims for other chemicals and growth regulars have been rejected time and again. Malformation a major disease discussed separately in the book.

## Manganese.

Manganese can be used as micronutrient and also for control post-harvest decay. It is available in the form of maneb, mancozeb, manex, manebgan, manzain 80, mancofoland and manganese sulfate and mancozeb, it also has zinc ion. It has double action as fungicide and micronutrient.. It is started 2 weeks after fruit set and 3 sprays with 0.3% maneb or mancozeb are applied. The last is used to control anthracnose. It helps in control of post-harvest fruit decay. In addition to this application. manganese can also be used in soluble form like sulphate etc and as micronutrient it has no fungicide action.

## Magnesium

It is a macro-fertilizer and some times is also classified as micro-nutrient. It is satisfactorily derived from magnesium sulphate and sulphate of potash-magnesia. It is to be mixed with potash in proportion of about 15-20% of the latter.

## Calcarious soils and micro-nutrients.

On soils with pH over 7.5 there always is deficiency of copper, zinc, manganese and iron. Sindh soils with high pH are deficient in all these elements, but there is chronic shortage of zinc and iron. These are to be sprayed, zince can be applied on the ground but it is cheaper to add it to other elements by spraying as shown in table below.

**Table VI. Trace element spray dose (Spray Program)**

Element	Tree Condition	Spray Dose	Spray Timing
Copper as Copper oxychloride.	Non-bearing with serious deficiency.	500g/100 L.	Preferably after harvest when new growth starts, in 3 sprays and also from flowering to a month before harvest.

Bordeaux Mixture	Same as above	500L Cu+500g lime in 100c water	Some as above
(a) Zinc as ziram or Fuklasin (20% Zn)			
(b) Metiran or Polyram (16% Zn)		120-150 g per 100 litres	Ziram can be combined with most insecticides and wetting agent is not needed.
(c) Zinc Sulphate	Tree of any age.	0.8%	It has no fungicide action.
(d) Zinc+Mangane se (Mancozeb).	Tree of any age	80% WP, 350 to 3000 grams per acre or 100 grams 100 L.	3-4 sprays at monthly intervals.
Magnesium as salt	Young non- bearing trees.	1 kg per 100 L plus wetting agent.	Three times at 3-4 weeks interval in spring. It can be applied even in September
Iron as Ferrous Sulphate (Feso <sub>4</sub> ) Ferrous nitrate.	Trees of any age	0.2%	Can be but mixed with Zn sulphats and boron and 3-4 times a year.
Ferrous Nitrate			Not to be mixed with copper
Fe NO <sub>3</sub>	Trees of any age	0.1 %	Can not be mixed with copper
Fe-Sequestrene-138		1 to 5 ppm	Can not be mixed with copper
Boron as boric (18%) or Borax (11%) or Solubar.		0.8% or 144 g, actual B, per 100 litres 1.3% or 144 grams actual B per 100 L.	

#### **Micronutrient Dormancy Sprays November To January.**

Copper. Same dose as above, 2 weeks  
before or after winter oil spray.

Iron. After copper spray.

Boron. Preferably before flowering.

#### **Surface Dressing to Acidic Soils.**

Surface dressing can be applied, at the time of flowering, in the following doses in acid soils, pH less than 6.5. In alkaline soils of pH over 7.0 they can get fixed to soil. And foliar application is the only solution.

**Table VII. below than gives surface dressing doses of various elements.**

Element	Dose	Timing
Copper as Copper sulphate.	250g per tree spread out, around tree to 3 meters from tree butts.	Best time, end January.
Manganese as Manganese Sulphate	Same as copper, but 500g for young trees and 2 kg for large trees.	Same as copper
Zinc as Zinc sulphate.	2 kgs per tree	To be ploughed in to a depth of 10 cms by inter cultivation tools.

**Pre Plant Macro And Micro Nutrient Doses Per Acre As Ground Application To Acidic Soils.**

Table VII below gives ground application doses of various micro nutrients.

Chemical	Dose
Superphosphate.	0.6 tons
Magnesium SO <sub>4</sub> (epsom slats)	100 kgs
<b>If soil is deficient.</b>	
Copper Sulphate.	20 kgs
Zinc-Oxide.	100 kgs.

These are to be incorporated in to soil to a depth of 12 inches (30 cms). Copper and zinc can get fixed to soil of pH over 7.0.

**Black Tip control with Boron, Copper and Manganese.**

It is caused by sulfur dioxide of the brick kilns around cities. Yellow spots appear on the fruit first and turn brown and black as fruit ripens on the tree. Control is possible by Borax sprays 600 grams/100 litres or Gelatine at 1.0% +0.01 to 00.05% copper sulphate and manganese sulphate as spray.

## CHAPTER - 14

### FOLIAR FEEDING OF NUTRIENTS TO MANGO

Foliar feed is new concept in growing fruit trees. It is costlier to supply, than ground feed and its effect is not long lasting. It can however remove deficiencies quickly. Environmentally it is clean. A ground application of fertilizer is not without adverse effects. Many fertilizers are toxic to soil fauna and chlorides, phosphates and sulphates kill earthworm. Nitrogenous fertilizers leach down in the soil, ammonia volatilizes, phosphates get fixed to soil and chlorides increase salinity. Some trees like peaches, nectarines, and almonds do not up take nitrogen foliarly and others take in limited quantities only. Mango and apple can up take nitrogen in form of urea at 2-4 % during fruit development and even larger quantities during post-harvest. Young trees can take 6% urea without leaf burn. Foliar feeding amounts to direct application of nutrients at the site of their metabolism.

In general NPK in various doses can be applied to mango provided that total soluble salts in the solution do not become too high to produce toxicity. For the past 20 years we have foliarly fed mango for full supply of macro and micronutrient needed chemicals. These chemicals used for disease control were also for increasing fruit set regularizing harvest date, by about a fortnight producing clean spot less fruit free of anthracnose stem end rot etc and we have supplied this in 12-18 annual sprays and no ground dose is used. Best timing for ground application is 50% at flowering and 50% just before harvest. Foliar feed can be in that proportion. Some times foliar feed response is very rapid, but it take two years to show improvement in yield and in this period some ground applications may also be resorted to. Foliar feed may not replace ground feed unless it is applied frequently and in adequate doses.

#### **Macro-Nutrients as Foliar Feed.**

##### **Urea.**

The following are some out standing results of foliar feed of urea and mango production.

- i. Nitrogen in form of urea at 2-4% increases fruit weight. TSS, sugar and ascorbic acid, but delays its maturity by about 15 days. An advantage in extending harvest season. Weight increase is about 25% and TSS about 16%. Delayed harvest may fetch better prices or push the grower in mid season glut for his early varieties.
- ii. Foliar spray with 4-6% urea increases vegetative growth, size of panicles and fruit set and also it reduces fruit drop in the next year, when used soon after harvest.

- iii. Urea spray reduces natural fruit drop by 20-45% and thereby increases yield.
- iv. Application of 2-4% urea in December (pre-flowering), February (Full bloom), April (Fruit set) and August (post-harvest), increases panicle length, duration of flowering, fruit set and yield in the next year.
- v. Foliar spray of urea 4% used at pea stage i.e. 1 to 10 March and again 35 and 50 days later (15 and 30 April) at Hyderabad (Sindh) have increased yield.
- vi. Foliar spray of urea at 4% repeated as in above case, delays fruit maturity by 2-3 weeks.
- vii. Foliar spray with urea 5 times at 1 to 2%, fortnightly in November, December and early January, delays flower bud opening, increases number of perfect flowers, improves pollen viability, increases fruit set and yield. It reduces malformation to less than 5% in notoriously affected cultivators Deshri and Chausa, due to delay in flowering. Malformation is decreased in early emerging flower varieties
- viii. Urea at 1%, 6 times from July to December in the "On" year to alternating cultivars Sarwarnarika markedly stimulates vegetative growth and panicle emergence (50%) against 25% under control and also increases number of perfect flowers and yield.
- ix. Urea at 4-6% applied to juvenile trees, increases length of terminal shoots and growth with out leaf scorching.
- x. Foliar application of urea increase length of terminal shoots, number leaves per shoot and also leaf area per shoot.
- xi. Weight of fruit is maximized with 4% urea.
- xii. At 4% urea applied in July and again in December once each time, reduces duration of flowering.
- xiii. Even 2% urea spray increases fruit weight by about 25%, ascorbic acid by 10% and TSS by 16%.
- xiv. Of all treatments, 4% urea is the best if applied as above said.
- xv. Foliage spray with urea at 1 to 2% is reported to have increased fruit size by about 8%, when it was post fruit-formation spray.
- xvi. Urea at 6% does not burn leaves but produces more vegetative growth.
- xvii. Urea at 2% one month after full bloom reduces post fruit-set drop by 18 to 46%, if spray is continued at marble size and 15 days later, fruit weight increases by 25%.
- xviii. Urea at 2% plus 2,4,5-T or 2,4,-D at 20 to 40 ppm at pea stage have increased fruit weight and sugar content, and reduced fruit drop.

### **Phosphates.**

Following are some outstanding effect of spray of phosphates on mango production

- i. Orthophosphoric acid at 0.5% alone or with 2% urea, applied 3 times in September, November and March increase panicle length and yield.

- ii. Double super phosphate or Tripple super phosphate can also be used at 2 to 4% in place of orthophosphoric acid which is difficult to get in Pakistan.
- iii. Three sprays with urea and Double or Triple Supper Phosphate at 4% each in December, March and July have increased yield by 75 to 100 percent in India. In 1998 we had tried 4 sprays of urea at 4% + DSP at + 2% and potassium chloride at 1.35% respectively in December, March April-May and June with increase in yield, average fruit size increase by 25-30% and late harvest of Sindhuri by two weeks when it was unavailable in Sindh.
- iv. Phosphorus and potash can be applied as  $N_2H_2PO_4$  and  $KH_2NO_4$ .
- v. Double super-phosphate as foliar spray is more effective than DAP and SSP. It can be 2 to 4% when applied in November, December, February, March, April and May without ill effects. Phosphate translocates from leaves to fruit at fruit-set stage, at much higher rate than from roots and at later stages of fruit development.
- vi. Foliar application phosphate salts along with fungicides diniconazole (Merit at 12.5%) or mycolobutanil (Sisthane) or penconzole have succeeded in increasing yield by controlling fungus, as well as supplying phosphate in high pH soils.

### Potash

Following are effects of spray of potash to mango:

- i) For spray chloride of potash ( $KCl_2$ ) is considered better than potassium sulfate. ( $K_2SO_4$ )
- ii) Murate of potash ( $KCl_2$ ) at 1.35% can be added with urea at 1% and will give beneficial response. At high concentrations,  $KCl_2$  is toxic.
- iii) Potash is applied as Potassium nitrate ( $KNO_3$ ), potassium phosphoric acid ( $KH_2PO_4$ ), potassium chloride ( $KCl_2$ ) or potassium sulphate ( $K_2SO_4$ ).
- iv)  $KCl_2$  at 1.35% gives better results than at 1%.
- v)  $KNO_3$  plus  $NaH_2PO_4$  at 0.6% also increases panicle emergence as result of 3 sprays after decapitation of fruit bearing panicle.
- vi) Potash sprays at 3% once in addition to decapitation soon after harvest triples number panicle shoots.

### Nitrogen in Combination with Phosphate

The following are some effect of nitrogen plus phosphate sprays on mango.

- i. Urea plus double superphosphate each applied at 3 and 4% gave heaviest terminal shoots, longest number of leaves when applied 3 times a year in December, March and July.(post harvest)
- ii. Application of nitrogen in combination with P increases fruit set, pancile length and yield, if applied in June and December and at full bloom. The normal dose is urea and Double or triple superphosphate 4%.
- iii. Phosphates are readily taken up by leaves in presence of urea.

- iv. Urea and double superphosphate sprays at 2 to 4%, when sprayed in December, April and July, increase panicle length, number of secondary branches, fruit, set and yield, when sprayed together, or separately or only if one of them was sprayed.
- v. Post-harvest dose of 4% urea + 2% double super phosphate to biennial varieties after removal of panicle manually immediately after harvest and repeated twice more fortnightly will make them regular.
- vi. Combination of 4% urea and double superphosphate increases yield by 75-100% if applied in December, at full bloom in February and four weeks later.
- vii. Foliar absorption of phosphates is improved if applied together with urea and phosphate uptake is twice as much from leaves compared to roots. December, January sprays can have urea at 2% and DSP at 2%, about 4 times in the period.
- viii. We have also tried triple superphosphate in place of DSP as it is 100% soluble in water with similar results.

### **Nitrogen Phosphate and Potash Combination**

Following are some results of foliar sprays of combinations of nitrogen phosphate and potash.

- i) 1 % urea + 1% DSP + 1% KSO<sub>4</sub> from 15 September to 15 December in all 7 fortnightly sprays to alternating tree increased yield 5 times the controls during "Off" year. Flowering and fruiting does increase, but proportion varies in various cultivars. The important factor is post-harvest flush which must be achieved by removal of panicle immediately after harvest and tree quickly induced in vegetative flush by fertilizing or foliar feeding.
- ii) Six sprays of major elements fortnightly from 15 March to 1 June, have given successful results in controlling fruit drop, increasing total soluble solids (TSS); sugar: acid ratio, fruit quality size and yield.
- iii) Full bloom and post-bloom sprays can be; urea 4%, DSP 4% and KCl<sub>2</sub> - 1.35% at full bloom, 5 weeks later again another 4 weeks later and 3-4 weeks before harvest. First two sprays delay fruit maturity. Three sprays help in fruit maturity. Three sprays after March increase yield. Sprays at 2% urea and DSP are ineffective.
- iv) Juvenile trees can be sprayed 4% urea +2% DSP + 1.35% KCl<sub>2</sub> without damage.
- v) NPK consisting of urea 1.35% murate of potash at 1.25% and sodium - orthophosphate at 0.7%, all sprayed from mid October to mid January at monthly intervals increase yield.

### **Nitrogen and Potash Combination**

Following are some results of nitrogen and potash combinations.

Combination of potassium chloride at 1% and urea at 1%, 6 times at 15 days interval, from 10 September until 15 December increase yield. These 7 doses for Sindh, can be can be 10 and 25 September, and 10 and 25 October 10 and 15 November and 10<sup>th</sup> December.



Flowering and fruiting does increase, but proportion varies in various cultivars. The important factor is post harvest flush, which must be achieved by removal of panicle immediately after harvest and tree induced to produce vegetative flush by fertilizing or foliar feeding.

- i) If fruit weight is to be increased, and harvest delayed, 4% urea thrice from pea size at 2-3 weeks intervals, will achieve the results. Less than 4% urea does not work, in delaying maturity, but for increasing weight even 2% urea will work.
- ii) For increasing number of panicles, one or two sprays with potassium chloride at 1.35% are needed, in addition to 1% spray with urea and  $\text{KH}_2\text{PO}_5$ .
- iii) There is a claim from India that number of fruits increased by 60% by NPK application at 1%. This may have worked on nutrient starved varieties but our results were not as astonishing.
- iv) Potassium nitrate ( $\text{KNO}_3$ ) sprays at 1 to 2% to induce flowering in tropics but not in sub-tropics, beyond latitudes of 22° N and S.  $\text{KNO}_3$  has 11% nitrogen and 44% potash. Since it is an ingredient used in gum powder, it is not legally available to flowers in Pakistan.
- v) Potassium nitrate ( $\text{KNO}_3$ ) promotes flowering probably by ethylene biosynthesis in mango. With higher dose of 2%, flowering has been induced earlier by one month in tropics. Application of  $\text{KNO}_3$  is made two months before desired date of flower induction.
- vi) Even in tropics  $\text{KNO}_3$  has no effect on fruit numbers, size, weight and TSS.
- vii) Heavy dose of  $\text{KNO}_3$  at 8% is reported to increase flower shoots two to three times, when applied along with decapitation of flowers or buds in December or January.

**A) General Accepted Doses For Foliar Feed Of MacroNutrients As Percentage In Water.**

Source	Nitrogen	Phosphorus	Potassium
Urea.	2-6%	-	-
Urea + Double or triple Superphosphate.	2-4%	2-4%	-
Potassium Nitrate			2-8%
Potassium Chloride.	1%		1.35%

**MiroNutrients as Foliar Feed.**

Micronutrients specially inorganic sulphates act as fungicides. Copper sulphate or organic coppers play very important role in fungal diseases control besides they supply nutrition.

**Copper.**

- i) To control anthracnose (if it rains in February) prochloraz plus  $\text{CuOCl}_2$  at 350 grams per 100 litres is sprayed every fortnight during flowering. It also increases yield. For anthracnose control, copper is to be applied monthly.
- ii) Copper compounds control powdery mildew but if mildew is established copper is ineffective.
- iii) Copper oxychloride controls anthracnose, if applied at 3 weeks interval and mancozeb at every 2 weeks (250 grams in 200 L), but the former is better and more effective than the latter. Prochloraz increases yield, if applied with copper every fortnight during flowering and after-wards.
- iv) In humid areas, anthracnose is controlled by 5-6 sprays of copper before flowering and 2-5 weekly sprays after fruit-set.
- v) Post rain sprays with copper in September, October reduce anthracnose. Copper sprays at 0.4%  $\text{CuSO}_4$  and 4 monthly sprays from August to December, control anthracnose and bacterial black spot (BBS)

### **Zinc**

Zinc sulphate increases fruit retention by 25-35%, when applied at 20 days interval during fruit development i.e. March to June. Zinc spray at 1% fortnightly from 1 December until fruit set by 28 February increases flowering and reduces fruit drop. Zinc up to 24 kgs per acre can be applied on ground. It increases yield when applied by sprays in November, December and applied 5 weeks before harvest of each variety at 1%. It improves fruit quality. Zinc sulphate 0.2 to 0.4% increase number of hermaphrodites flower in mango. In Sindh on zinc deficient soils, quarterly application of zinc sulphate at 1% are effective in maintaining zinc level in leaves. Zinc sulphate at 0.8% in December, increases yield and quality. Alternatively it can be applied at 0.25% by 5-6 sprays in November, December, and early January at fortnightly intervals. Zinc sulphate at 10%, and two weeks before harvest i.e., around mid May, improves post-harvest life and reduces spoilage. It also increases TSS and lower acid.

### **Iron**

High pH soils are deficient in iron. Ferrous sulphate applied to soil gets fixed. As foliar feed, its effect is temporary and needs to be repeated 3-4 times a year. Iron needs to be sprayed as ferrous sulphate ( $\text{FeSO}_4$ ). Ferrous nitrate  $\text{FeNO}_3$  can also be used at the same rate. Wetting agent is to be added for best result.

### **Boron**

Single annual soluble ground application at 100 to 200 grams per tree is phytotoxic. Spray is to be limited to no more than 0.5 kg boron a year per acre. Boron should preferably be applied once in November and twice during post-harvest by splitting above doses. Annual ground application of 50 grams soluble per tree or 2 kg year per acre per year is adequate and may be repeated next

year, if leaf analysis shows deficiencies. Boron is essential for flowering and should be sprayed in December.

### **Cobalt**

Cobalt sulphate applied prior to flower bud differentiation in September, reduces malformation and if repeated at mustard and again at marble stage at 100 ppm, it increases fruit size, weight TSS, TSS, TA ratio and total sugars.

### **Use of Calcium in fruit ripening.**

Calcium Carbonate at 200 grams per 100 litres assures uniform and early ripening of fruit. Calcium carbonates used in Bordeaux mixture promotes early ripening, whereas urea at 4% delays ripening. The two are antagonistic.

### **Combination Of Iron, Zinc, Copper, and Manganese Sulfates and Boron as foliar Feed.**

Bacterial black soot, antracnose, button mayers, and Sarnah are controlled by copper sulphate at 1%, zinc sulphate at 200 ppm along with 4% urea and three sprays are applied starting at pea to marble stage on 15 March, 15 April and 15 May. Copper, zinc and manganese sprays from March to July can control bacterial black spot (BBS). Iron can not be mixed with copper or boron. 2, 4-D cannot be mixed with sulphates of zinc, iron, manganese and potash.

### **Conclusion.**

- Foliar feed is effective only in presence of wetting agents and high volume sprays.
- Small Quantities applied more frequently are better than large quantities.
- Combined with disease control measures, frequent foliar feed becomes economical and effective.
- Foliar Feed being a new method, requires more data collection, leaf analysis, dose adjustments and results of experience else where.
- Initially foliar feed has to be combined with ground feed, until tree adjusts to foliar up-take over a period of 2-3 years.
- Heavy NPK fertilizing and high intensity cropping causes micronutrient problems and thus there application of latter is a necessity.
- There is antagonistic relationship between F-Mn, Fe-Zn, Fe-Cu, Cu-Mo, Fe-B and these make problem of micronutrient application complicated.
- In some varieties like Sensation, zinc, copper and boron increase internal break down and so do potash and magnesium.
- Penetration of chemical through leaf cuticle depends on pH of solution. Molasses can acidify the solution. Spray solution of pH 5.5 is idea, .Spreader is must.
- In Spain six sprays of major elements starting from 3-4 weeks after fruit set, produce excellent result. For Sindh these can be 15 and 31 March, 15 and 30 April and 15 and 31 May, Spray on 15 June can be for post-harvest flush in Sindh.

Over doses of some spray ingredients can get fixed to high pH soils and do not damage plant roots. In acid soils there is easy availability of iron, copper, zinc, manganese and without leaf analysis, they should not be applied.

## CHAPTER - 15

### FOLIAR FEED TO MANGO, BASED ON PAST 10 YEARS EXPERIENCE BY AUTHURS.

- Double super-phosphate can be used at 2-4% without ill effects. It is absorbed better with 2-4% urea.
- Urea can safely be used at 2 to 2.5% in summer after harvest. June and July sprays can be combined. Juvenile tree can be applied 4% Urea. Urea at 4% at pea, stage marble size, again 4 weeks later controls, bacterial blacks spot and anthracnose and increase fruit size.
- $KCl_2$  can be applied, but suggested dose is to be limited 1.35%.
- Copper is toxic to flowers. Use of copper compounds during flowering is justified only if it rain heavily.
- Zinc can be used at 0.8%. We apply only  $\frac{1}{2}$  kg in 200 litres drum.
- 2,4-D at 20 ppm reduces fruit drop, if applied at full bloom and pea stage.
- In August alternating trees like Chaunsa, Sawarnarika, Langra, Siroli are sprayed with micronutrient to make them produce vegetative flush The same may be done to all varieties pruned after harvest and panicle removed
- Pre-Flowering dose of  $N_2$  has to be 1/3rd of total.
- At least 3 out of 5 pre flowering sprays have to be done before flower bud differentiation which takes place in December.
- Iron is to be sprayed 3-4 times a year, in November, March and September.
- To neutralize zinc, lime is added at 50% of zinc.
- Zinc sulphate at 1% increase fruit retention.
- Biennial varieties need decapitating of panicle, immediately after harvest.
- Boron is to be limited to 600 grams or boric acid to 400 grams, once a year, Boric acid needs to be dissolved in hot water.
- 2,4-D is to be used thrice at time of flower bud differentiation (December) at pea stage (February), and at marble stage (April).
- NAA at 45 ppm at marble stage can improve fruit retention.
- Scales are serious problem from April to July. They can be controlled by  $\frac{1}{2}$  kg washing soda in 200 litres drum or by summer oil or suitable insecticide.
- If it rains anthracnose will be a serious problem. Use prochloraz +  $CuOCl_2$  every fortnight even during flowering. Bordeaux mixture can also be used
- For mildew control, nimorod 40-60ml/100L or Rubigon 30ml/100L or Topass 20g/100L or Bayton 50g/100L. Can be used. caustic soda is also effective.
- Neelum and Sawarnarika are immune to mildew.
- Copper must be applied other-wise bacterial black spot will take its toll in varieties prone to it.
- While spraying urea, Cu, Zn, Mn must be added for control of BBS, anthracnose, etc.
- $NH_4NO_3$  or  $KNO_3$  will not induce flowering beyond  $22^\circ N$  and S.

- Chemical sprays mixture should be neutral and neither acidic nor alkaline.

### Specific behavior of mango

- Plant deficient in P takes it at twice the rate foliarly i.e., double the rate as it takes from roots.
- Old leaves uptake less P than the young leaves.
- At low concentrations uptake of P and K is less but increases hyperbolically at high concentrations.
- P and K can be at 1% but urea can be 8%.
- At high concentrations of P and K leaf damage occurs.
- Root activity is low during reproductive stage (mid January to harvest) and foliar feed can be great help.
- Addition of sucrose can reduce leaf damage by urea, but sucrose needed will be 5-1/2 times urea and is uneconomical
- $\text{CuSO}_4$  is to be limited 2 kgs per acre per year for foliar feed
- Trunk, branches, bark, twigs, shoots and foliage absorb NPK foliarly.
- Even leafless trees take NPK through bark and twigs, and urea,  $\text{KNO}_3$  and phosphoric acid easily move in to above parts.
- Ethylene is effective in producing flowers in low-latitude tropics. It does not work in sub-tropics.
- Urea at 1 to 2% will delay flowering in early varieties when applied in November and December.
- Urea + DSP or TSP all at 2 to 4% sprayed in November, March and July increase yields and without illeffect.
- Urea at 2 to 5% prior to or during flowering preferably at full bloom has beneficial effect on flowering and yield. (January).
- Urea at 1 to 2% Just before flower bud differentiation, delays flowering and there by decreases malformation and increases number of perfect flowers and also increases, yield.
- Biennial varieties should be decapitated of pedicule (fruit shoots) immediately after harvest and be followed by 2% urea sprays once or twice to induce early new vegetative growth, which will turn into flowering. in one of sprays iron may be added. (June-July).
- Urea at 4% during full-bloom or at pea stage and 7-8 weeks after pea stage increases fruit yield and delays harvest by 15 days. This may be applied at 4% with mildew control of February 10 to 25 and again on 1 to 15 April. Low temperature at the time of bloom below  $4.4^\circ\text{C}$  ( $40^\circ\text{F}$ ) and  $0^\circ\text{F}$  lead to lack of pollination.

Urea plus DSP at 2 to 4% has been used in India to (Sindh timing in November, March and July). For increasing size fruit and yield, DSP is safe to use at 2 to 4%.

$\text{ZnSO}_4$  can be used at 0.8%.

Two iron sprays are essential for non-mulched trees.

KCl potassium chloride dose cannot be more than 1.35%.

Boron is to be limited to 300 grams in 100 liter drum once a year or 200 grams boric acid in 100 litres of water

2,4-D at 20 or 40 ppm in November at time of flower bud differentiation again at 10-20 ppm at pea stage and again a third time at marble stage (April), reduces fruit drop .Fruit retention is improve by 2,4-D at 50 ppm + urea at 4%.

Ethephon or ethrel at 400-800 ppm or 80 to 160 grams in 200 litres + surfacant at full bloom improves fruit retention.

NAA at marble stage at 45 ppm can improve fruit cetaintion.

In case of severe anthracnose during flowering caused by rain Copper oxychloride of 400gm 100L every 3 weeks and Mancozeb at 200g/ in 100L every 2 weeks can control anthracnose, bacterial black spot and fruit drop. Monthly sprays in March to harvest can help.

Prochloraz spray + copperoxychloride every fortnight during flowering can control anthracnose.



## CHAPTER - 16

### GROWTH REGULATORS AND MANGO

#### Role of 2, 4-D.

2, 4-D at 20 or 40 ppm in November (time of flower bud differentiation), March (full bloom) and April (pea to marble stage), reduces fruit drop. Manganese, Copper, iron potash and zinc and other sulphates can not be mixed with 2,4-D. Fruit retention is improved by 2,4-D at 50 ppm + urea at 4% also . 2 or 4% urea + 2,4-D or 2,4,5T or NAA at 20,20 or 40 mg per litre used as spray in December, March and May beneficial, weight of fruit increases, sugar, TSS, ascorbic acids and acidity ratio were increases duration of flowers shortenes, (37 days against 50 days for controls.) and Fruit retention enhances and yield increases.

2,4-D at 10 to 20 ppm and pea stage once, or NAA at 25 ppm thrice or planofix or chlorofnoxil-acetic-acid at 25 ppm reduce fruit drop and increase productivity. The time to apply NAA is thrice at is mustard, pea and marble stage (February, March, and April for different varieties of Sindh)

#### Role of 2, 4, 5-T

2,4,5-T can be used at 20-40 ppm at pea stage for the reducing fruit drop, increasing weight TSS and sugars .

#### Role of NAA.

Fruit weight and yield is increased by 45%, if NAA is sprayed at 10 ppm, 4 times at:

Fruit bud differentiation (December)

Just before flowering opening (NAA may inhibit bud break?)

Pea size (March).

Marble size (April).

It improves fruit retention and yield. NAA at 100 ppm at full bloom and 25 ppm at mustard, pea and marble stages can reduce fruit drop like 2,4-D. It also increases number of hermaphrodite flowers. Combination of NAA with urea increases fruit weight. Chemical deblossoming with NAA at 500 ppm at full bloom, reduces fruit set by 30-40%. Combination of urea + NAA to pre-anthesis panicles, increases fruit weight. It is better to apply three NAA sprays, first at protective mildew control, second at pea stage and third at marble stage. NAA at 120 to 150mg L<sup>-1</sup> + 4% urea increase percentage of pulp, TSS and sugars, reduces acidity and increases yield.

#### Role of NAA and GA<sub>3</sub> in flower induction reducing fruit drop and retaining it.

Experimental work done world over has shown that:

Spray with Indole Acetic Acid (IAA) 1000 ppm, in August and September and again in February, March just before flowering, produced more flowers.

Spraying with Planofix (containing NAA) at 20 ppm at the mustard, pea and marble stage 12 and 3 weeks after pollination, improved fruit retention, but best results were obtained by spraying at marble stage, at 20 ppm. NAA at 45 ppm at marble stage reduced fruit drop increased fruit size and yield by 45 to 50%. NAA and GA<sub>3</sub> sprayed at pea stage at 25 ppm, increased size and quality of fruit. NAA methylether at 25, 50, 75 and 100 ppm, helped retention of mango fruit on tree, increased its size and weight, brought early a maturity and improved quality by increasing TSS and reducing acidity. The best was 25 ppm. From the above it appears that NAA at 5 ppm, three times at full bloom, pea and marble sizes, does same job as one spray at 20,40, and 45 ppm. The exact dose is still a guess work and may vary from cultivar to cultivar.

#### **Growth regulators both in Tropics and Sub tropics.**

Polyamines (supermine, putrescine) at 10<sup>-3</sup> M and 10<sup>-4</sup> M or manganese oxide (MnO<sub>3</sub>) at 2-4% increase fruit retention.

#### **Triazoles, (Paclobutrazol), 1-20 grams a.i, per tree.**

Triazoles retards growth, but yield also comes down, due to lack of growth. Uniconazole also does the same.

#### **Paclobutrazole (Cultar or PBZ) at 25° 28'N**

Cultar at 2 grams per tree as soil drench applied in two consecutive years at authors farm 3 months before bloom, reduced tree height and diameter, but did not induce flowering. it probably does not work in sub-tropics for flower induction, but does dwarfen trees. For one or two year old tree 1.25 to 2.5 grams and for five year old tree 10 grams dose is recommended in tropics.

#### **Effect of PBZ and UCz**

They do not cause flower induction in sub-tropics. They reduce number of vegetative flushes. They produce one flush in 75 days, against two or three in control, reduce internodal length, reduce shoot length, reduce height increment. Cause precocious flowering in non bearing trees in tropics and flowering 6-8 weeks earlier in tropics and also yield increase.

#### **Paclobutrazol in South India in tropics.**

Soil and foliar sprays promoted flowering in South India on 18°N. Soil drench at 5-10 grams produced earliest flowering. Fruit yield in general was 2.5 to 3 times as compared to control due to PBZ drench. Yield per tree in at 10g was 83 kgs, at 5 grams 66 kgs and control 32 kgs.

#### **Plant growth regulators paclobutrazol in mango production.**

Paclobutrazol (Cultar a gibberellin biosynthetic) used as drench increases yield, where as foliar application gives mixed results. Doses are 5 to 10g a.i per tree as drench. Timing is post-harvest to induce early flowering and early maturity.

**Paclobutrazol (PBZ) in flowering and mango near Bangkok (Thailand) on 12°N in tropics.**

Rate of application is 5-10 grams a.i, of paclobutrazol as drench. Foliar application is 1000-2000 ppm a.i. Majority of trees treated produce flowers between 102 to 120 days after application, as against 137 days of controls, which flowered only in 30% cases.

**Potassium nitrate  $KNO_3$   $NH_4NO_3$  Ammonium Nitrate and other nitrates and Paclobutrazole on mango in Venezuela on 10°-15°N to induce flowering in tropics.**

Flowering with  $NO_3$  is inconsistent and several sprays are required for satisfactory results. Rate of  $NH_4NO_3$  is 2% and  $KNO_3$  at 4%. The shoots have to be at least 5 months old, to react to  $NO_3$  component. PBZ drench reduces size of fruit, but not  $NO_3$ . PBZ drenches produce compacted vegetative shoots, which are more susceptible to diseases.

**Role of Ethylene in flower induction, yield enhancement, advancing maturity.**

Ethylene keeps increasing in leaves and potential flowering shoots prior to flowering. The increase in ethylene takes places from June to December and sharply after January, the flowering month at Hyderabad (Sindh). Ethylene is higher in the leaves in "ON" years rather than in "Off" years. It may be a flower trigger, though Dr. T.H. Davenport of Homestead (Florida) is of the view that there is consistent lack of evidence regarding ethylene production and development events involved in flowering (personal communication).

**Ethylene application to mango in subtropics.**

Ethrel (Ethephon) at 200 ppm, applied at pea stage, causes earlier maturity by 10 days.

**Ethylene application to mango in subtropics.**

Ethylene is effective in producing flowering in low-latitude tropics. It does not work in subtropics.

Smoke generation can help against frost and it can also induce mango flowering, if done in December and January. It is successful in Philippines in cultivars Pico and Carabao, but result from other areas is contradictory. Smoke contains ethylene. It may work only in tropics.

**Ethephon induced deblossoming .**

Hand deblossoming reduces malformation and delays flowering. A dose of 100 ppm Ethephon or Ethrel at prior to flower differentiation is commonly recommended in Canary Islands for delaying flowering by de blossoming. Delays powdery mildew attacks. Destruction of panicles or deblossoming also Ethrel at 800 ppm works and no leaf damage occurs. Wetting agent at 1 gram per

litre is used. When temperatures are over 15°C, vegetative growth is ensured against flowering. Hand pruning of blossoms and Ethrel increases yield. Ethrel is substitute for hand pruning. Ethrel gives higher yield than control by more than 100-120% against control, and also increases number fruits. Hand pruning give slightly higher number of fruit than chemical methods. Best timing for tip pruning is first week of December, but it works if cold spell continues up to mid February, other wise there is no flowering. On 25°N and S, it will work in some years and not in others.

#### **Flower Induction in Biennial Varieties by Ethephon.**

Ethephon increases flowering and fruiting in "Off" year in biennial trees if applied at full flower stage at 800mg L<sup>-1</sup>. It destroys, apical dominance provided cold weather persists for another 6 weeks. Ethephon at 200-2000 ppm, advanced flowering in cultivar Langra by 15-20 days in an "On" year, but during the "Off" year, it caused heavy abnormal flowering. Langra in heavy feeder and fertilized properly it produces heavy crop regularly. Ethephon at 200 ppm or 400 ppm + 1% urea increased flowering in cultivar Deshri, Ethephon at 400-800 ppm + surfacant, at full bloom stage, improves fruit set and its retention.

#### **Ethephon and yield.**

Ethephon at 500 ppm foliarly applied 6 times from end of vegetative growth in autumn has given higher percentage of flowering and greater number of panicles and fruits in Eghypt. Ethrel (Ethephon) spray at 5 days interval from September onwards increased flower formation on non-bearing shoots in India. Ethephon 200 ppm was used to induce heavy flowering in "Off" yea in biennial varieties. Application started in September in Bangalore India and continued at 15-20 days interval, 4-5 times. Consecutive application for 3 year did not cause and decline in vigour of yielding ability of trees. Ethyrel at 500 ppm one month before flowering increased flowering by 50% in Maxico. Flowering was also advanced by 7-days .Ethrel (48% Ethephon) applied 15 days interval in Maxico starting one month before flowering in cultivar Haden, increased number panicles by 55 and 44% over control, when dose was 1000 and 500 ppm respectively. In Homestead (Florida) on 25°N, KNO<sub>3</sub>, NH<sub>4</sub>NO<sub>3</sub>, Ethephon or combinations have failed to promote flowering.

#### **Role GA<sub>3</sub> in Flower Induction or Fruiting.**

Spraying mangoes with GA<sub>3</sub> (Gibberlic Acid )at 100 and 200 ppm three times, at weekly interval in February and March increases fruit size, weight, TSS and ascorbic acid content. Spraying is done from mustard to pea stage but its dates change from year to year to climatic variation. Gibberlic acid applied to 4 year old mango, two months before flowering at 50 or 100 ppm and at fortnightly intervals increases number of male flowers. Even the number of hermophrodites increases. GA<sub>3</sub> applied at 100 ppm after flower formation produces vegetative growth.

#### **Gibberlic Acid as Flower Inhibitor**

GA<sub>3</sub> at 500-3000 ppm applied on first November and first December inhibited and delayed flowering in following February-March (Timing is about 4 and 8 weeks before flowering initiation). Yield can increase thereby GA<sub>3</sub> sprayed to Taimura in Egypt at 50 ppm in mid November delayed flower opening and increased number of perfect flowers, leading to four times yield.

#### **GA and its effect on chemical composition.**

GA<sub>3</sub> at 50-150 ppm applied to Langra in "Off" year increased N<sub>2</sub>, P, K, Ca and Mg in the leaves and there was more flowering in "Off" year. GA<sub>3</sub> at 50g/L or + urea at 4% increased fruit set by 62.5% and also the yield. Urea 6% + GA<sub>3</sub> at 30 ppm applied on 5 and 20 December in Sindh gave highest yield.

#### **Chemical deblossoming of mango flowers.**

Chemical used are:

- Cycloheximide = 3-{2-(3,5 dimethyl-2-oxycyclohexyl)} at 0.25 to 0.5g L<sup>-1</sup>,
- 2 hydroxyethyl glutarimide. 0.45 to 0.6% 4ml L<sup>-1</sup>,
- Dinoseb = 2 - sec - Butyl - 4,6 Dinitrophenol. At 0.5ml to 1ml L<sup>-1</sup>,
- PCP = Pentachloro - phenolmonohydrate sodium salt. At 5.0 to 10g L<sup>-1</sup>,
- Hydrogen cyanamide (Dormex) at 2.5ml L<sup>-1</sup>,

Early emerging flowering are males. Dormex (hydrogen cyanamide 49%) at 0.5% before 10 January can kill flowers and induce deflowering 4-5 weeks a latter. It increase yield 5-10 times, but climate has to cool and night temperatures below 15°C times, for next 6 weeks, to induce second flowering, Hydrogen cyanamide at 0.4% destroys apical dominance, if applied in November-December. The above chemicals doses can be used for deflowering of mango. New flowers come in 18-25 days if temperatures are right. These chemicals damage the panicles and new panicles develop. They can reduce malformation by producing late flowering. It takes 6-11 days for panicles to wither by 5-7 cms. It takes another 15-20 days for new panicle to emerge and 50% of all treated shoots flower. Cycloheximide causes 50% of leaves to burn severally. Dinoseb does the same damage as cycloheximide. PCP causes petiole burning. Important factor in the process is that temperatures have to be low (below 15°C) for long enough and at least for next 6 weeks to produce abundant auxiliary flowers.

#### **Role of Alar and cycocel in Flower induction.**

Foliar spray with cycocel (chlormequat) at 200 ppm and Alar (damnozide) each at 5000 ppm at monthly intervals induce early and intense flowering, if spray is done at monthly intervals from May to January. There is positive co-relation between ascorbic acid and flower initiation. The number of shoots increases 2 to 3.5 times by its application. This spray dose also works in "Off" year. Effect of the chemicals was to increase fruit bearing shoots by 25 to 90% and reduce respiration rates. With same dose of spray, 50% more flowering have been obtained.

#### **Other growth regulators for increasing flowering.**

In Thailand thiourea at 1.0 or 0.5% sprayed to run off, produced bud break in about 15 days against controls, which took 31 days. Thiourea at 1.0% can produce defoliation. B-90 (N-dimethyl amido succinamic acid) and MH (Malehydrazide), when applied at 5000 ppm to Baganpali delayed appearance of subsequent flush and increased the number flowering shoots and yield. NOA (B-naphthoxy - acetic acid) applied at 50-150 ppm increased N,P,K, Ca and Mg in the leaves and there was more flowering in "Off" year. NOA performs better than GA<sub>3</sub>. Irnthioinine or ascorbic acid at 100 ppm sprayed on biennial mangoes in "Off" years in two successive months after harvest July-August for Hyderabad (Sindh), were effective in making them regular.

#### **Increasing hermaphrodites.**

BA at 50mg L<sup>-1</sup> + Ca<sup>2+</sup> at 2% increased proportion of hermaphrodite flowers.

#### **Increasing fruit size.**

Cobalt sulphate sprays prior to flower bud differentiation in the first week of October is reported to have reduced malformation by 84 to 95%. This may be due to delayed flowering. Cobalt nitrate also improves fruit weight, size, TSS, acid ratio and total sugar if applied at marble stage. The size increase can be as much as 50% or more.

AgNO<sub>3</sub> at 200 ppm at marble stage also increases fruit weight by 50%. Salicylic acid at 1 gram in 100 liters of water applied twice at pea and marble stages, increases fruit weight by 50%. Cobalt nitrate {Co(NO<sub>3</sub>)<sub>2</sub>} at 100 ppm at pea stage and repeated 20 days later at Marble stage. Increase fruit weight. Planofix (NAA 4.5%) 44 grams in 100 litres of water or NAA 10 ppm applied twice at pea stage and 20 days later at in marble stage, increases fruit size. Urea sprays also increases the size as discussed under foliar feed.



## CHAPTER - 17

### IRRIGATION OF MANGO.

Mango is a deep rooted tree and its tap roots can go 8-9 meters (26.66 to 30 feet) deep. The maximum concentration of roots is in top one meter. Irrigation doses, therefore should penetrate to one meter depth. Mango tree can tolerate salts up to 800 ppm in irrigation, water, but enough extra water is needed to leach down these salts from root zone with next irrigation and atleast 25% more water than evapotranspiration. For best yields, most mango varieties in cool areas of subtropics need water in winter too. Water stress affects yield adversely. In warm winter tropical areas, water has to be stopped to stress trees to flower, but yield is poor as compared to cool winter areas, where irrigation is not stopped. If enough winter chill is normally available for flowering, water need not be cut down, as roots are not dormant in winter. With irrigation, they would grow and store extra energy for flowering and fruit development, with lesser fruit drop and better yields. Mango trees could be watered to about 60% of pan-evaporation by trickle irrigation. For flood irrigation amount of water that seeps down is to be applied extra. This is about 25 to 30% of total water applied. There is more seepage in case of winter flood irrigation. In Sindh, on precisely leveled land, at least 63-75 mm (2.5-3 inches) of water is applied by flood irrigation almost every week from mid April to end June and fortnightly in other summer months. In winter evaporation is only 63mm (2.5 inches) in December and February and 45 mm (1.5 inches) in January and evapotranspiration about 65% of it. Rest of irrigation water, thus seeps down carrying nutrients with it. Adjusting flood irrigation to longer number of days can be a solution, if soil can hold irrigation water for that duration. Irrigation practices as followed, in Sindh are only a guess work and are based visual examination of soil. In order to reduce seepage and loss of water the row length should not be more than 75 meters or say about 250 feet. Since rows run north to south and in Sindh each acre is 264 feet north to south and 165 feet east to west, row length of 264 feet will be ideal. If irrigation water is hard, there will be more fibre. Excess fertilizers can produce excess fibre. While planting seeds, husk is removed and seed planted with hump close to ground level.

#### **Practical use of evaporation**

Pan evaporation is more than actual evaporation from large free water surfaces. The latter is 85% of the former. For mangoes, crop factor of 0.8 is considered adequate. Thus means, 80% of Pan evaporation or about 68% pan evaporation. Since data of methological department are based on pan pan evaporation, the factor of 68 may be used but meterological data is already corrected free water surface evaporation, factor of 0.64 is to be considered as crop factor.

#### **Crop factor as related to free surface water evaporation.**



Crop factor for mango during various months in Australia has been calculated and converted to our months in Hyderabad given in table blow:

Table showing mango crop factor in Queensland and Hyderabad Sindh.

Month	Month Queensland	Queensland Factor	Hyderabad Sindh Factor
February	August	0.64	1.0
March	September	0.75	1.0
April	October	0.86	1.20
May	November	0.83	1.40
June	December	0.73	1.40
July	June	0.73	0.9-1.20
August	February	0.83	0.9-1.0
September	March	0.79	0.8
October	April	0.75	0.75
November	May	0.73	0.7
December	June	0.64	0.64

In Queensland humidity is high and therefore, these figures do not apply to Sindh, where they have been corrected for humidity compensation. During flowering very large surface of flowers leads to very high evaporation. Large vertical area of tree exposed to atmosphere at high temperature and low humidity increases evaporation from April to June and even part of July by forty percent.

#### **Mango Irrigation.**

Demand for water in Sindh exceeds pan evaporation by 40% on and after 1 May. In April it is 20% above pan-evaporation.

#### **Water Quality**

Water for mango should be less than 1 deci Siemens per meter 1ds/ m or 640 ppm. 2 deci Siemens per meter 1280 is detrimental to mango tree growth.

#### **Water requirement according to tree architecture.**

Tree has surface feeder roots upto depth of 80 cm (32 inches). They are located between 30 cms from the trunk to about 30-60 cms beyond canopy. Tree also has tap roots which extend to depth of 3.0 meters (approx 9.8 feet). Tap roots also supply water and nutrients to the tree. The purpose of irrigation is to keep at least top 1.2 meters of soil moist.

#### **Flowering fruit set and water requirements.**

On set of flowering makes rapid increase in water requirement of tree.

Large quantities of water evaporate from large surface. In Sindh the evaporation during the flowering period is low because of low temperatures, but humidity

during the period is also very low of 20-25% from mid January to end March. Water loss from flowers can be very high, against evaporation of 2.5 to 7 inches (6.35-17.8 cms ) and in February and March, water requirement can be 1.5 to 3 times i.e., about 7-9 inches.or (18-23cms). At least two fifteen days irrigation are needed in each of these two months. Water stress during flowering can result into poor flower development and limited fruit set. Once flowering and initial fruitlet drop is completed, water requirement will fall slightly by the end of March, but evaporation of 10 inches in April will need at least 3 doses of water. Water requirement then increases reaching its peak 3-4 weeks before harvest. Yield will be less if water requirement is not fully met with, pre mature fruit drop will occur, size will reduce and fruit will be susceptible to diseases. Its post harvest life will also reduce. Water stress during last month of fruit development can increase risk of sun-burn. Reducing irrigation before harvest advances maturity of fruit and increases dry matter content, but there is risk of fruit drop, smaller size and splitting of fruit, if rains occur.

#### **Irrigation during post harvest period.**

Irrigation immediately after harvest will encourage early shoot growth. Early vegetative flush will increase carbohydrates reserves and more uniform flowering.

#### **Dormancy.**

Once vegetative flush is completed, with holding irrigation can stop activating new vegetative flush. In case of late harvest of some varieties from 15 August to 15 September, the new vegetative flush will come around end September.

#### **Tips for managing with limited water.**

- i) Eliminating weed competition.
- ii) Interrow grass sward is mowed down frequently.
- iii) Trees are mulched to minimum depth of 6 or 15 cms.
- iv) Not over fertilizing with nitrogenous fertilizers as new leaf area produced will add to evaporation.
- v) Irrigating at night and applying water to active root area only.

#### **Effect of hard water.**

If irrigation water is hard there will be more fiber.

#### **Actual Irrigation practice in Sindh**

In general in Sindh irrigated mango orchards are applied water as under:

#### **Non Fruiting Trees (Present Practice)**

**Table showing interval of irrigation in Sindh.**

Sr. No.	Season as per Tando Jam Climate		Interval of Irrigation
1-	Summer	(1 <sup>st</sup> April to 30 <sup>th</sup> Sep.)	Every 7 days
2-	Autumn	(1 <sup>st</sup> Oct to 15 <sup>th</sup> Nov.)	Every 10 days

- 3- Winter (15<sup>th</sup> Nov. to 31<sup>st</sup> Jan.) Every 15 days  
 4- Spring (1<sup>st</sup> Feb to 31<sup>st</sup> March) Every 10 days

This seems to have worked satisfactory except doses can some times be too dangerous inadequate.

### Bearing trees (Present practice

Table below shows the practice or irrigation in vogue in Sindh.

Sr. No.	Time	Month	Irrigation Intervals
1-	Flowering	Mid January to mid February	Once before or during start of flowering with fertilizer dose.
2-	Flowering to pea size	Mid February to mid March.	No irrigation
3-	Fruit maturity period.	Mid March to mid July.	Every 10 days.
4-	Rainy season.	Mid July to mid September	Every 15 days, adjusted, according to rain water.
5-	Autumn	Mid September to end October	Once a month usually around first October.
6-	Winter	November - mid January.	No irrigation.

The out-come of this practice is very low yields. Tando Jam has about 225 + 25 Chill Units. Most of local mango cultivars need less than 150 chill units. Cold stress is enough to induce flowering and stopping irrigation water is unnecessary. Water stress of two and half months followed by single dose of irrigation with fertilizers and again this followed by another stress during flowering for a short time, but it probably produces more male flowers due to earliness in flowering. Usually in the southern Sindh, winds with velocities of 15-24 miles (25-40kms) per hour, start from April to September and fruit drop under such severally stressed conditions is heavy, untimely resulting into low yields of three tons per acre. Though this yield is at par with the general average for the whole of South-Asia, but is poor for Sindh, due to its rich soils, adequate, and cheap water of low salinity from the river Indus, dry climate, less pest problems due to very hot summers and cool winter and in general is better managed by the middle class growers. Looking back to mango history in Sindh, almost all early commercial mango cultivars came from South India and the practice of stopping irrigation water came from Coimbatore and Bangalore in south India. The early government horticulturists of Sindh were trained at Pune, also in South India. South India does not have adequate chill and water stress is invariably practiced. Rains coincide with dates of water stress. No rains during flowering protect them from shattering and anthracnose. We imitate this condition of over head rain by stopping to soil, resulting into low yields. Mildew is recent problem in Sindh and spread on a large scale in 1980. It is being recommended that water should be stopped during flowering, as low humidity will provide protection against mildew. Present writers have observed that mildew fungus is fully established in

all orchards and it comes when temperatures rise to 24° C and when temperature further rise to 28° C, mildew is killed. Protection sprays a week or two before and during mildew attack has invariably saved the crop. The present recommendation of water stress has not stopped or reduced mildew. It has reduced yields. Experiments at Mirpurkhas (250-300 Chill Unit) showed that there was no difference in yield, whether irrigation water was stopped or not. The present writers have been practicing irrigation doses of about 2,000mm each to mature trees near (Hyderabad 250 chill hours) as under:

Table showing annual doses of irrigation at writers farm.

Annual Cycle	Months	November of flood irrigation	Total Irrigation Doses
Flowering	15 January to 28 February	Every 15-20 days, depending on soil moisture.	2-3
Pollination to marble size	March	Every 7-10 days depending on how soon warming starts.	2-3
Fruit development to maturity.	1 April to 10 July.	Every 7 days.	14
Post harvest and rainy season	10 July to 31 August	Every 15 days (rain-fall to be adjusted with irrigation dose.)	2-3
Autumn	September - October	Every 18 days	2-3
Winter dormancy.	1 November to 15 December	Every 22 days	2
Flowerbud swelling	15 December to 15 January.	Every 22	1-2
Total annual doses			26-30
Total water applied at 2½inch dose per irrigation			65-75 inches (1650-1900 mm)

**Note:**

On 25° N and S usually mangoes are regular bearers, except those originating from higher latitudes, which turn biennial due to genetic traits. This is case at authors' farm where low altitude South-Indian varieties are regular bearers but not the northern Indian varieties.

In condition of severe aridity, usually there is no pre-harvest vegetative flush except in biennial trees as trees are over stressed by crop-load. Post harvest

recovery takes 6-8 weeks and vegetative flushes occur from July to October depending on early or late harvest October flushes usually do not flower and fruit, except if winter in long. Those which flush in July usually bear fruit next year. The late varieties flush late and become biennial. The October flush could be matured by sprays with macro and micronutrients specially doses of urea.

### **Irrigation of young trees.**

Young trees need more water as wind has tremendous drying affect on young growth. Mulching with 6 inches (150 mm) layer of grass in 6 feet or about 2 meter diameter invariably helps but still they need water, once a week in summer. This 2 meter diameter applies to young trees, but large trees have to be munched under the whole canopy. With out mulching they need water very 3-4 days, as top (150 mm) of soil dries up within a few days.

Rough guide for weekly irrigation of young trees by trickle irrigation is as under:

<b>Year</b>	<b>Winter irrigation per tree litres per week</b>	<b>Summer irrigation per tree, in litres per week</b>
Year 1	50-60	100-120
Year 2	150-80	250-300
Year 3	200-250	350-420

The upper limit will take care of hot and dry areas.

### **Irrigation during fruit development.**

Demand for irrigation water in Sindh is as under:

<b>Months</b>	<b>Dose of irrigation</b>
February	20-25% less than pan evaporation
March	15-20% less than pan evaporation
April	20% more than pan evaporation
May	40% more than pan evaporation
June	40% more than pan evaporation

- With irrigation matching pan evaporation fruit weight is 20-25% more than 65% pan-evaporation and with irrigation 40% more than pan evaporation weight is also 50% more.
- Water deficit can cause fruit drop right up to a few days before harvest and makes fruit size abnormally every small.
- Late vegetative flush of October dose not differentiate into flower buds. Stopping water after late August flushes i.e. around 1st September for 4-5 weeks will not mature this flush and October flush wont come. There are snags that in the same variety all trees do not flush at the same time but are staggered and if more than one variety exists in the same area flushing will not coincide. Thus the practice of this method becomes limited.

### **Flood irrigation and frequency.**

In flood irrigation soil of Sindh, having little slope, usually minimum 2-3 inches (5-7.5 cm) irrigation dose of water is applied. If monthly water requirement is 12 inches the irrigation schedule can be worked out from following example. Most of Sindh soil has water holding capacity of 80 water per meter depth. Assuming we apply 4" doze of water it would wet 1.2 meters or 48 inches soil which can make available 2 inches of water, but in the next irrigation wetted area would be 72 inches and water available will be 4 inches during the week. In the third week water will saturate 8 feet and water available will be 4 inches and as daily evaporation is 0.4 frequency of irrigation could be every 10 days, at rate of evaporation under present water shortage, the best policy will be install piezometers or tensemeters which will pay for themselves within a year.

### **Irrigation of mature trees.**

Bearing trees require between 1,200 - 3,000 litres of water per week, depending of the canopy of tree, humidity and temperature. In humid Queensland it is 200L per week but Sindh is dry and it should be at least 50% more, but again much depends on spread of roots and in rich Indus alluvial soils, root zone is much larger.

### **Stopping irrigation to mature trees.**

Usually limited irrigation is applied in Queensland when trees are dormant and evaporation rates are very low. This period usually is October to January. In Sindh pan-evaporation from first October to end January is 16 inches (400 mm) and trees can get too stressed, for a good crop, if irrigation is stopped altogether. In coastal areas of Sindh, where winter is mild and there are inadequate chill units to break dormancy, water is stopped for many weeks to induce flowering and irrigation is re-started after 60-75% flowers have opened. The present writers of the view that water can be applied at the bud swell, about 15-20 days before medium flower burst. In the presence of adequate winter chill, this practice does not suit arid climate of interior Sindh and winter irrigation may be continued, even if there is some vegetative growth. In Sindh there is normal irrigation canal closure in January and no irrigation water is available for above 3-4 weeks. This is adequate supplementary aid to induce flowering. Again due to shortage of water in the river Indus in February, canal supplies usually are low in most years and trees also get some stress during flowering. Fruit formation is probably more with additional flowering, but fruit drop is very high. It is yet not known, what April to July or level of moisture is optimum for inducing flowering in following January and February months? It is a guess work, without any scientific evidence.

### **Post flowering irrigation**

Frequent irrigation from March to end of harvest period, has invariably increased the yields. In order that October flush does not occur as it will not differentiate into flower buds it is being suggested by some horticulturists that water can be



stopped from 1 September 10 October, but limitation of this method have already been discussed.

### **Post flowering irrigation.**

With irrigation matching 100% pan evaporation, fruit weight increases by 20-25%. Low irrigation delays peel colour development, reduces quality and weight of fruit. Yield too is lowered. During flowering evaporation from flower surface is very high due to large area exposed to atmosphere and frequent irrigation can meet this demand and about 80 cms of top soil have to be kept moist. Egyptian experiments on irrigation 18, 25 and 37 times a year showed yield of 24,5,31.5 and 32.3 kg per tree. The results show that 30 irrigation a year would also give same results. (Horticultural Abstract August 1979). Limited observations by present authors showed that weekly irrigation from end March to 10 July, increased yield by about 20% over the area getting less supplies. Evaporation of 12 inches (308 mm) in each of the months April, May and June in Sindh, is severe enough to cause fruit drop, even with adequate irrigation. High average maximum temperature of 42°C in May and 40°C in June, also causes stress in tree and consequently fruit drop, which irrigation practices probably are not able to cope up with. In a hot arid climate of Sindh fruit drop, its size, quality and post harvest storage life are influenced by irrigation practices, during the growing stage of fruit. No work on these aspects has been done In Venezuela, 7,14 and 21 days irrigation gave yield in ratio of 3:2:1 i.e., 287, 177 and 96 kgs per tree. Importance of frequent irrigation therefore cannot be over looked.

### **Stopping irrigation, dry weather and anthracnose.**

Dry conditions do not seem to be effective against anthracnose, as has been observed in Sindh orchards. The prevailing humidity being below 50% may be helping against some diseases, but stopping irrigation will reduce yields returns.

### **Canopy areas and irrigation**

A thumb rule is to provide about 7.5-8 litres of water per week, per square meter of canopy area of 10 years old tree, if trickle irrigation is used and pan-evaporation is around 50 mm during the week. However prevailing temperatures, humidity, wind velocity and water holding capacity of soil can change water requirement.

### **Irrigation and nutrients.**

Apart from water the requirement of trees, it is allowed to seep down to reduce salt build up in the root zone. This quantity how every small also leaches down nutrients . Application of macro and micro-nutrients has to take care of this essential component of irrigation system, other wise yield will reduce. Irrigation without fertilizing will reduce yield.If salt built up in soil profile is not reduced by leaching through extra irrigation water, yield will also reduce.

### **Irrigation during fruit development**



Water use is 40% more than pan-evaporation during fruit development and in final stage of ripening, it is 60% higher. During flowering and pollination it is lower than pan-evaporation by 20-25%. With irrigation matching 100% evaporation, fruit weight is increased by 20-25%.

#### **Irrigation of bienniality.**

- To turn an alternating tree to regular bearer, water is not to be stopped in "ON" or "OFF" years (October, November and December.)
- Prolonged with-holding water in autumn will cause fruit drop from mustard size to full maturity

#### **Irrigation and flowering.**

Certain varieties like Kali Siroli has high chill requirement may actually get into vegetative phase due to irrigation. It requires stopping water even in sub-tropics having 350 chill hours.

#### **Under tree minisprinklers versus over head sprinklers**

Mango will develop severe disease problems in case of over head sprinklers. There will be severe attacks of anthracnose, stem end rot, bacterial black spot, nutrient leaching from leaves and other minor disease. Under tree sprinklers can resolve the problem by keeping off wetting of foliage. Under tree sprinklers also have advantage of micro spray covering small area in the first two years. In the third year canopy area will increase and be covered by increasing spray diameter. As tree grows bigger, larger sprinklers are used to cover the whole canopy area and 2 feet (60 cms) beyond.

#### **Wetting depth.**

Wetting depth has to be 80 cms to 1 meter (32 to 40 inches) of soil.

#### **Irrigation scheduling and monitoring.**

To maintain soil moisture ten sensors are used. They are cheap and easy to install and can be used by growers themselves and monitored, but they are labour intensive, not accurate in extremely wet soils, and are less accurate in the top 10 cms of soil. The other instruments used are; capacitance probes.

## CHAPTER - 18

### FLOWERING HOW IT TAKES PLACE AND FLOWERING MODELS.

#### **Inflorescence.**

Mango produces usually 10-60 cms long panicle with 1000-600 flowers, which are polygamous, with male, female and hermaphrodite flowers on the same panicle.

#### **Flowering time.**

Time of flower bud differentiation in mango, coincides with beginning of short days of fall i.e, October - November in Sindh. The same applies to lychee and citrus, but in some mango varieties flower in September, showing that flower bud differentiation is independent of short days, unlike lychee and citrus .Flower buds are generally borne on terminal buds of shoots produced during previous season. Hence production of new shoots is absolutely essential. Contrary to common belief, our observations show that cultivar Sindhri flushes four times a year. The non fruit bearing shoots flush in April and subsequent flushes occur in July to October. Flowering in maximum in September flush, followed by August and if flush occurs in October it produces least flowers. July to September flushes is intermediate. April flush produces second flush from August to October and it is the subsequent flushing time of which determines flowering. Flowering time for each cultivar differs from year to year. Ordinary calculations of chill hours below 7.2°, 10° and 12°C, do not give exact clue to flowering date.

There are complex climatic variables like; lowest temperature of the season, hours not only below 10° C, but also below 4.5° C and between 4.5 to 10 or 12° C, monthly maximum temperature differences between average monthly mean and monthly minimum temperatures, soil and air temperatures, relative humidity, saturation deficiency, dew point, continentally, temperature variability after bud swelling , quality and quantity of sun-light, optimum combinations of climatic factors, soil moisture and other unknown environmental factors, which govern, the time and extent of flowering. Night temperature between 10-12° C promote flower initiation. In low latitude sub-tropics, these temperatures are common, but at temperatures below 10° pollen viability is affected and number of hermaphrodite flowers on polyembryonic varieties is reduced resulting into low or poor yield. These and many little understood factors, which govern flowering and its time and vary from cultivar to cultivar and year after year. The annual flowering dates differ from each other so much that no single factor or combination of factors can be used to predict correct dates. In Sindh flowering starts in the first week of January and continues to mid March for different varieties. This is as defective as another model of mango ripening date, in which accumulation of degree days above 16° C with maximum at 35° C is considered as determinant of maturity period of mango and 2,206 degree-hours is considered

as time from flowering to maturity. However, even this model varies from cultivar to cultivar. Both these models essentially are guess work.

Flowers that open when night temperature, are below 10° C are unlikely to fruit, although these temperature promote flowering. This is more so in Australian polyembryonic variety R2 E2, a seedling of Kent. It is polyembryonic and its performance in sub-tropics needs to be verified for temperature regimes.

#### **Climatic modeling for mango flowering fruiting and maturation.**

Base temperature of 12° C has been used for calculating pre-flowering chill accumulation, but this is not reliable as some cultivars do not flower at 12° C in laboratory conditions. Flower initiation may be caused by growth check due to dry weather or cold conditions leading to stress, but stress alone does not lead to flowering. Zill mango has more perfect flowers and bear seven fruits per panicle and against it, Edward has very low percentage of perfect flowers and bears one fruit per panicle. This aspect has not been studied in South Asia, varieties with higher percentage of perfect flowers usually bear large number of fruits, than those with lower percentage of perfect flowers. Most of Pakistan varieties have lower percentage of perfect flowers.

#### **Flowering and fruiting.**

Final number of fruits is in proportion to flowering, but this varies for each cultivar. Cultivar to cultivar flower number do not reflect on numbers of fruits, Hermaphrodite flowers too vary in their ability to fruit, from cultivar to cultivar.

#### **Physical methods for flower induction.**

- Water stress will cause growth check.
- Low temperature have critical minimum, for growth check.
- Atmospheric stress and high vapor pressure cause growth check.
- Stem or trunk girdling can cause growth check.
- Urea sprays at 2 to 4 percent 8-10 weeks before flower bud differentiation development and flowering, increases number of perfect flowers and yield. It also reduces malformation. Some cultivars are self un-fruitful and need cross pollination, which is done by common house flies, insects and bees.
- Increase in number of bees has increased fruit setting even in self-fruitful varieties.

#### **Last vegetative flush and mango flowering.**

Flowering date is more closely related to degree hours below 18°C, than to the date of last vegetative flush. Mango growth ceases at 12°C and ripening date is connected with heat-sum, as well as level of moisture stress before flowering, but it is not well understood. Flowering may be related to both the soil moisture and temperature.

#### **Preventing young mango from flowering in flowering season**

Mangoes can flower in the third year and taking fruit from it would stop its normal growth and maturity. It may not be allowed to fruit in by application of GA<sub>3</sub> at 50-100 ppm, 3-4 months before flowering, as this will prevent flower and differentiation.

Tree should not be allowed to flower in the first three years of their life. Flowers are removed when they emerge fully. Earlier flowering removal may lead to re-flowering.

Keitt which has dwarf size tree can be allowed to grow to mature tree before it is allowed to flower. This will take about 4-5 years. During the third and fourth year, its flowers need to be removed. Even after removal of full length flowers in mid January it reflowers as late as mid March.

## CHAPTER - 19

### BIENNIALLY IN MANGO

#### Environmental factors

Mangy mango cultivars show biennial bearing trends. The cause are many including genetically binnial and are discussed below:

- i) Seedling mangoes cultivars prolonge vegetative growth for periods of 6-8 years or more and grafted ones 3-6 years depending or variety, but biennial cultivars show much longer periods for first fruiting than regular bearers, against seedlings of regular bearing cultivars and also polyembryonic cultivars both of which have shorter juvenile periods.
- ii) Normally under Sindh's climatic condition non-bearing and biennial mango trees, conditions have three to four cycles of shoot growth, and three of root growth, but in regular bearing trees, there are three cycles of shoot growth and two cycles of root growth
- iii) In biennial bearing mangoes four flushes can occur annually one after flowering in shoots bearing no flowers and two or three after harvest. These usually are in April, July, September or October in Hyderabad. Flowering in the next year mostly is on April and July flushes. No flowering occurs in September-October flushes but in subsequent January i.e. after 16-18 months these flower and fruit. It is thus, that the next year's crop is small, while subsequent year's crop is heavy.
- iv) The regular bearing mangoes at Hyderabad show only one or two flushes after harvest up to September and some times October. The first flush though light, produce most of the crop in other words the trees which produce early flush on 25°-28'N, are regular bearers and those not producing this flush become biennial. The late cultivars which are harvested in August usually produce first vegetative flush in September - October and may produce a light crop next year, but much depends on its heredity.
- v) It has also been observed that regular bearing tree either do not produce any flush or produce small flush, while it carries fruit from February to endof harvest. The regular and biennial mangoes therefore, can easily be observed in each April from lack of vegetative flush in regular varieties.
- vi) Alternative bearing trees take 18 months from harvesting to next flowering. Essentially they are late cultivars. Beyond 28° N and S harvest in later than those on 24° or 25° by about 4-5 weeks and there summer temperature also fall down, for new vegetative flush. In such areas even regular mango of farmer areas became biennial.
- vii) In Biennial trees the level of glucose is higher in the "On" year than in the "Off" year and at the time of bud formation glucose and fructose contents of leaves decrease, but during inflorescence they rise sharply. Thus probably, it is

- sucrose content, rather than C:N ratio which is higher in shoots during autumn and winter than in regular varieties.
- viii) Interval between two periods of heavy fruit in some trees may be two or three or more years, and in some cases even six years. Sindhuri variety has clearly shown this cycle of one good crop, two average and two poor in every five years
  - ix) Irregular or biennial bearers have a general tendency to over bear or and exhaust the tree, during the bearing year.
  - x) Early flush of new shoots if mature by mid-August to end September may result in fruit bud differentiation before end October. If differentiation is too late, there will be a crop failure next year. In some varieties flushing as late as November, flower bud differentiation takes place in time to flower in March and also fruit, but this is peculiar to some cultivars but otherwise uncommon.

#### **Alternating habit.**

If tree makes weak growth because of unfavourable temperatures or soil fertility, a heavy crop may take many years or longer. If in Hyderabad flush is inflorescence, and the next flush on the same branchlet is after more than 6 months i.e. September-October and it will take 18 months for this branchlet to flower. This means no inflorescence in the next year.

Internal factors affecting in flower bud induction (FBI), in mango are heredity or genetic and Juvenility. External factors affecting flower-bud differentiation (FBI) in mango are low nitrogen resulting in to low vegetative growth, gibberllins i.e.( GA<sub>3</sub> ) inhibit flower-bud-induction (FBI), Auxin Transport (TBA) promote inhibitors of FBI and auxins and anit-Auxins have no significant effect. ABA or Cytokinin response is not known.

#### **Flush period and flower bud differentiation at Hyderabad on 25°28'N**

##### **April flush:**

Flower bud differentiation is complete between mid-August to end September.

##### **Mid July-Mid August Flush.**

Flower bud differentiation starts by August and completes by end October.

##### **End August Flush:**

Flower bud differentiation, which starts by end August and may or may not complete by November

##### **September - October Flush:**

Usually no flower bud differentiation takes place during the year and no flowering will take place on new shoots. This growth will put on new vegetative growth in next April and flower in subsequent year.

The above should not be considered a hard and fast rule as some regular or late cultivars do not follow these rules.

### **Biennially in the Punjab and North-Western provinces of Pakistan (30°-32' N)**

In the Punjab mango grows up to 31°N. there is delay of about 5 to 6 weeks in flowering and harvesting as compared to those at Hyderabad (25° 28°N). Due to difference in latitude delay in flowering and harvesting is by about 28 days. Hyderabad gets highest summer temperatures in the first fortnight of May against July on 31°N, a delay of 2 months. After completion of harvest in the Punjab in July and August, there is usually limited vegetative growth in late August. The September growth again is limited and does not differentiate into flower buds. The net result is that regular bearing mangoes of Hyderabad are biennial in the Punjab. The following is the cycle of growth in the Punjab:

- a) Limited Vegetative growth in the next year from March to mid-August.
- b) From Mid-August to February there is no vegetative growth.
- c) Fruit bud differentiation takes place between August and December i.e. 12-16 months after harvest.
- d) The spring (March-April) growth produces maximum flower buds in following year i.e. after twelve months.

This pattern is governed by physiological factors namely;

- i) Shoots bearing fruit seldom make extension growth during the whole year on 31°N and seldom bear crop in the next year. For fruiting new growth is essential.
- ii) Shoots making extension growth largely bear crop next season provided extension is early in the season, soon after harvest.
- iii) Antagonism between productivity and growth on the same shoot during the growing season shows that fruiting and vegetative growth is always at expense of each other.
- iv) Most of cultivars of northern India are biennial, whereas most of cultivars of South India are regular showing the bienniality can not be corrected by cultural practices or fertilizing.
- v) Leaves of many mango cultivars are not able to cope up with high demand for photo-assimilates needed for regular flowering and high yield and thus there is more vegetative growth and less flowering.
- vi) There is lack of information regarding actual net photosynthetic rates in leaves in different growing conditions.

### **Bienniality of 15°-30°N and S**

At Kununura 15°-30° Western Australia, many varieties are not only biennial but may show five light crops followed by one heavy crop. In years of heavy crop fruits are small, and in case of light crops fruits are large, respectively making 15 to 20 and 8 to 12 fruits per 6.5 kg tray or box. Yields can be 200 fruits per tree at 8-10 years age. Some trees can produce 1000 fruits a year, of which 60% can be top quality.

**Regular bearing of alternate mangoes caused by factors other than physiological or hereditary.**



Rains during flowering can shed male and female flowers. Besides rains, powdery mildew, which is well established in Sindh and insect and pests also attack flowers and they shed. Farmers are not able to carry out timely control of powdery mildew, which comes when ambient temperature rises to 24°C and is killed by temperatures over 28°C. This period may vary from 4-5 days in some years to 15-20 days in others at Hyderabad. To control mildew at least 3 weekly sprays are needed in some years and farmers fail to do it. Mildew can cause 100% flowers to shed on many shoots. If somehow flowers get destroyed due to rain, wind, mildew and etc, vegetative growth starts immediately and it produces fruit next year. Shoots bearing fruit do not develop vegetative growth, until after harvest.

#### **Alternate bearing standards varieties.**

Biennial varieties produce less mango in “Off” years. Reduction in 10-15% of yield is moderately biennial. 3-7% difference in yield is weakly biennial and 40-80% difference is true bienniality.

#### **Vegetative growth and its relationship to bienniality.**

The productive shoots originate sub-apically or laterally on fruited shoots. Major flush occurs in March-April. If it is carrying substantial quantity of fruit a weak growth may occur on non bearing shoots. If some of flower or fruit branches on biennial variety are pruned in February, March, flush can occur on these shoots and make tree regular. Minor or stray flushes of September-October adversely affect fruit bud development. There is dormancy in fruited shoots after harvest and therefore fruited shoot do not produce vegetative growth soon after harvest. Fruit bud differentiation is favoured by temperature of 8°C to 15.2°C at night and day temperature of 19°C. At RH of 55-75% or more and night temperature of 22°C-13°C also accelerates fruit bud differentiation.

#### **Over coming biennially.**

- a) Early post-harvest vegetative growth by pruning and chemicals or applying nutrients.
- b) Breaking dormancy in fruited shoots that sets in after harvest, by pruning tips of removing whole panicles.
- c) Enriching fruited shoots with nutrients to restore the depleted reproductive energy.
- d) Development of new shoots during fruit development period by removing some flowers.
- e) Reducing heavy crop load in “On” year. Promote sub-tropical or lateral fruit bud differentiation in fruited shoots by bio-chemical methods.
- f) Retarding root activity during “Off” year to suppress vegetative phase and consequently promote reproductive phase.
- g) Genetically non-biennial trees turn biennial due to aging and neglect. Such trees can be made regular by de-harving branches, regular supply of soil moisture, fertilizing, micronutrient application and disease control.
- h) Shoots decapitation can induce flowering in alternative varieties. Timing is 6-8 weeks before flowering.

- i) Shading reduces flowering by delaying flower bud differentiation. Shading has to be removed and trees opened up to sun-light.

Following are some methods of producing more energy in tree to overcome bienniality

- i. Three monthly sprays of  $\text{KHPO}_4$  + urea each at 1% starting one month before harvest to two months later.
- ii. Two sprays of TIBA at 100 ppm at 20 days interval during fruit bud differentiation (December)
- iii. Chemical deblossoming in "On" year by NAA at 500 ppm at full bloom, reduces fruit load and those shoots grow vegetatively and fruit next year.

Pruning one inch (2.5 cms) 2 cm of fruited shoots in mid November, in the "On" year can produce flower shoots in the two to three months and over come bienniality.

These are further discussed in next chapter suggesting specific methods to make biennial tree a regular one to some degree.

## CHAPTER - 20

### HOW TO CHANGE BIENNIALITY IN MANGO

If a tree is genetically (hereditary) biennial it there is no way to make it regular, but if it is not hereditary biennial, following method can be used to make it regular:

- i. About 1 kg of actual nitrogen applied to 15 or more years old tree after harvest and the same amount applied the time of flower bud swelling, can make tree regular. Almost double this amount in "On" year, may induce early post harvest vegetative flush.
- ii. In an "On" year also more irrigation water needs to be applied for health of tree and water may not be stopped in autumn, if it is expected to produce no crop.
- iii. Trees are to be protected from disease, pests, insects and frosts.
- iv. Neelum and Desheri are regular and Chausa, Fajri and Sensation are genetically irregular bearers in Pakistan and cannot be changed by cultural practices. Nutrition and other cultural practices and make only small improvement due to this measure. Irrigation frequently after fruit set will reduce fruit fall, but not change bienniality.
- v. Shoot decapitation induces auxiliary flowering in alternate bearing mangoes, if carried out between October and December, but new shoots can also turn vegetative.
- vi. Langra probably is not genetically alternating in Sindh's environments. It turns biennial due to heavy fruit production, but with increased doses of NPK and micronutrients it become regular after three years. We realized that the variety had potential of 600 kgs of fruit per tree a year and tree was being given less nutrients than removed in the harvest
- vii. Plant stress induced by low temperature, drought and girdling is known to check vegetative growth, but is limited to some cultivars and some geographical locations. Accumulation of carbohydrates in shoot apex are associated with the synthesis of floral stimulus.
- viii. Sawarnarika a genetically alternating but being a late mango was fetching good prices. To make it regular we pruned 50% flowers, 200 mm (8 inches) beyond the panicle at full bloom the production was about 65% in that year but again 65% in the next year two. It still is alternating because only half of shoots new flower each year and fruit size increase is about 30%, but the latter is due to sprays of nitrogen, phosphates, potash and micronutrients from December to mid July a fortnight before harvest.
- ix. Biennial varieties decapitated of panicle or fruits shoots immediately after harvest, followed by 2% urea, once or twice, are induced to an early new vegetative growth which will turn in to flowering.

### **Environments for flowering. Water Stress or Chill Stress.**

In the tropics mango fruit more regularly at 2000 feet elevation or a little higher, than at lower level, as trees get their chilling requirements at these altitudes regularly each year. At low level, there has to be dry period to cause water stress, followed by blossoming. Water stress used an alternative to winter chilling can easily be achieved in dry winter areas by stopping irrigation in autumn and early winter, prior to flowering. Rainy season in South Asia too and prolonged rain-fall before and during blossoming can reduce fruit set, by reducing water stress, interfering with insect activity for pollination and causing mildew, anthracnose and bacterial black spot problems.

### **Stopping irrigation water.**

Stopping irrigation preceding flowering for 2-3 months, helps to induce heavy bloom, where winter are warm. Like dry weather, stopping irrigation, is effective against anthracnose and other fungal diseases, associated with high humidity to a limited scale only and should not be considered as remedy.

### **Flower induction .After stress by winter chill, drought by stopping water.**

After cool winter, flowering takes place over a period of 5-8 weeks from beginning January to 10 April in most cultivars in northern parts of South-Asia. In South India and Sri-Lanka flowering takes place in December after 2-3 months of dry period from September to November. At authors (25° 28'N) farm flowering takes place from 15 January to 10 March for various cultivars. In low chill areas with holding water for 2-3 months before anticipated date of flowering will induce it. Some shy bearers are made to flower by exposing their roots but this does not work in case of varieties inherently alternating. Root pruning is done in different ways. Some times a circular pit about 30 cms wide and equally deep is dug under the canopy, at a distance from trunk where 12 to 19 mm roots are encountered. It usually is done about 6 weeks prior to anticipated date of flowering. Ring remains open for a few days and after adding to each tree 2 to 4 kgs each of Single Super Phosphate (SSP) and Sulphate of Potash (SOP) mixed with soil, ring is refilled. It promotes flowering but its long term effects are not known. The other method of pruning is to dig a part of area under canopy manually or by ploughing implement or rooter. Since each branch of a mature tree is fed by roots usually lying under its own part of canopy different areas of roots are exposed each year, covering whole canopy in 3-4 years.

### **Ringling and Girdling.**

Ringling of shy producers after harvest can produce heavy crop next year. Girdling response to flowering depends up on width of cut. Narrow cuts heal in short time and produce no response, whereas wider cuts can kill tree by starvation, if they do not heal in time. For girdling, tree has to be healthy, vigorous and with mature terminals. Girdling may be injurious to the tree in the long run and as a precaution, half of branches are girdled in one year and the other half in the other year. Girdling has increased flowering and up to 10 fruits

per cluster can be produced. Girdling has given inconsistent consistent results. Its long term Effects are not known

### **Flowering**

Night temperature around 10-12°C and dry conditions promote flowering. Flowers reach full bloom within 25-30 days after initiation. The number of perfect flowers ranges from 1.25 to 81.0%. Late season flowers and those inside the canopy are perfect. Percentage of perfect flowers is higher in the apical rather than central or basal zone of flower panicle. Shoot containing 35 leaves, when ringed below the 20<sup>th</sup> leaf from terminal and terminal bud removed, inflorescence will initiate from the most distal lateral buds. This shows that Auxin causing inflorescence comes from buds. Time of ringing at Hyderabad (Sindh) for varieties harvested in June and early July is about end of August after the first vegetative flush is over.

### **Effect of low temperature during flowering.**

Low temperatures of minus 0.5 to 1.5°C (29-31°F) or lower, can cause damage to flowers or growth flush. Flowers are more tender and can be damaged, even above freezing temperature up to above 4.5°C or (40°F). Baganpali flowers are damaged even at 10°C. If they have opened at higher temperatures prevalent earlier. At mean temperature of 18.3°C (65°F) or below, mangoes do not show any growth and flowering may be delayed. If after flowering average temperatures remain low like 18.3°C (65°F) or in these ranges, where growth rate is low, the fruit will mature proportionately late. This occurs about twice in every 10 years at Hyderabad and harvest is delayed by about a fortnight. Reverse takes place in temperature rise fast after flowering and harvest can be earlier by 2 to 4 weeks. This has been observed to occur once every 10 years.

### **Growth at 20/15°C day and night temperatures.**

Cultvars which do not grow at 20/15°C are: Carabao, Kensington, Alphonso, Desheri, Florigon, Glenn, Irwin and Sensiaon. All of them grow at 25/20 and 30/25°C. Carabo, Kensington, Deshri do not grow at 20/15°C but the rest of varieties grow at these temperatures. The new growth in terms of leaves is proportional to temperatures and at high temperatures leaf formation is more in Kensington. Nam Dok Mai Alphonso, Florigon, Glenn, Irwin, Haden and Sensation produce panicles at 15/10°C. At end of 20 weeks concentration of starch. In the woody tissue of root trunks, is influenced by temperatures. At 30-25°C starch content is 4.8% and at 15/10°C it is 15.9%. Colder months help in accumulation of more starch than hotter months. Irwin accumulates twice as much starch, as any other cultivars at 30/20°C. At 25/20°C Kensington accumulates maximum starch.

This is also shows Irwin can be a better producer, since panicle formation is governed by starch accumulations.

### **Temperature and flower bud induction**

In an experiment in Australia, flower production in Haden mango at various temperatures was as under.

- 15/10°C                      87%
- 25/19°C                      60%
- 31/25°C                      0%

Flower induction at 15/10°C occurs in Kensington, Nom Dok Mai, Alphonso, Florigon, Glenn, Irwin, Haden and Sensation. It needs research to find out flowering temperatures for local varieties of Pakistan. It will help in future breeding programmes.

### **Pollination, Pollinators and fruit set in mango.**

Insect species visiting mangoes are:

Coleoptera, Diptera (flies, wasps, bees), Heteroptera, Hymenoptera, Lepidoptera, and Large ants. Various insecticides reduce insect activity, but deltamethrin (decis) at 5 gram a.i. in 200 litres used for control of hoppers, although reduces pollinators, but their activity, is restored after 3 days. With use of deltamethrin there is increased fruit set as compared with other chemicals. Maximum fruit set per panicle occurs in late panicles and minimum in early panicles being 2.66 compared to 1.66 respectively. Insecticides other than deltamethrin, which have given similar result are Cypermethrin and Fenvalerate. Late flowers have 11.80% perfect flowers as compared to 6% in early flowers in same varieties. Very early, early and mid season panicles produce 1.66, 2.0 and 2.66 fruits respectively. Pests like hoppers and leaf weevil, cause extensive damage to flowers. Highest fruit set is on late emerging panicles.

### **Bees as pollinators.**

Although bees play a significant role in pollination of mango, but they pollinate many other crops near an orchard and their protection is the duty of every grower. Bees are killed by many chemicals and other agents on the farm and these have to be understood by all growers.

### **Bee poisoning and control**

Bee poisoning is caused by:

- i) Insecticides used on crops during flowering.
- ii) Drift of toxic sprays into adjoining crops
- iii) Contaminated water drunk by bees
- iv) Contaminated pollen or nectar collected by bees.

These need control.

### **Pesticides which affect bees.**

- a) Miticides
- b) Organic phosphorus compounds
- c) Carbamates
- d) Organochlorides

- e) Prethroids
- f) Rotenone
- g) Sulfur dust or lime sulfur
- h) Petroleum oil
- i) Herbicides
- j) Defoliant
- k) Desiccants
- l) Pyrazophos fungicides (other fungicides)

Grower can control drift of the chemicals to adjoining lands and not to contaminate water flowing to his or other land.

**Self pollination.**

Self pollination produces 0-1.68% fruit set and cross pollination 6.4 to 3.4% but there are cultivar differences.



## CHAPTER - 21

### CAUSES OF FRUIT DROP

Out of several thousand panicles produced on tree only 0.2 to 0.5% produce harvestable fruit, the rest drop before harvest. The fruit drop may be due to:

- i. Inadequate soil fertility.
- ii. Insufficient soil moisture.
- iii. Low temperatures at the time of bloom. Temperature below 40° F (4.4° C) but above freezing i.e., 32° F (0° C), are associated with lack of pollination and aborted embryo or mostly small fruit.
- iv. Changes in connecting wall between layer of cells in fruit stem and also in abscission layer. These changes are controlled by hormones which in turn are controlled by other factors.
- v. Fruit drop at marble stage indicates that though pollination has taken place fertilization is incomplete, and fruits are embryos less.
- vi. Excessive fruit drop occurs in most of fruit plants and in case of mango more so in the "Off" year. In the "Off" year drop can be as low as 1 to 2%.
- vii. South Asian varieties have mono-embryonic types affected a little by abortion of embryo.
- viii. Fruit production of polyembryonic seeds and fruit fall is associated with abortion of embryo. Development of nuclear embryo is generally sufficient to set and mature crop.
- ix. There is a correlation between perfect flowers and fruit-set in mono-embryonic cultivars. There is a better correlation between fruit-set and polyembryony.
- x. Pests like; scales and scabs weaken panicles by sucking and fruit drop occurs.
- xi. Diseases like; bacterial black spot and powdery mildew are also causes fruit fall.
- xii. In some fruits or their cultivars abscission layer has tendency to form before fruit is properly mature. In such cases fruit drop occurs.
- xiii. Too much summer heat with temperatures over 45° C reaching 49° C in some years, have caused heavy fruit drop by stem end rot, bacterial black spot and etc.
- xiv. Competition between fruits for limited food and moisture supply is throughout the period up to harvest, with better storage of nutrients in tree, drop is reduced. This means tree health is to be maintained.
- xv. In Sindh 25-30% fruit falls down in the months of May and June. It is caused by anthracnose, bacterial black spot, stem end rot and other fungal diseases as well as competition for nutrients. The role of heat stress also plays its part and so does irrigation. There is combination of many factors which need not be repeated. In practice it is caused by changes in connecting walls between

layers of cells in fruit stem or also abscission layer. The changes are controlled by hormones which are controlled by other factors discussed before.

- xvi. Polyembryonic varieties R2E2 is a seedling of Kent. It is polyembryonic and its performance in sub-tropics of Sindh needs to be verified for temperature regimes. Limited experience shows excessive fruit drop, but needs to be watched further.

#### **Climatic modeling for mango flowering fruiting and maturation.**

Base temperature of 12°C has been used for calculating pre-flowering chill accumulation, but this is not reliable as some cultivars do not flower at 12°C in laboratory conditions. Flower initiation may be caused by growth check due to dry weather or cold conditions leading to stress, but stress alone does not lend to flowering. Zill mango has more perfect flowers and bears more fruits per panicle and against Edward has very low percentage of perfect flowers and bears one fruit per panicle. This aspect has not been studied in South Asian cultivars. Varieties with higher percentage of perfect flowers usually bear large number of fruits than those do with lower percentage of flowers.

#### **Fruit Drop patterns and timing.**

As already discussed there are about 1000-2000 flowers per panicle each 5-7 mm diameter and only 0.1 to .5% may mature to produce fruit. Tree cannot support all fruit formed on it and end result is fruit fall according to the following pattern.

- i) The first wave of flower shedding occurs soon after blossoming through lack of fertilization. Drop continues for a few weeks, depending upon cultivar. Cross pollination by bees and other insects can reduce this fall.
- ii) The second wave of shedding takes place at mustard stage. It is competition for nutrients at this stage, when about 5-10% fruit standing on the tree drops. It occurs about 25-30 days after pollination.
- iii) The third wave of shedding takes place between mustered and pea stage.
- iv) The fourth wave of shedding takes place, when fruits are of marble size i.e. 1 to 1.5 cm diameter. Up to 5% fruit falls at this stage. For Hyderabad Sindh area, it occurs at end March or early April, about 30-45 days after pollination. It depends on tree size and vigour and if flowers or fruit lets are too many as compared to tree size, more of them will fall down at this stage.
- v) The fifth wave of fruit drop for Sindhuri and other early or midseason varieties, occurs on ripening in May and 25-30% fruit on the tree falls this stage. It is competition for nutrients and also abscission layer being affected by anthracnose, bacterial black spot, stem end rot and other fungal diseases.
- vi) The fruit fall continues from here onward at a slow rate until the harvest, and break down of stem-end by various disease problems, causes considerable loss of fruit in the last 2-3 weeks prior to harvest.

- vii) In Hyderabad Sindh area wind velocity of 25-40 km from April 15 to end September for minimum 10 hours a day and 10-24 km for another 10 hours also is responsible for fruit drop, through exact losses by this factor have not been studied.

### **How to prevent fruit drop.**

Fruit fall can not be prevented, but can be reduced to a limit and yields increased by the following methods:

- i. Maintenance of adequate soil moisture by irrigating, frequency depending on pan-evaporation, winds, humidity and temperatures.
- ii. Proper weed control by mulching or application of herbicides, rather than frequent inter-cultivation which causes root damage.
- iii. Preventing root damage of tree by agricultural implements.
- iv. Eliminating root damage by water logging and root fungus.
- v. Maintaining adequate supply of nutrients (nitrogen, phosphorus and potash in soil including adequate supply of micronutrients like: copper, zinc, molybdenum, boron, iron, manganese and etc.)
- vi. Maintaining adequate level of nitrogen and reducing excess of carbohydrates.
- vii. Powdery mildew and gummosis control before flowering and after fruit formation.
- viii. Sindh soils are deficient in zinc. Zinc sulphate sprays at 1% can lead to increase in fruit retention by more than 30%.
- ix. Urea at 2% plus 2, 4, 5-T at 20-40 ppm at pea stage, increases fruit size and retention.
- x. Harmonic deficiency removal by 2-4-D at 25 ppm once, or NAA at or planofix or chlorofix or acetic acid at 25 ppm thrice reduce fruit drop at mustard, pea and marble stage. When pedicle is of short length (as in Langra) its fruit does not fall.
- xi. Controlling stem end rot, bacterial blight, anthracnose and other fungal diseases from flowering to harvest.
- xii. Controlling scales, scab, hoppers and other pests during fruit development.

### **Starch loss in fruit drop.**

The abscised fruit of Sensation mango weighed 72 kgs and its dry mass was about 25% or 18 kgs. It contained 7 kgs starch. The 18 years old tree roots also contained about 7 kgs starch. In this tree after initial abscission, of total 1074 fruits, only 350 survived until harvest. The later drop accounted for 4.5 kgs of starch. Thus total starch wasted was 11.5 kgs. This was about 3-50% of total starch in the tree. This loss of starch accounts for low yield in mango compared to its size.

### **Effect of fruit thinning, pruning on tree starch reserves and retention of fruit.**

If a tree sets large crop and is left to its own devices, it will shed more fruit than necessary and thus reduce the yield. Root starch is maximum in January at the

time of flowering and reduces to minimum by time of harvest, when it rises again. Wood starch is maximum in January and gradually comes down to nearly 50% by time of harvest. It further falls down during vegetative growth and rises quickly in October to January. Fruit starch rises with its growth and follows S-curve to harvest. As it rises it depletes the wood and root starch. Leaf starch comes down with fruit development and rises after harvest. Starch falls steeply with fruit development, rises again a month before harvest and reaches peak before start of vegetative growth. On maturation of vegetative growth it rises again. If 50% of fruit is thinned it does not affect number of fruits at harvest, but size is increased and thereby the yield. Thinning of fruit by heading back half of the branches, is less labour intensive and increases fruit size and opens it up for light penetration. If more fruit is left on tree than it can mature, higher is percentage of fruit drop and smaller is size of fruit.

**Early flowering lead to early harvest.**

If night temperatures are low, fruit take longer to develop, since the fruit development slows down. Reverse takes place if night temperatures are high during fruit development.

## CHAPTER - 22

### WIND BREAKS

#### **Wind damage to trees and management by wind break**

Wind may break branches cause misshapen plants, damage fruits or vegetative growth, soil loss, abrasion of plants by blown soil, loss of production or quality of produce. wind blown soil particle hit plant trunk, branches, stems, leaves, fruit and flower and causes damage to plant tissues and through damage reduce carbohydrate production and damage chloroplasts in the leaves. On continuous winds, even at low velocities windward side plants bend in opposite direction misshapen plants and fruit is reduced in numbers and also in size and becomes poor in quality including scratches. On windward side large size leaves are blown away. In general production will decrease. The solution is suitable windbreak scientifically designed.

#### **Windbreaks and essential management tools.**

Winds are damaging to trees and other crops. Imagine winds bending a tree and latter returning it to its position or winds pressing against tree continuously. A 21 foot (6.4 meter) wind mill, encountering wind velocity of 16 miles per hours ( 2.66 kms per hour) will develop 1.0 horse power. The tree must produce that much horse power to keep straight and that energy comes from root, trunk and branches which then produce less fruit to compensate for the loss continuous winds from same direction can bend the tree, defoliate leaves on windward side and reduce its productivity. Cyclones and other gales can completely uproot fruit trees or break branches. They usually cause heavy fruit drop and remaining fruits on the tree gets damage by rubbing. Even wind breaks as low as 20 Kms (12 miles) per hour cause damage by rubbing as well as fruit drop. Cold winds usually being dry, pick up moisture from soil, leaves and flowers, usually delaying maturity and off setting size of crop. Winds also affect pollination insects and also pollinator, by drying out reproductive parts of flowers. Only well designed windbreaks can reduce the damage by winds.

#### **Design of wind break**

Windbreak protection depends up to height of windbreak trees, through their permeability, direction of winds with respect to wind breaks, wind velocity and distance between the wind break rows. Taller the wind breaks more effective they are, but effective height of windbreak is its height above the crop it protect.

#### **Permeability.**

Windbreak should have some amount of permeability for some of air to pass through and to balance effect of wind passing over the wind break and causing turbulence, which will be damaging. In ideal conditions about 45 to 55% permeability to windbreak is considered as ideal. It will reduce wind velocity to almost half, above the crop. In normal winds occurring annually at not more than 40 kms in Southern

Sindh, but most of the time below 25 Kms, this is ideal, but cyclones can even uproot the wind breaks and damage trees, Slight movement of wind through wind break forms a cushion to slow moving air on both upward and downward side and therefore no turbulence. Once windbreak causes turbulence on upward and downward side it is more on downward side. If permeability is low, protection can get reduced and even damage can occur in it. Turbulence can be highly damaging in or breaking limb of trees. Windbreaks laid in square pattern will be better for facing wind velocity from any direction and calculation of wind break should aim at 15 kms. Wind velocity above the crop to be protected. This could be achieved by keeping height of windbreak above the crops  $1/9^{\text{th}}$  of the height of wind breaks. Generally  $1/10^{\text{th}}$  is considered as suitable but  $1/19^{\text{th}}$  has proved more effective. If windbreaks are too wide, they protect fewer acres. The width of wind breaks from each other should not be more than 9 times its height above the crop.

Any gaps in the windbreaks can cause serious funneling and turbulent conditions. Access roads invariably become a serious problem. Our experience shows that wind breaks three times as wide as the access road on opposite side of access may overcome the problem.

#### **Permanent wind breaks.**

They must be planted some years before planting the tree crops, so that they protect the crop from first year onwards, when trees will be only 1.0 meter height and would reach 5 meter height in next 5-6 years.

#### **Types of wind breaks**

They may be categorized as permanent or temporary as planted or constructed and also dense or permeable. Temporary wind breaks provide protection to young plants for short periods, though they are planted close to plants to be protected. They shade them and deprive them of sunlight and may even compete with the plants for moisture and nutrients.

Permanent windbreaks usually are tall trees, but they should be fertilized like the plants to be protected and also insects and diseases controlled.

Permanent windbreak trees are to be very tall and with enough foliage to act as wind break. A trial in Pakistan showed that *Eucalyptus camaldulensis* is not a good wind break as it loses lower branchlets periodically and bottom is always open to winds. At the top too it has limited foliage, besides its root system is should 30-60 meters beyond all sides and deprives all trees of moisture and nutrients in that area.

For every country local pines or *agathis robusta* will be most suitable. For Sindh Jamun is highly suitable reaching a height of 20-25 meters and dense enough to stop at least 50% of wind. However it is host of all mango and other fruit crop insects and must be sprayed along with later, whenever they are spread.



### **Some important precautions.**

Single row windbreaks are used where land is so valuable that only small space can be spared for windbreak. This applies to both Sindh and the Punjab, where single row windbreak is planted. Windbreak tree species must retain their foliage to ground level and top should be fairly dense. Jammon or Jasmolan is suitable wind break for Sindh. Wind break rows of three to four are more effective and are less effected by gaps caused by missing trees. Jammon is slow growing and fertilizing and plant protection can enhance its growth and height. It can be single row due to its thick foliage. A wind break provides shelter up to 25 times its height, but trees to be protected may also be tall and therefore protected length  $L = (T_1 - T_2) \times 9$ , where  $T_1$  is height of wind break,  $T_2$  height of trees to be protected, with all units in meters or feet

### **Synthetic wind breaks.**

They are made of plastic but are costly to install, though have low maintenance cost of on irrigation, fertilizing and plant protection. It reduces wind velocity uniformly and is more efficient.

Perforated plastic sheets are supported on pine or steel posts 100 mm diameter for moderate winds are 150 mm posts for strong winds. The plastic has to be permeable by about 40%. The main components of such windbreak are:

- Pine posts.
- Nail and felt washers.
- Galvanized flats or clouts
- Staples
- Bluemet of about 1.0 to 1.5 meters.
- Cement, and sand

Presently it will be costly to have the synthetic wind breaks in Pakistan.

### **Some advantages and disadvantages of windbreak.**

Although wind breaks have some advantages, but wind has some benefits as it plays an important role in pollen and seed dispersal and has important advantage of cooling plants on the summer days of high temperature provided that the soil has enough moisture to stop desiccation. Gentle winds prevent development of stagnant atmosphere and deter plant diseases that might otherwise thrive. While this works winds may discourage beneficial insects and make it difficult to control pests and diseases and weeds. Spraying is difficult during winds due to drifts in other non-target plants. Strong winds during high temperature increase water loss from plants, leading to desiccation. Even moderate winds have detrimental effect and prevent plants from reaching full potential, where temperature are low and there is continuous wind, plants suffer frost damage. In general windbreaks have numerous advantages and are rarely disadvantages.



## CHAPTER - 23

### TRAINING OF TREE AND PRUNING FOR MAXIMUM HEALTH AND PRODUCTION

#### **Why to prune and train.**

There has been no work or data on effects of pruning and training of the trees for early yield in the South Asia, but data from USA and else where, have shown astonishing results of training of trees and grafting on nine month old root stock; and transplanted three months later. They produced first and appreciable crop in the third year but we pruned flowers to get crop in year four. It was an outcome of proper management, high density planting, regular irrigation, year around mulching as an alternative to intercultivation for weed control, applying macro and micronutrients foliarly, retarding wind effects, disease control, pruning to shape trees ideally to vase -shape, and cultural operations to combat climatic extremes and etc. Training started from the date of nursery planting. It was also observed that, those factors had positive influence on the growth and girth of trunk and early flowering.

#### **Young mango tree care and training**

Young mangoes have same leaf, stem and root diseases as to mature tree and in South Asia the mortality is very high as plants are available from rural and primitive nursery men, who use diseased stones for seedlings, which take about a year to 18 months to be ready to graft instead of 6-9 months.

The growers are also advised against local people's practice of covering trees in hot and cold climate. Locally non-technical people cover plants against hot summer Southern winds in summer and direct sunlight. They make a small conical hut covering it the plant and leave a small opening to the North. No sunlight falls on leaves, photosynthesis is reduced and mortality can hit 25%. However water is applied weekly.

When winter comes to save trees from cold winds of north, trees are covered the same way leaving a small opening to the south the mortality can hit another 25%. We have developed a method of putting mulch consisting of weeds, grasses etc, around the young trees about one foot (30 cms) around the stem and 18 inches (45 cms) high, leaving only leaves of plants outside and even on frosty nights the mortality is reduced to less than one percent. The mulch actually raises ground temperature by about 5°C and roots do not get damaged.

As regards fertilizing of different countries have been using different doses and none of them are in agreement. For young trees recommendation similarly vary. Many years experience have shown us that small monthly ground doses of NPK every month of from February to end October in all 9 times a year gives good growth and also weekly sprays with 1% urea have enhanced growth. In addition

we have been using urea 1% triple super phosphate, 1.0% and potash 1.33 % along with 250 grams each of copper and zinc, 125 grams of manganese every month along with pesticide or fungicides and also 250 grams of boron once a year. These plants remain very healthy and have fruited in 3 years, a commercial crop is produced in year 5 and maximum yield derived year 7.

We allow trees to grow on single stem until about 40-48 inches (1.0-1.2 meters) tall, then cut off top 3-4 inches (7.5-10 cms) immediately below a whorl of leaves and 3-4 branches grow from below the point of cut. If they are less a second cut one or two inches below this point will give at least 4 branches .They can be bent to form about 45° angle with the main stem or trunk by spacers or by using soft plastic strips .When these four branch became a 18 inches (45 cms) long they are tipped to produce two branches .This process is repeated for 3 years when each original four branches produce total 32 branchlets. These could produce fruits in year 4 but it may be better to allow them to grow a little more and flowers are removed to get first commercial crop in year 5.

#### **Commercial cultural practices.**

The common shaped produced for commercial practices are:

- Pruning for light penetration.
- Pruning to produce vase -shaped tree.
- Pruning to produce hedgerow.
- Pruning to produce pyramidal trees.

None of these methods are known or practiced in Pakistan except by a couple of growers in the Punjab.

#### **Objective of pruning.**

The chief purpose of pruning is that basic tree structure should have freedom from poor crotch angles and tree should be established in the first three years after planting. After three years no further tree structural training is done, except for removal of damaged mishapened or porturding limbs. This factor is invariably neglected, as there is no emphasis on this subject in South-Asia. Wisely pruning can maximize light interception by the trees, resulting in to better health and high yield. Department of Agriculture in Sindh has been recommending 45 or 50 feet spacing between trees, in square pattern for most of cultivars and even for semi-dwarf cultivars like Banganpali Deshri, Neelum, and Swarnarika, 35 foot spacing was adapted against their recommendations. Trees did not meet each other even in 20 years. The tree spacing as recommended by the department in 1960s 17, 20 and 27 trees per acre at 50 x 50 and 40 x 40 feet many places tree did not occupy the entire space in 35 years and therefore in the year 12, we planted one additional tree at the center of each square, making 70 trees per acre. The wide spacing was essentially based on old practices of *Malis* or gardeners who knew that with prevalent cultural practices, fruit trees do not give economic return for the first 12-15 years and common convential crops are raised as intercrop. This practice continues to this day and they plant cotton, wheat, oil seeds, vegetables, and etc in the inter-space. The different

cultural, nutritional and irrigation requirements of two competing corps, further delay fruiting of trees and give economic returns.

### **Pruning from nursery tree to first fruiting season.**

It is preferable that nursery plant should be about 30 inches (75 meters) tall at the time of planting and if not, it should be allowed to grow to that size on a single stem after transplanting, before training operations are commenced. The end of main shoot should be snipped, when about 30 inches (75 cms) tall, so that three or four shoots emerge from this point vertically up or horizontally but not down-wards. These shoots will be future branches or scaffolds. Low initial branching at 30 inches (75 cms) is desirable for manual harvesting and there should be no branches in first 24 inches (60 cms). Keitt should have no branches in the first 1.0 meter as its long panicle will touch the ground and fruit will be spoiled. Shoot should preferably not form at the same point, but be spaced from different points on the trunk in different directions. Inside of tree should have no sucker growth and, emphasis should be placed on spreading

Rather than allowing tree it to become tall it is allowed to spread Dead wood should be removed as it occurs. Tree height should be controlled, so that tree is not more than 6 meters tall at maturity. Length of three or four shoots or branches should not touch the ground but should be horizontal at maximum 45° to the ground. The side branches will again develop new shoots when pinched or shortened to 45 cms (18 inches). They should be allowed to produce 2 or 3 subsidiary shoots. No further training is needed. Major pruning of bearing trees should be done immediately after harvest. Secondary pruning to remove suckers may be carried out in winter at the commencement of canopy dormancy. Spread of tree branches to interfere in the other branches other trees should be prevented by pruning.

Seedlings usually go straight up. If grafted at about 12-18 inches above the ground. New branches can be left at 24-30 inches (60-75 cms) height. In high density planting increased yields are possible from high and selective pruning. Branches and subbranches should be at 45° to horizontal and 90° to each other to minimize wind damage. Branches near ground are topped every 3 years.

### **Pruning bearing trees.**

Bearing trees showing signs of congestion have to be pruned to improve yield and quality of fruit. If tree is too tall, all branches are cut back to 3-4 meters (10-13 feet) from ground level. Tall branches are cut back to a point, where there is strong evidence of side branches. Standing back and observing the tree will give good idea, where to prune.

Allowing some branches to help shading of trunk and avoiding sun-burn is essential for success of pruning and training. In pruning bearing trees heavily, it is best to retain all basic frame work, but cut large branches back to healthy wood. Severe skeletoning consist of cutting back the frame, to work to a point, where 1 or 2 meters of main branches are left. Best time for pruning is immediately after harvest, to allow

maximum growth in July-October period. Heavy fertilizing alone can guarantee adequate growth.

Sucker growth is very prolific, if trees are heavily pruned. Several of vigorous shoots arising from upper sides of branches are retained for future basic frame of tree. Unwanted sucker growth may be cut down in winter and process of sucker removal is continued, until selected shoots dominate. All internal shoot growth may be pruned in early stages of development. Tree height should be limited to 6 meters, though shorter than this is better. Side branches of tree may be controlled at convenient height, so that fruit does not touch the ground.

Secondary pruning season is during dormancy in early winter. It will take two and some times three years for severally pruned trees to begin cropping again, but fruit produced will be greatly improved in size, appearance and quality. Pruning every 5 year, or pruning 20% of tree a year is probably the solution in a mature tree. In our own program we prune one fourth of tree every year and thus renew the whole tree every fourth year. We also cut about 8 inches of all branchlets beyond panicle after harvest as new growth after harvest to flowering of each branchlet or shoot is about 8 inches (20 cms). This keeps size of tree nearly the same for many years.

#### **Pruning of mature but too tall trees.**

Pruning of mature tree is essential to keep the trees to manageable size for spraying and harvesting. Pruning is done immediately after harvest. Topping of tallest branch of tree is done at about 4.5 meters or about 15 feet. Pruning back of low branches is done to stop their interfering with other trees or each other. Interior of tree has to be opened up to allow sun light and spray penetration, where growth is too thick. Excessive long growth is cut back irrespective of where it occurs. Branches are cut back above the growth rings which have multiple buds.

#### **Pruning non bearing young trees.**

Ideal tree should have 3 or maximum four branches and not more.

Tree height should not exceed 6 meters, so that future harvest takes plants from ground.

Pruning is carried out with purpose of

- a) Shaping trees
- b) Opening center
- c) Allowing free movement of air in the tree.
- d) Allowing sun light to enter the trees.

The trees may be allowed to grow to one meter height, then cut back to 0.6 or 0.7 meters. The cut is to be given just below a whorl of buds. If cut is given above whorl of leaves or bud 7-8 branches will develop and even when thinned to 2 branchlets, this will be a weak point. If cut is given just below whorl or leaves, there would be only 2-3 shoots and all well spaced and strong. These shoots may be allowed to grow 1.0 meter and cut back below the whorl at length of 0.6 meters or even 0.5 meters.

## **Mango decline**

Mango decline is caused by many fungi and nutritional deficiencies. The fungus cause tip die back, gummosis and vascular discoloration. In South Asia major case is fungus *L. Theobroma*, blight, canker, defoliation by anthracnose, die back, gummosis, wilt vascular. Remedy to all this is pruning of infected limbs and encourage new but healthy growths.

## **Hedgerow in fruit cropping**

### **Hedging.**

Hedging has been tried commercially in Florida. Tree rows are 25 to 30 feet (7.5x9 meters) wide with trees at 20 feet with in row giving 72-87 trees per acre. When congestion starts, the hedge is clipped by machines after every 5 years after harvest on the top and sides. There is no crop for next year, but the following year a good crop is harvested. Some growers hedge one side of row in one year and another side in another year. This way about half the crop is harvested in those two years. It appears very promising. It has been tried in Australia, with plant spacing at 4 to 6m (13-20 feet) within the row. Row space however has to be more to allow sun-shine on both sides of rows which run, north to south. Tree height is not allowed to become more than 6m (20 feet). Vase shaped sides of tree row, allow fruit to hang along the free side of foliage and maximum area is exposed to sun-shine. For hedgerow, trees are allowed to inter-grow and then pruned to two outer-sides to create hedge row effect. Tops of trees are also pruned.

## **Tatura trellis.**

### **General**

A new method training this tree on wired trellis called Tatura trellis has been tried at Tatura in Australia. In this method up to 200 trees are planted per acre. Management of tree size is achieved by growth regulators. In most mango cultivars flowering takes place on lower and more horizontal, branches of the tree. Flower emerge from shoots which are two to six months old. Growth regulator are used to induce regular flowering. Flowering of tree is genetically connected with mother plant and selection of mango cultivars is done to suit the trellis system by keeping spacing of trees as under:

- Row Spacing 6 meters
- Distance between plants. 1 to 2 meters

The two arrangements give plant density of 666 and 333 trees per acre.

Mechanical harvester called Trel-Pik built to harvest can pick a number of fruits with out difficulty, but in South-Asia manual methods may be used.

### **Implication of trellising for this tree.**

The mango trees usually produces 3 to 5 flushes a year. Least vigorous varieties of temperature fruits are suited to trellis, as they take time to develop canopy. Studies are being conducted at Kunnuurra (West Australia) on 3 varieties of this fruit crop, grown on trellis system.

### **When to prune**

Best time to prune is, just before tree starts a new flush and since a number of flushes occur annually it can be before any flush. Bearing trees may be pruned immediately after harvest. Pruning should also include removal of all dead wood.

### **Care and after care in pruning.**

Pruning should be done with a saw or sharp object and diagonally at about 10 degrees to avoid damping of rain water on the cut surface. The cut should be painted with lime dissolved in water or PVA. No major pruning should be done to a tree less than three to four year old. Bearing trees if pruned severally will fruit after about three years. Next pruning should start twelve year after first pruning. Fertilizing and irrigation has to be regular. Moderate pruning of young trees in the first three years of life will help establishment a healthy orchard.

### **Sunburn**

In pruning care may be taken that southern side branches are not cut down low enough to expose trunk to Sun light.

### **Central leader versus open vase.**

Central leader and closed vase trees have fewer terminals shoot the yields are subsequently lower Open vase has advantage over other systems except palmate. Number of open vase trees per acre will be about 66.6% of central leader, but yield in kgs/m<sup>3</sup> will be more for open vase, ultimately central leader will have more yield per acre, but not in initial years

### **Principles Of Pruning and Definitions.**

**Heading.** It means cutting of shoot or branch to remove a portion of them. A portion of shoot or branch is removed and a portion remains.

**Tip pruning** It means light heading and a small piece of top and of a shoot or branch is removed.

**Tipping.** It means removal of only the apical bud.

**Thinning** It means removal of an entire shoot or branch and cut is made flush with adjoining branch.

Pruning encourages new vegetative growth and new leaves are efficient producers of carbohydrates. Thus new shoots play an important role in replenishing carbohydrates.

### **Mango Tree Pruning.**

General principles:

Tree has to be single stem and when more than 1.0 meter say 1.2 meters, they are pruned to 0.8 to 0.9 meters to start branching. In case of keitt they are allowed to



grow to 1.2 meters and cut at 1.0 meters for branching. The heading to branch should not be performed during November to February, the dormancy period. Is March to October is most appropriate time. Done during cold month inflorescence may come up which is not desirable. Once shoots start they are tipped i.e, only apical bud is removed and as few as possible leaves are removed. Removal of none of leaves is better. Tipping is done when the shoots are pencil thick. Weak shoots are not tipped until they become pencil thick. Tipping is done from March to October and not during cold period.

### **Size Maintenance Pruning.**

Early fruiting will limit size of canopy and reduce yield in subsequent years. Yield is directly related to the size of canopy and canopy has to be allowed to grow to occupy the allocated space before fruiting. Once in fruit, tree grows only a short time after harvest. Crop load also determines how much energy is available for vegetative growth. In the trees bearing heavy crop post-harvest vegetative growth may be delayed and may not occur until next spring Thus tree bears no crop. In cultivars, which are late and have tendency to bear heavy crop (Keitt and Kent), the fruiting may be delayed for 3-5 years, so that they occupy the allocated space .They can also be planted very close for best results. In high density planting at 2x5m or 400 trees per acre, first crop can be taken after 3 years. When young, the trees can be pruned 2 inches (5 cms) behind the point of stalk (penicle) bearing the fruit.

### **Size Maintenance Pruning.**

It is performed shortly after harvest All growth which occurred after previous seasons harvest is removed. If hedging is done, it is performed every four years. Prolific flushing must occur shortly after size maintenance. Water and nutrients should not lack after harvest. Mango weevils hide under crevices and loose bark. Size pruning eliminates them.

### **Training For High Density Planting.**

There is tremendous scope for increasing productivity of an orchard by increasing planting density. Tree and size can be maintained by heading back branches shortly after harvest and being the site where latter bud broke and developed after previous harvest. Trees have to be pruned to create a compact tree which will fill allotted space in shortest possible time of 3-6 years.

### **Fruit thinning.**

Fruit thinning of Sensation mango can double the revenue. Thinning is effective if done early leaving one fruit per panicle. Size increase is substantial and tree revenue could double. Its yield is reduced by about 12%. Revenue is highest for 20 March to 10 April thinning in Hyderabad. The yield of un-thinned tree is slightly higher by 10% but market prices are low. The maximum revenue comes from 50% thinning which reduce number of fruits by 25% but total yield in terms of weight would be the same.

### **Conclusion**



Pruning of tips does not increase yield and it can even be less by 5%. Apical bud pruning gives higher yield than pruning 5.0 cm depth. Difference is about 20%. Pruning increases fruit size. Later the pruning, greater is the size. Earlier the pruning less is size increase. Very late pruning is risky.

### **Special pruning methods for dwarf and heavy bearing mango tree.**

Both have apical dominance and branches are cut back regularly to improve tree size.

The following are some steps to be followed:

- a) Branches are cut back behind a node and
- b) When growth is crowded some branches are removed.
- c) Shoots which are not exposed to sun light are pruned, to improve light penetration, air circulation and free spraying the interior.
- d) Low growing branches are removed.
- e) Upward growing branches are pruned at 4 to 4.5 m.
- f) Tree height for high density planting has to be controlled to maximum 6 meters and not beyond.
- g) Branches should not touch the ground.
- h) Major pruning should be after harvest.
- i) Secondary pruning may be carried out in November at commencement of dormancy.
- j) Trees should not interfere with each other.
- k) Increased yields are possible from high density planting and selective pruning.
- l) Pruning reduces time to flower, flowering period is shortened and harvest dates are shortened to 2 to 3 pickings. By pruning the tree on 15 December, we can induction of flowering will start on 13 January, after 28 days. Flowering duration will be about 45 days i.e., up to 28 February thus pruning has to be 45+28 days earlier i.e., latest on December 15. One can start pruning or chemical spray on December 10 and complete it on December 15.

### **Tree height.**

Pruning is aimed at producing a tree about 6m height

### **Height of branches.**

The tree after planting is pruned so as to start branching about 30 inches (75 cms) from ground and three to four branches are selected. These branches should preferably be at different heights in different directions. This is done by snipping rather than pruning.

### **Side Shoot Or Branch Pruning**

Side shoots are snipped at height of about 20-5 cms, allowing two to three shoots to dominate. Downward growth is prevented by pruning.

### **Distance within the row.**

4 to 6 meters is probably correct distance, if height of tree is not more than 6 meters. If tree height is restricted to 15 feet (4.5 meters) tree spacing can be 3 meters in the row.

### **Pruning of Bearing Tree.**

The following factors are to be kept in view

- i) All internal shoot growth may be pruned in early stages of development.
- ii) Tree height should be limited to 6 meters.
- iii) Tree side branches may be controlled at convenient height, so that fruit does not touch the ground.
- iv) Major pruning season is after harvest.
- v) Secondary pruning season is about November on early December.

### **Rejuvenation of mango tree.**

When tree is too tall its branches shade lower branches, cut entry of light and production lowers. To restore production it is cut back to 4-5 m (13.3 to 20 feet) above ground level. If branches have started at lower height, tall branches are cut back to a point, where there is strong evidence of side branches. Standing back and observing the tree will give good guidance. Where to skeleton the tree allowing some branches to help shading of trunk and avoiding sun-burn is the best solution. Painting trunk with white water soluble paint or 20% lime in water and 1% Copper Sulfate will resolve the problem but long lasting paint are also available Annual repaint maybe needed till near foliage shades the trees. Best method is to retain all basic frame work but cutting large branches back to healthy wood. Severe skeletoning consists of cutting back the frame to work to a point where 1 or 2 meters of main branches remain. Best time for operation is June or July to allow maximum growth in July-October period. Sucker growth is very prolific on trees which have been heavily pruned. Several of vigorous shoots arising from upper sides of branches may be retained for future basic frame of trees. Unwanted sucker growth may be cut in about November and continued until selected shoots dominate. It will take 2 years for severally pruned trees to begin cropping again, but fruit produced will be greatly improved in size and appearance

### **Young mango tree care and training**

Young mangoes have same leaf, stem and root diseases as to mature tree and in South Asia the mortality is very high as plants are available from rural and primitive nursery men, who use diseased stones for seedlings, which take about a year to 18 months to be ready to graft instead of 6-9 months.

The growers are also advised against local people's practice of covering trees in hot and cold climate. Locally non-technical people cover plants against hot summer Southern winds in summer and direct sunlight. They make a small conical hut covering it the plant and leave a small opening to the North. No sunlight falls on leaves, photosynthesis is reduced and mortality can hit 25%. However water is applied weekly.

When winter comes to save trees from cold winds of north, trees are covered the same way leaving a small opening to the south the mortality can hit another 25%.

We have developed a method of putting mulch consisting of weeds, grasses etc, around the young trees about one foot (30 cms) around the stem and 18 inches (45 cms) high, leaving only leaves of plants outside and even on frosty nights the mortality is reduced to less than one percent. The mulch actually raises ground temperature by about 5° C and roots do not get damaged.

As regards fertilizing of different countries have been using different doses and none of them are in agreement. For young trees recommendation similarly vary. Many years experience have shown us that small monthly ground doses of NPK every month of from February to end October in all 9 times a year gives good growth and also weekly sprays with 1% urea have enhanced growth. In addition we have been using urea 1% triple super phosphate, 1.0% and potash 1.33 % along with 250 grams each of copper and zinc, 125 grams of manganese every month along with pesticide or fungicides and also 250 grams of boron once a year. These plants remain very healthy and have fruited in 3 years, a commercial crop is produced in year 5 and maximum yield derived year 7.

We allow trees to grow on single stem until about 40-48 inches (1.0-1.2 meters) tall, then cut off top 3-4 inches (7.5-10 cms) immediately below a whorl of leaves and 3-4 branches grow from below the point of cut. If they are less a second cut one or two inches below this point will give at least 4 branches. They can be bent to form about 45° angle with the main stem or trunk by spacers or by using soft plastic strips. When these four branches became a 18 inches (45 cms) long they are tipped to produce two branches. This process is repeated for 3 years when each original four branches produce total 32 branchlets. These could produce fruits in year 4 but it may be better to allow them to grow a little more and flowers are removed to get first commercial crop in year five.

## CHAPTER - 24

### WEED CONTROL

#### **Weed Control By Intercultivation Between Fruit Trees**

There are many method weed control of which most popular in South Asia is intercultivation. It has many advantages and dis-advantages, discussed below.

- i. The greater and worst enemies of fruit trees can lower yield by 33%.
- ii. The trees which are intercultivated in summer produce more leaves during flush and also yield more.
- iii. If there is clean cultivation in winter and ground temperature is higher, than if it has grass growing on it. For this reason clean cultivation of small trees can help in their survival in winter, spring and fall, but not in areas of winter frost as night temperature of surface of soil will be low due radiation from soil. However clean cultivation can raise root temperature during day but not at night. The relationship between root temperature and flowering has not been studied for mango.
- iv. The plant should not be intercultivated within canopy from April to harvest as bare soil can get heated up and reflect heat to fruit, which may develop internal break down.
- v. Digging, and disking causes feeder root loss productive tree can lose lot of yield by frequent digging with harrow.

#### **Weed control in young trees.**

Grass cover should be maintained between rows and controlled by slashing. Mulching around the trees can reduce weeds and lower ground surface temperature during the day and raise it at night time.

#### **Herbicides.**

Cover crops have usually failed to establish and farmer resort to intercultivation resulting into rootlet damage. Herbicides can get rid of weeds but leave soil bare and prone to temperature fluctuations. Shredder mowers are most common and can be used to some degree of slashing weeds and grasses, but are difficult to use under the trees. For high yields, one meter radius around newly planted trees should be kept free of weeds year around by herbicides, mulching or slashing.

Herbicide Gramoxone is used for general weed control and Glyphosate (Round up) is used for hard to kill weeds. Any contact of herbicides with trunk or leaves is to be avoided. Gramoxone (Paraquat) 0.5 litres per hectare is applied twice annually and gives better control of weeds. For short lived weeds, Paraquat (Gramoxone) or Diequat (Reglone) or mixture of these like Triquat at 1.5 litres / 200 litres, and 300 ml wetting agent is used. For broad leaf weed, Diquat at 30 m per 200 litres of water is used. For perennial weeds, Glyphosate at 1 litre / 100 litres of water is used.

**Pre-Emergence Weed Control.**

In order that weed seeds may not emerge the following three herbicides are used as pre-emergence application and ploughed in 15 cms(6 inches) deep.

- Diuron + Orzalin.
- Diuron.
- Simazine.

They kill weed seeds and weed roots and give protection to young crops for a few weeks.

**Mulching**

Mulching is a new tool in weed control and orchard management and is discussed in next chapter.

## CHAPTER - 25

### MULCHING

Mulching leads to the development of healthy soil, adds organic matter, NPK and micronutrients to soil, makes, root zone porous, increases moisture in the root zone, help drainage and aeration, lowers soil temperatures in summer, raises them in winter, increase soil fertility and helps in quick growth of plant, early first fruiting and higher yields, by suppressing weeds, providing nutrients and even antibiotics, growth regulators and hormones also aeration to the roots.

#### **Permanent bed cropping of fruits nuts and some perennial tree crops.**

Permanent bed cropping for annuals or non perennial crops is being promoted for the past 10-15 years in South East Asia and Australia. Its advantages are that soil is not being compacted and weeds and stubbles of crop are being used as mulch. It is an efficient system, but needs training to growers and there is limitation to type of crops.

We have successfully used permanent beds for various crops including fruit crops and spacing of rows varies between 2.5 meters for grapes, 4 meters for citrus, 4.5 meters of peaches, plums, and pomegranate, and 6 meters for mango, lychee and logan. The beds are 2 meters wide, 25-31 cm high, except 1.2 meters for wide and same height grapes. These allow for rows 2.4 m for grapes, 4.5 m for citrus, 4.5 for peach, plums, pomegranates and 6 meters for mango, lychee and longan. The furrows are irrigated to supply water to ridges and produce weeds, in the furrow, weeds are cut and dumped on ridges as mulch, described in separate chapter. It is after couple of years that real advantages of permanent beds, furrows, mulching and saving of water are seen and realized almost as magic.

#### **Advantage or mulching.**

Following are details of above described advantages.

Continued exposure flowering are details of above described advantages of soil to atmosphere leads to compounded problems of soil deterioration, loss of colloidal and microcompaction and reduces root penetrability. There is co-relation between degraded soil and fruit production, and decline. Mulch organic matter maintains soil and fruit production, suppresses weed growth, conserves moisture and reduces soil compaction. Besides weed control, mulch prevents fruit defects and helps to increase its size due to macro and micronutrients, growth regulators, antibiotics, hormones etc., and there by mulching improves health of tree and fruit. Mulching can help in overcoming the tree decline. In high pH soils it can reduce pH to near 7.0 at contact point with soil and thereby absorption of copper, iron, and manganese from soil. Mulch keeps ground moist for longer period than exposed soil and interval of irrigation is elongated, thereby saving water. Mulching reduces soil temperature in summer and increases it in cold season.

Mulching 5-8 cm (2-3 inches) deep under tree canopy increases root growth, canopy density and improves leaf colour as compared to clean cultivation or herbicides use. For good results, 10 to 25 (4 to 10 inches) of mulch consisting of weeds and other organic waste available on the farm should be maintained under the tree year around. Mulch reduces fertilizer doses other wise needed by providing NPK and micronutrients. Mulch increases root growth within 6 months, but visible response to yield and canopy health can occur after 2 years. Mulch is to be kept out of contact with trunks of fruit trees to stop bark diseases and canker as constant moisture against trunk promotes these diseases. Mulching can double the yield of some fruit crops as compared to fertilizing alone.

### **Mulching and soil temperature.**

Following are effects of various types of mulches.

- i. Organic mulches decrease temperatures during day time by reflecting solar light and radiation. They are insulating materials and behave that way.
- ii. Black plastic mulches raises soil temperature during the day.
- iii. Inorganic materials will increase temperature during day due to heat retention and will consolidate soils, due to their heavy weight.
- iv. Night temperatures are raised by organic mulches by reducing radiation loss from soil. Inorganic mulches and black plastic will reduce night temperature due to radiation.
- v. Clear plastic will increase soil day temperatures by 4-5° C as compared to black plastic and probably 5-6° C higher than organic mulches. The effect is opposite at night time, when due to radiation night temperature will fall down.

### **Disadvantages of herbicides against mulching**

Herbicides ultimately create poor soils and are not advantageous. With herbicide application, soil pH in alkaline soils will further go up, soil organic matter will go down and soil will get exhausted and becomes harder. Finally soil drainability will reduce. Either permanent ground cover should be maintained or mulching be done to prevent erosion as well as act as buffer against high soil temperatures and heavy rains, against the use of herbicides.

### **How mulch works and helps living organisms in soil.**

In natural communities of plants, there is mixture of species determined by the total environments. This complexity tends to give buffering capacity and stability to soil which resists unfavorable weather conditions. Less complex communities in arid regime and mono-culture system of agriculture are more vulnerable to weather influence. A number of micro habitants can develop over time and this function leads to species diversity and vice versa. Over time and equilibrium develops between plant species, enhancing or driving benefit from each other, to fulfil its particular requirement. Mulch creates this system like nature.



The system ultimately will have a large bio-mass in the soil and plant roots caused by diverse micro-organisms and invertebrate animal population and their break down products. A steady state develops between organic and in-organic soil components to enhance plant growth. Such associations involve development of Rhizobium bacteria's, each one specific to host species, utilizing soil nitrogen to a symbiotic relationship, where one is beneficial to other. Protected roots of most fruit plants are infected with an organisms, which make soil phosphorus more available to the plants. If soil environment is inhospitable physically and chemically to a population of organism, the plant root growth and its function is impaired. This is specially so on highly acid soils, which are not hospitable to some population organisms. There is specialized sub-group of fungus called my carhize, which may either be ectomycorhiza or endomycorhiza, which play a significant role in making available soil phosphorus to some tree species.

### **Organic matter in soil and how it benefits the plants.**

Beneficial effects or organic matter in soil are well documented and a few well known are:

More even soils surface temperatures, increased organic carbon levels, increased nutrient release , increased cation exchange capacity, increased soil organisms capacity, which leads to increased soil fertility and increased physical and chemical processes in soil complex. New thought has to given to triangular relationship between organic matters, living forms above soil and soil properties in them-selves, reflect soil nutrients, soil porosity, nutrient transfer to various level.

### **Types Of Mulches.**

#### **Living mulches.**

Barley, rye (perennial and non perennial), clover, forage crops, oats, field peas beans, maize and bluegrass are called living mulches. These are ploughed in or cut and spread.

#### **Non living organic mulches.**

Saw dust (maximum layer about 2 - 2 ½ inches thick layer), compost (2 -2 ½ inches), peat moss (2-2 ½ inches layers), tobacco stems, lawn clippings, shredded paper, card boards, straws, sugarcane residues, bagasse, brush and stump chipping, nut hulls, of hay, corn cobs and leaves, grass clippings, manure, peanut shells, cereal stubs, barn grass, rice husk (not more than 2-2 ½ inches thick) chopped weeds etc.

In organic mulches and plastics are not as good as living or non living organic mulches

#### **Advantages of mulching.**

Mulching promotes worm and bacterial populations which give the following advantages:

#### **Earth-worms and bacteria produce:**

- Antibiotics.
- Vitamin
- Growth regulators.
- Growth promoters
- Ready made slow release, fertilizer.
- Macronutrients;NPK,Ca,Mg,Sele
- Micronutrients; Cu,Zn,Mn,Fe,B,M,Ni,Cr
- Kill, nemutrients.
- Kill pathogens.
- Worms digest soil nematodes and reduce Their population to 1/3<sup>rd</sup>.
- Useful bacteria level increased, about 1,000 times more then surrounding soils.

**Mulching promotes worm and bacterial populations which give the following advantages:**

- Increase soil aeration, 30% or more
- Rate of infiltration increased, many times as non-mulched land and us 1.5 inches per minute.
- Soil profile is made more humid as air in burrows, has more moisture team best of profile.
- Uniform nutrients is top one foot soil profile as worms excrete nutrients at different depths and redistribute in the root zone.
- Increase water holding capacity many times as worms burrow area in 5 times the surface area.
- Worms increase grass growth in undisturbed but mulched soil by100-300% in 2-3 years

**Land under conventional crops raised under synthetic fertilizers and herbicides promotes:**

- Nematodes
- Aphids
- Fungi (some harmful type )
- Viruses
- Earthworms reduces all above so large extent.

**Methods to eliminate earth worm enemies.**

- **To eliminate earthworms enemies human assistance is in following of forms is needed:**
- Not disturbing soil
- No till operations
- Elimination of herbicides, pesticides and insectidies.
- Use of mulches.
- Green manure.
- Animal excrete
- Using natural sources of fertilizer

### **Earth worm predators.**

**Deep ploughing reduces worm population by 40% and shallow ploughing by 15% by exposing them to their predators namely:**

- Snakes.
- Rats.
- Birds.
- Foxes and jackals.
- Ants.
- Cane toads
- Earwig
- Sunlight also kills them by high temperature dehydration and light.

### **Pesticides and fungicides harmful to earth worms.**

**The following pesticides and fungicides kill earth-worms are:**

- Aldicarb.
- Bemomyl.
- Carbaryl.
- Carbofuran.
- Chlordane.
- Copper Oxide.
- Dasinit.
- Heptachlor.
- Oxamyl.
- Parathion
- Phorate
- Thiabendazole.

### **What does organic mulch supply to the plants.**

**Mulch as plant material supplies following items to the plants.**

- Potash, very large quantities.
- Phosphate, medium quantities.
- Nitrogen, small quantities.
- Calcium, sufficient.
- Magnesium, sufficient.
- Sulfur, large quantities.
- Micronutrients. ( Fe,Cu,Zn,Mn,B and Mo), sufficient quantities.
- Vitamins, adequate.
- Plant hormones, adequate.
- Growth regulators, sufficient.
- Regulating, pH.
- Antibiotic, supervision of disease and pathogens attacking the plants.
- Saving plants from herbicide damage
- Saving plants and soil from damage of clean cultivation soil.
- Saving soil from compaction.

- Regulating temperatures, reducing summer day temperatures and raising night temperatures in winter.

### Chemical analysis of dry vermicasts nutrients.

The following chemical composition of vermicasts.

<b>N u t r i e n t</b>	<b>R a n g e p e r c e n t a g e .</b>
• Nitrogen.	1-4
• Phosphorus.	0.3-3.5
• Potassium.	0.2-2.1
• Sulphur.	0.24-1.63
• Calcium.	1-2.2
• Magnesium.	0.3-0.6
<b>Range, Parts per million parts or ppm</b>	
• Manganese.	0.4-1.6
• Zinc.	185-1005
• Copper.	22.3
• Boron.	-46
• Molybdenum.	18-7
• PH.	6-5-7.0
• Iron	0.4-1.6

### Permanent bed cropping of fruits nuts and some perennial tree crops.

Permanent bed cropping for annuals or non perennial crops is being promoted for the past 10-15 years in South East Asia and Australia. Its advantages are that soil is not being compacted and weeds and stubbles of crop are being used as mulch. It is an efficient system, but needs training to growers and there is limitation to type of crops.

We have successfully used permanent beds for various crops including fruit crops and spacing of rows varies between 2.5 meters for grapes, 4 meters for citrus, 4.5 meters of peaches, plums, and pomegranate, and 6 meters for mango, lychee and logan .The beds are 2 meters wide, 25-31 cm high, except 1.2 meters for wide and same height grapes. These allow for rows 2.4 m for grapes, 4.5 m for citrus, 4.5 for peach, plums, pomegranates and 6 meters for mango, lychee and longan. The furrows are irrigated to supply water to ridges and produce weeds, in the furrow , weeds are cut and dumped on ridges as mulch, described in separate chapter .It is after couple of years that real advantages of permanent beds, furrows, mulching and saving of water are seen and realized almost as magic.

## CHAPTER - 26

### BAGGING OF MANGO

**A new tool in clean fruit management is bagging of individual fruit in cloth, paper or plastic bag.**

#### **Advantages of bagging.**

Bagged fruit does not develop sooty mould, under size and wind scar problems, though about 4 percent fruits become rusty. Stem end rot and anthracnose are reduced by 50 to 80 percent. Un-bagged fruit does not have ripeness problems but bagged fruit may have some problems with skin colour.

#### **Effect of bagging in red colour varieties.**

Bagging reduces area of red on the fruit as well as intensity of red colour. Sun light induces bright red colour. Bagging has no effect on dry matter, fruit weight, flesh colour, TSS: TA ratio, lentil spotting and eating quality when ripe. Red colour of skin however is reduced.

#### **Time for bagging**

It should be done when fruit has passed golf ball stage i.e., after initial fruit fall. In Queensland they put bags on, when fruit is 10cms long. This will be first week of May in our area and first fortnight of November in Queensland.

#### **Bagging material choices.**

- Bagging with plastic bags resulted into losses of moisture from fruit in softening process.
- Bagging in plastic bags also hastened softening and colour development after harvest.
- Bagging in paper bags had no influence compared with unbagged control fruit, in weight loss or ripening characteristics.

## CHAPTER - 27

### HARVESTING

#### **Pre-harvest treatment for skin colour improvement**

Pre-harvest sprays of benomyl at 1.1 kg per Ha (440 grams per acre) in 3,300 litres of water, increases intensity of skin colour in Kent mango and increased its TSS. It is not true for all varieties. Mangoes while still on the tree when dipped in Ethrel at 500 ppm ripen after two days. Fruit quality is enhanced, TSS: acid ratio increases and colour is improved. Commercial marketability requires 13% TSS.

#### **Fruit Maturity.**

This is indicated by, skin colour changes from dark green to light green and then to yellow etc. shoulder rise above panicle connection and broaden, stem end sinks and fruits swells and panicle colour changes from dark green to light green or pale or yellow.

#### **Fruit ripening**

The observed changes in mango before reaching harvesting are the following. In hotter regions time between flowering and ripening is shorter. Fruit ripens the best if kept with stem end down and covered with damp cloth to avoid shriveling. Blossoming and fruit ripening on same tree may continue for longer period in hotter regions like Sindh than in areas less warm areas like Florida. Some south Asian varieties may set their main crop in mid summer and ripen it in mid winter. Sugar content varies between 2 to 11% when fruit is fully grown, but still is green. If fruit is still left on tree until green colour fades sugar content may rise from 11 to 17% or more. Commercial marketability requires 13% TSS.

In ripening following bio-chemical changes take place:

- i. Sugar content of flesh rises and acidity falls.
- ii. Colour of seed changes from white and fleshy to brown and papery.
- iii. Fruit harvested at early stages are firm and requires two weeks to soften to eating stage.
- iv. Fruit harvested at late stage takes 2-4 days to ripen.
- v. Fruit harvest too early, sweats, gives up moisture and wilts before softening.
- vi. Flowering extends to: 4-6 weeks and fruit at different stages of development ripens at different times on a tree and ripens over longer period. Strip harvesting is not satisfactory of mango, specially in varieties which flower over some length of time.
- vii. In Israel picking starts at lower end so that sap from upper fruit does not fall on lower ones. From lower end they go up.

- viii. Another practice in Israel is to pick fruit with stem end, keep it on ground for an hour to bleed sap, but disadvantage is that stem end rot can be problem due to fungus infesting mango soil in all orchards world over.
- ix. Another method in Israel is to pick fruit and immediately wash it in strong stream of water for 3-5 minutes, but then it needs waxing to restore skin polish.
- x. Fruits having thick leathery and waxy skin have better shelf life and they are not attacked by fruit fly, unless fruit is allowed to soften on tree or drops due to other causes close to near maturity.
- xi. Stem can exude latex sap, which stains skin and spoils fruit.
- xii. If fruit is harvested with secateurs 5-8 cms or 2-3 inches of panicle is left attached to fruit when it is placed with stem end up, exudation can be prevented
- xiii. Blunt blade secateurs 1mm wide or pliers, if used for cutting panicle can reduce exudation.

### **Maturity standard for picking mangoes.**

Mangoes for pickling need to have more acid and less soluble solids to give it better taste and shelf life. The acceptable standard are, less mature fruit just after the beginning of endocarp hardening, when little reduction in acidity and increase in soluble solids has occurred is the best time for mangoes. Common belief that only seedlings are suitable for pickling is untrue.

### **Standards for mango fruit maturity.**

Following are general standards for mango maturity.

- Specific gravity. 1.01 to 1.02 will cover most mangoes.
- TSS: acid ratio. 12 : 1 or more.
- TSS. Minimum 12° Brix
- Fifty percent colour development is requirement before it is marketable.
- There are different times for the maturity of each cultivar of mango, varying probably from 100 days to 140 days or even more, after full bloom. For Haden it is 105-115 days. Early varieties have shorter maturity season and late varieties longer. For Sindh varieties from full bloom to earliest harvest date of the ripening in days are shown in table below:

Table Showing harvest date from full bloom in Hyderabad area.

Variety	Date of full bloom	Earliest Date for Harvest	Days of Ripen
Irwin	1 February	15 May	104
Langra.	15 February	5 June	110
Desheri	20 January	28 May	118
Bombay Green	20 January	13 May	113
Chausa	1 February	30 June	150
Kali Siroil	1 February	15 June	135
Baganpali.	20 February	1 July	130



Swarnarika	10 March	10 July	122
Sensation	20 February	1 August	161
Neelum	20 February	10 August	171
Keitt	20 February	20 August	181

**Note:**

Sindhri Flowers in 3 stages on 20 January, 5 February and 20 February. It matures in 3 stages, from 23 May to 20 June.

Maturity of fruit is also known from percentage of fruit which sinks into water at 25°C. It varies from 15% for Sensation to 53% for Zill and when internal pulp has turned 10 to 15% yellow. Such fruit takes 15 days to ripen at 21° C as compared to 3-4 days or less for fruit harvested later at end of season of a particular cultivar. The harvesting season could be extended to about 20 days for any variety by this method.

**Shoulder or Stem as indicator of maturity.**

Shoulder or stem end relationship for maturity does not hold good for all mangoes cultivar.

**Heat sums to predict fruit maturity of mango.**

There is new method of predicting mango starting by heat sums. It is (average temperature of the month minus 12°C x days in the month. At 12° C there is no growth and therefore, it is the indicator of zero heat sum.

The above can be converted to heat sums to predict harvest dated of above varieties. Heat sums indicates the dry matter content of mango. Dry matter rises gradually in a linear from, but during the last 150 heat sums or about 7-15 days it raises fast from 14.5 to 17%. The days to eating ripe after harvest, also reduces from 12 days to 9 days during these last heat sums to 7 days or so.

**Maturity and colour development relationship.**

Mango picked too early will develop little colour and will have poortaste. The colour development requirement is 50%, before it is marketable. Fruit coloured to 50% and shipped at 12°C to Europe, will ripen to enroute by air within a day or two. Some Florida cultivars like Tommy Aitkin and Sensation do not need colour development while picking and sending them to market or exporters, as they already have coloured skin. For various cultivars colour development is different and growers as well buyers have to know it. Calcium carbide is put in mango boxes in South Asia to ripen it. A dip of mango in ethylene at rate 1.0 m<sup>1</sup>L<sup>-1</sup> for a few second can hasten ripening. Mango ripening can also be achieved by dipping fruit in Alar. GA<sub>3</sub>, Cycocel etc.

**Effect of harvest date on physical characteristics of mango and weight less in ripening.**

These vary from fruit to fruit and in general the pattern is as under:

- i. The fruit weight keeps increasing on the tree, but the weight comes down if fruit is allowed to mature on tree. Up to 10% weight loss can be expected.
- ii. Skin colour keeps developing if picking date is delayed, even if fruit is allowed to ripen on the tree.
- iii. Early harvested fruit takes 12-13 days to ripen, in country containers and weight loss can be 15 to 20%. Mango therefore should not be picked too early, as loss in weight for every day until ripening is more. At the correct time of harvest, weight losses in ripening can be a low of 5-7%.
- iv. Contractors buying fruit at farm gate on weight basis know this and deliberately delay to take away the boxes for 1-2 days, for fruit to lose weight by moisture loss.
- v. Mango loses weight during ripening process by respiration, internal chemical changes and moisture loss. The loss depends on the time it takes to ripen.
- vi. Time to ripen in storage is governed by date of harvest for different cultivars.
- vii. In general loss at ambient temperature can be 1.0 to 3.2 grams for 100 grams. Weight loss is more in terms of both days to ripen and daily loss in weight.
- viii. In the same mango tree, larger the fruit better it ripens and has superior quality.

#### **Harvesting for best quality.**

Keeping this in view that larger fruit ripens better; it is preferable to have 3 picks, which will be:

- |                                     |               |
|-------------------------------------|---------------|
| • First picking.                    | 10-20% fruit. |
| • Second picking (one week later)   | 40-70% fruit. |
| • Third picking (2 or 3 week later) | 10-50% fruit  |

#### **Harvesting and sap flow.**

A major problem with most mango varieties is sap flow, while tearing or severing fruit from stem. Sap oozes out of stem and if it drops on skin of fruit, it damages it by making stains. It is caustic and needs to be removed immediately. It can be removed from fruit with 1% solution of dehydrated lime or alum or citric acid or sodium bicarbonate wash, but within about one hour of staining. It has also been observed that less mature the fruit more is sap flow.

In commercial practice to overcome the problem, fruit should be severed from stem by clippers with about 2-3 inches (5-7 cms) of stem attached and brought to shed for further destaning. Stem is destalked in shed with stem end down on a meshed rack or commercial desaping conveyor. Conveyor moves slowly and sap drips out before fruit reaches dipping tank. Sap keeps flowing out for one hour after picking from tree. Picking early morning is better as sap flow is less.

#### **What cause green ripe mangoes.**

Causes of green ripe mango.

- i) **High Nitrogen.**

Percentage of red on the skin is inversely proportionate to nitrogen (N) in fruit. It is 60% at N=0.8 and only 90% at N=0.4%. Mango colour increases with lower nitrogen.

**ii) Irrigation.**

Trees suffering from water stress have more green colour on the skin.

**iii) Shade.**

Fruit in shade has more green colour.

**iv) Maturity.**

More mature fruit on tree, less the green colour.

**v) Ripening above 22°C**

If ripening temperatures are lower than 18-22°C, fruit retains some amount of green colour. However above 22°C it softens earlier and below 18°C, it softens late.

**How to enhance yellow or red colour on mango.**

Skin colour on mango can be enhanced by the following method.

- i) Avoiding excess nitrogen fertilization
- ii) . Applying adequate irrigation.
- iii) Maintaining open canopy.
- iv) Avoiding over crowding of trees.
- v) Harvesting only mature fruit.
- vi) Maintaining optimum ripening temperature of 18-22°C.
- vii) Pre cooling fruit by using forced air cooling.
- viii) Transporting fruit at 13°C, ensures early and uniform ripening.

In general all above factors have to be taken care of.

**Harvesting Methods and care.**

- a) Fruit should be clipped with at least 5-7.5 cm of stem left intact though 7-10 cms is still better
- b) . If stem is broken, sap can burn fruit or cause diseases.
- c) Picking should be done early in the morning.
- d) Harvested fruit is to be removed from under the tree as early as possible to avoid over heating and stem end rot fungus in soil attacking fruit.
- e) With a few minutes of sap contact with fruit, it should be washed with chemical discussed under sap flow.
- f) Packing should be done with stem end down.
- g) Left stems to be removed from the packing shed to avoid contact with fruit.
- h) Fruit falling from height of more than 12 inches (30 cms) will be damaged, as it will split or crack and will not ripen evenly. If it does not split it will bruise and will not be marketable.

**Post-Harvest exposure of fruit to sun light.**

Alphonso exposed to sun for 5 to 240 minutes immediately after harvest showed the following internal break downs:

- 5 minute exposure. 20%
- 120 minute exposure. 100%
- Not exposed at all. 10%

Usually one hours exposure to sun reduces post harvest life by one full day.

### **Mango harvest season assessment in Queensland (Australia.)**

Their standard mango is Kensington and comes around December. The others ripen later by time shown below:

- Palmer (5 weeks after Kensington)
- Zillate (5 weeks after Kensington)
- Kent (6-7 weeks after Kensington)
- Keitt (7 weeks after Kensington)
- Brooks late, 8-10 weeks after Kensington, and has little or no competitor , but it has yellow skin and is not attractive.

### **Florida Harvester.**

Florida built first manual harvester of mango trees in 1960s. It leaves half an inch stem length, on the fruit but in some varieties sap still flows out.

### **Indian harvester**

Dr. B.P Wasker and S.D. Masalker. R.S. Department of Horticulture. Mahatama Phule Krishi Vidapeeth Rahuri 413 Maharashtra (India) have built a harvester a modified form of, Florida harvester. Present authors also built a similar harvest. Our harvester is made of steel and that of Florida of plastic.

These harvesters increase number of fruits harvested per person and is double than manual harvesting practiced in Pakistan. On dwarfs varieties height having of 15-20 feet (4.5-6.0 meters), only 25% labour was used to harvest fruit with secteurs from ground.

### **Heat treatment of mango and stem End Rot.**

Heat treatment is less effective for stem and rot. Hot treatment controls some fungi if heated at 46.5°C for 10 min., but not that caused by *Botryodiplodia Theobromae*. Fungus responsible for stem end rot and chemicals are available for it.

### **Infrared radiation and alternative to hot water treatment.**

Inferred radiation exposure for 3 minutes is as effective as 5 minutes of dip at 52°C.

## CHAPTER - 28

### YIELD

#### General

South Asian cultivar selection was not based on yield per tree, possible number of trees per acre, returns per unit weight, gross and net returns per acre and was based on taste alone and therefore the yields are low. South Asian mangoes yield first crop usually after 5 – 7 years and first commercial crop 10 years. Floridan mangoes bear the first crop after 3 years and first commercial crop after 5 years. Our varieties had not been selected on the basis of yield, whereas Floridan varieties were selected on basis of yield as well as market acceptability.

#### Factors governing mango yield.

These factors are:

- i. Girth of trunk and size of canopy. Contractors in South Asia use these as basis for predicting yield.
- ii. Moisture level during fruit formation period.
- iii. Size of previous crop.
- iv. Number of vegetative flushes during the preceding year and also their timings.
- v. Weather conditions before and during flowering period.
- vi. Control of insect infestation and diseases.
- vii. Fertilizer programmes
- viii. Pollination conditions.
- ix. Climatic conditions specially chill hour in winter and temperatures during fruit development. High winds blowing from south-west at 25-40 kms per hour from April to September in Southern Sindh delay the first crop by 2-3 year by defoliation of branches in summer.
- x. All the above and other complex interactions govern mango yield.

#### Leaf numbers this area and fruit yield in mango.

Fruit development utilizes carbohydrates either currently produced or stored as reserve. Biennial bearing is directly related to the reserve source, which can be new leaves, old leaves, bark, wood and etc. Carbohydrates are one of many items utilised. Ribulose 1,5 - biphosphate Carboxylase are other items. In various varieties 10 to 30 leaves support one fruit to maturity.

#### Quality.

Quality acceptance in international market is changing fast and growers have to adopt to new buyers taste.

- Fruit exposed to sun-light during growing season (March-September) are larger, have higher percentage of pulp and TSS and greater sugar to acid ratio.
- Larger fruits 350-800 grams in future would be preferred. Small fruits will be acceptable at low prices.

- Red, purple, orange skinned mango have already been preferred in international market. All other cultivars including green skinned will only be accepted by the processors at low prices. Yellow skinned mangoes will be acceptable at prices between above two classes.
- It is time that growers realize these trends and make changes.

### **Bearing age:**

Seedling mangoes come in to bearing in six to seven years depending upon soil fertility and cultivar but commercial harvest comes of to year 10. Grafted varieties can bear in two to three years, but commercial crop in year 5. It is advisable to prune flowers and fruits on young trees during first few years, to promote vegetative growth and increase size of tree.

### **Maturity of South Asian Varieties.**

In the year 10 tree produces 400 to 600 fruits and about 60% of maximum yield at maturity. In the 15 to 20 year tree reaches its maximum yield, if orchard is properly managed, but reduces to even 66%, if proper management is some what relaxed . After 40 years, yield declines abruptly. As tall trees sheds all lower branches

### **Yield during young age (year 5 to 15)**

The yield of Sindhri and Chausa at Hyderabad according to age has been recorded as under:

<b>Age in years</b>	<b>In tons / acre</b>
- 5	0.5.
- 7	1.
- 10	1.5
- 15	3
- 25	2.5
- 30	2.0
- 35	1.5
- 40	1.0
- 45	0.5

With 100 trees per acre in prolific bears like Langra it can be 2 tons in 5 years, 5 tons in the 7 years, 10 tons in the 10 years and then trees have to be pruned or alternative tree removed. The yield after 10 years will be 10 tons per acre and continued up to year 30. A yield of 500 bushels or 30 tons per hectare or 12.5 tons per acre is not uncommon for Tommy Aitkin in U.S.A. Kent in an experimental area had given 725 bushels per acre i.e. 45 tons per hectare or 18 tons per acre. A potential of 32 tons per acre has been accepted by experts, with some varieties Israel is producing 16 tons per acre.

### **Yield of new Indian cultivar Amparli.**

It can be planted at 640 plants per are i.e., at about 8.3 x 8.3 feet it gave yield in all years as under:

Table showing yield of Amarpali per acre for different years of age.

Age in years	Yield
- 4	4.6
- 5	5.32
- 6	7.0
- 7	8.88
- 11	22.11

#### Yield data of some mango varieties from South Africa.

Spacing 10x8 meters i.e., 50 trees/acre.

Age of trees 8 years.

Performance as in table below.

Cultivar	Yield per acre in tons in the year 8.
Peach.	6
Kensington.	6.8
Zill.	Less than 4
Sensation.	Less than 4
Tommy Aitkin.	Less than 4

#### Yield per acre.

Average national yield of mango per are in Pakistan is 3-4 tons per acre, but 6-8 tons per acre is possible in well managed individual orchards of limited growers.

#### Yield in high density planting.

High density 100-200 trees per acre, with 4.5 m height and diameter, can give average yield, of 70 kgs per tree and it can be 10-20 tons per acre at maturity (6-8 years in tropics and 10 years in subtropics.)

#### Pulp yield and quality of some Floridan mangoes.

Pulp yield of some varieties is as under:

Cultivars	TSS	Pulp yield percentage.
- Irwin.	16.0	75.07
- Edward.	21.2	76.85
- Palmer.	20.5	73.2
- Keitt.	21.5	78.95

As compared to above South Asian varieties have large and thick stone and pulp yield of Anwar Ratol is 45%, Chausa with large stone 60% and Sindhri 65-70%.

#### Yield pattern of some mangoes like Keitt in tropic and subtropics



Age	Kg yield per tree at 150 trees per acre. In Tropics	Kgs yield per tree at 150 trees per acre in Subtropics
0-4	0	0
4-8	10-70	30-70
8-10	70-110	50-100

## CHAPTER - 29

### PACKING OF MANGO FOR MARKET.

#### **Packing Material**

The packing materials in common use are paper, wood, wood wool, polythene, paper tissue, new print etc. Of these polythene wrapping gives better results, less fruit weight loss, extended storage life, due to less accumulation of carbon dioxide and moisture, both of which reduce respiration. In packing, shredded paper is also used to line top, bottom and sides and places between fruits, to stop rolling and cause bruising. Polythene pouches have failed to give good results.

Cotton waste, grass and leaves have also been used as lining material in containers of wood, Tamarisk basket and pottery were also used in Pakistan. Old News papers are used for lining in Pakistan. They are cheap but may already be fungus infected or can get fungus infected during transit to end user. Wood wool (saw dust) is not recommended for packing, as it may contain harmful organisms and may absorb moisture. Plastic inserts with molded cups are recommended. These do not hold fruit too tight, but prevent their movement by and robbing fruit together.

#### **Wrapping paper.**

Wrapping is done in butter paper.

#### **Compression strength of Packages.**

- Compression strength packages has to be 700 kgs at 60% R.H.
- If cartoons are to be stored under refrigerated conditions for more than 5 days, compressive strength of 800 kgs is needed.
- For refrigeration cartoons are to be wax dipped to avoid moisture absorption.
- Polytyrene boxes have to have 200 kg strength.

#### **Packing requirements.**

For sales abroad single layer tray package should be used. For bulk packing double layer packs are used. In this case the fruit is to be tightly packed to avoid vibration and rub damage.

#### **Packages box sizes.**

In Pakistan all type of fruit is sold by volume in boxes or baskets. In mid seventies for mango sales the boxes were 18½ x 18½ 10 inches (47x47x25.4 cms) or about 2 cubic feet or about 56 litres. Due to inflation the market men as well the growers started reducing the boxes size. In 1995 it was 16x16x10 inches (40.6x40.6x25 .Cm) or slightly less than one cubic foot. In 2000 it has been reduced to 15x15x9 (38x38x23 cms) or about 0.75 cubic feet. It only gives some psychological satisfaction to the street vendors that prices have not raised too much. The retailers sell it to the consumer by

weight. The end user has to pay more per kg firstly due to inflation and secondly for the cost of packing and handling per kg of fruit

In Sudan they use 16"x10"x5 3/4" or (40.6x6x25.4x14.5 cms) box for mango packing. It is about 0.5 cubic feet. The same size was used by present writers for some new varieties introduced in Sindh for the first time. They become unpopular with agents and retailers due to small un-conventional size and weight for weight returns were less than 70%.

#### Australian mango package sizes.

In Australia packing sizes are under:

Packages	Internal dimension (mm)	Style	External dimension (mm)	Palletization L+2W
Traditional	L*-450	One piece, hinged	485x300	1085
Cartoon	W-290	Lid one piece,	480x320	1120
	D-90 to 150	Open top two piece telescopic	To 485x320	To 1125
AUF carton	L-460 to 465	One piece, open top	490x330	1150
	W-300 to 304	Two piece,		
		Telescopic	488x326	1140
Polystyrene	L-450	Open top	487x335	1157
	L-2900			
	D-100			

\* L - Length, W-Width, D-Depth.

\*\* Standard pallet is 1165 mm square.

#### Bulk packing recommended for mangoes in Australia, Europe and Northern America.

Packages method Australian		AUF/8 Trays Single Layer	AUF/12, 9 litre layer	AUF/12, 18 litre bulk
External Length	(mm)	485 to 490 mm	380 mm	380 mm
External Width	(mm)	325 to 330mm	285 mm	285 mm
Internal depth.	(mm)	90 to 105mm	90 to 105 mm	180 to 200 mm
Number per layer on pallet: Australian palet (1165x1165)		8	12	12
Euro/North American pallet (1200x100mm) LD-7 air freight pallet (3020x2080mm)		36	54	54

**Different Australia packages.****For 8 trays.**

485/490x325/330 mm or 19 ½ x 13 inches, 8 per layer.

**Pallets.**

They should accept 6,8 or 12 packages per layer. Pallets for over-seas shipping are:40 x 48 inches (100 x 120 cm) as popular in Europe and Northern America.

**Air Freight pallet sizes.**

120 x 80 x 64 inches (3030x2080x1600 mm)

**Packages sizes for export and retail market.**

6.5 to 7 kgs cartoon share common. 11 to 13.5 kgs cartoons are occasionally used.

**Standard pellets sizes.**

Standard size of pellets is 1.00x1.20 and 0.8 x 1.2 meters.

Cartons are to be bundled in 2x2 or 3x3.

**Single layer trays.**

Single layer trays for export, hold 6.5 kgs of mango. Fruit should be placed on stem end down, to avoid bruising and also as the other end is much cleaner. Recent practice is to pack in single layer trays with sufficient holes prevent fruit from over heating. Single layer fibre board polystyrene tray pack is better. Size recommended is AUF/8.

**Packing and tray sizes.**

- Australians standard is 12-15 fruits in a tray of 6.5 kg i.e. 430-540 grams weight of each mango of acceptable quality.
- The fruit bulk-bins are 500 kg or 20 bushel capacity and each crate takes 25 kg.
- Plastic trays with moulded open cups are now used. Trays are available in counts of 13,15,16,18,20,23,25 and 28. The dimensions are 10 mm less than carton they fit in. Fruit are packed with stem end down.
- Cell packs with fibre board packing are more costly than cup trays. They were costing Rs. 20 in 2005.
- Australia also uses 18 litres or 0.66 cubic feet boxes for bulk packing.

**Wrapping materials.****Film Wrapping of mangoes in post-harvest**

Decay is more with plastic film wrapping even at 20°C and fruit does not develop colour and post-harvest life is reduced, unless ethylene absorbent is put in the polythene bags. This is because carbon dioxide increases to 20% and oxygen is reduced to 5.4% and fruit develops off flavour.

**Transport injury or Abrasions injury and losses.**

Skin blemish is caused by the following.

- i) Vibration damage is caused by loose packing in single layer or multiple layer packs. Packs should be tight but should not be press tight.
- ii) Bulk packs should be slightly over packed and settled by initial vibration for a few seconds.
- iii) Fruit is scratched on dirty equipment used during post harvest and the equipment for post harvesting packing has to be cleaned regularly.
- iv) Brushing time is reduced by cleaning brushes. Long cleaning time over 30 seconds, can increase bruising of fruit skin bruising of fruit skin.

## CHAPTER - 30

### POST HARVEST TREATMENTS TO MANGO

#### **BioChemical changes in mango after harvest.**

Mangoes for transport to long distances or storage over some period should be clipped from stock, so that skin is not broken or tissue exposed for fungal attack. After harvest sugar content rises due to hydrolysis of starch respiration increases and sugar and acid deplete rather fast. Life of fruit at tropical and sub-tropical high temperatures tends to be short due to high temperature causing biochemical reactions. Unlike other fruit ripening mangoes show climatic rise in respiration, but do not produce any ethylene. However in the ethylene atmosphere, they ripen faster by increase in respiration. Fruit ripens best if kept with stem end down and covered with dampened cloth to avoid shriveling.

#### **Post-harvest diseases.**

Post-harvest rots are worse after storage treatments compared to level of infection in non-treated fruit. This subject is not yet explored properly, though following types of internal break downs occurs.

- i. Stem end rot (*Dothiorella dominicana*).
- ii. Anthracnose (*Colletotrichum loesporioides*.)
- iii. Alternaria rot (*Alternaria alternaria*)
- iv. Transist rot (*Rhizopyhus stotonifer* )
- v. Aspergillus rot (*Aspergillus niger*)
- vi. Bacterial black spot (*Xanthomonas comretis*.)
- vii. If diseases are controlled in the field, post harvest control is not necessary, when fruit is to be consumed within a week of harvest. Diseases are controlled by pre-harvest sprays and post-harvest treatment and packing house shed hygiene.

#### **Post-harvest physiology, Softening or ripening of mango.**

Rate of ripening mango can be reduced substantially by reducing temperature, but below 10-12°C fruit can suffer chilling injury. Modified atmospheric storage with low percentage of CO<sub>2</sub> results in unfavorable fruit response. Cultivars differ in responses to modified atmosphere and some develop disorders.

Post harvest ripening of mango takes 2 or 3 days to more than 15 days and this depends on stage of maturity of fruit at the time of harvest and cultivars themselves Sindhri takes 15 days, if plucked on 15 May, 10 days if harvested on 23 May, 7 days when harvested on 1 June, 5 days, when harvested on 10 June and 3-4 days if harvested after 15 June. Those harvested on 15 May are unripe on the tree and these on 23 May still contain some extra acids.

Ethylene used in South Asian, in form of calcium carbide, stimulates ripening by producing ethylene. It improves colour, but if used on fruit, which is not fully

mature, it affects its quality. Mango pre-ripened with ethylene, fetches high prices, early in the season, is ripening but anthracnose and physiological breakdowns are also reduced.

### **Physio-chemical and organic changes during post-harvest and consumer acceptability**

Brix value, i.e, TSS accounts for only 20% acceptability. Sugar content, pH and titratable acidity are important factors involved in taste and acceptability. Eye appeal is another very important factor and blush as well as flavour given by mango also has appeal. Modified atmospheres invariably effects quality and probably also flavour adversely.

### **The use low temperature.**

Critical temperatures below which chilling injury occurs in 7-13° C. Ripe mangoes can be kept at 2° C for several weeks with out appreciable further deterioration, but not unripe mangoes.

### **Use of modified atmosphere.**

Modified atmosphere has resulted in formation of off-flavour in the fruit although fruit can be stored at ambient temperatures for 3 weeks in low oxygen. In above case fermentative decarboxylation takes place with formation of Aldehydes and alcohol. TSS and pH too are reduced below normal level. Wax coating at ambient temperature postpones ripening from 6 to 9 days but ripening abnormalities occur both in skin and flesh. Modified atmosphere does not stop softening of mango, as it does in case banana.

### **Use of low pressure.**

By reducing atmospheric pressure to about 4 Ib per square inch or say 100mm Hg or mercury column mango ripening can be delayed, if storage temperature are 13°C. In this case ripening is normal as regards pulp texture is concerned, but the fruit skin colour is affected.

### **Post harvest disorders.**

This subject is not yet explored properly to find how internal break downs occur.

### **Influence of temperature adaptation and physiological stage on mango in storage**

The following are some observation on storage of fruit at various temperature regimes.

- i. Mangoes are usually damaged in storage below 12° C.
- ii. Chilling jury at 4° to 8° C can occur after 10 days of storage.
- iii. 30 days storage with pretreatment shows slight shriveling.
- iv. Fruit with no pretreatment will show severe signs of chilling on 30 days storage.
- v. Pitting will cover about 50% of surface of fruit in 30 days, if no pre treatments are used.
- vi. Fruit will show some rubbery texture.



- vii. Mango ripened and stored with or without low temperature adaptation shows no chilling injury.
- viii. Some mangoes like Haden fully ripened may be stored at 2° C or 12° C for 4 weeks without injury but not the un-ripe mango which will show chilling injury.
- ix. Unripe fruit with no pretreatment stored 7° C suffers from chilling injury.
- x. Loss of water from fruit causes shriveling.
- xi. Some preripened mangoes stored at 7° C will show about 50% stem end rot (SER) but the temperature varies with cultivar

### **Physiological and chemical changes in mango during ripening by down etc.**

Mangoes stored at 20 and 25°C in propylene enriched air accelerated fruit ripening measured as weight loss was 125 mg per kg per hour against 110 mg per kg per hour in air. The peak occurred after 2 days, which coincided with initial softening. There is no difference in storage at 20° C or 25° C but skin colour development is less at 22° C than at 25° C. In case of Kent mango similar figures were 105mg per kg per hour at 20° in propylene enriched air and 80 mg per kg per h in air. This occurred 4.3 days from harvest and softening started 5 days from harvest. Skin colour development and quality of colour increased more slowly in air. It is concluded that skin colour, flavour and texture is better at 20° C. Propylene ripening at 25° can help in removing defects that occur in air ripening. Similar results could be had for cooling.

### **Post-Harvest handling of mango. Harvest and Maturity.**

The following are some interesting observation but this varies from cultivar to cultivar and no work has been done on this important aspect.

- 1) Indian claim that at 1.02 specific gravity (SG) mango has short storage life.
- 2) At 1.0 to 1.02 SG, it ripeness more slowly and has longer storage life.
- 3) Below 1.0 SG it ripens slowly, has longer storage life but increased susceptibility to infection and poor quality development.
- 4) Specific gravity standards vary from variety to variety.
- 5) Carabao is mature, if it sinks into waters i.e. SG more than 1.0
- 6) Haden has SG 1.02 at proper time of harvesting.
- 7) South Africa considers fruit as ripe when a particular percentage sinks into water which is 15% for Zill, 53% for peach and 15% for Sensation.
- 8) Time of 90 days from flowering to harvesting for some varieties and 105 for others is also suggested, but it depends upon degree-days. These have already been discussed.

### **Control of fungal diseases by heat treatment and fungicides.**

It is done in the different methods discussed below:

Dipping in heat water containing 1 gram benomyl in 100 litres of water at 51.5° C for 15 minutes. Or at 55° C for 5 minutes, as at 10 minutes heat injury can occur on in hot water. Done at 46° C for 75 minutes but without use of chemical. In all these cases, anti-fungus chemicals have to be added. Storage is then done at 12.8° C.

Fungicides used in anti fungus treatment are:

Benomyl, Zineb, Diethyldithiocarbamate, Borax and Kasugfangcinchloride.

**Fumigants used for post harvest treatment are;**

Ethylene chlorobromide, methylbromide, phosphine, methyl formate, ethylene oxide and ethylene dibromide, the rate of application is up to 24 mg/litre.

**Irradiation.**

The amount of irradiation is different for each variety and depends on what diseases are to be controlled. High dosages cause fruit damage. There is also limit to irradiation dose by some countries importing mangoes.

**Post harvest fruit fly control by fumigation.**

Fumigation for 2 hours with 20 mg per litre of EDB (Ethyldibromide.) methyl bromide at 32 and 48 mg per litre for 2 hours at 21°C has caused decay. However these two chemicals have been phased out in 2005 as Ozone layer depleters . There is protest by USA against this ban and EDB will be atleast around for next decade.

**Storage**

Ripe fruit can be stored 7.2° C up to 4 weeks. Unripe fruit storage has to be above 12.8° C, for not more than 3 weeks. Alphonso can be kept at 7-9° C up to 7 weeks, but it also depends on cultivars. Most Florida varieties store best at 12.8° C but Keitt gets chill injury at 13° C after 10 days.

**Controlled atmosphere storage.**

Controlled atmosphere means decreasing oxygen (O<sub>2</sub>) increasing carbon dioxide (CO<sub>2</sub>) and increasing relative humidity (RH.) All these 3 can be achieved by sealing fruit in polyethylene bags. Simply wrapping fruit in polyethylene bags will increase storage life. Polyethylene wrapped fruit sent to England by sea from West Indies has lower soluble solids, higher acidity, less skin and pulp colour and less disease development, all symptoms of delayed ripening. Quality of fruit removed from refrigeration and ripened at 23° C for 2 days was acceptable for marketing, but these results are controversial.

**Storage in controlled O<sub>2</sub> and CO<sub>2</sub>.**

Following are a few examples of controlled storage (CA)

- i. Alphonso and Raspuri, stored at 9.2° C and 7.5% O<sub>2</sub>, for 5 weeks.
- ii. Alphonso and Raspur, store at 6.4°C and 75% O<sub>2</sub>, for 7 weeks.
- iii. Keitt stored in atmosphere with 5% O<sub>2</sub>, 5% CO<sub>2</sub> at 13°C for 20 days.
- iv. Haden with 6% O<sub>2</sub>, 10% CO<sub>2</sub> at 8° C, has double the life as of above. Julie 5% O<sub>2</sub> 5% CO<sub>2</sub> at has been tried for 4-5 weeks.

This shows that for each cultivar controlled atmosphere has to be different.

**Hypobaric Storage.**

Fruit which took 16 days to ripen at 760 mm Hg and 13°C, took 30 days at 100 mm Hg and 35 days at 75 mm Hg. At 50 mm Hg fruit was desiccated. At 250 mm Hg,

fruit took as much time as at 760 mm Hg. There is some scope in this method which needs further research.

### **Chemical Control of Ripening.**

2, 4, 5-T at 6-1500 ppm 2, 4-D at 20-60 ppm delayed ripening, but potential of these chemical is not known.

### **Ripening.**

Optimum temperatures for different cultivars vary and are in the range of 18-24°C. Better colour is possible at 15°-18°C, but decay is likely in immature fruit. At 26.7°C fruit ripens with strong flavour and some mottling of skin, but not so much with cultivar Kent and Keitt. Ethylene or CaC<sub>2</sub> or Ethephon (2 Chloroethylphosphonic acid, Ethrel) will shorten ripening time, produce uniform ripening, promote yellow colour development and increase flavour of immature fruit. Recommend dose for ripening are:

- Ethephone 500-1000 ppm
- Ethelene 5-10 or 10-20 ppm.

Higher concentration induces discolouration in the former cases.

### **What treatments are needed after harvest for local market?**

For local consumption or export and sale within 8 days the treatment may be limited to harvesting, de-sapping, washing, fungicide application, quality grading, sizing packing, palletising and transport.

### **Post harvest disease controls for extending shelf-life**

The brief history of post harvest is:

The development had started in 1900's, but modern approach came after 1960. In 1962, hot water immersion at 45-60°C was suggested and was found effective to 50°C for 30 minutes and at 55°C for 10 minutes. Higher temperature or longer times caused fruit damage. In 1972, it was demonstrated that adding 1 gram of Benomyl or Thiabendazole per litre of water at 54.4°C with or without fungicides caused scald injury. In 1976, temperature was reduced to 51.5°C with Benomyl dip at 500mg/litre, without reducing the efficiency. Heat treatment increased rate of colour development; but caused no scalding or shriveling to the skin of cultivar Kensington pride, stored at 25°C and assessed after 11 days in Australia. In 1978, one minute treatment at 52°C to Tommy Aitkin in a solution of one gram of benomyl per litre of water and stored at 13°C for 17-18 days and ripened at 22°C reduced damage from 64% to 17% in Florida. It was found that benomyl was not effective when applied in cold water or hot water applied alone at 52°C without Benomyl. In 1982, Improdione in hot water at 55°C for 5 minutes gave control. In the same year Prochloraz was found effective in cold water in case of avocado. Cold water dip of fruit in Prochloraz (55 ml per / 100 L) for 2.0 minutes using a on return spraying rack was effective. Black spot formation to mangoes was controlled by vitamin K, Aureofungin and

borax, against *Rhizoetoniabataicola*, when unripe mangoes were dipped in these solutions.

### Post-Harvest Chemical Dip.

Conference in Mazatlan Mexico jointly sponsored by USA office of International Cooperation Administration and Development USAID and Ministry of Agriculture Mexico in June 1989, on post-harvest treatment arrived at the conclusion that; for hot water treatment before dip, mango temperature has to be above 21.1°C (70°F). Dipping at 52°C in 0.1% Benomyl for 2 minutes gave Anthracnose control, however this dip did not control stem end rot, caused by *Diplodia Natalensis* (*Botryodiplodia Theobromae*.)

### Post harvest control of fruit fly by chemical dip.

Table below shows the chemical control methods and rates of chemicals.

Insecticide	Treatment	Stage	Survivors viable pupae	Mortality %	Conclusion
Dimethoate.	Dip 1 min.	Eggs larvae	77 159	99.8% 99.56	Banned
Fenthion	Dip 1 min	Eggs larvae	12 8	99.96% 99.97%	Allowed
Dimethoate.	Spray 16 1 min <sup>-1</sup> m <sup>2</sup>	Eggs larvae	258 8	99.33% 99.98 %	Banned
Fenthion	spray 16 1min <sup>-1</sup> m <sup>2</sup>	Eggs larvae	274 0	99.6% 100%	Allowed

Dimethoate is now banned in Pakistan and only Fenthion can be used

### Ethephon and fruit quality.

Mango dipped in 1 to 2g per litre solution for 1-2 minutes accelerated ripening of Keitt mango and is useful alternative to constructing gas chamber. The effects are:

- TSS is increased.
- It increases percentage of red area on skins.
- Flavour improves.
- Fruit remain firm.

### Precautions in hot water treatment.

Following are important precautions.

- Dip temperature. 59°C.
- Duration of dip. 2 minutes.
- Benlate or Benomyl concentration 1g per litre.
- Benlate is to be mixed separately.
- Topping up of Benomyl is necessary.
- Dip solution is to be continuously agitated by circulation pump to provide oxygen.

- Entire dip is to be replaced every 3 days.
- Gas or electric heater is to be thermostatically controlled.
- Fruit to water ratio has to be 1 kg fruit and 3 litres of water, as no loss of heat can occur at their ratio.
- Bonlate (Benomyl) is no longer available in USA since 17 July 1989, but it is still being manufactured for use in developing countries.

#### **Stem end rot control.**

- Unheated Prochloraz can be used as non-recirculating spray to control stem end rot as hot water Benomyl dip does not control it.
- Dipping in Sportak solution at 55 ml/100 litres of water for 2 minutes, controls stem-end rot. This is done after hot water dip against anthracnose. Mango is to be dried before application of Sportak.
- FAW/WHO allows Prochloraz at rate of 2mg per kg of whole fruit.
- Australians use 5mg per kg of whole fruit.

#### **Prochloraz spray versus Benomyl dip.**

- Hot water Benomyl is treatment for long storage against anthracnose.
- For short term storage, Prochloraz dip at 55ml per 100 L of water at room temperature used as non-re-circulating spray over fruit for 2 minutes gives control. Best is two Tx2 nozzles at 46 psi (320 kpa) and 16 litres solution per hour.

#### **Prochloraz and hot Benomyl combination**

1982 combination of fungicide such as Benomyl plus Improdione in hot water were found better than any one of chemicals. Cultivars vary in tolerance to water treatment and immersion in Benomyl. Dip at 55° C for 5 minutes, causes severe shriveling to some cultivars. Some cultivars do not shrink but lose luster. Waxing in some cases immediately after dipping obviated shriveling and maintained the fruit finish. Many cultivars are affected by dip at 50°C for 10 minutes, followed by storage at 24-26°C, for 10 days. Hot dip to remove sap and dirt and treated fruit show much better colour, Cold water dip in Prochloraz to controls anthracnose and stem end rot, is effective but for short period only. Fungal spoilage of mango during post harvest can be reduced to a low of 4% with one week storage, by dip in hot water and Benomyl.

#### **Post-harvest dip in Ethephon.**

Ethephon at 500, 750 and 1000 ppm reduces spongy tissue and it enhances ripening by 2-3 days. 500 ppm was considered better, as rates higher than 500 ppm affected keeping quality

#### **Hot water for soft brown rot control.**

Benomyl 50% wettable powder in concentration of 1000 ppm active ingredient controls, soft brown rot.

#### **Disinfecting against fruit fly.**

- Presently water vapour treatment (VHT) to disinfect mango is being practiced in mango countries. They are also working on improving technology for pre-harvest controls in the field. Vapour heat treatment technology is costly but is acceptable in Northern America, Japan and China.
- In north American they allow dipping of mango in hot disinfection water at 46.5°C for 75 minutes instead of vapour heat treatment, for anthracnose and fruit fly control.
- Ethelene Dibromide used for fly control by fumigation is no longer acceptable in USA or Japan.
- Canada allows Prochloraz and Benomyl hot treatment.
- Mango import has increased many folds in USA, since eighties.
- Due to seed weevil, mango import from Philippines Australia and Thailand is prohibited in USA.
- Registered packing houses in Mexico and Latin America have registered suppliers, who bring mangoes only to these packing houses.
- Heat treated mangoes, sell at very high prices in Japan.

### **Hot water treatment equipment.**

#### **Layout of HW disinfecting machine along with weight sizer.**

This simple drawing shows how to disinfect mangoes against fruit fly. Baskets of mango are put on moving rollers at required temperature of water say 46°C and they move from one end to other in 60-75 minutes. Their movement is controlled by speed of conveyor. Fresh rinse is to remove any sap or dirt. Fungicide application will enhance post harvest life as well as cosmetic look of fruit, but its use will depend on the acceptance of mango importing country. Sorting table will be for removal of unwanted fruit. Weight sizer will grade fruit in different sizes including under weight and rejectable pieces. To protect fruit from re-infection by fruit fly, the whole premises from desaping to end of packing has to be protected by proper screens and even box holes covered with screens, allowing air and moisture movement. Mango season temperatures in Pakistan hit maximum of 42-49°C. It will be economical to hold water in an over head metallic tanks to save cost of heating the boiler. The temperature control over in the hot water tank has to be maintained accurately by sensors.

#### **Cost of vapour heat treatment in Australia**

- It costs 5 Au cents per kg in Australia
- Capital out-lay is A\$ 2.0 millions for plant and equipment giving a capacity of 50 tons per day and 300 days a year of which 60 days are dedicated to mango
- EDB treatment costs 8 cents per kg. It is simple cheaper on capital outlay, but is illegal since January 2006.
- If only mango is handled for VHT (vapour heat), cost will be 20 cents per kg.

### **Hot water damage.**



5 minute dip at 52°C causes no damage, 1 minute dip a 55°C can cause no damage in many cultivars, but not in all.

#### **Sap burn.**

Fresh fruit dipped or washed in water containing 1% Alum within a few minutes of contact, can remove sap spots.

#### **Lentical spotting.**

If mango is held more than 5 minutes in hot water for washing or any post-harvest disease control, the corky tissue in lentil (breathing pores in skin) will swell and become pronounced. Such fruit when ripened, will appear to have dark spots.

#### **Post-harvest handling and Impact damage.**

Hard unripe mangoes crack internally near seeds. Some times break up takes place in form of surface cracks. Critical drop height, at which damage occurs, is more than 12 inches (30 cms)

#### **Pressure bruising.**

Pressure bruising occurs as mangoes start ripening specially in bulk bins.

#### **Waxing.**

Since natural wax of mango is removed by hot water treatment, light wax can be applied. Thick wax quoting will suppress the metabolism of ripening process by reducing respiration. Wax has to be light and is applied by dipping or applied by piece of cloth. The following are common methods.

- i) Spray of Mersion in wax emulsion (6% waxol-W-Emulsion) reduces loss of weight and spillage of mango. Storing at higher RH, and room temperatures 29-35°C in 200 gauge polythene bags, with 0.6% ventilation, has the same effect.
- ii) Wax emulsions containing 8-12% solids were most effective for prolonging storage life of mango by two weeks in case of mango Banglore and 6-8% in case of Neelum.
- iii) Wax emulsion containing 0.4% SOP increases storage life of mango by 2-3 days only.
- iv) Fruit dip in hot water and coating with wax delays fruits rotting.

#### **Some effects of post-harvest use of chemical wax emulsions on mango.**

Waxes are being used on citrus, tomato, banana, apple, potato, avocado, papawa and lychee. Various waxes contain the following constituents:

- 15% paraffin in emulsion.
- 20% Bee wax and resin.
- 45% paraffin and resin.
- 20% resin emulsion.



### Condition of fruit to be waxed

Fruit can be treated at 52°C for 5 minutes in 0.5 g per litre fungicides or other approved treatment and is dipped in 5% concentration of above waxes and stored. However waxed fruit takes longer time to ripen to eating stage and extension of shelf life reduces the eating quality of fruit thus waxed.

### Gamma Irradiation.

#### General.

This treatment is in the early stages of development with regard to mango. Irradiation has a number of advantages over chemical treatment and it leaves no chemical residue. There also is reduced risk of resistance and effectiveness against broad spectrum of organism, including a number of insects. Heat treatment combined with irradiation to prolong storage conditions was developed in 1982. Irradiation was further made more effective by incorporating fungicides into wax, applied after heat treatment, but prior to irradiation. This was still further improved by using combination of Improdione at 1 gram per litre plus Benomyl at same rate at 52°C for 5 minutes. In case Keitt, stored for 4 weeks at 12°C, 93% fruit was saved.

#### Gamma radiation doses.

Mortality of mango seed weevil resulting from gamma radiation at various doses as percentage

Stage.	Untreated		Treated					
	n	%	0.3 n	KGY %	0.6 n	KGY %	1.0 n	KGY %
Larvae	23	0	20	65	12	100	10	100
Pupa.	11	0	16	50	15	100	37	100
Adult	36	0	30	80	32	100*	27	100
Total	60	0	66	68	59	100	74	100
	25		53		56		54	

Some reaction could be obtained from adults dosed at 0.6 kgy, but they were more bound and incapable of voluntary movement.

### Post harvest spoilage of mangoes by *Penicillium Cylopium* and control by irradiation.

A dose of 25 krad treatment normally used, failed in case of mango but dose of 500 krads produced effects but following doses worked under certain conditions.

- A dose 20 to 32.9 Krads kills mango weevils in seeds.
- Dose of 16-28 Krads will delay rate of spoilage organisms.
- Irradiation of immature fruits can spoil fruit due to inadequate disease control.
- Irradiation should be at proper maturity i.e., colour break stage.
- Irradiation should be that of dry fruit, as wet fruit has adverse phytotoxicity on the skin.

- Irradiation has depressing influence on colour development, therefore application of ethylene before cold storage is recommended. Ethylene has to influence after cold storage.
- Jelly seed is associated with period of storage.
- Application of 6% Acetelmonoglycerids wax-coating before irradiation increases storage life.
- Irradiation does no change chemical composition of mango.

#### **Storage temperatures for mango.**

- It is not safe to store green fruit below 10°C (50°F) for any length of time.
- Chilling injury can occur if green fruit is stored at 40°-45°F (4.4-7.2°C) for 5-20 days.
- Storage temperature up to 52°F (11-1°C) and above cause no injury in some cultivars, but in others damage occurs even at 13°C, which should be considered as storage temperature for most cultivar.
- Mangoes stored at ambient temperatures losses more weight than those at 7°C to 10°C. Those at higher cooling temperatures lose more moisture than at lower temperature.
- At 12.5°C (54.6°F) storage, shelf-life is 2-3 weeks.
- Fully ripe mangoes can be held at 0 to 1°C for 6 weeks. The skin will darken but pulp will remain fresh.
- Mango fruit dip in wax emulsion (6%) and Captan (0.5%) or MH (2000-4000 ppm), for 5 minutes and stored at 32°C or 90°F had storage life of 9-10 days against 6 days for control, at the same temperature and weight loss was 1.3-4.2%, against 14-15% for controls. The ascorbic acid content was un-effected by this treatment
- Cooling to 13°C may be done within 12-15 hours of harvest.
- Storage temperature of 12.5°C and ripening at 23°C for 2-3 days gives satisfactory results.
- Maintaining fruit at 13°C will keep it for 21 days, but no more than three layers of mango are to be used.
- Best ripening temperatures of mango are at 70-75°F (21-23, 9°C).
- Un ripe fruit is held at 12-12.8°C (54 to 55°F) in transit.
- Commercial ripening of Florida mangoes is done with ethylene as at 10-20 ppm at 18.3 to 21°C (70°F) for 12-24 hours and 95% RH, followed by shipment to destination.
- At 22°C fruit will ripen in 7 days. Fruit develops the brightest and most attractive colour at 15.5°F (60-65°F) , but for flavour, last 3 days storage, at 21-23.9°C (70-75°F) is needed.
- At 26.66°C (80°F) fruit develops strong flavour and molted skin.
- Higher the storage temperature greater is weight loss in fruit and spoilage is more at higher temperature than at lower temperature. At lower temperatures, fruits can be held for longer period.
- Alphonso is best mango for storage and long distance transportation.
- Storage life of ripe mango may be increased by a few days, without skin or pulp injury at 45°F.

- Optimum temperature for skin colour is 16°C and 27°C for flavour.

### Storage and loss of weight.

Hot water treatment at 52°C for 2 minutes in 0.1% Benomyl solution and holding it at 13°C (55.3°F) for 17-18 days and again softening it for 3-4 days at 22°C (71.6°F), gives 17 to 25% loss in Tommy Aitkin and Kent respectively. In other words it is only profitable to delay sales by 3 weeks if prices are expected to double during the period.

### Controlled atmosphere.

- Mango post-harvest life is only 4 week under controlled atmospheric (C.A) storage conditions at 13°C.
- Controlled atmosphere (CA) has to be at 13°C (54.4°F) and not below it, as it will then not ripen properly.
- CA at 13° C (55.4°F) will slow down colour development resulting in to softening before colouring.
- Under CA condition fruit is susceptible to Alternaria rot.
- Storage life in air at 10° C is 2-3 weeks.
- Temperature for optimum fruit colour and quality development is 20°C.

### Storage Environment.

In 1978 mango lots were held in refrigerated pack-house at 10°C (50°F) or slightly more temperature, in some cases.

### Storage Behaviour.

Storage of following Brazillain cultivars in environments shown in the second column, and detailed as Temperature (T), Relative Humidity (RH), carbondioxide and nitrogen in the air (N) showed no deterioration for periods shown in the last column of table below.

Cultivar	Environment				Storage life days.
	T°C	RH %	Carbon dioxide	N	
Carlota.	8	90%		80%	2 weeks
Haden.	8	90%		80%	2 weeks
Jasmin	8	90%		80%	3 weeks
Sao Quirino	8	90%		80%	3 weeks
Carlota	8	80%	6%	80%	35 weeks
Haden.	8	90%	6%	80%	30 weeks

### Storage behaviour of Florida Cultivars.

Fruits of mango cultivar listed below were stored in following environments and storage period was as under:

Cultivar	Environment		Storage Days
	T°C	RH %	

Tommy Aitkin	12°C	85-90	33 days.
Zill	12°C	85-90	28 days.
Haden.	12°C	85-90	21 days.
Mamey	12°C	85-90	12 days.

This shows that different cultivars have different post-harvest life under the some environments.

### **Ventilation in Storage.**

Air flow rate is limited to 1 litre per fruit, per sec and, at static head of 9 mm of water.

### **Transport and Abrasion injury and losses**

The following are causes and consequences of transport injuries.

- i) Vibration damage is caused by loose packing in single layer or multiple layer packs. Packs should be tight but not press tight.
- ii) Bulk packs should be slightly over packed and settled by initial vibration for a few seconds.
- iii) Fruit scratched on dirty equipment used in post-harvest. The equipment for harvesting has to be cleaned regularly.
- iv) Brushing time is reduced by clean brushes. Long cleaning time over 30 seconds, can increase bruising.
- v) Losses in transport can be 30-40% if transported in heaps.
- vi) If mango is transported in bulk bins (350 kg), 70% of bottom layer fruits get bruised.

### **Un-marketable Fruit.**

Un-marketable fruit percentage varies between 10 to 40%.

### **Ripening of mango.**

- Ethylene spoils fruit quality as compared to calcium carbide.
- Ripening rate can be enchanted by dipping fruit in 2-chloro-ethyl phosphonic acid or by use of ethylene gas.

### **Fruit ripening environments.**

Ambient temperatures of 30-35°C (86-95°F) under shed results in ripening mangoes to an excellent quality, but more losses occur due to off flavours for any temperatures above 27°C during ripening.

The best environment for ripening is, 22°C or (71-72°F) and 85-90% R.H. A 18°C (64°C) a more attractive colour is obtained, but a few days at 22°C (71. 6°F) is necessary for the best flavour. Temperature of 26°C (78.8°F) has deleterious effect on quality of fruit.

Fruit stored at pressure of 100 and 75 mm Hg ripened after 25 and 35 days at 13°C (55.4°F), but for best flavour, it was exposed to 25°C for 3-4 days at normal atmospheric pressure.

- Ripening mangoes gives out heat and moisture. Wrapping material has to be permeable to air, and moisture. Plastic material is not to be used. Tissue paper is preferred.
- Fruit transportation over long distances has to be done in cold storage conditions. Low temperature of 7.2°C (45°F) will damage fruit physiologically. A Temperature of +13°C (55.4°F) is acceptable but post-harvest decay will be fast. Cold storage temperature of about 10°C or (50°F) may be ideal but not for all cultivars.

#### **Effect of calcium carbide on ripening.**

Calcium carbide at 2 g per 4-5 kg fruit box or 8 g in 20 kg box, produces fruit of best palatability. In ripening of mango, calcium carbide gives better results than ethylene.

#### **Ethylene gas in ripening.**

Ethylene gas as post-harvest treatment to promote colour and uniform ripening, is recent introduction. Benlate and Nu-Film 17 for anthracnose control, also improves colour but does not produce ripening and ethylene has to be an additional treatment. Brooks, Kent and Palmer mangoes after harvest treated with ethephon at 100 and 1,000 ppm ripened earlier than control. Taste of fruit was also better than control, which took longer time and allowed anthracnose lesions to develop, accompanied by undesirable flavours.

To ripen mango quickly, it is dipped in solution of 20 ml or ethrel or ethephon in 20 litres of water, for a few seconds. Ripening time will be reduced.

#### **Retarding mango ripening and increase storage life.**

Following are some methods used to retard mango ripening.

- i) Alphonso mango dipped in Cycocel (chlomequat), Alar (Deminozide), GA<sub>3</sub> or Menadioebisulphate (Vitamin K) has retarded ripening at 28°C (82°F) storage. Brix was low and firmness was high.
- ii) BA applied as 2x10<sup>-4</sup>M or 200 parts per million parts for 6 hours dip, retarded ripening of mango, increased TSS, sugars and organic acids, but amino-acid were reduced. It delayed ripening, but chemical composition of fruit under-went a change and taste of fruit was different from normal.
- iii) Delay in ripening of mangoes can be achieved by putting potassium permanganate (KMnO<sub>4</sub>) blocks wrapped in polythelene films and placed in polythene bags containing mangoes and stored at 10°C or (50°F). Storage life is increased to 20 days.

#### **Post-harvest ripening of mango.**

Ethylene treatment at 100 ppm reduces ripening period and gives it deeper colour. Ripening rate can be enhanced by dipping fruit in 2-Chlorethyl Phosphonic acid or by use of ethylene gas.

#### **Cooling.**

Cooling is not needed if ripening is planned within 10 days, but even in this case mangoes ripened at 70°F or 21°C have less damage than at higher temperature.

## CHAPTER - 31

### MANGO DISEASES.

#### **Anthracnose Symptoms and causes.**

It is a fungal disease which invades inflorescence, fruit, leaves, panicles , fruit stem and young and mature fruits, in the following manner. Stalks show presence of narrow black spots one centimeter long, and remain on trees after healthy but unfruitful panicles have fallen down. On axis of flower panicles, lesions appear as small brown to black spots which enlarge coalesce and cause entire inflorescence to blacken and wither before fruit set.

- Late infections, produce depressed black lesions on young fruit, which usually results into fruit drop.
- Spore of causal fungus are splashed by rain and spray water on new leaves and fruits.
- Under wet conditions anthracnose can cause complete loss of flowers and young fruit.
- It is not a serious problem in dry climate but having been neglected in Sindh for years, it is present in every orchard and causes serious losses. Lately do to climatic changes rains occur at time of full bloom and destroy the inflorescence .
- Infections on large fruit (4-5 cms dia), do not develop in to lesions, but remain dormant until fruit begins to ripen. The dark depressed circular lesion develop on the ripening fruit and enlarge covering almost entire fruit. Under moist conditions (i.e. if rains come early, or in the late varieties after rains, infections usually develop in to lesion and salmon to orange coloured spores are produced.)
- Masses of pinkish orange spores may develop on blotches.
- On young leaves infection causes small brown to black lesion which are sub-circular to angular in shape, lesions enlarge, coalesce and destroy large areas around the leaf edge. Several affected leaves usually curl. In moist conditions salmon to orange spore masses form.
- Infection increases after July-August rains in Sindh and is carried over to flowering. Copper sprays in September and October will reduce incidence during flowering in January-February.
- Lesions from over a range of temperature 10-30°C and also under wet conditions of 95-97% RH. Thus they can be produced through out the year in Hyderabad area, except April to on set of rains in July-August.
- Dew does not promote its dispersal.
- Dead wood or old senescent mango litter does not promote it.
- Infection periods can vary from 2-14 days.
- Examination of stalks will reveal presence of narrow black spots one centimeter long.



- These flower stalk tend to remain on tree long after healthy ones, in which fruitful panicles fall down.

### **Causes.**

It is caused by fungus (*Glomerella Cinaulala* and *Collectrotricum Gloeosporioides-Penz*) produced at 10-30°C and 95-97%.RH

- The fungus produces black spots, 5mm diameter which cause distortion and splitting as fruit grows.
- It also causes dots to large blots of pinkish orange, spores on the skin of fruit.
- Wetness by rain can trigger blossom blight at 22-25°C, the temperatures usually prevalent for 2-3 weeks in February or March in Sindh. It is serious in wet areas, unlike powdery mildew which is a problem of dry areas. In some years rains for a few days destroy inflorescence completely in some varieties. Rains in February can destroy total in florescence in Baganpali in Hyderabad area.

### **Effects.**

- Anthracnose destroys inflorescence and prevents fruit set.
- The disease is particularly devastating on young leaves which results into defoliation and die back of flush growth. It is common in Sindh.
- Wet weather during flowering causes blossom blight and destroys flowering and prevents fruit set.
- Infection continues until harvest, but disease remains latent until harvest and returns during fruit ripening period with severity.
- Infections occur on flowers and panicle as minute brown or black spots which eventually cause death.
- Fruit will have black spots of various forms, causing fruit rot.
- If rain occurs during flowering, anthracnose will effect the whole panicle, flowers and young fruitlets, which will shed. It is also leads to blossom blight.
- It is particularly divesting on young leaves, which get defoliated and die back.
- If it rains after sprays, fungicide gets washed off and re-spraying is essential.
- Anthracnose appears 2-3 weeks after 20% flowers are at red coloured to red open stage and first spray should be applied at 20% red colour stage. It may be repeated every 3 weeks until fruit set.
- Major source of inoculum for blossom blight is diseased immature leaves. Its various manifestations on mango include blossom blight, leaf spot, fruit resetting and fruit rot. Humidity rains and heavy dews during critical infection periods increase disease incidence.

### **Cultivars susceptible and resistant anthracnose.**

All south Asian mono-embryonic varieties are susceptible to anthracnose.

### **Highly susceptible cultivars**

The cultivars which are highly susceptible Anthracnose are:

Sindhuri,Baganpali.,Manranijan,Wilard,

### **Cultivars resistant to anthracnose**

These varieties are Edward, Earlygold, Mayaguazano, Carrie, Elamendi, Glenn, Irwin, Carabao, Alphonso, Nam Dok Mai, Florigon, Crimson Blush of Australia, Tommy Aitkin, Keitt, Sensation, Sabre, Saigon, Ameliore, Brooks and , Kensington,

### **Cultivars moderately susceptible to anthracnose.**

These are: Sawarnarika,Keitt, Neelum and Kensington Pride.

### **Control of anthracnose.**

Mancozeb weekly during blossoming and monthly until harvest. After harvest copper Oxychloride is recommended as substitute for Mancozeb. In dry areas of Pakistan 5-6 sprays from preflowering to fruit set and one or two sprays after fruit set are needed until harvest. Copper Oxychloride at 0.35% every week from 2 inches long panicle to fruit set, then monthly total 12 applications controls post-harvest anthracnose. Since 1975 anthracnose was controlled by Benomyl at 1.121 kg per ha or Maneb at 1.68 kg per ha (80% ai) and Nu Film 17 at 125 ml per 100 litres or Trifon1956 at 15.6 ml per 100 litres of water. All worked satisfactorily. Benlate is no longer manufactured for use in USA. Since 1980 it was controlled by spraying every week with 0.16% Mancozeb during blossoming and then monthly until harvest. The spray dose consisted of Mancozeb, 800 g/kg a.i at 2 g/litre or 200 grams in 100 litres water. In 70's the following 3 chemicals were also used to control anthracnose,Cupravit Azul at 0.35%.,Ferradol at 0.2%, and Diathane M45 Mancozeb at 0.2%

All treatments gave the same results.

In early 80's following chemicals came into use:

Zineb or copper Oxychloride at 0.25 kg per 100 litre was applied at 15 days interval until harvest. Other treatments used against anthracnose were,Melprex 0.2%,Cupravit 0.2%,Polyram. ,Coal tar 0.2 % (affected branches were cut off and other sprayed Burganny mixture. 0.25%,Zerlate. 0.25%,Fermate.0.25%,Cobox. 0.25%,Anthracol 0.2%,Diafolation. 0.2%, Trimiltox. 0.2%. Deconil 0.2%, Liro-monzeb.0.2%, Boreaux mixture (3:3:50 i.e. 3:3 Ibs in 50 imperial gallons) or 600g:600g:100 Litres.

### **Latest treatments**

- i) Prochloraz + copper Oxychloride applied fortnightly can control and Anthracnose and increase yield many folds.
- ii) 4% copper Oxychloride in low volume just before flowering improves fruit set.
- iii) Chlorothalonil is one of the latest recommendation.
- iv) Sequential spraying with triple mixture of fungicide insecticides and foliar fertilisers Mancozeb, Captatol. Chlorothalonil is the best of all.
- v) When infections become visible Prochloraz is applied.
- vi) After harvest every new flush is sprayed with copper Oxychloride.

- vii) Mancozeb spray 200 g per 40 litres water per acre, for low volume sprays or for high volume sprays of 320 litres per acre of 800 g Mancozeb are needed.

Prochloraz is applied alone and also strategically i.e., alone or copper plus, Mancozeb It has been shown that Prochloraz plus copper applied either fortnightly or strategically during flowering, give for greater yields than does copper plus Mancozeb, Mancozeb does not control anthracnose and as result little fruit is set. Strategic application of Prochloraz alone also does not result in statistically greater yields than jointly with copper.

#### **Post harvest control of anthracnose in fruit.**

The following are chemicals and their doses.

- i) Prochloraz dip at 0.55 ml per litre for 2 minutes controls anthracnose as well as stem end rot.
- ii) If Benomyl is used for control dip time is 5 minutes at 48.5 to 52.5° C, and dose is 0.5 to 1.0 grams per litre.
- iii) Heating fruit at 46°C for 2 hours controls anthracnose and stem end rot.
- iv) Funga 500 EC at 500mg per litre for 3 minutes, as post harvest dip controls anthracnose. Higher doses are not more effective.
- v) Imazil or Fungafloor at 500 mg per litre in hot water reduces anthracnose up to 88%.

#### **Post-harvest anthracnose control in cold storage.**

Anthracnose is completely inhibited at 10°C, but is partially reduced at 15°C and it is resumed rather severally as temperature was raised for ripening. Most mango varieties are subject to chilling injury at temperatures below 13°C. Field situation involving removal of infected twigs, flowers and fruits needs to be carried out.

#### **Prochloraz dip.**

Prochloraz has given good control of Anthracnose but not of stem-end rot. Overall, it has been less effective than hot Benomyl dip. However growers prepared to accept lower control levels for increased convenience may find it useful as no heating of water is required. Sufficient data is yet not available and Prochloraz is likely to become a non-recirculated spray.

#### **Comparison of hot Benomyl and cold Prochloraz dips for Anthracnose and stem end control.**

Treatment	Anthracnose	% Stem-End	% Acceptable
	0-5 Scale	Rot	
Untreated.	3.0	37	10
Heated Benomyl dip at 52°C for 5 minutes in 1 g per litre.	0.5	6	86
Prochloraz, 30 second dip at 0.55 ml per litre	0.9	37	40

Prochloraz 1 minute dip at 0.55 ml per litre	0.7	61	30
--	-----	----	----

#### **Dip tank size.**

- Usually 34x34x25 inches (86x8x63.5 cms) deep tank is used and has capacity of about 60 litres of water and 90 kgs of fruit. Heater of 4 KW provides required heat. It takes 30 minutes for initial heating.
- Crate to hold fruit and dip is to have capacity of 90 kgs. Two crates of 45 kgs each can also be used at a time.
- Large tanks can be built having capacity of 250 kgs of fruit and 1200 litres of dip.

#### **Management strategies against anthracnose in the orchard.**

- All internal growth should be removed leaving only peripheral foliage on the tree.
- Flush leaves or suckers originating from main branches should be pinched off, as they appear.
- Winter pruning of defoliated branch terminals and dead leaf terminals may be done.
- Diseased leaves should be defoliated.

#### **Field Control Methods.**

- Field spray with protectant fungicide during fruit development
- Post-harvest treatment of fruit in hot water Benomyl (Benlate)
- If there is wet season during flowering fungicide sprays be applied weekly during blossoming to increase fruit set, but in dry season fruit setting usually is satisfactorily. In the both above cases, monthly sprays after fruit set, reduces pre and post-harvest losses.
- Rain water on foliage at any stage before harvest will wash down fungicides from foliage and reduce its effectiveness. Re-spraying then becomes essential.

Latest control against anthracnose during flowering, if it rains is spraying with Mancozeb 200 grams per 100 L and copper Oxychloride at the same rate, combine with Prochloraz. The old methods of 1960's to 1980's have been superseded as they are less effective. They also control bacterial black spot, Mancozeb is sprayed every two weeks and copper every third week. Start is made with copper. The two would be combined when turn comes. This is done during flowering and at least 4 times afterwards during fruit development.

#### **Stem end Rot (SER)**

Stem end rot is caused by fungus *Diplodisnate lensispole-Evan* at temperature of 13-25°C. This fungus lives in harmony with tree bark and stem tissue. The other fungus involved are *botryodiplodia theobromae* and *Phomopsis mangiferae*. Of these the first is very common. Fruit keeps them out until it is mature and then fungus grow from stem into fruit. It happens either in injured fruit or comes via the cut surface of attached panicle of stem end scar, when panicle is removed. If fruit is left in orchard for 8 hours after harvest, infection can be 10-25%. Infection is spread by leaf litre or

trees that have gone too old. Old trees have more problems. Well fed trees resist the disease and unhealthy trees promote it. High temperatures during fruit development and rains before harvest promote it. Shadier side of tree i.e, north, has less problem of disease.

### **Symptoms of stem end rot.**

The symptoms are, blackening of flesh around the stem end and rapidly becoming soft and decay. In a short time whole fruit may show these symptoms and rot. It is a common post-harvest disease.

### **Factors Promoting Stem End Rot.**

Following are some factors promoting it.

- i. If fruit is allowed to ripen on tree It is avoided by early harvest.
- ii. Exposure to high level of ethylene and calcium carbide promotes it in storage.
- iii. Chlorinated water dip increase the rot level.
- iv. Rot pathogen occur in orchard and on harvested , fruit should immediately be removed from orchard. It should not be allowed to touch the ground.
- v. As pathogen enters from stem end, remedy consists in blocking the stem end, against entry of pathogens. Mango should be picked up with about 5 inch, long stalk. Major portion of this stock is cut off under methylated sprit having still one inch attached to stem. This end is then dipped in molten wax.
- vi. High temperatures over 22°C in the market chain promote it and reduce shelf life.

### **Chemical control Methods.**

- i) Both stem end rot and anthracnose can be controlled by carbendazin at 1 gram per litre of hot water dip at 52°C for 5 minutes
- ii) Phosphoric acid sprays reduce it.
- iii) Prochloraz helps as pre-harvest spray. If combined with copper it is better. It should be applied after hot water treatment with carlpendazin.
- iv) Frequent copper oxychloride sprays suppress the organisms which produce it and it has negative effect. Benomyl is best if used along with hot water immediately after harvest. Doze is 0.1% at 52°C.
- v) Heating at 46°C for 2 hours controls stem end rot and anthracnose.
- vi) Since long storage favours it, susceptible varieties should not be stored too long, even though chemically treated.

### **Post-harvest control of chemically treated stem end rot.**

Benomyl dip in hot water at 52-55°C for 5-10 minutes. Substitutes of Benomyl in order of their effectiveness in non cool storage are:

1. Hot carbendazin.
2. Hot prochloraz. Cold treatment is ineffective.
3. Hot thiabendazole.

After these treatments, mangoes can be maintained at 22°C for 13 days. In case of cold storage at 10°C for 2 to 4 weeks stem end rot was more than 25% and some times hitting 50%.

### **Stem End Cavity versus stem end rot.**

It is different from stem end rot and develops when fruit is allowed to ripen on the tree. If fruit is harvested earlier, cavity is avoided. Flesh around the stem end feels spongy and cavity is found under the flesh, when cut open. Damage is localized and develops on ripening fruit. Some times stem end cavity and stem end rot become indistinguishable, specially to layman.

### **Bacterial black spot (BBS) of mango**

#### **Occurrence.**

It is promoted by fungus *Xanthomonas compestris*, which lives in leaves, bark and stem. It is favoured by wet humid weather, high relative humidity, winds and increases with rain. Black cankers mostly filled with gum occur on stem. Black lesions consisting of 2-3mm diameter on fruit enlarge to 10-15mm oval to circular form, star shaped cracks and there also occurs gummy exude on fruit. It affects leaves, stem and fruits. On leaves it forms annular lesions and scars and tissue dries up. Fallen leaves are also source of disease. Affected fruit appears healthy until it ripens. Disease is also favoured by wet humid weather, rains and wind. It has been reported from South Africa, India, Brazil, Reunion Islands and Australia. It is more severe in fibre-less cultivars. It is also common in peaches and other stone fruits. It occurs on young branches, stem, leaves and buds and is finally transmitted to fruit.

#### **Sources of infection of Bacterial Black Spot (BBS)**

The sources of infection are:

Summer canker, fallen leaves and rains, specially those wind driven.

#### **Symptoms of Bacterial Black Spot.**

The following are symptoms of BBS.

- i. The disease begins with water spots or lesions on leaves after summer rains i.e., in August or September. The best time to start control is in September.
- ii. Initially water soaked spots appear around stomata. These enlarge with yellow spots circular to oval in shape and 1-15 mm in size. The centres of lesions darken in colour and frequently crack open to form star shaped cankers 8-15 mm deep. Exposure of underlying flesh attracts insects and tissue discolours as it is invaded by secondary micro-organism.
- iii. With infection, old leaves become silvery and dead.
- iv. Elongated stem cankers also occur on the bark and can cause terminal die back.
- v. Tissue dries out.
- vi. As compared to anthracnose lesions of which expand as fruit ripens, bacterial black spot lesions do not expand.



- vii. Disease attacks through natural openings such as stomata wax-oil glands, leaf scar and panicle.

#### **Effect of Bacterial Black Spot.**

It can affect 25-40% fruits on the tree and these become unmarketable. Lesion of it do not expand as fruit ripens. In this respect it is different from anthracnose, where lesion increase in area. It causes heavy fruit drop, which is in addition to unmarketable fruit at the harvest.

#### **Cultivars highly susceptible to Bacterial Black Spot.**

Sindhuri is highly susceptible. Among Australian cultivars Nam Dok Mai is most susceptible and among Floridan cultivars Keitt shows moderate problems.

#### **Cultivars less susceptible to BBS.**

Sawarnarika, Chaunsa, Langra, Kensington, Zill, Tommy Aitkin, Kent, Keitt. are less susceptible to BBS

The first three are the Sindh cultivars. Kensington is Australian and the rest are Floridan.

#### **Non chemical remedies.**

The remedies against BBS are:

- i. Wind breaks to filter wind and slow down its force on leeward side.
- ii. In case of dense wind breaks, wind at high speeds causes vortex on leeward side, resulting into extensive damage.
- iii. Overhead irrigation is to be avoided.
- iv. Susceptible varieties are to be avoided.
- v. Disease free bud wood is to be used.

#### **Chemical protective sprays.**

From panicle emergence to fruit set (January to end March) regular sprays of following chemicals can reduce this disease.

- i. Mancozeb (200 per 100L) every 2 weeks during flowering, beginning with copper oxychloride every three weeks.
- ii. Combination of the two, if they fall on the same week.
- iii. Total sprays dose of above chemicals should be about 20 litre to mature tree and less to young trees.
- iv. New flush growth should be sprayed with copper Oxychloride or Bordeaux mixture every time to kill disease in young foliage.
- v. Post harvest sprays with copper Oxychloride in September, October and December also reduce BBS.
- vi. Copper Oxychloride and Zineb at 400g/100 litres. The first spray at is to be done at fruit set and there after every 14 days before harvest.
- vii. South African experience shows that bacterial black spot of mango occurs readily in humid field conditions. Reasonable control is obtained with



- streptomycin (Agrimycin 100) at (100 grams per 100 litres of water, but this treatment has adverse effect on fruit set, which reduces.
- viii. There is no full control of disease as yet, but copper fungicides have reduced incidence by about 30%.
  - ix. Removing and destroying severely affected fruit trees is only remedy. In South Africa 8, 000 affected trees had to be destroyed.
  - x. In Sindh it has been controlled by routine sprays of urea at 2% + copper sprays at 0.4% at monthly interval from August to December and again fruit from harvest. These sprays are used for control of anthracnose, and many minor fungal diseases and also to supply micronutrient copper.
  - xi. For control of BBS, modified Bordeaux mixture can be also used
  - xii. Inclusion of Chlorothanol with copper oxychloride has improved the control over the disease up to another 20% over copper in some cases. It is advisable to control BBS along with control of anthracnose, blossom blight, mildew and stem end rot and other minor fungal diseases. Copper oxychloride sprays at fortnightly intervals five times, before harvest can give control of most of fungal disease by 55-60% and increase yield by 30%. Fruit fall will also be reduced.

#### **Modified Bordeaux Mixture**

Soils of Sindh and Southern Punjab have high pH and therefore copper in Bordeaux mixture if in excess falls to the ground and gets fixed and does not create any problems of toxicity as it would do in acidic soils. Copper Oxychloride and other copper based chemicals are absorbed better. Only 0.5 copper in the Bordeaux mixture is used but still. Bordeaux mixture is cheaper. Old method of putting copper sulfate in earthen drums for 24-48 hours was cumbersome and new method is putting it into boiling water in non-iron vessel and it would easily get into suspension within half an hour.

The modified Bordeaux mixture is 500 grams copper sulphate 500 grams dehydrated lime + 0.5 litres light oil + 100 litres water. This mixture can control many diseases and some insects too. This is mixture is also called 0.5:0.5:100 + 0.5

#### **4. Integrated control of BBS, anthracnose button mayers and Sarnah.**

CuOCl<sub>2</sub> + Zineb + Mancozeb all at 200 grams per 100L water plus 5% urea, in all 3 sprays, one sprays at pea stage to marble size in March and two more spray 4 and 8 weeks later in April and May contribute these diseases. If copper is not applied, these diseases and BBS will take their toll and yield will come down.

#### **5. Powdery Mildew of mango (Oidium mangpifera Berthet)**

Mango powdery mildew, is shown by brown areas on the under side of mango leaves

- Powdery mildew is promoted by wet weather and frequent fog. It attacks leaves first.

- Powdered kelp spray controls mildew, as does sodium bicarbonate, but synthetic fungicides are common due to promotion by pesticide companies.

Anthracnose can be controlled by bimonthly application of copper. During flowering captan or mancozeb can be used.

### **Causal agent and symptoms.**

The causal agent *Oidium* sp., attacks flowers, which get covered with a white powdery fungus and are killed, stem and panicles turn black, the surviving fruit-lets fall, when they reach mustard size and remaining ones at pea stage, show purplish brown areas, which crack and became corky as fruit grows to marble size or beyond and falls, leaves are attacked on underneath side and affected leaves curl and distort.

The thinking in India was that it was caused by *Erysiphe cichoracearum* but others thought that it was due to *Erysiphe polygoni*. It is now believed that the cause agent is *odium magnifera* a wind borne fungus which causes infection after germination within 5-7 hours. Life cycle of mildew is completed in 9 days on vegetative shoots. It is promoted by wet weather, frequent fog or frequent heavy dew.

### **Behaviour of *Oidium Mangiferae*.**

Fungus germination is independent of relative humidity. It can occur between 20 to 100% R.H. It occurs when low winter temperature, rise from 20° to 24°C (68-77°F) and usually from 15 February to 5 March in Hyderabad area, but in some years it can be first fortnight of March. It can increase year after year, due to increased carry over of disease from previous years. Flowers set only a few fruits, which too become severally rusted. At 28°C mildew spores are short lived and are killed by heat. Fungus attaches itself within bud scales, where it remain dormant during rest of summer, fall and winter and appears again, when temperature rise to 24°C. Loss can be 25-40% from year to year and is more severe in dry areas.

### **Earlier partial control methods since 1960.**

- i. Hot dry spring weather with heavy dew at night, was considered conducive to mildew in South Africa in 1960 and 0.5:0.5:100 Bordeaux mixture gave some control if it was applied before flowering. Dusting with 50:50 copper oxychloride and sulphur powder mixtures or spraying, also gave the similar results. Copper Oxychloride alone gave some control. Copper is toxic to flowers and in general is avoided.
- ii. Powdered kelp spray controls mildew and so does sodium bicarbonate, but during dusting sulphur alone gave inconclusive results. *Bacillus Licheni* combined with phosphate salts gave some control, but copper was better.
- iii. Dusting with inorganic chemicals at the time of appearance of inflorescence and repeated twice at 14 days interval gave some amount of control, but better results were obtained if one protective spray of organic fungicides was also mixed with it.
- iv. During the same period application of sulphur or sulphur and copper oxychloride mixture sprays in January reduced incidence if protective sprays

were continued at 14 days interval in February until fruit set was well under way and temperatures had risen over 28°C, but as copper is toxic to flowers, instead mancozeb was used twice during February.

- v. These methods did not give full controls and new methods had to found.

#### **Latest mildew control methods (Organic fungicides for mildew control.)**

Organic fungicides have proved to be much superior but once used the mildew gets established and it becomes difficult to control it by inorganic chemicals alone. The following organic fungicides control it, if sprayed weekly during the period temperature are 24°-28°C. One of two sprays before temperatures rise to 24°C, applied at 14 days interval, reduce the damage to negligible and further if one or two weekly sprays are continued after its appearance.

Following is general recommendation from Australia, with time adjusted for Hyderabad area.

Stage	Time in Hyderabad (Sindh)	Dose in 100L of water.
Blossom beak.	21 January	Nimrod or Bupirimate (40-60 ml).
Full bloom	10 February	Or Rubigon or Fenarimol (30 ml)
Petal fall.	28 February	Pollinor or metiraminothral ilsoproyal (200g)
3 weeks after, petal fall.	20 March	Topass or panconazole (20 g)
6 weeks after petal fall.	10 April	Bayleton or triadimefon (50g) just before flowering and (100g) during flowering.
Last stage.	30 April	Saprol or triforine. (150ml)

#### **Note:**

Chemical are changed from time to time so that fungus do not develop resistance to them. Of all these bayleton was considered the best and only two sprays at 30g in 200 litres, 15 days before its anticipated arrival and on its arrival 60 grams in 200 litres, just 2 sprays during flowering gave full control. Bayleton has now been substituted by Bayton.

#### **Powdery mildew control by other organic fungicides and doses.**

For control of mildew doses of various fungicides used are given and elaborated Imugan (Chloraniformethan) at 0.5%. Mil-Col (drazoxolon) at 0.3%. Karathane LC (dinocap or Dnocp) at 0.15%. chinomethionate 50 mg a.i, per 100 litres. Propiconazole (Banner orbit), 20-50 grams i.e., per acre, Benomyl, Mancozeb, Dinocap, Carbedazim, Tridemorph or Trimephon, Agufon, Oxythioquinox, Bitertanol, Thiophanate, Landale, Methyl, metiram, Vigil, Punch (Flusilazole + Carbendazim) and some others.

#### **Mildew control in India.**

In India 3 sprays at 15 days interval of following two chemicals of are applied, Microsul (0.2% wettable sulphur) Bavistin (0.1% Carbendiazim) and Mancozeb applied for anthracnose control keeps powdery mildew under some control, but once established, mancozeb spray is not effective and one has to use organic chemicals. Latest findings show that mancozeb is totally ineffective.

**Varieties resistant to powder mildew.**

The South Asian varieties resistant in powder y mildew are:

Azamu-Sammar, Chanbeli Wali, Swarnarika, Chaunsa, Neelum, Malgoa, Zardalu, Banglora, Totapuri, Khurd, Janardan Pasand and Venraj, almost all cultivars of Sindh except above mentioned are affected by mildew except Sawarnarika and Chausa.

**Floridan and other cultivars highly susceptible to powdery mildew.**

Zill, Kent, Alphonso, Nom Doc Mai and Deshri.

**Floridan varieties moderately susceptible to powdery mildew.**

- Haden, Glen, Carrie and Keitt.
- In Pakistan Keitt shows resistance to powdery mildew.

**Floridan cultivars slightly susceptible to powdery mildew.**

These are ;Sensation, Carrie, Tommy Aitkin and Kensington.

As mildew takes heavy toll each year it is advisable to shift to cultivars resistant to it.

**6. Internal break downs in mango.**

**The different stages and types of break down are:**

- i) Premature ripening and softening of flesh adjacent to endocarp or seed. example are: Deshri, Sindhri, Haden and Nam dock Mai.
- ii) Stem end break down or stem end cavity which cause separation between vascular strands and seed.
- iii) Jelly seed or disintegration of flesh around seed into jelly like mass. examples are; Sindhuri, Deshri, Siroli, Tommy Aitkin, Kamerunga White, Van Dyke and Zill, and Sensation.

**Break down of Sindh Cultivars.**

Sindhri suffers from severe jelly seed problems most 100 percent large sized or late harvested fruits have jelly seed like the ones named in last paragraph. Chausa is another variety suffereing from 100% soft nose looking like spongy tissue.

- (i) Internal break down like jelly seed, soft nose usually does not occur in poly embryonic mangoes.

Chausa suffers from soft nose in almost 100% caused softens Deshri.

**Table showing foreign mango cultivars and their internal break downs.**

Cultivar	Jelly Seed %	Stem end bacterial down/cavity %	Premature ripening around seed %	Embryo type.

Carabao (Seedling)	-	-	29	P
Carabo (Clonal)	-	7	21	P
Carrie.	-	8	-	M
O.K. Rong.	-	-	40	P
Ono.	7	-	-	M
Roberts.	-	12	-	P
Sabre.	7	-	7	P
Sensation	11	-	11	M
Tommy Aitkins	42	27	-	M
Van Dyke.	26	38	15	M
Zill.	-	-	37	M

P= Polyembryonic

M= Mono embryonic.

## 7. Mango malformation, truth and myth.

### Mango malformation (*Fusarium monilifome* - sheld)

There are following three types of malformations namely:

- i. Abnormal development of Inflorescence.
- ii. Witch's broom like growth of shoots or vegetative malformation.
- iii. Seedling malformation, in which leaves get transferred into abnormal leaves .
- iv. The last two are less common than the first one, which is known to exist in India, Pakistan, South East Asia, Egypt, Syria, Israel, UAE, Mexico, Brazil and South Africa but not in Australia as yet. It is more severe in early flowering varieties. It probably is a subtropical problem. Varieties Sindhuri (Sindhura), Baganpali and Sawarnarika imported in Sindh from the South India in mid-thirties had no malformation problems until mid-sixties .Even today the problem is less severe in the varieties brought from South India. Although malformation was known in South and South East Asia, it was not known in Sindh until around 1960. Before 1947 Sindh had scattered mango seedling orchards around various towns in sweet ground water zone. Since malformation is not transmitted by seed, the province was immune.

### Malformation in South Africa.

The following in South African study of this malady.

- Trees Infected More than 1 to 28%.
- Losses. 10% or more.
- Returns reduction. 20%.
- Maximum loss to some growers. 30%

The cultivars of northern India were introduced in Sindh via the Punjab in fifties and early sixties of last century and the disease first appeared at the Horticultural Research Station (now Horticultural Research Institute) Mirpurkhas, from where it spread to the whole Sindh.

### **Cultivar Susceptibility against malformation**

Desheri, Chausa, Langra, Bombay Green, all Siroli strains, Alphonso, Fajri Gulab Khas. Tommy Aitkins, Kent, Haden are susceptible to mal formation. Deshri can have 90 percent infection in some years.

### **Least Susceptible Varieties.**

Kent, Keit, Baganpali, Langra, Sawarnarika are least susceptible to malformation Sindhri is moderately subseptible and only on early flowering panicles.

### **Causes of Malformation.**

South African studies show that it is caused by *Fasarium moniliformeshed*, but this cause of malformation was not known until recently and horticulturists had started attributing them to the following groups of problems during the past 35 years.

- Soil properties.
- Soil deficiency. (Egyptian claim)
- Zinc deficiency. (Egyptian claim)
- Temperature prevalent during the season and severity being inversely related to temperature.
- Micro-nutrient deficiencies or excesses and imbalances of various chemicals.
- Harmonic imbalances, lack of NAA or excess of gibberellins.
- Physiological causes related to age of vegetative flush, the previous spring flush having maximum malformation, summer flush having less problem and early autumn flush having the least (Taimur mango in Egypt)
- Unidentified fungus.
- Insects.
- Unknown.

The remedies suggested were to control all above deficiencies, but the results were always unsatisfactory and contradictory. None worked satisfactory from year to year, cultivar to cultivar and place to place. The present writers have observed that malformation in neither seed transmitted nor controlled by trace elements. Fungicidal sprays or growth regulators. Copper sprays for anthracnose and other fungal diseases have given some response in some years but not in others.

### **Results of micronutrients, growth regulators foliar sprays to reduce malformation.**

Application of copper, iron, zinc, manganese and boron at 400g/100L during post-harvest period reduced malformation at some farms in some years but not in others. However if due to climatic conditions flowering was delayed, malformation was much less.

### **Experiments in India with Growth Regulars.**



Experiments in India with growth regulators gave in consistent results as shown below:

- i. NAA at different concentrations gave some promising results, but results were inconsistent. Fruit set and yield of unproductive mango trees with malformation was improved by spraying with NAA at 200 ppm, applied once in October or November before flower bud differentiation, followed by hand de-blossoming of affected panicles in April. This method was reported to have reduced mango malformation by 40-50% and number of healthy panicles, was increased 25 times.
- ii. NAA at 50 ppm increased total number of panicles, but had no influence on incidence of malformation.
- iii. Deblossoming at first bud burst plus NAA application at 200 ppm, 4 months before flowering i.e., in October in Haryana (India) gave control in Deshri, but not in Chausa.
- iv. NAA applied at 150 or 200 ppm in Deshri and Bombay Green in October (November for Sindh) at Khanpr (U.P India), reduced malformation, but effect varied from year to year.
- v. NAA at 200 ppm, reduced malformation and increased yield on 20 years old trees by about 500-600%.
- vi. In a three year trial, NAA (200 ppm) applied in mid October to trees of mango reduced malformation significantly, as compared with 150 or 250 ppm, but of all three treatments 200 ppm appeared to be better. NAA spray at 200 ppm before flower-bud differentiation followed by dikegelac at 4500 ppm at bud burst, increased number of hermaphrodities in Deshri in India. NAA at 200 ppm followed by deblossoming was not better than NAA alone in another experiment in India.
- vii. Mango malformed trees were made productive by deblossoming at bud burst stage (December/ January) and spraying with NAA at 200 ppm, increased percentage of perfect flowers. The yield was 5.5 times in Deshri and 30% more than control in Chausa.

All above treatment with NAA seem to give limited results varying from year to year and were effective if accompanied by suitable climate and other chemicals.

#### **Chelated iron as Malformation Control in Sudan.**

- Mango bud malformation was reduced by chelated iron application of 100 to 200 grams per tree of containing 6-7% iron in 20 year old mango trees in Sudan.
- Chelated iron at 50-100 grams per tree at 3-4 year age, reduced mango malformation when these trees fruited next year. Sequestrene - 300, containing 10% iron, applied at 450 gram to each tree in the fifth year, increased yield from previous only 5 trees to 212 and in the sixth year to 468 fruits.



- Again 50 or 100 grams of Sequestrene 300 iron (Na Fe DTPA) containing 10% metallic iron reduced the number of malformed shoots to less than 12%. Higher rates were more effective.

### **Flower delaying as malformation control.**

Our observation over many years shows that early flowering induces of malformation and is reduced if flowering is delayed. Treatments with urea at 1-2% as foliar spray delayed flowering and gave some control in India. Five to seven fortnightly spays with 2% urea, and 2% triple super phosphate, 1.35% potash and small doses of micro nutrients from 10 November to 5 January, delayed flowering and there by eliminated malformation on authors farm on over ten years emergence and then it declines. In case of Deshri up to 65% of flowers produced by 10 January are malformed in Hyderabad area in some years. If flowering is delayed by 2 to 3 weeks the problem is reduced.

### **Pruning as Malformation Control In Sindh**

We followed the practice recommended by South African researches and following were results.

- i. Good results have been obtained by pruning 30 cms to 1.0 meter long shoots with 3 besipetal nodes which were observed as swollen abnormally behind malformed node in the past years. Affected shoots and at least three additional nodes, when removed give good control. Sterlising saws and secateurs with 0.5 calcium hydrochloride or 10% bleach (Jik) solution after every pruning cut, gave 50-70% success reduction.
- ii. Pruning and burning of branches have given 80% success if secateurs were sterilized after every cut.
- iii. Infection spreads by winds from malformed flowers was controlled by removing and burning malformed flowers as early as possible.
- iv. Malformed shoots should be pruned latest in April (Hyderabad season) but burnt as they release million of spores with would infect next season's flowers in the surrounding orchards by winds and also the pruning secateurs. If not sterilized after very cut tools.
- v. The infection spreads in first two weeks of November in South Africa (April at Hyderabad). It should be controlled by pruning in first two weeks of April in southern Sindh and the last two weeks in northern Sindh. For the Punjab timing is early May is effective only if all farmers do it annually for a few years, unfortunately agriculture extension is not year to this.

### **Field Control.**

The following methods can overcome malformation.

- i. Pruning of malformed tissue latest in April in Hyderabad Sindh are :
- ii. Deblossoming or chemical delaying of flowering by use of chemicals or nitrogen.
- iii. If trees can be skeletonised, applied fungicides and miticides for 3 years and new growth can come into full production in year. 4.

- iv. Cycloheximid sprayed at 250 to 500 ppm produced chemical deblossoming in Deshri and other varieties. Higher than 500 ppm can cause severe burning of leaves, besides killing panicles. After deblossoming new panicles emerge within 10-20 days and 2-3 panicles emerge instead of one per shoot, there by increasing yield. Malformation will be absent on new growth.
- v. Mechanical deblossoming done by the present writer, has the same effect, but is costly as four labourers were needed to deblossom one tall mature Deshri tree in a day. We had to top work all Deshri trees with other varieties and used sterilized saws for every new cut

Cultar and vapor grad delay panicle development by 20-30 days in the tropics but flowering percentage seemed to be un-affected. In sub tropics the results are inconsistent.

### **Conclusion.**

Some cultivars are genetically prone to malformation and others are not. Variation of malformation percentage from year to year is a climatic factor rather than physiological as has been observed by the present writers that in some years Chaunsa and Deshri have negligible number of malformed panicles and in other years a very high percentage. If December and early January are moderately warm, flowering starts at end December or first few days of January with high percentage of malformation, but if December and January are cool, not only flowering is delayed but it is profuse and malformation is negligible. The yield also is very high if chill continues in January and still more if it continues to the first fortnight of February. Pruning reduces incidence of malformation, but all farmers are to be motivated to do it simultaneously so that spores do not infect other trees and orchards. This requires strong government involvement.

It will be advisable to plant only malformation resistant cultivars. South Africa launched on extension project to over come malformation by removing infected branchlets and over 3-4 years and have nearly eliminated the problem. In Pakistan to growers hand over orchards to harvest contractors in December and their contractors have no interest in controlling and spending on disease which does not benefit them during the season.

### **OTHER MINOR MANGO DISEASES**

There are many disease of mango, other than the major ones described above. Of these some are more important in terms of economic losses than others as discussed in details here after.

#### **i) Algal spot or Red Rust.**

It is caused by *Cephaleuros virescens*, Leaf spots start as circular gray green areas that eventually turn red.

**ii) Alternaria rot (Alternaria alternata).**

It is transport rot. Mangoes treated with CO<sub>2</sub> at 35% for 24 hours do not show alternaria rot.

**iii) Transit Rot (Rizophus Stolonifer)**

It is also transport rot.

**iv) Aspergillus rot (Aspergillus niger).**

It is also transport rot.

**v) Amillaria Root Rot.**

It is caused by root rot which leads to leaf fall twig die back and death of tree. Bark also separates and disintegrates. Control consist of removal of deed tree and burning at up along with major and minor roots.

**vi) Scaly Bark.**

It is neither caused by virus nor by micro-organisms. Irregular cracking occurs on the lower trunk which develops deep furrows. Craks may be upto 20mm deep and extend from ground to main branches. If the cracking is severe, the tree may become stunned.

**vii) Mango Bark Malformation.**

It is common in Sindh. It exists in Hawaii, Columbia, Philippines, Mexico, Florida, India etc. Seedlings of many clonal cultivars develop this trouble, when used as root-stock.

**viii) Black mould rot or Black rot.**

It is a serious problem in South Asia caused by fungus Erwinia magnifera but routine use of fungicides in the orchards and post harvest treatments control it. Treatments with fungicide including benzoate propionate, copper compounds, diphenylamine etc. work.

**x) Green Colour of fruit.**

Excess nitrogen application can cause in.

**xi) Black tip.**

Caused by sulfurdioxide gas generated by brick kilns near by. The symptoms appear when fruits are about 1 or 1 ½ inches or 25-38 mm long, distal tip turns black and it spreads covering the whole tip. The area near it is aetioloated and top area of fruit is green. Tip becomes soft, but rest of fruit is compact and hard and does not ripen. It is unfit for any use. Mangoes exposed to fumes and smoke from brick kilns using coal containing sulfur are affected by black tip diseases. The same is the case with vegetables and fruits at most active stage of their growth. In mango it is due to June exposure sulfur gas, but foliage and plants are not damaged.

### **Remedy.**

Kiln location should be 1500 meters from valuable orchards and Kilns should not be allowed to operate from beginning of March to end of mango season. Chinney height should not less than 40-50 feet so that it dilutes effect of gasses. Brick kilns should also be made smoke less by law.

### **History of Chemical Control of Black tip.**

- i. The control methods have changed over years and their applications and dozes are listed below. Attempts were made to make it more economical and effective.
  - ii. Borax 3 sprays at 600 grams per 200L (1958).
  - iii.  $\text{CuSO}_4$  at 0.1%, Gelatine at 1% (1961).
  - iv.  $\text{MnSO}_4$  at 0.05% + Borax at 600 gram per 100L (1961)
  - v. Washing soda at 0.5% (1965)..
  - vi. Caustic soda at 0.2% + Borax at 700 gram in 100 litres (1971).
  - vii. Caustic soda at 0.8% (1971).
  - viii. Sodium carbonate at 2% at marble size + borax at 0.6% (1985).
  - ix. Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ), at 0.5%, 1 to 5 times starting before flowering and ending 30 days after fruit set at an average of once every 4 weeks.
- These worked to some extent but not fully and due to large scale construction even around small towns, the problem has now taken serious turn as sulfurdioxide affects all kinds of agriculture crops.

### **xii) Blossom Blight Mangoes.**

It can not be separated from leaf blight (No xii below )

It occurs in Egypt South and East Africa, Mazamlique, Congo, India, Pakistan and Sri Lanka. It cause *Bacillus mangifera* fungus on leaves and rainfall during flowering , specially when temperature is below 30°C and other fungal diseases like; anthracnose caused by *collectorichum gloeosporioides*, bacterial black spot caused by *xathomonas compestris* are present, but main causes is fungus, *Bacillus mangifera* and *pseudo-monas mangifera indicae* is found in diseased blossoms and all these cause the drop of flowers. Two heavy rains in March in Hyderabad area, caused severe blossom blight in flowers ready to pollinate but young new growth was save.It seems to attack flowers already opened.

### **Control of blossom blight.**

Copper compounds alone do not give any control. Various other chemicas for control needed are:

- i. Benomyl at 0.2% fortnightly give some control.
- ii. Benomyl + copper oxychloride give good control.
- iii. Copper oxychloride + Zinc (Milfox at 0.3%) give some control, but not adequate
- iv. Copper oxychloride plus mancozeb gives intermediate control and two applications at 4 weeks interval are needed.

- v. Pyrazophos or Flusilazol also control it.(a.i.) Flusilazol at    grams or pyrazophos at same rate or at 20 grams per 100 litres has given the best control. Both these chemicals have 20% actual ingredients.

**(xiii) Leaf Blight**

Lesions on leaves and twigs appear as small yellow spots that gradually enlarge. Surrounding tissue turns dark brown and eventually gray in colour. Lesions are circular at first, turning irregular later and may involve most of leaf surface. Blight is then passed on to blossom, which shed, reducing yield. Of above chemical can increase yield by 40-80%.Fertilising is to be done with care, as growth during wet weather can be heavily diseased, but if temperatures are over 30°C there is no fear. Best time to apply fertiliser is 3 weeks before harvest.

**(xiv) Bloches on tree due to exposure to Sun.**

There can be two causes of it zinc deficiency or high heat of sun. When zinc deficiency is the cause, leaves curl like stickle, become leathery and narrow. One or two sprays of zinc a year will control the disease.

There are bloches on trunk; and branches they are caused by excessive heat penetrating the tree due to thin leaf canopy. Sun burn of trunk is different and can cause bark diseases and bark separation. Bloches are not harmful. Sun burn of trunk is controlled by water based white paint or lime at 20% and copper sulphate at 1 percent mixed it.

**(xv) Soft Brown Rot or Brown Spot**

It is caused by fungus *Physalospora* and possibly by *Pestalotia mangifera*-Butler. It differs from stem end rot in the development of random lesions over the fruit surface. Infected areas darken in part only and remainder retains a distinct buff brown colour. It is more severe in cultivars, coming from northern India and the east Punjab in Pakistan than old Sindh varieties. It is more common in seedling mangoes than in grafted ones. It is also more common in early flowering cultivars than late flowering.

**Post-harvest treatments against brown rot or brown spot.**

Immersion of fruit in benomyl 0.1% solution in water at 52° C for 4 minutes gives some control, but it is not always satisfactory for long term storage. Immersion in benomyl plus impropidione each at 0.1 solution at 52° C for 5 minutes and coating with tag wax, containing benomyl followed, by irradiation within 8 hours of heat treatment, improves the control.

**(xvi) Gummosis.**

It is caused by *Phytophthora cinnami*.Control is removing in feeted spots by saw or sharp tool and painting with copper sulphate paste.

**(xvii) Mango Canker.**

Its sign is stem thickening and develops in bark. Organic fungicides do not control it. Inorganic copper compounds control it.

**(xviii) Mango decline.**

It is indicated by low fruit production and diseased out look of tree. It is caused following factors.

Anthrachnose accumulation of fungal diseases, old age, neglect and lack of care, lack of nutrients and micronutrients, inadequate soil moisture.

**Control of mango Decline.**

Adequate soil moisture control of fungal diseases with fungicides adequate fertilization and micronutrients mulching with dry organic matter and maintaining the cover instead of inter cultivation. And if limbs of tree have been damaged pruning them near the trunk. And allowing them to produce a few shoots each to form new branches can lead to production will restart after 2 years.

**(xix) Fruit rot.**

It occurs in the orchards as well as storage.

**(xx) Shoot galls.**

Shoot gall is caused by psyllid *apsylla* and is serious pest in the South-Asia. Infected terminals dry out and further growth stops. Galls are formed on leaf axil and insect enters galls. Galls interfere with inflorescence. Large trees appear to be unharmed, but can have lower yields and can die if subject to moisture stress. In Sindh trunk galls on Langra are common and do not seem to reduce its yield.

**(xxi) Mango leaf galls.**

Cecidomyid midges cause damage to mango. Larvae bore inside leaf tissues, and feed within, forming war like galls on leaves and causing their premature leaf fall. These are classified as, *Procontrainia*, *Maatleiane*, *Amraemyia* and, *Virigi gallicola*. The sources of infection are Nursery Soil and Grafting tools. There is no cure, but seeds, seedlings and cuttings can be treated with commercial biological control agent. Trimming away or chiselling out all diseased parts and bitumenous painting can be great help. Projecting stubs are not to be left. Paining can help against spores of wood rotting fungi. Control is possible with spray of the following chemicals, 2 or 3 times:

- Demetonmethyl.            0.05    to    0.125%
- Phospamidon.            0.05    to    0.125%
- Monocrotophos.        0.75    to    0.125%

These are applied twice at 15-20 days interval in August in U.P (India) and in late July in Sindh. These chemicals also control many insects.

**(xxii) Jeely Seed.**

**General.**

It is worst problem in Deshri, but is also common in Langra, Sindhuri, Sirolis Neelum, Fazli, Alphonso and a number of other varieties of the South Asia.



Among the Floridan cultivars, it is common in Sensation, Tommy Aitkin, Irwin, Van Dye and Kent, it is presumed that it could be reduced by using less nitrogen, but fruit size and yield will reduce. If there is delay in harvest, jelly seed becomes most common. It is serious problem in Sindhri. At Hyderabad Sindhri harvested on 1 June showed no problems and that harvested to 10 June will show problem in 80% fruits. Again bigger the size of fruit more is the problem. Jelly seed is no problem if harvest takes place about 7 days before full maturity on the tree. This is common occurrence in many mango cultivars specially when picked up late and allowed to attain large size on the tree.

Bio-Chemical Changes In Jelly Seed Portion are higher acid, higher ascorbic acid, low carotenoid pigments, less amylase activity in spongy tissue and 1.5% starch as compared to nil, in the healthy tissue. Early picking gives some control.

**(xxiii) Pale green small leaves, crinkled margins and die back.**

It is caused by iron deficiency. Iron sprays or chelated iron by ground feed or spray may control it.

**(xxiv) Pre-Mature ripening.**

It is common in Florigin and Nom Dock Mai. Sindh's cultivars Sindhri, Deshri and Siroli have this trouble.

**(xxv) Sap Burn.**

Sapburn is an important factor in reducing post harvest quality, following are some effects:

- (a) Sapburn is an important and in many mango cultivars sap oozes out from stem and spreads close to the skin. Sap contains chemical which are caustic, burn surface skin of mango and spoil in appearance. These chemicals are recognised as terpinolene and alkylresorcinol, which injure the skin and fruit.
- (b) Rain before harvest or irrigation increases volume of sap and oil.
- (c) Amount of total sap is reduced if destemming is delayed.
- (d) Sap burn varies from cultivar to cultivar some are sappy others are not.
- (e) High oil content of sap reduces rapidly after first 5 seconds.
- (f) Wet fruit is more susceptible to sap induced browning.
- (g) Cool storage can increase skin browning.
- (h) Cool storage increase skin browning by keeping fruit wet through condensation.

**Sep removal.**

Placing fruit into detergent, just before stem removal over comes the problem.

**Detergents in Sapping.**

House hold detergents do not work satisfactory. Agral is solution.

**Crates Cleaning.**

To avoid skin browning, the crates should be cleaned after every use.



### **Conveyors.**

Conveyors for de sapping in packing house should always available.

### **Sap burn Chemistry.**

Mango sap has two parts, oil and protein sugar. It is oil that causes damage, but oil dries to 50% in 10 seconds and to 3% in 90 seconds. No damage occurs after 90 seconds.

### **De Stemming Under Water.**

On desaping under, water oil comes up and causes injury, but if water contains 1% lime no injury occurs. It is cut with long stem and after some time stalk is trimmed to about 1.35 cm or ½ an inch sap flow becomes minimum.

### **(xxvi) Scab.**

It is caused by fungus *elsinoe mangiferae* and is dispersed by rain.

### **Symptoms.**

Infections on young fruit are greyish to greyish brown with dark irregular margins and finally centres become covered with cracked, fissured and corky tissue. It is a problem in young trees and leaves. It is present in American-continent and is reported from Florida, Cuba, Puerto Rico, Brazil, Panama and etc. It does not occur in Australia. Scab originates in young tissue and lesions circular dark brown and black and 1-2 mm diameter. Under moist condition, velvet like olive tan, fungal growth is visible in lesions. On older leaves it is 5-6 mm diameter, with white gray centres and narrow well defined brown borders.

### **Control of Scab.**

It is not a problem, if fungicides and insecticides are applied regularly. Use of copper oxychloride at 100 grams/100 litres of water or Bordeaux mixture every 2-3 weeks, or Mancozeb control it.

### **(xxvii) Soft Nose in Mango.**

Soft nose is attributed to excess nitrogen. It is common to most cultivars of South-Asia. Among Floridan cultivars it is common to Tommy Aitkin and Kent. Hawaiian cultivar Ah Ping is sensitive to it and so is Ameri. Among Pakistan varieties it is very common in Chausa and to a less extent in Sindhri. Mango picked early does into show the problem.

There is no control except in reducing nitrogen, which in turn then would reduce size of fruit and yield. It is attributed to excess level of nitrogen, lower calcium level and late picking. Early picking may reduce it.

### **(xxviii) Sooty Mould in Mango and other fruit crops.**

It is caused by several species of fungi in the group of capnodiales. Host range consist of ever green shrubs and trees that harbour infestations of scale insects, mealy bugs and aphids. It is common in citrus and mango. A dark growth forms

on the surface of leaves, twigs and fruit. The growth is entirely superficial but affects respiration of fruit and leaves and over all size of fruit decreases.

#### **Relationship of sooty mould to insects.**

- The density of sooty mould depends on extent of insect infestation and type of insects, Control can be achieved by preventing ants from climbing trunks by applying 1 % petroleum oil, mixed with 0.1% maldison to trees in early spring (January in Sindh). Ants kill predators of scales, mealy bugs and aphids and increase honey dew secretion by these insects. Then fungus grow on honey dew and form black mould presence of sooty mould is undesirable on fruit. Mango scale was controlled by prothiofos at 100 ml per 100 litres of water better than other chemicals in South Africa by applying it in mid April and early June and for Sindh October, December. Cuprovit or copper oxychloride plus any insecticide like roxion, topsin and etc., kill fungus and control mould. Metasystox 25% EC 150 grams/100 litres kills scale insects. Ziaziano 60% EC 1 per 100 grams per litres also kills. Sooty mould can also controlled by washing and brushing but is combersome. Many new insecticides control it.

#### **(xxix) Mango Split or Crack opening.**

Long drought followed by heavy irrigation can cause it. Proper soil moisture will control it.

#### **(xxx) Successive new flushes with small leaves, short/stems and leathery or curried leaves.**

These, are caused by zinc deficiency and zinc sulfate sprays once or twice a year will control it.

#### **(xxxi) Spongy tissue development in mango fruit.**

Spongy tissue in phonso reaches 50% in vigorous trees and 90% in weak trees.

#### **(xxxii) Transit Rot.**

It is caused by fungus *Rhizophus stolnifer*. And lack of packing house shed hygiene is main cause of it.

#### **(xxxiii) Die Back.**

It is shown by wither of leaf tip, twig bight and stems drying.

Die back of leaves is caused by anthracnose and beside three fungi namely: *Botryodiplodia theobromae*. *Phoma* and *Fusarium*, which kill the tree. Gummosis too can bring slow death of tree. In addition, it is also caused by high summer temperatures.

Copper oxy-chloride at 0.1% controls it when applied in September – October Bordeaux mixture controls it. It is caused by over fertilisation, salt toxicity or soil contamination and these also need control, besides irrigation to leach down salts.

Die back of mango (vaticilium wilt) is different and is caused by soil bearing fungus verticilium and also atrum, a tomato fungus, which can survive for 15 years. Only soil fumigation can control it.

**(xxxiv) Upper surface of mango leaves turning reddish brown every year in December to February.**

Caused by Avocado mite, which reduces tree vigour. Its control is sulfur spray or miticides.

**(xxxv) Skin Browning**

Its causes are sap buildup, packing wet fruit, dust in field contains, dirty packing shed and equipment and prolonged cool storage.

**Different types of skin browning.**

Type	Symptoms.
Etch	Some form of lentical damage.
Smear	In streak or ring pattern.
Blotch	Lighter in colour than smear.
Spot	Cellular damage similar to Blotch.
Resin canal	On nose of fruit or mid portion and causes discolouration of fibers in flesh.
Abrasion	Brown scratches.

These are discussed below.

**Etch.** It is caused by dirty picking containers with moist sap or fruit packed in wet condition, high concentration of detergent and sap collection on packing machinery.

**Smear.** It is caused by high concentration of detergents and fruit wet from more than 2 hours.

**Blotch.** This due to sap falling on skin of fruits.

**Spot.** Fruit picked in wet weather. Fruit dropped from more than 50 cms.

**Abrasion.** Reason for it rubbing of fruit on containers and transport over dirty roads and jumps and over filled packages.

## CHAPTER - 32

### INSECTS PESTS OF MANGO AND THEIR CONTROL

Mango is subject to serious insect attacks by a number of insects to its various parts, During all stages of its growth, roots trunk, branches, twigs, leaves, flowers and fruit are attacked by different pests, causing from moderate to severe damage. This is mostly due to congestion of trees and neglected hygienic conditions prevalent in the orchards. The various pests and their control measures are discussed below.

#### **Scale insects, mealy bugs and white flies.**

All type of scales are found in mango. Scales are categorized soft and hard. Mealy bugs and white flies also fall in this group. The various type of scales are; soft brown scales, cottony cushion scales, hard scales (mealy bugs), mango scale (*Anla caspis bercularis*), pink wax scale, San Jose scales (*Pinnaspini strachni*, most dangerous of all scales.), snow scales (common on trunks and branches of young trees cause cracking of bark), white mango scale, oriental red scale, white wax scales and mango shield scale.

Mango scales occurs through out the year but activity is greatest from March to June. Their numbers decline after summer rains in July. They are not very active in cool winter. Scales are attacked by small wasps, laybirds, predatory thrips, mites and lacewigs.

#### **Natural enemies of mango scale:**

A spidiotiphagus citrinus (Parasite wasp) and chellocorus (Coccinellid beetles) feed on mango scale, but they are not enough and additional chemical control is essential. Chemical control usually kills natural enemies of scales too.

**Growth regulators in control of scales.** Growth regular IGR Buprofezin (Applaud) controls mango scales.

**Effect of scale infestations** Scale causes excess leaf loss and die back in mango tree.

#### **Miscellaneous mango insects.**

**White ants.** To kill white ants, the following chemicals are used. Malathion.

**Beetles.** They make burrows of size of lead panicle and carry fungi. The latter produce blue stains on wood.

**Mango tip borer.** Causes wilting and dieback of growing tips and is most severe in autumn.

**Coconut bug.** It is not present in Sindh, but with introduction of coconut in the southern Sindh, it can reach rest of Sindh.

**Flower eating caterpillars.** Small brown black caterpillars. Control is spray during flowering diptrex at rate of 85ml/100 L of water.

**Flatid.** It is 1/3" long triangular scale and hops when disturbed.

**Leaf minor** Larvae of leaf minor causes blisters on leaves which rupture.

**Mango bud mite.** Bud is damaged and it become discoloured and stunted.

**Tea red spider mite.** Raddish brown mite on upper surface of leaf, visible with magnification of X 10.

**Red rust.** Algal spot caused by *cephaleuros virescens*.

**Red banded thrips.** Insects with bands at nymph stages.

**Mango seed weevil.** It is present in South Asia. Fruit is damaged when insect emerges from seed and come out. It causes fruit drop and post-harvest losses. Seed dehusking before planting.

Decis at 50g per 100L or seven 50 WDP at 0.1%.

**Other insects are** thrips, scales, mealy bugs, mites, shoot borers, leaf rollers, white flies, black flies, gall insects and aphids are other insects and their control is the same as white flies, scales and mites.

**Blossom pests of** pests blossom are, midges *contarinio* sps and *Erosomyia Indica* which destroys 70% flowers and fruit set. Hopper caterpillars, thrips and mites belong to this group.

**Pests of buds and leaves.** There are thrips (peaks during dry season, decline in rainy season), cecidomyiidae, Gall midges a delicate minute fly, mites (gall forming) by promoting fusarium, diaspodid. armoured scale, white and black flies and mealy bug.

### **Fruit fly**

Mediterranean fruit fly does not exist in South Asia but there are a number of other fruit flies which attack more than a hundred fruits, nuts, vegetables and etc., some of which are: apple, apricot, avocado, banana, barbadose cherry, capsicum, citrus (grapes fruit, lemon, kumquat, orange.) chillie, grape, guava, feijoa, fig, loquat, mango, mulberry, Natal plum, olive, , pears peach and nectarine plum, persimmon, passion fruit, plantain, pear, pomegranate, prickly pear, quinces, rose apple, rose, tomato, sapodilla, strawberry and walnut *zizphus* sp in South Asia.

### **Fruit flies in Pakistan.**

- Lower Sindh has *Dacus zonalus*, saunders fly.
- Upper Sindh and the northern Pakistan have this and another fly *Docus Dorsalis* hanpd.
- East Punjab (India) has 6 types of fruit flies. Probably the Pakistan Punjab and Sindh have all those 6, but these have not been studied in Pakistan.
- There still are other sp, *Dacus Oliverus* and *Dacus ferraineus* in Florida and Queensland fruit fly in Australia. They are not present here.

### **Fruit fly control by Protein bait sprays.**

This is the best product for fruit fly control and should be applied as under.

- i) Yeast protein is a by-products of same food in beer industries. It is produced during brewing of beer or stout. This product is available a panicle protein insect lure with an active consistent of 420g per litre proteins auto-lysate.
- ii) Bait should be applied on lower third of tree and to under side of leaves where flies normally feed on normal yeast protein excreted by leaves. The whole volume could be placed in foliage 0.5 to .75 square meters or 6 to 9 square feet.
- iii) Bait should not touch the fruit.
- iv) It should be applied to the north side of tree which always in shade and flies avoid the parts exposed to sun.
- v) Repeated weekly doses should be applied at the same place.
- vi) Bait applied is 100-200 ml to every alternate tree. Spray is done at 415 kp (=60psi)
- vii) To bait is mixed maldison or other insecticide at rate of 50ml of protein autolysate and 20 ml maldison and 500 litre of water.
- viii) Amount of bait applied is 100g ai/ha against 600 gram for cover spray.

### **Negative effects.**

Precaution in use of this bait are.

- i) Protein autolysate is to be kept cool during storage at 10°C
- ii) Once diluted it has to be used within 36 hours, when it can become smelly.
- iii) For bait to remain in suspension it is to be agitated.
- iv) Applied to fruit it can discolour it.
- v) Yeast contains 420g/L protien autolysate which is protein insect lure.
- vi) Protein baits attract both males and females.

### **Fruit fly and season.**

Winters are usually free of fruit fly problems.

### **Role of fruit plercing moths.**

The holes left by percing months are used by fruit fly for ovipostition.

### **Ground control of fruit fly.**

Burying rotting fruit more than 12 inches (30 cms) deep is as precaution.

### **Fruit fly control in mango orchard.**

Spraying host plants with mercaptothion 25% wp at about 300g + 8 kg sugar per 100 litres of water, spraying in April and May preferably starting or 6,4,3,2 and 1, weeks before harvest with any of the following chemicals at about 1 litre/tree or a section of tree.

- i. Diptrex 8% SP 200 grams in 100 litres of water.
- ii. Labaycid 5%, 225g/100 litres water.
- iii. Phosdrine 24% EC 6 oz/100 gallons water.
- iv. Trichlorfon 95% wp at 50 g + 8 kg sugar with 100 litres water.
- v. 200 ml protein outlystate orhydrolysate + 100 litre water.
- vi. Ac-12880 (American Cynamide)
- vii. Bi 85 EC (VEB Chemie Kombinat)
- viii. Fenthion at 0.6%
- ix. Deltamethrin 0.002% a.i; gives 83% control i.e. 2 grams ai, per 100 litres water but ai, in delfamethrine is 5% and therefore, 40 grams per 100 litres are needed.
- x. Fenvalerate at 0.1% as effective as Deltamethrin.
- xi. Malathion 74g + 8 kg sugar + 100 L water as bait.
- xii. Devigo.

### **Spot spraying or bait for furit fly control.**

- Microcapothion 25% wp 300 g + 8 kg sugar/100 litres of water.
- Trichlorfon (chloroform trichloro methane) 95% at 50 g + 8 kg sugar with 100 litres of water.
- 200 ml protein hydrolysate in 100 litres of water (Total one litre pert tree or part of tree)
- Basit contains methyleuggenol. Growing plants is the vicinity of mango and spraying them with baits will provide good control as experienced by the authors.

### **Ripening fruit fly infected mangoes.**

Mango infected with fruit fly fumiggated with ethylene dibromide (EDB) at 20g per cubic meter for 2 hours at 20°C gives complete control.

### **Chemical dip.**

Fenthion or dimethoate system also kills and larvae in fruit if dipped in the solutions at 100g per 100L water for about 1 minute. Dimethoate is banned for use in Pakistan, but Fenthion is allowed.

### **Non-Chemical post-harvest control of fruit fly.**



VHT (Vapour heat treatment)

Methyl bromide is no longer legal to use, as it damages ozone layer as well as human neurological system. It used at particle in its fungi and form by injection around it is released slowly. It is highly efficient in kill in said fungus parasites, weed seeds and disease pathogens which damage crop. It is used in Hawaii on pineapple, tomato in California and also in Florida. Under Montreal Protocol farmers complain that substitutes are not as efficient. These views of growers are accepted by the Government. This means methyl bromide and ethrens dibromide are not going away and will be available for atleast a decade. Now question is whether Europe is going to allow fruit treated with EDB to be imported? We have to wait for an on show.

### **Fruit Fly control in India.**

Damage is reduced to 4.6%, if fruits were harvested at physiological maturity as compared to 10% in fully ripe mangoes. Methyl Eugenol 0.2% bait at 4 traps per acre run for 18 weeks reduced fruit fly population by 71%. Other traps are used at rate of 6 per acre.

Mango juice at 5% was most effective poison bait (36%)

Deltamethrin 0.02% a.i., gave 83% control.

Fenvalerate 0.15% was as effective as Deltamethrin.

### **Other additional baits are;**

Protein hydrolysate (5%), Mollases, Gur, Mango Juice, Ethyl alcohol + Gur. Fermented juices of: lemon or grapes or orange or apple or banana. Dichlorvos 0.5% was added to above bait. Sugar 5% was also added to all juices, as preservative. The bait having been prepared .200ml liquid was added in each bottle. Traps were hung at 5 feet height.

### **Disposal of Fenthion, dimethoate and prochloraz dip mixture.**

1. 3 Slaked or hydrated or quick lime at 3 KG added to per 100 litres of waste solution and kept it for 60 days.
2. The dip of fenthion or prochloraz can be sprayed under orchard trees at 1000 L per hectare.
3. Fenthion can be diluted and reused in a an approved spray program.

### **Mango mealy bug.**

It is common pest. Its hosts are: citrus, bear, guava, mulberry, plum, peach & fig. The nymphs congregate near tender shoots and by sucking sap, and cause the shoot to dry.

### **Mealy bug life cycle.**

Table below gives the mealy bud life cycle.

Stage of Development	Duration in days	
	Female	Male.
1 nymphal	45-71	45-71

2 nymphal	18-38	18-38
3 nymphal	15-26	5-10
Pupal	Not met with	9-15

### **Sanitary measures for control of mealy bug.**

Ploughing and inter cultivation under trees in August (for the Punjab and September for Sindh) sweeping away all rubbish from infected trees, burning and trampling those under feet of animals. Banding trees to stop climbing of insects. Bands can be slippery bands: like oil cloth 2-2 inch wide fluffy bands, sprayed or coated with chemicals, and sticky bands:,with 4 inches or 10 cms with coating of molasses, Rosin axle, and grease

### **Ground Control of mealy bugs.**

Putting insecticidal rings around trees, spreading agroicide dust 1:10 in form of rings around base of tree. A 200 guage plastic band 25 cm wide, nailed to trunk and earthened and treated with methyl parathion dust every 0 days interval, gave the best control against mealy bug. Other chemicals for dust spray on trees are Dimecran, Folidol-M, Metasystox, Endosulfon, Guasathion, Fenitrothion, Malathion etc.

### **Biological Control.**

By use of pseudoa pycus ulilis available from Biological Control lab Rawalpindi.

### **Mango borer (Batocera Refomaulata A,B, ruba and acanthophorust.)**

#### **Shoot Borer.**

It is widely spread in South Asia, South East Asia and Far east. Insects which damage shoots, also damage flowers. Small tip borers and fruit spotting bugs, attack flowers and shoots and destroy them. It is these tips from which inflorescence will differentiate. Tip borers, which are present year around, but maximum damage is done in September and October. Noctuids tunnel tips of shoots and inflorescence. They damage trunk, lay eggs from July to September in crevices of bark of branch 1 to 6 inches thick.

**Control** is by removal of dead branches fumigation of tunnels in wood and plugging them with listumn or clay. Heavily infected trees to be cut down and brunt. Half tablet of phostoxin in each bore hole gives good control, but it is no longer available, but the following chemicals are currently in use. Sprays are done at 3week interval for two months or 3 sprays. This will eliminate the problem.

### **Mango weevil (Sternochelus Magniferae)**

Seed weevil exists through out the world except American continent. Mango seed weevil is widely distributed in Africa, Pacific Islands and Australia. Eggs are laid in the fruit and larvae tunnel into seed, where further development to adult stage occurs. Prior to emergence of adults. Fruit shows no signs of infestation. It can cause fruit drop and post-harvest losses by rotting of stone. Late maturing

varieties are more vulnerable to damage. Most affected varieties are, Baganpali 82% and Langra 48%. Fallen fruit stone is attacked by weevil. Eggs are laid over months, but hatching takes place in 3 days. It is difficult to determine these 3 days.

#### **Gama irradiation doses.**

Mortality of mango weevil, resulting from gamma irradiation at various doses to given in table below.

STAGE	UNDERRATED							
	n	%	0.3	KG Y	0.6	KG Y	1.0	KG Y
			n	%	n	%	n	%
Larva.	23	0	20	65	12	100	10	100
Pupa.	11	0	16	50	15	100	37	100
Adult.	36	0	30	80	32	100	27	100
Total	60	0	66	68	59	100	74	100
<b>No of Fruit</b>	<b>52</b>		<b>53</b>		<b>56</b>		<b>54</b>	

Some reaction could be obtained from adults dosed at 0.6 KGY but they were moribund and incapable of voluntary movement.

#### **Mites.**

##### **Mango bud mite**

It infects fork of mango tree or trunk producing galls. Upper surface of leaves turning radish, brown every year in December to February. It is caused by atacado mites which reduces tree vigour.

**Sanitation Control.** Galls must be removed and burnt.

**Chemical Control of Mites** is sulphur spray or any other miticide, which controls oligonychus yethersi on mango. Sulfur cannot be applied at temperatures more than 30°C. Mites not controlled with sulfur may be controlled by aramite, Kelthane, Ovex, tedion or chlorobenzilate.

#### **Thrips.**

**Red banded thrips.** They are active during flowering and are found on under side of leaves.

#### **Hoppers**

They belong to the genus indecorous namely; indecorous clypealis, indecorous atkinsoni and indecorous niveosparus .They remain on the crown of tree during the day and in the evening come down to trunk, where from they climb back at sun-rise. If condition is moist, they remain below during day. They reduce vitality of the plant. Hoppers suck sap from shoots, flowers and fruit. It is a major pest of mango. Losses from fruit and flower shading not some times reach 95%.

Hopper breed twice a year, February – April and June-August. Their presence can cause fruit drop April and June – August.

**Chemical Control** is removal of congestion in trees, pruning to allow free passage of air, tree trunk to be washed with chemicals to kill hoppers on their downward journey. Some of chemicals used are Decis, Endosulfan, Carbaryl, Folidol – M, Bugmaster, Gusathion, Septene, Parathion, Seven an Fenthion. Spraying is to be done ever 10-15 days during their attack. Protective sprays are done in December (first spray) second spray in January, third spray 20 days after the second spray. By mid or end March their attack becomes severe and sprays are neater. If mango hopper is seen during flowering, spray by ULV method is done so that flowers and fruitlets do not shed. During flowering out side sprays are avoided the reder falling of flowers. It has become most serious pest in Sindh. Its alternate host is fig and must that be sprayed simultaneously. Many cultivars are susceptible but a few are immune.

#### **Leaf miners.**

Larvae of leaf miner mine in young leaves of juvenile and bearing trees. *Acroscoops rygonoma* mine in bark covering greater part of tender shoots and petioles causing abscission of leaves. The time of attack is end September to mid November.

#### **Nematodes.**

##### **Root knot:**

- They burrow in side plant root system and keep reducing yields.
- Nematodes are recorded in mango through out the world.
- These are controlled by applying fenamiphos (Necacur) into irrigation water at 34 litres per hectare every March. Application of 1-2 dibromo-3 chloroan (DBCP) gives growth and yield responses. The dose of DECP is 20 litres per 4200 square meters or about an acre. Necacur increases yield by about 50% and when DBCP formulation was added, yield increase was about 150% over the control.

For nematode control, DBCP can easily be applied through irrigation water, at 20 litres per acre.

#### **Some chemicals in common use.**

Various mango insects above categorized are pests. Table below for example. gives some chemicals and their doses in Australia We suggest that growers discuss with manufacturers or suppliers. Doses of chemicals are different but so are the prices. Growers has to find out cheapest but effective chemicals for each pest per acre . Some chemical controls a number of insects.

#### **Insects and pests of mangoes and their control.**

The table below gives the details of insects and pest, their scientific name, chemicals to control and their doses.

<b>Insect &amp; pest</b>	<b>Scientific name</b>	<b>Chemical control</b>	<b>Dozes.</b>
Banana spotting bug	Amblypelta Iutescens Iutescens	Endosulfan	0.2L/100L(350g/L per product)
Common mango scale	Aulacaspis tubercularis	Carbaryl Chlorpyrifos	70g/100L + 1L petroleum oil. 0.1/100L
Fig leafhopper	Austrasca australica	Carbaryl	1.3kg/100L
Flattid planthoppers	Flatidae	Carbaryl	90g/100L
Flower eating caterpillars	Lepidoptera	Endosulfan	0.2L/100L (350g/L product)
Fruit spotting bug	Amblypelta nitida	Endosulfan	0.2L/100L (350g/L product)
Green tree ant	Oecophylla smaragdina	Chlorpyrifos	0.1kg/100L
Large mango tipborer	Penicillaria jocosatrix	Endosulfan	0.2L/100L (350g/L product)
Leafminers	Acrocercops sp.	Methidathion	0.125L/100L
Mango bud mite	Eriopyes mangiferae	Dicofol	48g/100L
Mango planthopper	Colgaroides acuminata	Carbaryl Endosulfan	90g/100L 0.2L/100L (350g/L product.)
Mango scale	Phenacaspis dilatata	Petroleum oil Methidathion	1.25L/100L 1.25L/100L + 25ml surfactant
Mango seed weevil	Sternochaethus mangiferae	Methidathion	0.125L/100L
Mango tipborers	Noctuidae	Methidathion	0.125L/100L
Pink wax scale	Ceroplastes rubens	Carbaryl Methidathion	90g/100L 1.25L/100L + 25ml surfactant
Fruit fly	Dacus tryoni	Dimethoate	75ml/100L
Red banded thrips	Selenotrrips rubrocinctus	Endosulfan	0.2L/100L (350g/L product)
Small mango tipborer	Chlumetia euhysticha	Endosulfan	0.2L/100L (350g/L product)
Soft scales	Coccus spp	Petroleum oil	1kg/100L
Tea red spider mite	Oligonychus coffeae	Dicofol	48g/100L
Flower eating caterpillars	Lepidopetra		

Banana spotting bugs	<i>Amblyopelta lutescens</i>		
-------------------------	----------------------------------	--	--

## CHAPTER - 33

### MANGO PROCESSING AND PRODUCTION.

Besides dessert, in mango has many products, which are commercially produced and when their quality is good, market acceptability increases and these products become popular . As years, pass demand of quality fruit for desert will increase and lower quality fruit will be used for processing.

#### **Dual purpose trees.**

Trees can produce high and low quality fruit simultaneously, for fresh market and processing. Such trees have not been identified in Pakistan or searched, though there are many

#### **Mango products.**

Following are various mango products in commercial use.

- Un-ripe fruit in pickles chutneys and culinary preparations, or oven dried.
- Frozen skin.
- Amchoor. (sun dried and seasoned with turmeric), can be oven dried to eliminate dust and produce a uniform product superior to Sun shying.
- Curries, raw mangoes are cooked as vegetable or added to other dishes.
- Mango pickles for Vitamin-C and flavour.
- Mango jelly from peel.
- Puree and canning of puree.
- Shakes.
- Preserves.
- Pectin. Canned fruit slices and nectar.
- Dried mango slices Some Philippine varieties are processed as dried slices fetch high prices then deserter any other product of mango.
- Squash.
- Seeds kernel and skin for flour, food and feed.
- Slices in brine or syrup
- Pulp fruit bar.
- Powder
- Mango milk shake
- Vermicelli
- Frozen mango (5 parts mango, 1 pound sugar mixed and 0.1% ascorbic acid as calamansi juice added, packed in polythene bag and frozen.)

#### **Maturity for Processing.**

For best canned products TSS of 15% or more is recommended.

#### **Post-harvest handling for processing.**

The main requirements are:



- i) Anti-Fungal treatment of fruit is necessary.
- ii) Fruit is to be transported to factory at 12°C (53.6°F)
- iii) Fruit has to arrive at the factory in unripe condition.
- iv) Ripening is to be done in controlled conditions to minimize loss of moisture and retard rot development.
- v) Ripe fruit pulp has to be of some quality as dessert fruit.

### **Cold storage ripening for processing.**

The subject is vast and economic opportunities unlimited but operations needs ergonomic care and opportunities will come.

- For mango processing, cold storage to ripen is essential, as this would be a primary advantage for purchasing fruit in mid-season at lower prices. Some varieties can be purchased stored and disposed off after 10-15 days, when prices almost double. Cold store has to be very large.
- Unripe fruit storage at 12°C gives storage life of about 2 weeks. Longer storage results in to spoilage and is to be avoided.
- For ripe fruit, storage at 1 to 3°C can extend its life to 4 weeks. In such a case skin of fruit darkens, but for processing the internal quality is maintained
- Ripe fruit can also be kept minus 18°C for 4 months .This is now processing period will be extended.
- To minimize moisture loss from fruit, high humidity in storage space is to be maintained.
- Ninety five percent mango varieties can be ripened at 30°C (86°F) with optimum results, but relative humidity of 90-95% is to be maintained.
- Ethylene used in processing fruit for ripening is beneficial as ripening is faster ad losses are reduced.
- Some reliable ripening index is to be developed for processing fruit. this will help the industry.
- Mango juice or puree or its products can be stored at minus 18°C for 18 minths.

### **Puree.**

- This is made from pulp left over on seeds and skin in canning and drying process, which remove 90% pulp. The balance 10% sticks to seed and skin. This is recovered by brush finishers fitted with 1.5mm screen. If puree is to be taken from whole fruit, it is exposed to steam for 1 or 2 minutes soften the skin.
- Puree can be frozen, canned, dried or packaged in bag in box in containers. For freezing or canning, pH is to be lowered around 3.7 to 4.2, by addition of citric acid and then heating to 90-93°C in a heat exchanger and held for a few seconds. If frozen products is desired it is cooled to 5°C, before filling into polyethene bags packed in fibre cartoons or steel drums. Then it is frozen to minus 18°C or 0.5°F. it has life of four months.

### **Mango Slices.**

Mango slices immersed in sugar syrup have better keeping quality with regard to texture, if calcium-chloride is also added to syrup.

### **Mango peel.**

Mango peel which forms 20-25% of mango processing wastes, can be used for jellies like apple pomace as it is a good source of pectin.

### **Mango squash storage and effects on quality.**

Following are some of out standing effects of squash storage.

- i) Major effect is on reduction in ascorbic acid, which can even be reduced to less than 10% in some cultivars, but reduction to less than 25% is common, in most cultivars.
- ii) Total acid changes by only a small percentage and same is case with total sugars. However reducing sugars increase 6 to 10 folds, but pH changes almost very little.
- iii) There is change in colour i.e., increase in pH of yellow and slight decrease in orange. Increase are about 25-50% in yellow and decrease of 5 to 10% in orange.
- iv) Each variety imparts different taste to squash as they have different pH, total acidity as citric acid, brix, viscosity, specific gravity vitamin-C as mg per gram, total sugars, reducing sugar, brix to acid ratio titratable acidity, TSS. Tannin, colour and organoleptic score.

### **Suitable varieties for processing.**

Among South-Asia mangoes Deshari is best for processing, followed by Langra, Sufeda, Sirolis, Chausa, Malihabadi and Anopan followed in that order. Sindh's leading varieties Sindhri, Baganpali and Sawarika have not been given a trial.

### **Processing storage and use of processed products.**

Frozen mango pulp is used in fruit juice, yogurt, fruit ice creams and confectionery.

Processed mangoes or pulp can be stored at 0 to 10° C for up to 6 weeks. In home, mango could be stored in freezer at below freezing i.e. (minus) 18° C for 18 months.

### **Processing of green mangoes.**

Green unripened mangoes can be cut in slices and dried. If stored at 25 to 30° C (75-86° F) they will retain 75% vitamin C.

### **Dehydration**

Mechanical dehydration is better than sun drying. Tunnel and cabinet dryers will also work.

### **Mango kernel and skins.**

Mango kernel contain starch and unsaturated fats.

Waste products of slices, pulp kernels, skin can be used for animal feed.

## **MANGO PROCESSING .**

### **Technological aspects of producing mango products.**

Mango is produced almost in every tropical and low latitude subtropical country. The edible pulp varies between 60-75 in most of commonly popular mangoes, but in some cultivars it reaches 80-85% by weight. It contains 83% water about 15% sugars mostly sucrose, vitamin A, and 30 mg, of citric acid per 100 grams of pulp. These also contain glycolic, oxalic, mallic, tartaric acids. It contain amino acids namely; glutamic acid, allanine, glycine, serine and alpha -amino butyric acid. Juice and all kinds of preserves can be made from it. Pickles and chutney are made from unripe fruit. Mango slices, pulp and juice are canned and bottled. In canning slices, softening is a problem, which can be over come by firming agents like, calcium chloride and calcium lactate .Since mango season is limited and prices fall down during mango glut, this is time to procure raw materials and ripen it to good quality and hold it in cold store it, for processing further. Mango makes delicious jams and mango latex .They can be canned by two way called open kettle and cold pressure methods.

In open kettle method mangoes are washed, skin peeled, sliced to endocarp or seed, slices put in 60% syrup, cooked for 10 minutes, and citric acid or lemon juice added. This hot mixture is put in to cans or bottles and sealed and finally product is cold stored. The product is sweet to begin with, but after several weeks of storage becomes more satisfactory. Cold pack of 60% syrup is made, slices put in and filling by syrup poured over them and allowed to exhaust for 5 minutes before processing for 15 minutes at  $34.5 \times 10^3$  (psi) pressure and sealed before putting in cold storage. All above requires specialized equipment and without that quantity can not be maintained for long storage and export.

### **Mango powder.**

Unripe mangoes are used for making powder, which is added to various dishes. Mangoes are peeled, sliced and dried in sun. Slices are very small and pass for powder.

### **Bam Paparh**

It virtually means dried slices. Pulp is squeezed out from ripe soft mango, spread on some kind of mats, sprinkled with sugar and allowed to dry under sun. When first layer has dried second layer is laid above it for drying. This process is repeated till layer or slab become  $\frac{1}{2}$  to 1 inch thick. Lot of dust will collect in South Asian environment, a number of fungus and insects will attack it. Philippines have been selling mango slices of good quality by drying under proper sanitation and scientific methods, eliminating all insects, pests, fungus and bacteria and sealing thermetically. There is great scope for mango slices.

### **Mango pickles.**

This is common product of South Asia. Mangoes which are fully developed are sliced longitudinally with stainless knife and slices are kept in 2-3% brine to prevent blackening of cut surface. Then they are processed by adding following spices.

<b>Spices</b>	<b>Weight</b>
Mango slices	20kgs
Salt powder	5 kgs
Metne ground coursly	2.5 kgs
Kalaunji	600 grams
Turmeric	600 grams
Red chilli powder	600 grams
Black paper	600 grams
Saunf (Ani seed)	600 grams

The mixture is usually put in glazed pot and kept under sun for 4-5 days for slices to turn pale yellow. Some times rape seed oil is also added.

### **Sun drying yards**

It is practically impossible to avoid dust, sand and other liter like, collecting over the fruit being dried and more so, to remove this material from the fruit at later stage. In Southern half of Sindh below Nawabsha, high velocity winds blows from south west to north east from April to September and is loaded with dust. On other hand machine drying at 60° C (140° F) will cost on fuel. There are single piece drying ovens occupying one small room with air inlet and exhaust, which can dry many tons of fruit every forty eight hours to seventy two hours. The clean product they produce, will be more than compensated by high export price.

### **Sulfuring room**

It is another requirement, that fruit being dried is first exposed to sulfuring process, so that it maintains its colour. Again sulfur dioxide is irritating and shocking gas to human beings, sulfur dioxide also attacks, zinc and untreated iron and special care is needed for selection of materials for fumigation. Fumigation tarpaulin can eliminate building sulfur house, but disadvantage is that though strong and decay resistant, it is easily cut by sharp edges of tools, trolleys and trays and in general can not stand rough handling.

### **Jams**

Lot of care is required in handling jams. It is not house hold industry but is large scale production, if aimed at local and foreign markets. It needs the following items to be carefully selected, protected, experimented and samples, tested, almost on a day to day basis involving:

- Use of right equipment, jelly kettles, deep fat thermometers, jelly bags for extracting juice from fruit containers that can be sealed air tight with fresh lids.

- Use of right ingredients, good flavour, fruit with good color, sugar proper amount of pectin and citric acid and lemon juice added if needed.
- Filling and sealing jars properly, which are kept in hot water until used.

### **Cold storage**

Processing in jars is done in hot water bath at 87.7° C ( 190° F), for 5 minutes to ensure vacuum seal before cold storage.

### **Jellies**

Making jelly from juice either by short boil method or no cook method or even long boiling method, all of which need equipment, testing for pectin, and acid and adding sugar if needed, cooking juice and testing for jelling point.

### **Mango butter**

Half ripe mangoes, are peeled sliced. About 16-33% volume of sliced mango is added to water and cooked until it soft enough to mash. Fruit can be blended for flavour and colour, white or brown sugar added for darker butter and more for pronounced flavour, even species or lemon juice is added.

### **No sugar Jam and jellies.**

In this process even existing sugars in juice are reduced, and no sugar is added.

## **MANGO CANNING.**

### **Canning.**

- For canning, puree is filled at 90°C into cans which are hermetically sealed and inverted for 20 seconds before rapid cooling under water sprays.
- For aseptically packaged product, puree is cooled to ambient temperature in a heat exchanger and filled under aseptic conditions to multi-laminate foil bag and then packed in carton.
- Spray drying of puree for powder is cheaper than drum drying and vacuum puff drying.

### **Mango leather.**

- Mango leather can be prepared from puree by adding .2% sodium metabisulphide before drying in trays to 15-20% moisture.

### **Suitability of Some mangoes for processing.**

<b>Process</b>	<b>Varieties</b>
Canning (as slices).	Baneshan
	Swarnarika
	5/5 ie, (Rajapur x Langra.)
	Kent
	Keitt

Canning Juice (35% pulp)	Navaneetam
	Baneshan
	Goabunder
	Royal special
	Hydersaheb
	9/4 (Neelum x Baneshan)
	Keitt.

**Mango From 12 different countries. These sources of supply are:**

S. No.	Country	Month of Supply
1	Mexico.	April to September.
2	Brazil.	End September to February
3	South Africa,	January to March.
4	Venezuela,	November to May.
5	Peru.	November to March.
6	Puerto Rico.	April to September.
7	India.	March to Mid September
8	Israel	September to December.
9	Australia.	November to March.
10	Philippines.	
11	Thailand.	
12	Pakistan.	

USA is within logistical reach by sea from Thailand, Philippines, and Australia, but U.S.A., does not allow, fruit fly, and seed weevil in mangoes.

- Ethylene Di-bromide (EDB) fumigation has recently been banned against treatment of fruit fly.
- Hot water treatment is acceptable in U.S.A
- North American Mango Industry Association (NAMIA) works with exporting countries to facilitate treatment processing.
- Demand for mango in U.S has increased by 500% in 10 years.
- Mangoes should be marketed under a brand name not only in USA but Europe .
- U.S.A is concerned with seed weevil indigenous to mangoes from Philippines, Thailand and Australia, so they cannot export.
- Japan accepts vapour heat treatment to kill fruit fly larvae.
- Japan and USA require supervision at the point of treatment by their own inspectors, who certify that shipments have been properly treated. They are also inspect at the port of entry.
- Recent conference in Mazatlan Mexico was sponsored jointly by USA, Office of International Cooperation and Development USAID, Ministry of Agriculture Mexico in June 1989 and was organized on post-harvest treatment of mango . A few points presented were.

- Hot water treatment needs mango at above 21.1°C (70°F) before treatment.
- Fruit must be submerged at least 4 inches under the surface of water at 46.1°C (115°F) for 75 minutes (Lower limit 45.4°C or 113°F).
- But aggregate temperature, below 115° to 113°F ( 45-46.2°C ) should not be more than 10 minutes.
- USA animal and plant Health inspection Service international Services works closely with exporting countries and exporter processor to set up strict treatment procedures. They verify at packing plants, accept fruit only from registered growers. This was discussed at Mazatlan conference.
- Hot air treatment or vapour heat treatment has also been developed.
- F.A.O and WHO have jointly formed “Food standards programme under Codex Alimentarius commission”
- Committee on Tropical fresh fruits and vegetables, met in Mexico in June 1988 and agreed to draft proposed standards. The agreed to address pineapple, papaya and mango.

### **New import market for Pakistan mango.**

Singapore 76%, China, 14% Malaysia 9%, India 1% balance. Singapore is tourist town with hotels, restaurants, super markets and channels for re-export. Whole sellers of mango exist. Malaysia, imposed import duty of about Rs. 10 per kg of fruit in 1982. Hong Kong population is 7 millions. China provides cheap fruit to Hong Kong.

### **Presenting and packing for export**

- Product should have maximum shelf life.
- Fruit is to be harvested at correct maturity.
- Size should be acceptable.
- Brandh sticker should be put on each piece and marketing should be under that name.
- Consider polystyrene protective netting around each fruit.
- Carton should have maximum weight, to reduce one carton to fruit cost.
- At 13°C and 90% moisture storage life mango is 14 to 21 days.
- Respiration of mango is:
  - 3500 BTU per Ton per day, at 5°C
  - 9900 BTU per Ton per day, at 16°C
  - 25000 BTU per Ton per day, at 21°C
- For export following should be the basic criteria:
  - Regular supply throughout the season.
  - Pre-cooling and storage facilities.
  - Handling and packing facilities.
  - Common tray weight which in Australia is 6.5 kgs.
  - Canned (sliced mango) from Thailand was sold at Pak Rs. 120 per kg in Australia in 1999.



### Europe's Acceptable Varieties.

- European importers accept Haden, Kent, Julie, Ng, all redish and yellowish types Alphonso and Bribio. Europeans prefer yellow with greenish or redish tinge, except Madame Francis and Peach, which are given.

### International trade season of mango in various countries.

- It is opening up in Japan, France, Germany, U.K and USA. It can be available almost year around from one or other country of the world.

### Vegetative versus reproductive growth.

- Leaves of many mango cultivars are not able to cope up with high demand for photo-assimilates needed for regular flowering and high field.

### Chemical Composition of mango.

S. No.	Elements	Milligrams Per 100 Grams or percentage
1	Sugars.	10-20% but for most fully ripe varieties 16-20%. Green mature but un-softened fruit has 2-10 sugar.
2	Sodium.	1.00
3	Water.	76-85%
4	Acids.	0.54-0.67% for ripe 0.67-3.11 %for unripe.
5	Potassium	384
6	Protein	0.5%
7	Calcium	6.80
8	Magnesium.	41.90
9	Iron,	0.41
10	Copper.	0.16
11	Phosphorus.	28.40
12	Chlorine.	78.40
13	Moisture.	76.85%
14	Starch.	59.13% - 70%. Unripe fruits are rich in starch, which is hydrolyzed to sugars during ripening.
15	Fats.	8.66%-10%
16	Tannin	10.%
17	Fibre.	0.8 to 1.22%
18	Unsaturated fatty acids as part of total fats:	About 45%
19	Vitamin C.	Green mangoes cut in slices and dried, retain 75% of their vitamin C, if stored at 75 to 86% humidity
20	Other Vitamins.	It is rich in vitamin A, fair in vitamin B

		and has varying quantities of Vitamin C.
21	Aromatic Substances.	Give turpentine flavour. If present in small quantities it gives mango flavour richness.

## CHAPTER - 34

### USES OF MANGO

Mango is consumed more than any other fruit in fresh state and even by more people of the world than any other single fruit. Following are its common uses:

#### Uses of mango fruit.

- Eaten Fresh as desert food.
- Preserved by canning and freezing.
- Immature fruit eaten as vegetable.
- Chutney from immature fruit.
- Mango nectar.
- Juice used as puree or blended with juices of other species and aseptically sealed, can be stored for 2-3 weeks.
- Fabricated fruit pieces.
- Takes 3-14 days to soften once exposed to over 20°C.
- Dried mango products.
- Slices for storage by freezing possible, by first pecking each fruit and slicing down each side of seed.
- Frozen mango slices in syrup at 200 grams per litre and frozen at minus 18°C. Blast freezing possible at 30°C.
- Pulp and peeled slices can be frozen or dried.
- Drying would need 2 to 4% of metabisulphite, added as preservative.
- Pulp can be dried in sun or in forced air draft oven.
- Dried product (Sun or machine dried) or mango leather in dry state can be stored for 12 months.
- Squash.
- Jams.
- Jelly.
- Preservatives.
- Mango dyes are made from urine of animals fed on mango leaves, but prolonged feeding is to be avoided as it can kill animals due to tannins.
- Farming, landscaping, conservation animal feed, wind break, shading animal and human.

#### Nuisance Properties.

- Some people are allergic to the sap, of mango, which causes dermatitis, similar to that of poison food and ivermectin.
- People sensitive to sap, can eat, it, if some one else washes and peels it.
- Stringy varieties are used for juice and Jams.
- Reddish colour young leaves are used as salad or vegetable.
- Young fruit is eaten raw with sauce, ketchup, palm sugar and sambal.
- Very young fruits are pickled.

- Chutney is made from young mangoes.
- Brew of bark is also used against ailments.
- Leaves are also used against certain ailments.

**South Africa.**

- More than 50% of crop is processed to Achar, highly sought after by South Africa's black population and it is an unsaturated market, 10% is processed to puree and juices and only 30% is fresh fruit, which is marketed.

## CHAPTER - 35

### ECONOMICS OF MANGO PRODUCTION

In Pakistan there is land and water shortage, land hunger and owning even small piece of land a prestige, consequently land prices have risen multifold and presently if capital cost of land and infra structures at the site is included, no orchard or field crop will ever pay back its cost. The high density orchard can pay back all other costs in at least 12-13 years, though break in period i.e., owner no longer has to put his own money except returns from land, will be year 7-8.

With conventional low density planting of 25-40 trees per acre, break in period can be atleast 10 years and pay back period 20 years. Of course in both cases capital cost of land or interest on it is not included .The reason for this is suppression of prices of agriculture commodities for the past 60 years to feed rural and urban poor. In the year 2006 mango growers were getting Rs 7.00 to 8.00 per kg for their mango sent to whole sale markets, where as, for the same commodity price in Australia, South Africa, Florida and Israel was 10 times. This indirectly has affected the grower's ability to spend on improvements like better tools, deep well turbine tube wells instead of conventional pump in the pit, precision land leveling, better spray equipment, better mango harvesters, better picking and packing facilities, better pest control etc.

#### **Factors to be considered in economic analysis.**

These factors are as under:

##### **1. Capital cost**

- Land, shed and workshop, fencing.
- Tube well, irrigation, tractors, implements, utility equipment, packing shade and stores.
- Tree planting and maintenance up to end of year 5.
- Vehicles.
- Total cost up to end of year five.

##### **2. Major production costs.**

- Weed control.
- Pest and diseases control.
- Fertilizers.
- Irrigation (running cost).
- Slashing, and pruning labour and maintenance.
- Picking and packing or harvest costs including labour, boxes, packing materials.
- Freight to market, taxes en-route, loading and unloading.
- Agent's commission.

### **3. Owners or Contractors personal supervision charges**

This includes transport, correspondence, interest on borrowed money, supervisory staff, guards, power, telephone etc

### **4. Total cost.**

It would be sum of 1, 2 and 3 above.

### **5. Returns from crop and residual value of equipment and capital goods.**

General maintenance, office costs, accountants costs, government taxes, insurance and cost of market visits and depreciated value of capital equipment, structure and other goods.

6. The above will give net profit or loss from year to year, but if interest on cost of land purchased from borrowed money is included, the annual losses will keep increasing and orchards will never pay back.

### **7. Our experience of internal rate of return IRR during past 40 years.**

Our experience of internal rate of return shows that with high density planting, dwarfing trees by proper pruning, optimum inputs, mulching the year around optimum irrigation, pest and disease control, the IRR at high yields and high prices can be 30-40 %. At medium yields of 3-5 tons per acre it can be around 10% and at low yields of less than 3 tons per acres it can be -5 to + 5%

### **8. Mango profitability.**

- i) Internal rate of return should not be less than government loan rate + inflation (as determined by price of gold).
- ii) Break even period should not exceed 7-8 years.
- iii) Peak debit, should reduce after year 5.

Payback period is time required for accurate cash returns, equal to the accumulated cash cost and best period should be year 9-10, though year 12-13 is acceptable for medium management. Payback period: Beyond year 20, it may never pay back and most of Pakistan mango orchards belong to this category.