Lecture-10

Graft incompatibility and Stock-scion relationship

Learning objectives

- Importance of graft incompatibility
- External symptoms of graft incompatibility
- Types of Incompatibility
- Stock-scion relationships

Introduction

The inability of two different plant parts grafted or budded together, to produce a successful union and to develop into a composite plant is termed as 'graft incompatibility' (Fig.10.1). Graft failure can be caused by anatomical mismatching, poor craftsmanship, adverse environmental conditions, diseases and graft incompatibility. Graft incompatibility occurs because of following reasons:

- Adverse physiological responses between the grafting partners
- Virus or phytoplasma transmission
- Anatomical abnormalities of vascular tissue in the callus bridge.

External symptoms of graft incompatibility

Graft union malformation resulting from incompatibility can usually be correlated with certain external symptoms. The following symptoms have been associated with incompatible graft combination:

I. Failure to form a successful graft or bud union in a high percentage of cases.
II. Yellowing of foliage in the latter part of the growing season, followed by an early defoliation, decline in vegetative growth, appearance of shoot die-back, and general ill health of the tree
III. Premature death of the trees, which may live for only a year or two in the nursery
IV. Marked difference in growth rate of the scion and rootstock
V. Over growth at, above or below the graft union
VI. Suckering of rootstock
VII. Breakdown of graft union cleanly

Types of Incompatibility

Graft incompatibility is of two types 1) Localized (non-translocated) incompatibility and 2). Translocated incompatibility.

Localized (non-translocated) incompatibility

- Graft combination in which a mutually compatible interstock overcomes the incompatibility of the scion and rootstock.
- The interstock prevents physical contact of the rootstock and scion and affects the physiology of the normally incompatible scion and rootstock.
- A good example is Bartlett pear on quince rootstock. When mutually compatible Old Home or (Beurre Hardy) is used as inter-stock the three graft combination is completely compatible and satisfactorily tree growth takes place.

Translocated incompatibility

- It includes certain graft/rootstock combination in which the insertion of a mutually compatible interstock does not overcome incompatibility.
- This can be recognized by the development of a brown line or necrotic area in the bark at the rootstock interface.
- Consequently carbohydrate movement from the scion to the rootstock is restricted at the graft union.
- Hale's Early peach grafted onto Myrobalan-B plum rootstock is an example of translocated incompatibility.
- The tissues are distorted and a weak union forms. Abnormal quantities of starch accumulate at the base of the peach scion. If the mutually compatible 'Brompton' plum is used as interstock between Hale's Early peach and Myrobalan- B rootstock the incompatibility systems persists, with an accumulation of starch in the Brompton inter-stock.
- Nonpareil almond on Mariana '2624' plum rootstock shows complete phloem breakdown, although the xylem tissue connections are quite satisfactory. In contrast Texas almond on Mariana- 2624 plum rootstock produces a compatible combination. Inserting 15 cm piece of 'Texas' almond as an inter-stock between the Nonpareil almond and the incompatibility between these two component.

Delayed incompatibility

- Some apricot cultivars grafted onto Myrobalan plum rootstock will not break at the graft union until the trees are full grown and bearing crops.
- Graft incompatibility can take as long as 20 years to occur. Other examples are conifers, oaks and cherry on *pazza* (*Prunus cerasoides*) rootstocks.

Pathogen induced incompatibility

- These graft union failures resemble incompatibility symptoms, but are due to pathogens like virus or phytoplasma. *Tristeza* is an important example of virus induced incompatibility in citrus. Failure of sweet orange (*Citrus sinensis*) budded onto sour orange (*Citrus aurantium*) rootstock is due to toxic substance from sweet orange, but lethal to the sour orange rootstock.

- Other examples are black line in English walnut (*Juglans regia*), which infects susceptible walnut rootstocks, apple union necrosis and decline and brown line of prune, which is caused by tomato mosaic virus that is transmitted by soil-borne nematodes to the rootstocks and then to the graft union.
- Pear decline is due to a phytoplasma, rather than a virus.

Causes and mechanism of incompatibility

The large number of different genotypes that can be combined by grafting produces a wide range of different physiological, biochemical and anatomical interaction when grafted. Several hypotheses have been advanced in attempts to explain incompatibility.

A. Physiological and biochemical mechanism

- In case of incompatible combination of certain pear cultivars on quince rootstock, the incompatibility is caused by a cyanogenic glucoside, prunasin, normally found in quince, but not in pear tissues.
- Prunasin is translocated from the quince into the phloem of the pear. The pear tissues, breakdown the prunasin in the region of the graft union, with hydrocyanic acid as one of the decomposition products.
- The presence of the hydrocyanic acids leads to a lack of cambial activity at the graft union, with pronounced anatomical disturbances in the phloem and xylem at the resulting union. The phloem tissues are gradually destroyed at and above the graft union.
- Conduction of water and material is seriously reduced in both xylem and phloem. The presence of cynogenic glucosides in woody plants is restricted to a relatively few genera. Hence, this relation cannot be considered a universal cause of graft- incompatibility.

B. Modification of cells and tissue: The lignification process of cell in walls is important in the formation of strong union in pear-quince grafts. Adjoining cell walls in the graft union of incompatible combination contain no lignin and are interlocked only by cellulose fibres. With incompatible apricot/plum (*Prunus*) grafts some callus differentiation into cambium and vascular tissue does occur, however, a large portion of the callus never differentiates. The union that occurs is mechanically weak.

C. Cellular recognition: "Cellular recognition is defined as the union of specific cellular groups on the surface of the interacting cells that results in specific defined response e.g. pollen-stigma compatibility recognition responses with glycoprotein surface receptors in flowering plants."

It has been postulated that the critical event deciding compatible and incompatible grafts may occur when the callus cell first touch. There may be cellular recognition that must occur in successful graft union formation.

Predicting incompatible combination: To be able to predict in advance of grafting whether or not the components of the proposed scion-stock combinations are compatible would be of tremendous value. The different methods used are:

1) Electrophoresis test: This test is being used for testing cambial peroxidase banding pattern of the scion and rootstock of chestnut, oak and maple. Peroxidases mediate lignin production. Increased peroxidase activity occurs in incompatible grafts as compared to compatible auto grafts and adjacent rootstock and scion cells must produce similar lignin and have identical peroxidase enzyme pattern to ensure the development of a functional vascular system across the graft union. With electrophoresis if the peroxidase bands match the combination may be compatible, if they do not match incompatible may be predicted.

2) Magnetic resonance imaging (MRI): Magnetic resonance imaging can be used to detect vascular discontinuity in bud union of apple. High magnetic resonance imaging signal intensity is associated with bound water in live tissue and the establishment of vascular continuity between the rootstock and scion. Magnetic resonance imaging may be useful for detecting graft incompatibility caused by poor vascular connection.

Correcting incompatible combination: This is not a practical, cost-effective way to correct large scale planting of incompatible grafting partners. Plants would normally be rogued and discarded. With perhaps some isolated specimen trees of value, if the incompatibility is discovered before the tree die or break off at the union, a bridge graft could be done with a mutually compatible rootstock. Another costly alternative is to inarch with seedling of a compatible rootstock. The marched seedlings would eventfully become the main root system.

Stock-scion relationships

A grafted or budded plant can produce unusual growth patterns which may be different from what would have occurred if each component part of a graftage viz., rootstock and scion was grown separately or when it is grafted or budded in other types of rootstocks. Some of these have major horticultural value. This varying aspect of rootstocks will influence the performance of a scion cultivar or *vice versa* is known as stock-scion relationship.

A. Effect of stocks on scion cultivars

1. *Size and growth habit*:

- In apple, rootstocks can be classified as dwarf, semi-dwarf, vigorous and very vigorous rootstocks based on their effect on a scion cultivar.
- If a scion is grafted on dwarf rootstocks (e.g. M.9), the scion grows less vigorously and remain dwarf only. On the other hand if the same scion is grafted on a very' vigorous rootstock (*e.g.* M2) the scion grows very vigorously.
- In citrus, trifoliate orange is considered to be the most dwarfing rootstock for grape and sweet

oranges. On the other hand, in mango, all plants of a given variety are known to have the same characteristic canopy shape of variety despite the rootstocks being of seedling origin.

- But mango rootstocks like Kalapade, Olour have been found to impart dwarfness in the scion cultivars. Guava cultivars grafted on *Psidium pumilum* are found to be dwarf in stature. 'Pusa Srijan' guava rootstock also imparts dwarfness in Allahabad Safeda, a commercial cultivar of guava.

2. Precocity in flowering and fruiting:

- The time taken from planting to fruiting i.e., precocity is influenced by rootstocks. Generally fruit precocity is associated with dwarfing rootstocks and slowness to fruiting with vigorous rootstocks.
- Mandarin, when grafted on Jambhiri rootstock is precocious than those grafted on sweet orange or orange or acid lime rootstocks.

3. Fruit set and yield

- *The* rootstocks directly influence on the production of flower and setting fruits in oriental Persimmon *(Diospyrous kaki cv.* Hachiya). When it is grafted on *D. lotus*, it produces more flowers but only few mature into fruits. However, when *D. kaki* is used as the rootstock, the fruit set is very high.
- The influence of rootstock on the yield performance of cultivar has been well documented in many fruit crops. Acid limes budded on rough lemon register nearly 70 per cent increased yield than those budded on troyer citrange, Rangpur lime or its own rootstock. Sweet orange var. Sathugudi budded on Kichili rootstock gave higher yield than on Jambhiri or on its own seedling.

4. Fruit size and quality

- Sathugudi sweet oranges grafted on Gajanimma rootstocks produced large but poor quality fruits while on its own roots they produced fruits with high juice content and quality.
- The physiological disorder 'granulation' in sweet orange is very low if on Cleopatra mandarin seedlings, on the other hand, rough lemon seedling stocks induced maximum granulation.
- The physiological disorder black end in Bartlett Pear did not appear if *Pyrus communis was* used as the rootstock. When *P. pyrifolia* was used as the rootstock this disorder appeared, affecting fruit quality.

5. *Nutrient status of scion*

Rootstocks do influence the nutrient status of scion also. Sathugudi orange trees have a better nutrient status of all nutrients in the leaves when it is budded on *C. volkarimariana root stock* than on its own rootstock or Cleopatra mandarin stocks.

6. Winter hardiness

Young grapefruit trees on Rangpur lime withstand winter injury better than on rough lemon or sour orange. Sweet oranges and mandarins on trifoliate stocks were more cold hardy.

7. Disease resistance

In citrus, considerable variability exists among the rootstocks in their response to diseases and nematodes. For instance, rough lemon rootstock is tolerant to tristeza, xyloporosis and exocortis but is susceptible to gummosis and nematode. On the other hand, troyer citrange is tolerant to gummosis but susceptible to exocortis virus disease. Similarly, guava varieties grafted on Chinese guava. *(Psidium friedrichsthalianum)* resist wilt diseases and nematodes.

8. Ability to resist soil adverse conditions

Among the citrus rootstocks, foliate orange exhibits poor ability, while sweet oranges, sour orange, rangpur lime rootstocks exhibit moderate ability to resist excess salts in the soil. Similarly, in pome fruits, variation exists among rootstocks to resist excess soil moisture or excess boron in the soil. Myrobalan plum rootstocks generally tolerate excess boron and moisture than Marianna plum root or other rootstocks' viz., peach, apricot or almond.

B. Effect of scion on rootstock

1. Vigour of the rootstocks:

In apple, it has been found that if apple seedlings were budded with the 'Red Astrachan' apple, the rootstock produced a very fibrous root system with few tap roots. On the other hand if scion 'Goldenburg' was budded on the seedlings, they produced two or three pronged deep roots without fibrous root system. In citrus, if the scion cultivar is less vigorous than the rootstock, the rate of growth and the ultimate size of the tree is more determined by the scion rather than the rootstocks.

2. Cold hardiness of the rootstock

Cold hardiness of citrus roots is affected by the scion cultivar. Sour orange seedlings budded to 'Eureka' suffered much more from winter injury than the unbudded seedlings.

3. Precocity in flowering

Young mango rootstock seedlings (6 months to one year old) were found to putforth inflorescence when the branches from old trees are inarched which can be attributed to the influence of scion on the rootstock.

Factors influencing the healing of graft union

1. **Incompatibility:** Certain rootstocks and scions are incompatible, therefore the graft union between these two will not normally take place.
2. **Kind of plant**: Some species like oaks are difficult to graft, but apple and pears are very easy in producing a successful graft union.
3. **Environmental factors during and following grafting:** There are certain environmental

requirements which must be met for callus tissues to develop and heal the graft union.

a) ***Temperature*** has a pronounced effect on the production of callus tissues. An optimum temperature is essential for production of callus, In most of the temperate fruit crops callus production is retarded after 42.5^o C.

b) ***Relative humidity*** must be high is maintaining a film of water against the callusing surface is essential to prevent these delicate thin walled parenchymatous cells from drying.

c) Presence of **high *oxygen*** content near this surface is essential.

4. **Growth activity of the stock plants**: Some propagation methods, such as 'T' budding and bark grafting depend upon the bark slipping which means the cambial cells are actively dividing and producing young thin walled cells on the side of the cambium. These newly formed cells separate readily from one another as the bark slips.

5. **Propagation techniques**: Sometimes the techniques used in grafting are so poor that only a small portion of the cambial regions of the stock and scion are brought together. This may result in failure of the graft union.

