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Induction of Dwarfing in Fruit Plants

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A dwarf plant is that which is smaller than normal size at full maturity and possesses other characteristics like precocity, canopy architecture and time of flowering and altered fruit size.

Physiological dwarfism

Horticultural practices used to achieve dwarfing in fruit crops

- Selection of spur type scion cultivars.
- Use of interstocks.
- Pruning.
- Use of growth retardants.
- Control of nutrient elements.
- Root pruning.
- Girdling.
- Scoring.
- Bark inversion.
- Use of dwarfing or ultra dwarfing or semi dwarfing rootstocks.

Correlations for predicting dwarfing capacity of potential rootstocks

1. Percentage of live tissues of the root cross section.
2. Bark or wood ratio.
3. Percentage of medullary ray tissues in root cross-section.
4. High stomatal density of leaves.
5. Bark is key factor for dwarfness as it reduces translocation of auxins, sugars and other compounds.

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Methods to achieve dwarfism

1. Use of dwarfing rootstock.
2. Use of genetically dwarf scion cultivars.
3. Use of bioregulators.
4. Incompatible root stock.
5. Induction of viral infection.
6. Training and pruning.
7. Nutrients.
8. Phenols.
9. *Invitro* techniques.
10. Genetic engineering.

- **Use of dwarfing rootstocks**

Crop	**Dwarfing rootstock**
Mango	Vellaikolumban, Olour, Gomera-1, Ann, Totapuri Red small, Kerala dwarf
Apple	M-9, M-27
Guava	Pusa srijan, *Psidium friedrichsthalianum*, *P.pumilum*
Pear	Quince-C
Cherry	Colt
Plum	Pixy, St.Juliean A
Peach	Siberian C, St. Juliean X, *P.besseyi*
Citrus	Troyer citrange for Kinnow, Flying dragon for lemon, Cleopatra mandarin for Acid lime.
Ber	*Z.nummularia*

- **Use of genetically dwarf scion cultivars**

Crop	**Dwarf variety**
Mango	Amrapali, Arka Aruna, Neelum, Creeping
Papaya	Pusa Nanha

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Banana	Dwarf Cavendish
Apple	Spur bearing varieties
Cherry	Compact, Lambert, Meteor, Northstar
Peach	Red heaven
Sapota	PKM-1,PKM-3

- **Use of bioregulators**

A. Paclobutrazol

It inhibits GA synthesis and thereby retards growth, shorten elongation and reduces the intermodal length.

Dwarfing mechanism due to paclobutrazol

- Shorter internodes due to less GA in the tissues resulting from the action of PBZ.
- Reduces ABA levels in the shoot tips.
- Reduces the levels of cytokinins in treated trees.
- Enhances the total phenolic content of terminal buds and alters the phloem to xylem ratio of the stem.
- Reduction in trunk cross section area.
- PBZ @ 2.5 or 5g/lit tree resulted in 50 per cent reduction in tree volume.
- Paclobutrazol helps in making the plants dwarf by producing a retarding effect on the growth of the tree through inhibition of gibberellin biosynthesis.

B. Alar

It affects the Auxin and diamine oxidase forming the basis for growth inhibition. It lowers the membrane integrity allowing vascular contents to diffuse rapidly into the external medium.

C. Gibberellin biosynthesis inhibitors

a. Onium compounds

Cycocel

Mepiquat chloride

AMO-1618

Phosphon D

Piperioxim bromide

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b. Triazoles

Paclobutrazol

Uniconazol

Tripenthenol

BAS 111

XE 1019

c. Pyramidines

They inhibit cytochrome PASO which controls the oxidation of kaurene to kaurenoic acid. They inhibit gibberellin biosynthesis.

d. Others

- Tetcyclasis
- Inabenfide
- Morphactins: Chlorfuron, Chlorflurenol, Dichloroflurenol, Flurenol.

Use of incompatible root stocks

Z. nummularia produces genetic dwarfism and shows variable degrees of incompatibility i.e. inverted bottle neck formation at bud union and induces Dwarfness and can be exploited for HDP.

Induction of viral infection

The isolated cultures containing cachexia pathogenic variant of the Hsvd viroid forming a complex with cvd-w or exocortis (CEvd) induced shortening of shoots and reduction of canopy diameter, height and volume in lime. Viroid inoculated trees may give high yields while restricting tree size in HDP.

Training and pruning

Tree size control through pruning is limited grape, apple, mango and others temperate crops. Spinach bush and SVA (Single Vertical Axis) raised on M_9, M_7 and M_4 root stocks has been found to be promising for HDP with respect to size control.

Phenols

Phenols inhibit growth through of mitosis, cell division, cell elongation and increased oxidative decarboxylation of IAA. e.g. Caumarins.

8. In vitro techniques

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Seeds of apple cv. USDA4-2D were subjected to different levels of (0, 20, 40, 60 muM) BA and Thidiazuron to induce dwarfism via in vitro technique. Thiazuron more effective than BA in inducing dwarfism.

- **Genetic engineering**

The genes that induce dwarfing in fruit crops are GA2 ox genes, ipt, OSH and rol ABC genes, induce Dwarfness in *Arabidopsis*, Apple, Kiwi, Citrus etc. A C DNA encoding sorbitol -6- phosphate dehydrogenase (S6PDH), which is a key enzyme in sorbitol biosynthesis introduced into the Japanese persimmon induced dwarfism.

Anatomical, physiological and biochemical factors that appear to the cause of the dwarfing effect

1. Anatomy of dwarfing root stock

Dwarfing root stocks have smaller xylem vessels, less xylem fibres, besides having higher bark percentage, wood ray tissues per unit cross sectional area of root system.

2. Nutrition

Partitioning of carbohydrates between above and below graft union parts of the tree is affected by root stock.

3. Hydraulic conductivity

Reduced root hydraulic conductivity helps to induce dwarfism.

4. Translocation of water and minerals

Dwarfing root stocks are less effective in uptake of nutrients and water and their supply to shoots.

5. Phytohormones

Less auxin flow takes place through bark root stock.

6. Reduced root systems of dwarfing root stock

7. Depletion of solutes in xylem sap of scions by dwarfing root stocks.

8. Dwarfing root stocks induce restricted canopy development of scion variety.

9. Reduced net assimilation rates.

10. Reduced carbohydrates or phloem transport from leaves to roots by dwarfing rootstocks or inter stocks.