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Spongy Tissue in Mango Cv. Alphonso

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ARTICLE ID: 51

Introduction

Most mango cultivars grown in India and abroad belong to *Mangifera indica* L., a species native to Indo – Myanmar region. It belongs to family Anacardiaceae (poison ivy family) characterized by the presence of Resin canals. Kostermans and Bampard (1993) have described 69 species of *Mangifera*. Out of 69 species there are no less than 12 species enumerated under *species incertae sedis* (species that cannot be placed properly), because of insufficient confirming evidences. Majority of the *Mangifera spp*. and cultivars so far examined have 2n = 2x = 40. A single instance of tetraploidy (2n = 4x = 80) has been reported in a polyembryonic seedling of a South Indian cv. ‘’Vellaikolumban’’. Most of the members of the family Anacardiaceae are characterized by the presence of ‘’Resin canals’’. As per Mukherjee (1950), mango varieties originated through Allopolyploidy, most probably through Amphidiploidy.

Mango introduction to Florida began in 1861 with the importation of No. 11, a polyembryonic seed propagated cultivar from Cuba. The USDA introduced Mulgoa, an improved cultivar from India in 1889. Florida became a contemporary secondary centre of diversity for mango germplasm. In 1910, a seedling of ‘’Mulgoba’’ came into production in Florida. This selection was named as ‘’Haden’’. Haden and Keitt are the selections of Mulgoa. Eldon, Glenn, Lippens, Tommy Atkins, Zill, Springfels, Parvin, Osteen are progenies of Haden. Irwin is a selection from Lippens. ‘’Saigon’’ seedling selection was made from ‘’Cambodiana’’, a polyembryonic introduction from Indochina. Alice, Herman and Florigon are the selections of Saigon. Some of the Florida cultivars, Tommy Atkins and Keitt are resistant to Anthracnose. The mango cv. Carabao is from Philippines and Sindri is from Pakistan. In the Canary Island, Spain, a putative tetraploid ‘’Gomera – 1’’ was confirmed using both flow cytometry and chromosome count analysis. The mango cv.

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Sensation is the best pollinator amongst Florida cultivars. The mango cv. R2E2 produces predominantly polyembryonic seed with upto 30 % monoembryonic seed in some seasons. Unfortunately, the export trade of mango cv. Alphonso suffers a major setback from spongy tissue, a physiological internal breakdown disorder.

1. Spongy tissue is characterized by unripe, acidic, pale yellow or white, corky tissue with or without air pockets associated with an unacceptable off flavour in mesocarp tissue adjacent to endocarp.
2. In extreme cases, the whole portion becomes too soft resembling bacterial rot.
3. Fruits affected by this disorder do not show any external symptoms and the malady is detected only after cutting the fruits open.
4. This is reported to be caused by inactivation of ripening enzymes during fruit maturation stage due to high temperature, convective heat and post harvest exposure of fruit to sunlight.

Factors affecting spongy tissue in mango

1. **Fruit maturity: -** Early picked fruits might escape spongy tissue, while late harvested and tree ripe fruits showed higher incidence of spongy tissue.
2. **Nutritional factors: -** Spongy tissue was attributed to deficiency of calcium and boron. Spongy tissue is localized and is observed invariably in mesocarp tissue on surface of the stone only.
3. **Convective heat accumulation near endocarp: -** Katrodia (1988) attributed spongy tissue to accumulation of convective heat at endocarp. If convective heat were to be considered, the effect would be more pronounced at epicarp than endocarp, as high water content of the mesocarp would have dissipated it before accumulating at endocarp. Further, spongy tissue cannot be attributed to external factors like temperature, convective heat etc, as these do not vary, logically, between healthy and spongy tissue affected fruits on the same panicle.
4. **Inter – fruit competition and vascular disconnection: -** Spongy tissue was more than 30 % in panicles with more than one fruit as compared to only 5.7 % in one fruit panicles indicating influence of inter – fruit competition. Apparently, the vascular disconnection takes place at some point during ontogeny.

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5. **Seed recalcitrant and shift to germination mode:-** Loss of vasculature between seed and the parent tree triggers a cascade of developmentally important events as the program for embryonic growth is over ruled by that of germination, prompting the embryo to shift to germination mode. The cause of spongy tissue has thus been traced to shift of recalcitrant seed into germination mode and the consequent withdrawal of water and other resources from mesocarp by the physiologically active recalcitrant embryo with funiculus connection intact at hilum. Being a high priority sink and capable of draining resources from fleshy parts of fruit that metabolically active and growing seed, can therefore, be expected to induce spongy tissue.
6. **Environmental factors:-**Persistent warm weather (30 – 35^{o} C) coupled with high relative humidity (> 85 %), favour faster growth and development of fruits resulting in shift of embryo into germination mode and the consequent dependence on mesocarp for its sustenance.
7. **Significance of the physiological role of the seed:-** Physiological and biochemical studies (Ravindra and Shivashankar, 2004) have provided ample evidences on the causative role of seed and vindicated the direct relation between spongy tissue and shift of recalcitrant embryo into germination mode.

Spongy tissue in Alphonso mango – significance of *insitu* germination events

- Spongy tissue incidence was closely associated with physiological status of the seed during fruit maturation.
- The seed from spongy tissue affected fruits showed faster and high rate of germination, while a small percentage of fruits even exhibited vivipary.

In situ seed germination signal triggers the following sequence of events leading to the formation of spongy tissue in Alphonso mango

- Disconnection of vascular strands (funiculus) between the panicle and the endocarp during fruit or seed maturation phase.
- Shift of physiologically mature recalcitrant seed into germination mode.
- Diffusion of water and solutes from mesocarp into seed and consequent initiation of germination.
- Development of anaerobiosis due to build up of CO_2 in the mesocarp tissues near the endocarp, arising out of climacteric respiration.

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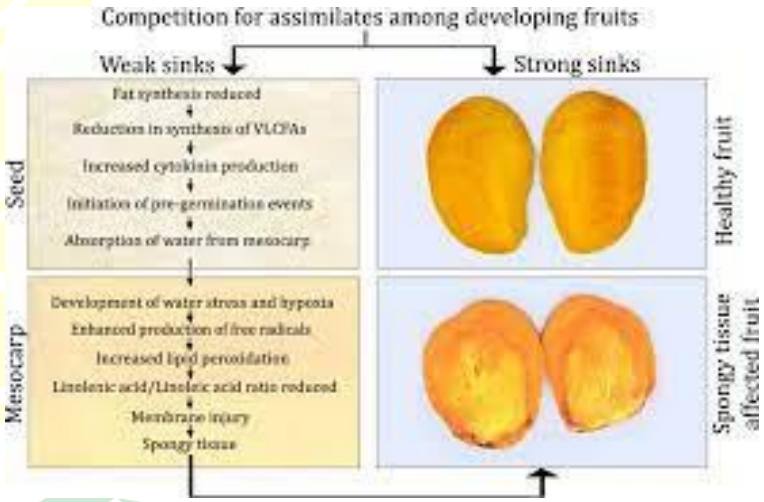
- Metabolic disturbances in the mesocarp such as increased accumulation of organic acids, reduction of pH, activation of cell wall degrading enzymes and free radical formation leading to the formation of spongy tissue.



Sequence of events in the development of spongy tissue in mango

Management strategies

1. Inducing metabolic quiescence of the recalcitrant seed through induction of appropriate levels of dormancy while maintaining the fruit quality through environmentally safe approaches.
2. Inducing seed dormancy or down regulating the seed metabolism without affecting the fruit growth and development was found to be the right strategy to prevent or arrest spongy tissue formation as it cannot be cured once developed.

‘’Arka Saka Nivarak’’ - An Innovative Technology

The product ‘’Arka Saka Nivarak’’ (pending patent award), is a novel and environmentally safe formulation developed by ICAR – IIHR (Dr V. Ravindra) for successful

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prevention of spongy tissue in mango cv. Alphonso. Its mode of action is that delays or prevents the shift of recalcitrant seed into germination mode through induction of dormancy or down regulating the metabolism of seed.

Co benefits of ''Arka Saka Nivarak''

1. Increased fruit weight (> 230 g)
2. Attractive appearance
3. Uniform external and internal colour development
4. Improved fruit firmness
5. Excellent pulp texture
6. Improved flavour, aroma and TSS
7. Extended shelf life of fruits (upto three weeks)
8. Enhanced anti oxidant capacity of the fruit pulp

Conclusion

Spongy tissue in mango cv. Alphonso can be controlled by preventing the shifting of recalcitrant seed into germination mode by spraying of Arka Saka Nivarak. The fruits should be harvested just prior to full maturity (do not allow ripening), preferably during early morning, and should not be exposed to direct sunlight.