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Studies on management of spongy tissue in mango (*Mangifera indica* L.) cv. Alphonso

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Abstract
The present study revealed that all the treatments had a significant effect on incidence of spongy tissue and quality aspects of Alphonso mango. The findings suggest that treatment T_2 (T_1 + spreading of 20 cm thick dry grass mulch at pea stage) displayed notable effectiveness in reducing the incidence of spongy tissue in mangoes harvested at both 85% fruit maturity and the tree-ripe stage, while the treatment T_5 (Foliar application Amrashakti (2.5%) at vegetative stage, 50% flowering and egg size fruit + Bagging with newspaper bags at marble stage) shown the better result in chemical aspects of Alphonso mango such as TSS, total sugars, reducing sugar, ascorbic acid and lowest titratable acidity. Further study observed that harvesting time had a key factor on influenced of spongy tissue incidence, fruits show less spongy tissue incidence (10.75%) when harvested at 85% fruit maturity as compared to those harvested at tree ripe stage (13.50%).

Keywords: Spongy tissue, quality, management, alphonso, mango

Introduction
Mango, scientifically known as (*Mangifera indica* L.) stands as a paramount tropical fruit crop of global significance, often hailed as the "King of Fruits," India's national fruit, boasts diverse vitamins.

Spongy tissue (ST) is only noticeable after the fruit has been sliced open and shows no outward symptoms, it poses a significant barrier to quality control in the export of mangoes. As one of the main mango-growing regions in Maharashtra, the Konkan region was closely monitored by Dr. BSKKV, Dapoli. As a result, Dr. BSKKV, Dapoli recommended a number of practices and developed number of varieties for the cultivation of mango growers in the Konkan region of Maharashtra. However, a large number of farmers in the Konkan region grew the Alphonso cultivar (developed by Dr. BSKKV, Dapoli) because of its fragrance, aroma, and demand in the international market. Despite this, the Alphonso mango has a major physiological disorder known as spongy tissue, University recommended many practices for control spongy tissue incidence but yet not completely success get and farmer had faced the major problem in exporting the ripe Alphonso mango which quality was hampered due to the spongy tissue. An extensive examination has been carried out over many years to determine the cause of disorganized spongy tissue however, different scientists have identified different causes. Spongy tissue is out of whack in Alphonso and other cultivars due to factors including cultivar, environment, season, nutrient management, harvesting stage, time, and various cultural practices, etc. Many researchers tend to focus their studies on a single causative factor for controlling spongy tissue, rather than exploring the various contributing factors comprehensively. However, despite these individual efforts, achieving a complete reduction in the incidence of spongy tissue disorder has proven elusive. Therefore, the consideration of all these factors collectively offers the potential for better control and management of spongy tissue incidence. Integrating irrigation management, nutrient application, and mulching aligns with sustainable agricultural practices, as it promotes efficient resource use, reduces waste, and maintains soil health. The combination of strategies encourages ongoing research and knowledge sharing within the mango industry, fostering continuous improvement in spongy tissue control methods.

Materials and Methods
The present investigation was undertaken at the mango orchard 'Centre of Excellence for Mango', College of Horticulture, Dr. BSKKV, Dapoli, during the year 2022-23 in Randomized Block Design (RBD) and data was analysed as per the Panse and Sukhatme

(1985) [8], 20-year-old rejuvenated mango plants selected for research trial with spacing (10x10 m) in lateritic soil condition, with the aim to lowering the incidence of spongy tissue and improving the quality of Alphonso mango. There were six treatments i.e. T_1-Foliar application of KNO3-1% at pea, marble and egg stage + Bagging with newspaper bags at marble stage, T_2- T_1 + spreading of 20 cm thick dry grass mulch at pea stage, T_3- T_1+ Irrigation @150 lit. At 15 days interval starting from pea stage to one month before harvesting, T_4-Foliar application of combination of (n-ATCA and folic acid) spraying at 50% flowering (1 ml/lit), pea stage (1.5 ml/lit), egg stage (1.5 ml/lit), and 75 days after fruit set (2 ml/lit) + Bagging with newspaper bags at marble stage, T_5-Foliar application Amrashakti (2.5%) at vegetative stage, 50% flowering and egg size fruit + Bagging with newspaper bags at marble stage, T_6- Control and four replications having two mango trees in each replication. One plant required minimum of 10 litres of water for the foliar application of chemicals, and spraying was done in the morning time. Potassium nitrate 1%, Amrashakti 2.5% and combination of (n-ATCA 10% and folic acid 0.2%) and cultural practices such as mulching with dry grass mulch was done at pea stage of fruit, bagging with newspaper bags (20 x 25 cm) was done at marble stage of fruit and irrigation application was done in accordance with the treatment plan.

Fruits of trees were separately harvested by (Nutan Zela developed by Dr. BSKKV, Dapoli) without any damage of fruits in the morning hours dated 5th, 9th, 12th, 17th, and 25th May and harvested fruits were transported from the orchard to the Fruit Science laboratory without any type of physical damage. In the laboratory one hundred fruits of each treatment, (25) fruit of each replication there were (04) replications and separately packed in newspaper and then stored in the laboratory of Fruit Science at ambient temperature and chemical analysis of ripe mango pulp as per the methods described by Ranganna (1997) [10].

Incidence of spongy tissue (%)

Spongy tissue incidence could be check at two stages of harvesting of fruits such as 85% fruit maturity and tree ripe stage, to take (100) ripe fruits of each treatment, (25) fruits of each replication and there were (04) replications that had bagged fruit and cut it into two halves on both sides, the occurrence of spongy tissue symptoms was noted.

The incidence of spongy tissue was calculated by using following formula and expressed as a percentage.

$$\text{Incidence of spongy of spongy tissue} = \frac{\text{Number of fruits exhibiting a symptom}}{\text{Total number of fruits examined}} \times 100$$

Results and Discussion

Spongy tissue incidence (%)

The results regarding to incidence of spongy tissue was presented in Table 1, visualised in Fig.1 and shown in plate 1. The presented results clearly indicated that there was significant difference observed in spongy tissue incidence when mangoes harvested at the tree ripe stage and 85% fruit maturity stage. The highest incidence of spongy tissue was recorded in where the fruits harvest at tree ripe stage as compared to those harvested at 85% fruit maturity stage. The mean values for spongy tissue incidence were (13.50%) at the tree ripe stage and (10.75%) at the 85% fruit maturity stage.

The lowest incidence of spongy tissue (3.61% and 8.05%) was observed in treatment T_2 - (T_1+ spreading of 20 cm thick dry grass mulch at peanut stage of fruit) at 85% maturity and the tree ripe stage respectively, which was (86.88% and 71.52%) less than over the control respectively. The highest spongy tissue incidence (27.50% and 28.26%) was recorded in treatment T_6 - (Control) at 85% maturity and the tree ripe stage of mango fruit respectively. The lowest incidence of spongy tissue (8.05%) was observed in treatment T_2 at the tree ripe stage which was at par with treatment T_4 (8.05%).

The study highlights that harvesting time is a crucial factor influencing spongy tissue incidence. Later harvesting is associated with higher levels of spongy tissue. Fruits harvested at 85% maturity exhibited lower spongy tissue incidence compared to those harvested at the tree ripe stage The lowest spongy tissue incidence was observed in treatment T_2 at both stages (harvesting at 85% fruit maturity and tree ripe stage). This result could be attributed to the combined impact of bagging, mulching, and foliar application of 1% KNO_3. The reduction in spongy tissue incidence can be attributed to multiple factors. Fruit bags shield the fruit from direct sunlight exposure. Mulching reduces soil temperature, thus minimizing the reflective heat from the soil which can lead to spongy tissue formation in mango fruit. Additionally, potassium nitrate contains two essential macronutrients: nitrogen and potassium. The potassium content strengthens cell walls in the fruit, reducing cell damage and preventing water movement from the pulp to the mango seed. This, in turn, reduces the incidence of spongy tissue and pre-mature germination of the mango seed. Similar results were found by Gunjate *et al*. (1979) [3], Burondkar *et al*. (2002) [2] and Haldankar *et al*. (2015) [4] and also Kireeti *et al.* (2016) [7].

Table 1: Effect of various management practices on the incidence of spongy tissue in per cent of mango fruits cv. Alphonso

Treatments	Incidence of spongy tissue (%)	
	At 85% fruit maturity stage	At tree ripe stage
T_1	5.67	9.40
T_2	3.61	8.05
T_3	7.71	13.45
T_4	7.50	8.13
T_5	12.50	13.75
T_6	27.50	28.26
Mean	10.75	13.50
S.Em±	0.33	0.32
CD at 5%	1.00	0.96

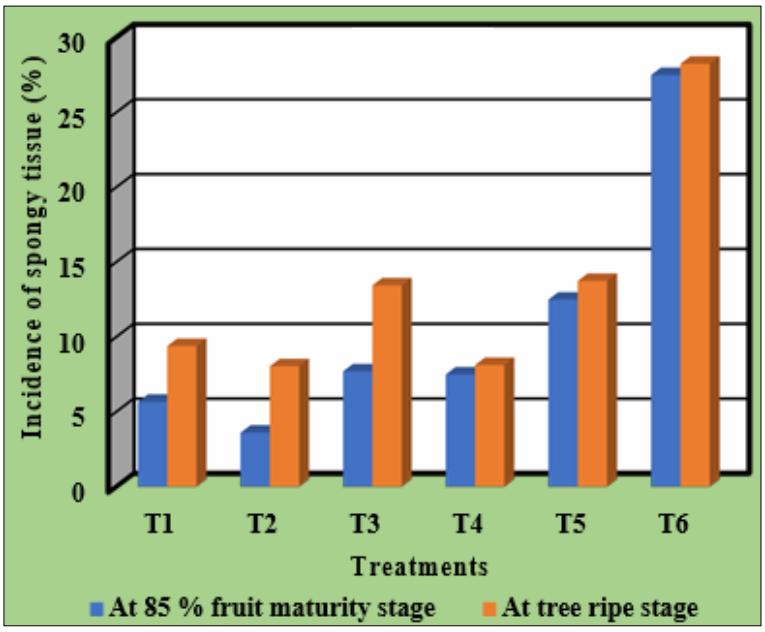

Fig 1: Effect of various management practices on the incidence of spongy tissue in per cent of mango fruits cv. Alphonso

Chemical composition

Effect of various management practices *viz.* foliar application of nutrients, plant growth regulators, mulching, irrigation and bagging on chemical composition of ripe mango fruit pulp was presented in Table 2.

The total soluble solids (TSS) did not show a significant difference. However, the highest TSS (19.25 0Brix) was observed in treatment T_5 (Foliar application of Amrashakti (2.5%) at the vegetative stage, flowering stage, and egg-size fruit, along with bagging using newspaper bags at marble stage) whereas the lowest TSS (18.00 °Brix) was recorded in treatment T_3 and T_6 (control). The lack of a significant difference in TSS between the treatments and the control may be attributed to the fact that TSS was measured at a similar fruit ripening stage, and Alphonso mango typically falls within the same range of TSS at full ripening stage while reducing sugar and total sugars was found significant difference among all the treatments. Treatment T_5 recorded the highest reducing and total sugars content (3.86% and 13.38%) respectively and it was at par with treatments T_1 and T_4, both showing (3.81% and 13.21%) reducing and total sugars content respectively, (56.36 mg/100 g) ascorbic acid content, the titratable acidity and pH found non-significant with a mean range of (0.41% and 4.23) respectively the highest ripe fruit pulp pH (4.47) was observed in treatment T_2 while the lowest fruit pH (3.40) was recorded in treatment T_6 (Control). The significant difference in reducing sugar total sugars and ascorbic acid content between the treatments could be attributed to the combined effect of bagging and foliar application of Amrashakti. Bagging enhances both the chemical and physical quality of the fruit by creating a microclimate inside the bag that promotes fruit growth and development. Amrashakti a multi-nutrient chemical, facilitates the conversion of complex polysaccharides into simple sugars by promoting the translocation of sugars from the leaves to the developing fruit. Similar results were reported by several studies Islam *et al.* (2019) [5], Jadhav *et al.* (2019) [6], Anugya *et al.* (2020) [1].

Table 2: Effect of various management practices on chemical composition of mango fruits cv. Alphonso

Treatments	Total soluble solids (°Brix)	Reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg/100 g)	Titratable acidity (%)	pH
T_1	19.00	3.81	13.21	55.63	0.40	4.36
T_2	18.25	3.09	12.32	42.36	0.45	4.47
T_3	18.00	3.05	12.15	41.51	0.46	4.41
T_4	19.00	3.81	13.21	55.63	0.38	4.35
T_5	19.25	3.86	13.38	56.36	0.35	4.41
T_6	18.00	3.05	12.15	41.51	0.43	3.40
Mean	18.58	3.44	12.74	48.83	0.41	4.23
S.Em±	0.37	0.01	0.20	0.29	0.03	0.39
CD at 5%	NS	0.05	0.61	0.89	NS	NS

Plate 1: Spongy tissue incidence of different treatments at ripe stage of mango

Conclusion

The current study concluded that harvesting stage of fruits and temperature had key factor on influenced of incidence of spongy tissue, the study suggested that mango fruits could be harvest at 85% of fruit maturity which observed less spongy tissue incidence as compared to those harvested at tree ripe stage. However, treatment T_2 displayed notable effectiveness in reducing the incidence of spongy tissue in mangoes harvested at both 85% of fruit maturity and the tree ripe stage. Treatment T_2's performance was at par with treatments T_4 were fruit harvested at tree ripe stage in addressing spongy tissue. Moreover, the treatment T_5 shown the better result increase in chemical composition of Alphonso mango fruit such as TSS, total sugars, reducing sugar, ascorbic acid and lowest titratable acidity which was at par with treatment T_1 and T_4.

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