Cranfield UNIVERSITY

Visit Report to India for Indian Horticultural Export Project.

7th - 21st September 1996

A.K. Thompson
Silsoe College, Cranfield University.

S.J. Taylor
Natural Resources Institute, University of Greenwich

Project C0894

R6641 -

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Distribution List:

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3. A. Gray (Natural Resources Institute)
4. M. Wilson (ODA)
5. J. S. Raju (APEDA)

SUMMARY

A two week visit was made to India with the following objectives:-

- to identify and prioritise fresh fruits and vegetables which have a potential for export development which is being restricted by technical factors in order to select crops on which the project should concentrate
- to secure collaboration for the project from APEDA, researchers and those involved commercially in the export marketing chain of fresh fruits and vegetables
- to identify a person who will work with the project for three years who could register for PhD degree on fruits and vegetables exports
- to gather technical and economic information and data on exports of fresh produce

Meetings were held with those involved in the various aspects of the fruit and vegetable export trade, from farm to port, and mangoes and speciality bananas were identified as the crops on which the project should be based. Collaborators were identified for mangoes from Konkan Krisshi Vidyapeeth, Dapoli, Maharashtra and the Association of Fruit and Vegetable Growers' Co-op Society of Andhra Pradesh. Both of which strongly indicated there keenness to co-operate.

It was recommended that the former was a suitable organisation to collaborate with on export of Alphonso mangoes, especially to investigate the physiological disorder of Spongy Tissue which was said to be a major limiting factor in export development. It was recommended that a member of staff or a recent MSc graduate should carry out a PhD research programme on this subject funded by the project and jointly supervised by project staff. Consideration needs to be given on how this could be financed since it was not part of the original project proposal. Research into Stone Weevil control was recommended by APEDA, but since this is essentially a preharvest problem it may be inappropriate for inclusion within the current project.

The latter organisation was not strictly within the target area but it is the main area for the production of export quality of mangoes by small farmers and on every other count it ideally suited the aims of the programme. APEDA agreed to select a suitable candidate for a PhD working through this organisation and let the project staff in UK know within about a month.

Considerable information was gathered on technical and economic aspects of fruit production and export from India which will be used for reports and evaluation.

Little specific work was carried out on bananas but the report identifies a research programme designed to address the factors limiting sea-freight export. A visit by a member of the team to India in January 1997 is planned to finalise the mango experiments to be set up in April. At the same time air-freighted exports of speciality bananas will be initiated to be used in simulated sea-freight trial in the UK.

ACKNOWLEDGEMENTS

We would like to thank Mr Raju and his staff of APEDA, in particular Mr Rawat, Mr Viswanathan, Mr Gautam and Mr Sharma, for their enthusiasm and the complete arrangements made during the teams visit. In addition we would like to extend our thanks to the staff at Konkan Krishi Vidyapith for their hospitality.

INTRODUCTION

1. This report presents the findings and recommendations arising from a two week visit to India, September 1995, as part of the Indian Horticultural Export Project (C0894). The visit followed on from an earlier trip by Dr Taylor (July, 1996) who had previously visited the Head Office (New Delhi) of the Agricultural and Processed Food Products Export Development Authority (APEDA), the key collaborator and co-ordinator of the project in India, to discuss the objectives and planned activities for the afore mentioned project. At the same time, APEDA's advice was sort in establishing the selection criteria on which the commodities for research would be identified . A priority ranking for a small number of fruit crops (mango followed by banana and possibly papaya) believed to have export potential for the European market was provided. Technical constraints to their development were discussed.

2. A desk study undertaken at Natural Resources Institute to identify Indian horticultural products with UK or European market potential identified mango, and in particular the Alphonso variety as having the greatest export potential, particularly if a protocol for their shipment by sea could be developed. A number of other commodities viz., melon and pomegranate were also mentioned as having some potential, but this was felt to be limited.

3. The objectives of the present visit were:

- to gather technical and economic information and data on exports of fresh produce (and in particular those commodities identified by APEDA and from the UK market survey) from Karnatika and Maharashtra states
- to identify and prioritise fresh fruits and vegetables which have a potential for export development which is being restricted by technical factors
- select crops on which the project should concentrate (this to be done in conjunction with a market survey in the UK)
- secure collaboration for the project from APEDA, researchers and those involved commercially in the export marketing chain of fresh fruits and vegetables
- identify a member of staff of an Indian agricultural university who could work on the project for three years and register for a PhD degree on fruits and vegetables exports

4. The visit was undertaken by Professor A.K. Thompson (Cranfield University) and Dr S Taylor (Natural Resources Institute) and co-ordinated by APEDA. Through APEDA, visits were made to research institutes/universities in Maharashtra and Andhra Predesh. Production areas in both states were visited and interviews were held with key personnel in the export chain, from farmer through to exporters. A

series of meetings were also held with clearing and forwarding agents, shipping lines and the container port authorities to study the logistics of sea transport and identify any constraints.

5. An itinerary of the visit and a list of the organisations and people met are provided in Appendices A and B, respectively.

VISITS

ODA Delhi. Mike Wilson, Senior Agricultural Adviser.

6. A short meeting was held with Mr Wilson who was appraised of the objectives and progress of the project. He described the current ODA work in the agricultural field in India. There were no programmes currently funded by ODA which impinged on this project. It is, however, likely that in the future ODA will provide technical assistance on crop production which would include relevant horticultural crops. This may interface with the project in that it could have a positive effect on the production of certain crops some of which would be suitable for export. It is therefore important to keep the ODA staff in Delhi informed of the progress of the project.

APEDA, Delhi. Mr Raju, Director

7. Mr Raju, Director of APEDA, expressed considerable support for the project. He commented that the project was very much in line with APEDA's mandate to develop Indian horticultural commodities and promote their exports with a view to maximising foreign exchange earnings and providing better income to farmers.

8. Mr Raju was of the opinion that the project should not be piecemeal but should concentrate on developing technologies for one or two crops. This approach has been adopted by APEDA who have concentrated their efforts in recent years on the development of the grape export industry in Maharashtra.

9. A number of other crops (mangoes, bananas, papaya, lychee) have been identified by APEDA as having potential for export, overwhelmingly, mangoes were considered to be the first priority. (This is very much in line with the findings of the UK/Europe market study.) India harvests 9.45 million tonnes a year of which only 3000 tonnes are exported to Europe. Alphonso, the chief variety exported to UK, is primarily grown in the Konkan region of Maharashtra. It currently achieves a premium price on the market, largely because of its quality but also to cover the high cost of air freight from India. The shipment of mangoes by sea was seen as a means of reducing price and developing sales. APEDA described a number of attempts by exporters to do so with varying degrees of success. The development of a protocol defining maturity at harvest through to conditions for sea freight (controlled atmosphere vs refrigerated) was felt to be key to the development of the mango export industry.

10. Copies of an exporters guide to grape export had been developed by APEDA. A similar guide for mangoes was considered to be a prerequisite for the development of the mango export industry. The guide could be based on the research done on the

project. From subsequent discussions with exporters it was clear that there is a need for such a guide now, and it was hoped by them and APEDA that the mango guide would not take as long to produce as the grape guide, some six years.

11. A key objective of the visit was to identify a suitable PhD student who would undertake a programme based on the research lines defined during the present visit. On the basis of Mr Raju's recommendations visits were made to research stations and universities in Maharashtra and Andhra Predesh that are active in postharvest technology. It was agreed that the cv's for a number of candidates would be submitted to APEDA for selection.

12. Agreement needs to be sought from ODA to include Andhra Predesh within the project area. The justification for its inclusion was on the recommendation of APEDA that this is the principle mango growing area and the quality of fruit renders it the area with the greatest potential for export. There was also a keenness among the small farmers in that state to collaborate with the project.

Indian Agricultural Research Institute, Delhi. Dr Susanta Roy (All India Co-ordinated Research programme on Postharvest Technology of Horticultural Crops)

13. A meeting was held with Dr Susanta Roy, Head of the Post-Harvest Unit and co-ordinator of India's research programme on post-harvest technology for horticultural crops. The post-harvest unit appeared to be actively carrying out research, including controlled atmosphere storage of mangoes, and had a good record of publications. They expressed a willingness and keenness to co-operate with the project. The possibility of providing a candidate to undertake the split PhD was discussed and Dr Roy identified a Mrs Nita Sen, a research fellow at the institute. The final decision is to be made in conjunction with APEDA.

14. IARI would be well placed to collaborate with the project in terms of facilities; the unit was well equipped with gas and high performance liquid chromatography, a colour difference meter, an Instron universal tester modified atmosphere packing equipment, 6 controlled temperature rooms, 4 controlled atmosphere storage lines and general laboratory instruments. There was also a food processing group with pilot plant equipment. However, IARI's locality in relation to the mango production areas pose a serious disadvantage to an effective collaboration. They have recently taken delivery of vapour heat treatment equipment supplied under Japanese technical co-operation arrangements. They will be using it for experiments on fruit fly control for fruit to be exported to Japan. If the experiments prove successful they will need to purchase the complete equipment costing some £2 million.

National Horticultural Board, Delhi. Dr R K Sharma

15. The Board, part of the Ministry of Agriculture, has a national co-ordinating role in research and development for the industry. They also collect and disseminate statistics. Many of these were relevant to the project and copies were provided.

In 1988 they established a Market Information Network called NHBNET which provides information (daily and monthly bulletins) to producers on market trends/prices for a number of fruits and vegetables in the major cities in India.

Exporters, Bombay

16. There was considerable interest in the development of exports of mangoes. The technical problems faced in developing these exports were considered substantial and it was strongly recommended that the project should concentrate solely on this crop, at least initially, and then move onto others. Alphonso mango had a good reputation on the local market and commands a premium price, but there is a lot of new planting so suitable quantities for export development should be available. It was pointed out that the development of the grape export industry had taken some 6½ years and it was hoped that mangoes would take considerably less.

17. Costs of leasing a 40 foot reefer containers has recently risen from $3,500 in 1995 to $5,950 + 8 % which is approximately $6,500 in 1996. There were also problems of delays in shipping containers out of the port which have been as much as 10 days for grapes. Exporters, however, agreed that the port authorities have been very accommodating for the mango shipments. The delays are particularly difficult since it prevents them planning deliveries ahead with importers.

18. For grapes fruit quality was cited as a problem and it was stated that an exportable portion of only some 10 % was common. The small farmers that the exporters dealt with were said to be very receptive to new ideas, but are very concerned not to be "taken for a ride".

Port Operations Centre, Jawaharlal Nehru Port Trust, New Bombay.
Mr A K Sen

19. A site visit was made to the recently developed container terminal at the Jawaharlal Nehru Port Trust (JNPT) in New Bombay.

20. Fresh produce for export usually arrives at the port already in reefer containers. There are two reefer container parks at the port, one with 156 plug points and the other with 64. The shipping lines employ workers who stay at the park and constantly monitor the containers' temperatures. At certain times of the year (March-May) the container plug points are insufficient and perhaps two containers will be parked at each point and the workers will constantly swap over the containers to ensure their temperatures are maintained. There is a planned expansion of the port and another park is scheduled to be completed within two years which will have a further 240 plugs. The port has a back-up generator which switches on automatically if the main supply is interrupted.

21. There were two charges that the POC made for containers. One was a single handling charge (2500 rupees) and the other was a daily charge (800 rupees) for the use of the plug. If containers remained for longer than 15 days there was an additional charge levied on a daily basis for the space occupied. The normal throughput of reefers was about 60% 40 foot and 40% 20 foot.

22. Containers can be stuffed in the port area. The Container Freight Station has facilities for receiving produce delivered from lorries for loading into the containers.

23. The POC authorities were very sympathetic to the special problems of transporting highly perishable fresh fruit and had introduced a green channel. Normally the port requires containers to be delivered to the port two or three days prior to the boats scheduled departure. However, for containers which contained highly perishable fresh fruit they were able to accept these the same day as the ship departed.. This was subsequently confirmed in discussions with some of the shipping line representatives. There may be problems with this in the future if very large numbers of containers are involved, but if the number does not exceed 10 containers, no problems were foreseen.

Shipping line representatives, Bombay

24. Under the auspices of APEDA a meeting was held with representatives of the major shipping lines in Bombay handling fresh horticultural produce. The logistics of sea transport and some of the problems faced by the shipping lines were discussed. It was reported that shipping times from Bombay to Felixstowe in UK varies from as little as 17 days for the fastest service through the Red Sea (CMB Transport Agencies India Pvt. Ltd.). The shipping lines, however, reported mixed results in the sea freight of mangoes to Europe: two 20 foot reefers containing mangoes (Alphonso) from Nasik arrived in the UK in a satisfactory condition, however there had been some problems with the shipment of three 40 foot CA containers holding Chausa mangoes from Lucknow. All the companies interviewed indicated a clear need for research in this area and were willing to collaborate in any future shipping trials.

> [Supplies of both 20 and 30 foot reefers were readily available. It was indicated that for mangoes it takes some 48 hours for harvesting, treatment, precooling, stuffing and transport to the port. Importers in UK require at least 4 days shelf life on arrival. this gives a total postharvest life requirement of at least 23 days.]

Forwarding agents, Bombay

25. There was strong support that the project should include sea-freight export development of speciality bananas. There are major supplies of this crop within 200 km of Bombay. It is a popular crop with small farmers since it provides them with a regular income and helps their cash flow. this is because unlike grapes or mangoes it can be harvested all the year round.

26. Costs of renting the Transfresh controlled atmosphere storage unit which converts a reefer container costs $1,850.

Konkan Krisshi Vidyapeeth, Dapoli, Maharashtra, Dr R B Dumbre

27. This is an Agricultural University which awards BSc, MSc and from 1995 a part taught, part research PhD degree. They also have a farm of some 600 hectares growing mainly mangoes and cashew. Research areas cover postharvest technology, fruit processing, propagation (they have pioneered and trained some 6,000 farmers, housewives etc. in a simple method of grafting), irrigation (mainly trickle), plant breeding and cultivation practices. The general impression given was one of an active innovative organisation.

28. The rainfall in the area is very high, but distributed over a three to four month period from June to September. Work had been carried out on mango harvesting using a "nipper" which cut the stalks to the appropriate length and thus avoided latex staining. They had also developed a maturity grading system based on the specific gravity of mangoes. They have found that fruit with a specific gravity of between 1.00 and 1.02 are suitable for export marketing. To achieve this in a packhouse fruit are placed in water and those that sink are removed and placed in a 2.5% salt solution. Those that sink in this solution are of the correct maturity for export. They had also developed a precooling system by placing the fruits in iced water for 6 hours after harvest.

29. Postharvest problems with mangoes were identified as follows:-

1. Internal spongy tissue which occurs almost exclusively on the variety Alphonso. This cannot be detected on the intact fruit, but it can reach levels as high as some 30 % affected. No cause has yet been identified, inspite of considerable research, and it is thought to be related to both preharvest and postharvest factors including harvest maturity and postharvest temperature. They considered this to be the most important problem in developing the export of Alphonso. They were very keen to develop a collaborative project on this one topic and it is appropriate to seek funding for a joint PhD programme. A literature review on internal spongy tissue was provided and is enclosed in Appendix 2.
2. Both anthracnose disease and stem end rot are major problems. With careful preharvest fungicidal sprays both these diseases could be controlled. It was also mentioned that postharvest fungicidal treatment (500 ppm Bavistan) can control anthracnose.
3. The problems of fruit damaged because of inappropriate postharvest handling was discussed and it was felt that these could be overcome with the use of plastic containers rather than traditional woven baskets.

Godrej Agrovet Ltd. Nashik, Dr K D Deshmukh, Marketing Manager.

30. The fresh fruit export is a minor part of a large company which has disparate interests. They started grape export to UK and Holland four years ago and, inspite of losses in the current years trading, they will continue and are interested in expanding into the export of other fruit. The packhouse was well designed, hygienic and had been approved by UK importers. They are not grape producers but by from some 400 small farmers. Their own workers harvest the fruit taking only bunches of the required

quality. This is commonly about 10 % of the crop but can be as high as 50 % with some efficient growers. They provide technical assistance to many of the farmers to ensure good agricultural practices and that the growers only use permitted pesticides and that they are applied at the appropriate level and the correct time. The fruit not bought by the exporters is harvested by the farmers and marketed locally. There is a good local market for grapes but the farmers receive approximately half the price paid by the exporters. There is competition between exporters and the system seems to be of benefit to small farmers.

31. Harvesting begins at about 06.00 and the first fruit will arrive at the packhouse some 3 hours later. The workers take plastic crates which will hold some 5 kg of fruit to the field and carefully harvest the bunches into these. On arrival at the packhouse the boxes are taken directly into the air conditioned packhouse where they are hand graded and trimmed on conveyor belts and packed into fibreboard coated cartons. The boxes contain a plastic bubble sheet at the bottom, above which is a polyethylene bag. Each bunch is first placed in its own bag and these are place in the larger bag in the box. A sulphur dioxide pad is placed above the grapes and the polyethylene bag is closed.

32. Boxes are taken to a forced air precooler until the berry temperature has fallen to 1 °C. This takes about 4 hours. Boxes are then taken to an adjacent cold room rum at close to 0 °C and the boxes are palletised. The reefer container pulls up to a door close to the cold room and the pallets are loaded using a hand pallet truck. This operation takes about ½ hour to load about 14 tonnes into the containers. The containers are then taken to the port and loaded the same day onto ships bound for Europe.

Oceanic Imports and Exports Corporation, Nashik. Mr Atul Sharma.

33. The operations for grape exports were similar to those described above. Interest by the company in growing and exporting green beans by air-freight to UK was expressed, but so far they had not been able to grow beans of a suitable quality.

Andhra Pradesh Agricultural University, Hyderabad, Andhra Pradesh. Professor M V Rao, Vice Chancellor

34. Discussions on collaboration between APAU and the project resulted in a large degree of empathy and a desire to collaborate in what the Vice Chancellor described as a very important but neglected area of research. He indicated his keenness to nominate one of the members of his Postharvest Technology Department or someone who had recently completed their MSc degree for the PhD degree funded by the project. However, before doing so he required a Memorandum of Understanding. This was because he required permission from the State Government to enter into such an agreement. Confirmation was required on whether the project can collaborate in Andhra Pradesh state since it was not included in the original ODA Country Framework Document. Unfortunately there were some student problems on campus which meant that it was not possible to see the facilities there and meet the relevant staff.

Association of Fruit and Vegetable Growers' Co-op Society of Andhra Pradesh. Mr K Prasada Rao, Executive Director.

35. The society represents some 300 small holder fruit and vegetable producers (each growing between about 1 and 5 hectares of mangoes) who are keen to get into the fruit, especially mango, export industry. The co-op had tried exporting mangoes by sea-freight with variable success. They were very keen to develop the industry on a large scale and were very keen to co-operate, even to the extent of supplying and office and secretarial facilities in Vijaya. They will be able to air-freight to UK different mango varieties at various harvest maturities in order that controlled atmosphere storage experiments are carried out. Contact with the Transfresh Corporation of USA had been made and they had indicated their willingness to co-operate with them on actual trial controlled atmosphere sea-freight shipments in the next mango season. Fruit of Banganapalli and Totapari were available for all this experimental work and suitable fruit of the former should be available from the second week in April until the end of May and for the latter from early May until mid June.

Mango farms in Andhra Pradesh State

36. Two farms were visited where a number of varieties were being grown. Trees at the farms varied in age between about three years up to 10 years old. Banganpalie was the main variety produced, as it commanded a premium price on local markets, followed by Totopuri which was a late yielding variety. Other varieties were produced only in small quantities. Cultural practices appeared good with copious use of poultry manure on one farm. Pest and disease control was based on advice provided by the State Extension Services and appears to consist of Some twice a year application of a fungicide and an insecticide. The farmers appeared satisfied that this gave good control. It was reported that there was considerable amounts of new mango orchard establishment in the area and that it was an economic viable crop for small farmers to produce for the local market. One farmer was inter-cropping with guava and using drip irrigation. One farm had a packhouse, they were growing grapes for drying into raisons and the packhouse was used for these. For the mangoes for the local market they were harvested into baskets, taken to the side of the field. They were then graded on the ground in terms of size and surface defects on the fruit and sold to middle men who visited the farms. These were transported stacked in the back of pick-up trucks without any packaging or protection, to the local market.

Principal Secretary of Agriculture, Government of Andhra Pradesh, Mr V Anandarau

37. A courtesy call was made to inform the PSA of the purpose of the project. He expressed his support and offered to help in any way he could. He also expressed the importance that he and his Minister considered the postharvest aspects of the development of mango exports were to farmers on Andhra Pradesh State.

Fruit exporters from Andhra Pradesh

38. Although three people attended the meeting only one (Mr N Sriranga Reddy) was actually involved in export. His companies experience was mainly involved with grapes but they had exported mangoes by air freight to the Far East and to Switzerland, generally with economic success. These had been only small quantities and the company was keen to develop the mango export business by sea freight.

APEDA, Hyderabad

39. There is no office of APEDA in Hyderabad and the area of Andhra Pradesh is cover by the office in Bangalore under the direction of Mr T A Viswanathan. Mr Viswanathan accompanied the project team during the visit to Andhra Pradesh and indicted that he would provide all the help possible for the project.

Directorate of Horticulture, Government of Andhra Pradesh.
Mr Ar Sukumar, Director.

40. Support for the project was expressed by the Director and staff. It was even indicted that they would be prepared to supply a suitably qualified member of their staff to take the PhD studentship post on the project and that such a person could be made immediately available. The Directorate of Horticulture' is responsible for issuing phytosanitary certificates to fruit exported from the State and would therefore be in a good position to ensure that the quality of fruit exported would meet the protocol and standards developed within the project.

Department of Marketing, Government of Andhra Pradesh.
Mr Vijay Mohan Lal, Additional Director.

41. The Department of Marketing had worked closely with exporters especially with the Association of Fruit and Vegetable Growers' Co-op Society of Andhra Pradesh. They had produced a lot of promotional material and developed a band "Sungold" for the local Banganapalli mango (which is also locally called Benisham). The literature was very professionally produced. Support for the project was expressed. The Department of Marketing co-ordinates the fresh fruit export activities in the state.

PhD Studentship

42. The position for the PhD student on the project was discussed at length at almost all the meeting during the visit. At the Indian Agricultural Research Institute in Delhi considerable help was given and the team were introduced to a member of staff (Mrs Sen) who was interested in the post and appeared well qualified and highly suitable. The only reservations were that since she was fairly newly married and her husband was working at the IARI in Delhi the time that she would have to spend in the UK and South India would make it difficult for her.

43. Mr P Naganand, the Additional Director of the Directorate of Horticulture of the Government of Andhra Pradesh also expressed interest in the post.

44. The Vice Chancellor of the Andhra Pradesh Agricultural University in Hyderabad agreed that he would nominate a member or recent graduate from his University for the post. This would also have the advantage that the University facilities and staff would also be brought into the project. The Vice Chancellor required a Memorandum of Understanding before he could proceed.

45. The Director of research of Konkan Krisshi Vidyapeeth in Dapoli, Maharashtra were prepared to collaborate in the project but they were keener to work on the "Spongy Tissue" disorder of Alphonso mangoes. He claimed that this was the only important factor which was limiting the development of the export industry of Alphonso mangoes.

APEDA, Bombay. Mr R P Gautam

46. The handling system for export of mangoes was described as follows:-

1. Fruit harvested in boxes and carried to a packhouse
2. Fruit dipped in benomyl fungicide
3. Fruit waxed
4. Fruit precooled in a forced air cooler taking some 6 hours to reduce their temperature to 13 °C
5. Fruit stored in a cold room at the same temperature
6. Cold store had a direct connection so that a reefer container could be reversed to the door.
7. The container was precooled and the fruit transferred so that the cold chain remained unbroken
8. The trucks which was used for have integrated diesel generators so that the refrigeration can be applied during transport to the docks.
9. On arrival at the docks the reefers were connected to the electricity supply at the docks to await loading on the ship

ACTION POINTS

47. The following points and those included in the wrap up meetings require action:-

1. Determine whether it will be possible to incorporate research into the spongy tissue problem of Alphonso within the project.
2. Consider recommending a revision of the budget allocation to include the PhD studentship for Konkan Krisshi Vidyapeeth in Dapoli to work on spongy tissue and possibly stone weevil of mangoes. A provisional estimate of costs was given as £3,000 to cover fees and materials for the three years. Supervisory visits could be incorporated within the currently planned visits.
3. Agree that the first priority should be to research into the various varieties of mango with speciality bananas as a second crop.

4. Set up experiments on the development of Spongy Tissue with Konkan Krisshi Vidyapeeth in Dapoli. This should be in the form of a PhD student registered locally with supervisory inputs from the project team. From reading the literature review it would seem a reasonable hypothesis that CO_2 metabolism or toxicity might be involved.. This appears not to have been previously investigated and would make a good starting point for a PhD, with, if verified, an investigation of preharvest and postharvest factors which could be manipulated to control it. Another aspect which could be considered if the hypothesis proved invalid would be to investigate non-destructive methods of assessment of the presence of Spongy Tissue.
5. Plan the experiments with Banganapalli mango fruit. These could be as follows:
    - Harvest fruit at different maturities based on such factors as shoulder formation, peel colour, specific gravity and total soluble solids content.
    - Transport samples of these to UK by air-freight at fortnightly intervals, starting mid April, for simulated sea shipment trials to be carried out. These will investigate different levels of O_2 and CO_2 and how these interact with temperature (probably 10 °C and 13 °C) over a 3 to 4 week simulated transport period. Fruit will be removed from controlled atmosphere storage and kept at 20 °C for 5 days to simulate marketing. An air control will be included. Physical, chemical and sensory characteristics of the fruit will be measured, before, and after controlled atmosphere storage and after the shelf life studies.
    - Carry out trials on postharvest hot water treatment of fruit and store them at 13 °C for 3 to 4 weeks to simulate sea freight shipment. The fruit quality to be assessed directly after storage and after and 5 days shelf life.
    - Investigate the various methods of assessing harvest maturity on the quality of the ripe fruit.
    - With the collaboration of commercial exporters one controlled atmosphere container and one reefer container shipment will be sent to the UK. This needs to be confirmed in terms of the risks involved at this early stage of the project.
6. Design experiments to determine the optimum conditions for sea-freight export of speciality bananas. This could be as follows:
    - Investigate methods of determining harvest maturity. This should include either colour coded bunch covers or ribbons applied at the first appearance of the fruit then the assessment of number of weeks to full maturity.
    - Assess the need for postharvest fungicidal treatment to control postharvest development of crown rot
    - Devise a postharvest handling protocol to ensure that fruits are not damaged.
    - In consultation with European importers and carton manufacturers in India evaluate the most suitable packaging methods. Consideration should be given to prepriced individual clusters each in its own polyethylene bag.

- Investigate the effects of modified atmosphere packaging on the marketable life of produce.
- Study the effects of controlled atmosphere storage on the marketable life of produce.
- Investigate the ripening conditions for fruit after transport and assess the effects of harvest maturity and transport conditions on the quality of the fruit.

A visit by a member of the UK team will be made to a suitable banana producing area selected by APEDA at the beginning of January. At this time air-freight shipments of fruit will be made to UK to begin controlled atmosphere storage experiments.

7. Discuss whether there is need for further market evaluation inputs at this stage, especially whether it is necessary for a UK market economist to visit India.
8. The design for hot water treatment equipment for the mango trials was discussed with the Executive Director of the VIJAYA association of fruit and vegetable growers' co-op societies of Andre Predesh. It would be necessary to provide equipment of sufficient capacity for up to 20 tonnes each day. It was agreed that AK Thompson would provide such a design that could be made and assembled in India.

Wrap up meeting with Mr S.K. Sharma, General Manager APEDA

48. The points agreed were:-

- APEDA would find a suitable person to fulfil the PhD post with a view to the person starting their work in UK by November 1996 and based in Andhra Pradesh while in India.
- The crops to be the subject of the project should be mangoes and speciality bananas.
- The project would seek funds for a second PhD student to be registered and to work at Konkan Krisshi Vidyapeeth in Dapoli on Alphonso mangoes.
- A design for small scale mango hot water treatment equipment would be supplied to APEDA so that one could be in place for the next mango harvest season in Andhra Pradesh.
- A meeting would be arranged at Silsoe College for the Director of APEDA
- The next visit to India by a member of the project team would be January 1997 to confirm the mango work and arrange for facilities in Andhra Pradesh and visit the banana producing area of Jalgaon in Maharashtra.

49 **Wrap up meeting with Mr J.S. Raju, Director APEDA**

A meeting was held at Silsoe College on 23 September. The action points above were discussed and a draft of this report was given to Mr Raju. He was very supportive of all the points described, and the selection of mangoes and bananas were in line with his own thinking. He asked if the following points could be incorporated into the project:-

- An investigation into the seed weevil to be incorporated into the work to be done at Konkan Krisshi Vidyapeeth in Dapoli on Alphonso mangoes.

- The project should be linked with markets. It would be useful to involve representatives from the UK import sector and supermarket technologists in this work especially when the team are setting up experiments in India.
- It is important that selected farmers be exposed to the way other countries produce mangoes and bananas for export. An approach will be made to enquire whether ODA have funds to support these visits. It was considered that some 20 farmers would be involved over the three years of the project (say 7 persons each year) and visits would be made to Latin America or South Africa.
- As part of the project it was requested that the UK team should be involved with the promotion of the two products mentioned above. APEDA arranges promotions two or three times each year and Project staff could be present at these to provide support.

APPENDIX A

ITINERARY OF VISIT

8th September (Sun): Arrive in New Delhi from UK

9th September (Monday):

a.m. - Introductory meeting with Mr Raju (Director) of APEDA
- Meeting with the Joint Secretary Mr S.M. Acharya in the Ministry of Commerce (and acting Chairman of APEDA)
- Meeting with Mr Raju, Mr Sharma (General Manager) and Dr Lal (Project Manager) of APEDA to discuss itinerary.

p.m. - Visit to IARI to meet key scientists in the Floriculture and Horticultural Division and the Entomology Department (VHT facilities).

10th September (Tuesday):

a.m. - Meeting with officials of the National Horticulture Board, Ministry of Agriculture.

p.m. - Visit to ODA to brief and discuss project with Mike Wilson.
- Travel to Bombay.

11th September (Wed):

a.m. - Meeting with Mr Gautam, Deputy Director of APEDA
- Visit to JNPT port facilities at New Bombay.

p.m. - Meeting with shipping lines handling horticultural produce.

12th September (Thursday):

a.m. - Meeting with key exporters of horticultural produce at APEDA office.

p.m. - Meeting with clearing and forwarding agents at APEDA office.

13th September (Friday):

a.m./p.m. - Travel to Konkan Krishi Vidyapith, Dapoli

- Meeting with the Vice Chancellor, Konkan Agricultural University

14th September (Sat):

a.m. - Meeting with key staff at the University to discuss project and areas of collaboration.
- Visit to University farm (mango orchards/plant breeding).

p.m. - Visit to Biotechnology Department

15th September (Sun): Travel to Nasik.

16th September (Monday):

a.m. - Visit to Godrej Agrovet Ltd.,

p.m. - Visit to Oceanic Imports & Exports Corpn.,

17th September (Tuesday): Travel to Bombay

18th September (Wed): Travel to Hyderabad

a.m. - Meeting with Mr Viswanathan, APEDA (Bangalore office), Mr Prasada Rao, President, Cheemalallpadu Fruit and Vegetable Growers Co-op Society
- Visit to mango orchards

p.m - Visit to mango orchards
- Meeting with Mr M.V. Rao, Vice Chancellor, A.P. Agricultural University

19th Sept (Thur):

a.m. - Meeting with Nr Naganand, Deputy Director of Horticulture Department
- Meeting with Mr Vijay lal, Director of Marketing, Department of Marketing
- Meeting with exporters
- Meeting with Mr V. Anandarau, Prl. Secretary, Agriculture, A.P. Government

p.m. - Travel to Bombay

20th Sept (Fri):

a.m. - Final meeting with Mr Raju, Mr Sharma and staff (APEDA)

p.m. - Travel to UK

APPENDIX B

LIST OF ORGANISATIONS AND PEOPLE MET

Agricultural and Processed Food Products Export Development Authority (APEDA)

Ministry of Commerce, Dehli

Mr S.M. Acharya, Joint Secretary in the Ministry of Commerce & Acting Chairman of APEDA

Delhi Office:

Mr J.S. Raju, Director
Mr A.S. Rawat, Deputy Director
Mr S.K. Sharma, General Manager
Dr B. Lal, Project Manager (VHT)/ Division of Entomology IARI
Mr D.K. Aggarwal, Field Officer/ Division of Entomology IARI

3rd Floor
Ansal Chambers No 2
6, Bhikaji Cama Place
New Delhi-110066

Tel: 91-11-6181708/6192141
Fax: 91-11-6195016

Bombay Office:

Mr R.P. Gautam, Deputy Director
Mr V.K. Vidyarthi, Asstt Director

Unit No 3, 12th Floor
MVIRDC Centre No. 1
World Trade Centre
Cuffe parade,
Bombay-400 005

Tel: 91-22-2183106
Fax: 91-22-2189681

Bangalore Office

Mr T.A. Viswanathan, Asstt. Director

12/1/1, Palace Cross Road
Bangalore-560020

Tel: 91- -3343425
Fax: 91- - 3364560

ODA

Mr Mike Wilson,
Senior Natural Resources Adviser, Dehli Office, but contactable through:-
Overseas Development Administration,
94, Victoria Street, London SW1E 5JL, UK
Tel. 44-(0)171-917-0285 Fax 44-(0)171-917-0491
Email: nredmw.vs2@oda.gtnet.gov.uk

Exporters

Maharashtra

Mrs Sharda Prabhuchimulkar (Manager/Export)
Eurofruits Pvt. Ltd.
6&7 Neelkant Apartments, Ground Floor
Amar Mahal,
Tilak Nagar
Bombay -400 089
India
Tel: 91-22-5228775/6
Fax: 91-22-5225254

Mr Nintin Agrawal
Eurofruits Pvt Ltd
Gate no 1031 Vadner Bhairav Road
Taluka Chandwad
Nasik 423 111
Tel: 91-2553-54165/54166/54173

Dr K.D. Deshmukh
Marketing Manager
Godrej Agrovet Ltd.,
Pirojshanagar
Eastern Express Highway
Vikhroli
Mumbai-400079
Tel: 91-22-5171861
Fax: 91-22-5170861

Mr N.M. Bage
Chief Executive
Growgood Exports
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Samant Wadi
Goregaon (East)
Bombay-400063
Tel: 91-22-8732695
Fax: 91-22-8734332

Mr Atul Sharma
Oceanic Imports & Exports Corpn.
126, Kadawa Mhalungi
Taluka Dindori
Nasik
Tel: 91-2557-21117
Fax: 91-2557-21072

Andhra Pradesh

Mr K Prasada Rao
President: Cheemalapadu fruit and vegetable growers co-op society
Executive Director: VIJAYA association of fruit and vegetable growers' co-op societies of A.P.
59-7-8, Ramachandra Nagar
Vijayawada-520008
Andhra Pradesh
Tel: 91-0866-475304
Fax: 91-0866-477984

Clearing and Forwarding Agents

Mr Uday Sait & Mr Deepak Trivedi
Ace Clearing & Forwarding
29, Lalsingh Bldg.,
Lohar Street
Bombay-400 002
Tel: 91-22-2085768/ 2085371
Fax: 91-22-2051852

Mr P. James
P. James
Custom House Agents: 11/600
203, Gulab Building
237, P.D'Mello Road
Bombay-400 --1
Tel: 91-22-2623587
Fax: 91-22-2621162

Shipping Lines

Mr Harish Shetty
Container Marine Agencies Pvt. Ltd.
Suite 502, Gulab
5th Floor
237, P.D'Mello Road
Bombay-400 001
Tel: 91-22-2622004
Fax: 91-22-2612832

Mr Ravi Menon
Assistant Manager - Marketing
CMB Transport Agencies India Pvt. Ltd.
Vakils house, 3rd Floor
18, Ballard Estate
Bombay-400 038
Tel: 91-22-2665380
Fax: 91-22-2622255

Mr Laval Fernandes
Assistant Manager - Marketing
Container Movement (Bombay) Transport Pvt. Ltd.
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Fax: 91-22-2873400

Mr Kanti Chandarana
Freightaids
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Mumbai-400 001

Tel: 91-22-2623539/ 2699990/

Fax: 91-22-2692381

Mr Ronald Deane
Manager, Sales
Maersk India Limited
102 Free Press House
215 Nariman Point
Mumbai - 400021

Tel: 91-22-2875071
Fax: 91-22-2043704

Mr Girish V. Gaikwad
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Seahorse Ship Agencies Pvt. Ltd.
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Tel: 91-22-2833131, 2883611
Fax: 91-22-20221992

Mr Leslie Correa
Marketing & Pricing Executive
Sea-Land Agencies (India) Pvt. Ltd.
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Tel: 91-22-2057950
Fax: 91-22-2096498

Mr P.K. Hui
Deputy General Manager
The Shipping Corporation of India Ltd.
Shipping House
245 Madame Cama Road
Mumbai -400 021

Tel: 91-22-2022849

Mr S.P. Mohile
Chairman, Karmahom Conference
4 Shoorji Vallabhdas Marg,
Mackinnon Bldg.,
Ballard Estate
Bombay-400038

Tel: 91-22-2610527
Fax:***

Jawaharlal Nehru Port Trust

Mr A.K. Sen, Manager Container Terminal

Port Office:
Administration Building
Nhava Sheva
New Bombay 400707

Tel: 91-22-7242377
Fax: 91-22-7242868

National Horticulture Board, Ministry of Agriculture

Dr R.K. Sharma, Deputy Director
Mr Y.S. Yadav, Personnel Director

85, Institutional Area
sector-18
Gurgaon-122 001

Tel: 91-124-341225/6
Fax: 91-124-342989

Indian Agricultural Research Institute (IARI)

Dr Susanta K. Roy (Project Coordinator PHT)
Dr R.K. Pal (Post-harvest technologist)

Division of Fruit and Horticultural Technology
IARI
New Delhi 1100122

Tel: 91-11-5788429
Fax: 91-11-740722/5752006

Konkan Krishi Vidyapeeth (Konkan Agricultural University)

Dr A.G. Sawant, Vice Chancellor (Agricultural Extension)
Dr Raghunath B. Dumbre, Director of Research (Agricultural Entomology)
Dr A.S. Chavan, Dean, Faculty of Agriculture (Agricultural Chemistry and Soil Science)
Dr S.P. Birari, Associate Dean, Collegeof Agriculture (Plant Breeding)
Dr M.B. Magdiem, Head, Department of Horticulture
Dr G.D. Joshi, Associate Professor of Food Technology (Horticulture)
Dr A.D. Rangauala, Associate Professor of Horticulture (Floriculture)
Dr B.L. Dhonukshe, Professor of Biotechnology
Dr J.C. Rajput, Associate Directore of Research, Regional Fruit Research Station, Veujuxla -416516
Dr D.P. Saualee, Associate Professor of Horticulture, Central Experiment Station, Waleauah, Dapoli.

Kankan Agricultural University
Dapoli-415712
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Andhra Pradesh Agricultural University

Mr M.V. Rao
Vice-Chancellor
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Government Departments of Andhra Pradesh

Mr V. Anandarau
Prl. Secretary, Agriculture & Agricultural Production Commissioner
Plot No. 815
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Mr P. Nagananad
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Mr Vijay Mohan Lal
Additional Director of Marketing
Department of Marketing
Hyderabad 500029
Tel: 91-040-242305

APPENDIX C

SPONGY TISSUE

SUMMARIES OF PAPERS 1987 TO 1995 AND REVIEW PAPER

The literature review provided by Konkan Krishi Vidyapeeth and the following summeries give no evidence that contradicts the hypothesis that spongy tissue is due to CO_2 toxicity.

General reviews

TI: Mango research in India - new developments.
AU: Chadha,-KL
AD: Indian Council of Agricultural Research, New Delhi 110 001, India.
SO: Indian-Journal-of-Horticulture. 1989, 46: 3, 279-294; 61 ref.
AB: A review and discussion under the following headings (and sub-headings): mango improvement (new varieties and hybrids, hybrids, and selection of superior clones); production technology (propagation, rootstocks, high density planting, pruning, nutrition, irrigation, and intercropping); physiological studies (physiology of flowering, mango malformation, fruit drop, spongy tissue, control of tree vigour, and clustering in mango); disease and pest management; and harvesting and storage.

TI: An approach to integrated post-harvest handling of mango.
AU: Roy,-SK; Joshi,-GD
AD: Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi 110 012, India.
SO: Acta-Horticulturae. 1989, No. 231, 649-661; 38 ref., Second international symposium on mango, Bangalore, India, 20-24 May 1985.
AB: Alphonso mangoes were harvested when the first fruits started to fall, and were classified by specific gravity (sp.gr.) as to whether they floated in water (sp.gr. <1.00), 2.5% NaCl (sp.gr. <1.02) or 5% NaCl (sp.gr. <1.04). Of the fruits harvested at this time, 17% were immature (sp.gr. <1.00); this compares with 1-2% immature fruit following conventional commercial practice for harvesting. Fruits of sp.gr. 1.02-1.04 had the best flavour and texture. With increasing sp.gr. the fruit colour improved, but the incidence of the disorder spongy tissue also increased. Chilling injury in cold storage at 10 °C occurred only in fruits of sp.gr. <1.02. A 5-minute hot (52 °C) dip in Bavistin [carbendazim] (1000 p.p.m.) solution gave the best improvement in fruit shelf life. Fruits stored at 10ø had longer storage life, higher moisture content and acidity, and higher levels of ascorbic acid and tannins, but lower TSS, sugar and total carotenoid pigment contents than fruits ripened at room temperature. In trials comparing containers for fruit transport, the least fruit weight loss and bruising occurred using partitioned, corrugated fibreboard boxes; the most damage occurred using conventional wooden boxes with dry grass and newspaper as cushioning material.

TI: Advances in horticulture: fruit crops - Volume 4.
AU: Chadha-KL (ed.); Pareek-OP
AD: Indian Council of Agricultural Research, New Delhi 110 001, India.
SO: 1993, xxxxvii + 1661-2127; ref. at ends of chapters.
PB: Malhotra Publishing House; New Delhi; India
AB: This is the fourth volume in a series of 13 volumes on Indian horticultural research and the last of the 4 volumes in this series which are devoted to fruit crops. This volume comprises 21 chapters covering fruit maturity, fruit ripening, harvesting, handling and storage, postharvest losses, irradiation, processing, making preserves and pickles, dehydration, wine making, utilization of fruit wastes, innovations in postharvest technology, biennial bearing in mango, mango malformation, mango disorders (spongy tissue, black-tip and internal necrosis), granulation in Citrus, guava wilt, ecophysiological disorders in grape, and fruit cracking. Volume 4 has its own subject and author indexes.

Causes of Spongy Tissue and its control

TI: Pattern of distribution of spongy tissue in the affected Alphonso fruits at different locations.
AU: Katrodia,-JS; Rane,-DA
AD: Department of Horticulture, N.M. College of Agriculture, Navsari 396 450, India.
SO: Acta-Horticulturae. 1989, No. 231, 873-877; 6 ref., Second international symposium on mango, Bangalore, India, 20-24 May, 1985.
AB: Spongy tissue, which occurred in 19% of mangoes at harvest, was localized predominantly at the distal end of the fruit, whereas postharvest exposure of fruits to the sun around midday resulted in the greatest occurrence of spongy tissue in the middle part of the fruit. This localization, sometimes on one side of the fruit only, points to convected heat as being the cause of spongy tissue disorder.

TI: Spongy tissue in mango - causes and control measures.
AU: Katrodia,-JS
AD: N.M. College of Agriculture, Gujarat Agricultural University, Navsari 396 445, India.
SO: Acta-Horticulturae. 1989, No. 231, 814-826; 23 ref., 1 fig., Second international symposium on mango, Bangalore, India, 20-24 May, 1985.
AB: The physiological disorder, spongy tissue, is peculiar to southern India, and affects up to 30% of mango fruits. It is a ripening disorder, characterized by fruits with a soft centre, with white corky tissue or internal breakdown. Affected fruits have a high content of unhydrolysed starch. Possible contributory factors to the disorder are reviewed. The disorder, which affects some cultivars more than others (Alphonso is particularly susceptible), appears to be caused by convective heat rising from the soil rather than by nutrient imbalance or pathogens. It can be alleviated by mulching or sod culture. Suggestions for further work are given.

TI: Spongy tissue development in mango fruit of cultivar Alphonso in relation to temperature and its control.
AU: Katrodia,-JS; Sheth,-IK
AD: N.M. College of Agriculture, Gujarat Agricultural University, Navsari 396 450, India.
SO: Acta-Horticulturae. 1989, No. 231, 827-834; 10 ref., Second international symposium on mango, Bangalore, India, 20-24 May, 1985.
AB: Symptoms similar to the physiological disorder spongy tissue were produced in Alphonso mangoes still on the tree and in harvested fruits by heating the fruits to 40-45øC by sun exposure, or by using infra-red radiation, a hot-plate or an incubator. These treatments resulted in inactivation of enzymes and inhibition of starch hydrolysis. In 2 field trials, sod culture utilizing Eragrostis [Spartina] cynosuroides, which grows naturally in Gujarat, completely eliminated the disorder. Ground temperature was reduced by 20ø compared with clean cultivation, thus reducing convected heat. Sod culture was more effective than mulching with paddy straw or mango leaves. Cover crops of mung [*Vigna radiata*] and cowpea [*Vigna unguiculata*] had no advantage, as they required irrigation, which increased humidity and pests.

TI: Biochemical nature of spongy tissue in Alphonso fruits.
AU: Katrodia,-JS; Rane,-DA; Salunkhe,-DK
AD: Department of Horticulture, Marathwada Agricultural University, Parbhani 431 402, India.
SO: Acta-Horticulturae. 1989, No. 231, 835-839; 16 ref., Second international symposium on mango, Bangalore, India, 20-24 May, 1985.
AB: Spongy tissue, occurring in fruits ripened indoors at room temperature (35 ± 1 °C) and in fruits exposed to intense sunlight (fruit pulp reaching 48ø), was analysed. Affected tissues had lower pH, lower ascorbic acid, beta-carotene, reducing and non-reducing sugar contents, lower amylase and invertase activities, and higher acid and starch contents than the unaffected surrounding pulp, which was similar to tissue from healthy ripe fruits. It is concluded that spongy tissue is a localized physiological disorder where ripening is inhibited, and is caused by overheating.

TI: Towards the understanding of spongy tissue development in mango cv. Alphonso.
AU: Sharma-MR
AD: National Bank, Bombay, India.
SO: Orissa-Journal-of-Horticulture. 1991, 19: 1-2, 50-56; 9 ref.
AB: The role of climate, locality, time of harvest, maturity stage, tree age, nutritional status and microorganisms in the development of spongy tissue are considered. Differences in chemical composition and enzyme activity of healthy and affected fruits are discussed. The symptoms of the physiological disorder known as soft nose are described and possible causes are discussed. Possible areas for future study are suggested.

TI: Possibilities of overcoming physiological disorders in mango by breeding.
AU: Iyer-CPA; Subramanyam-MD
AD: Division of Fruit Crops, Indian Institute of Horticultural Research, Hessaraghatta, Bangalore 560 089, India.
SO: Acta-Horticulturae. 1992, No. 317, 241-244; 23rd International Horticultural Congress, 27 August-1 September 1990, Florence, Italy ; 3 ref.
AB: In 1976, the cultivar Alphonso, which is susceptible to spongy tissue formation, was used in a breeding programme as a common parent and crossed with Banganapalli, Neelum, Kalapady and Janardham Pasand, which are free of the ripening disorder. Evaluation of progeny showed that spongy tissue formation is genetically controlled. The character is monogenic and susceptibility to the disorder is recessive, with Alphonso being homozygous recessive. Screening of the hybrid progenies enabled the isolation of 2 promising hybrids: Hybrid 10, characterized by its large fruit size (750 g), and Hybrid 13, more akin to Alphonso in terms of fruit colour, size, quality and flavour. Both are free of the disorder.

TI: More hybrids of mango.
AU: Pandey-RM
AD: Indian Institute of Horticultural Research, 255 Upper Palace Orchards, Bangalore, Karnataka 560 080, India.
SO: Indian-Horticulture. 1993, 38: 2, 4-5.
AB: Among crosses between varieties Alphonso, Banganapalli, Janardhan Pasand and Neelum, 3 superior hybrids were isolated. These hybrids have medium to large fruit with firm, fibreless flesh, a small stone without surrounding spongy tissue and attractive flesh and skin. Hybrid 10, Arka Aruna (Banganapalli X Alphonso), is a distinctly dwarf tree, precocious and regular in bearing, which gives a moderate yield. Hybrid 13, Arka Puneet (Alphonso X Banganapalli), is a semi-vigorous, heavy yielding variety. Arka Anmol, hybrid 17-3, is a semi-vigorous, moderate yielding tree. Two further hybrids which are still being evaluated are IIHR hybrid 11-2 (Alphonso X Neelum) and IIHR hybrid 20-8 (Neelum X Alphonso). Both are semi-vigorous with a regular bearing habit. IIHR 11-2 is a heavy yielding, midseason variety whereas IIHR 20-8 is a late variety with a moderate yield. Notes on cultivation techniques and crop protection for these new hybrids are included.

Detection of Spongy Tissue

TI: X-ray imaging for detecting spongy tissue, an internal disorder in fruits of 'Alphonso' mango (*Mangifera indica*).
AU: Thomas-P; Saxena-SC; Chandra-R; Rao-R; Bhatia-CR
AD: Food Technology & Enzyme Engineering Division, Bhabha Atomic Research Centre, Trombay 400 085, India.
SO: Journal-of-Horticultural-Science. 1993, 68: 5, 803-806; 10 ref.
AB: An internal physiological ripening disorder, 'spongy tissue', affects about 30% of Alphonso mangoes, the most popular Indian cultivar. Fruits show no external symptoms at harvest or on ripening but cutting reveals internal damage to the mesocarp which adversely affects fruit quality. Both fully grown green, unripe mangoes and ripe fruits exhibit the disorder. A non-destructive X-ray inspection method has been developed to detect affected mangoes. X-ray photographs and X-ray

images of fruits having spongy tissue show dark grey patches corresponding to internal cavities in contrast to light grey areas of healthy flesh. The method could be used for quality control for on-line detection and separation of mangoes having spongy tissue prior to packaging.

SPONGY TISSUE DISORDER IN ALPHONSO MANGO FRUITS - CAUSES AND CONTROL MEASURES - A REVIEW

G.D. JOSHI
Associate Professor of Horticulture (PHT)
and
B.L. Lad
Associate Professor of Agril.Botany,
Konkan Agricultural University, Dapoli,
Dist. Ratnagiri, Maharashtra State,
India 415 712

INTRODUCTION

The ripe fruits of Alphonso mango are affected by a serious malady known as "Spongy tissue" an important physiological ripening disorder also known as "internal flesh breakdown". The extent of losses caused by spongy tissue range from 20 to 60 per cent under the Konkan conditions. The occurrence of spongy tissue disorder was first reported by Cheema and Dani (1934) for the first time (Limaye et al., 1976).

Spongy tissue is the development of yellowish white corkky patches with or without air pockets in the breaK-down are not apparent at harvesting nor at ripe stage. It is only visible when the ripe fruit is cut open into two halves. The quality of mango fruit is very much impaired due to this disorder. Though the disorder is known to occur since long, its development is increasingly felt in the recent years because of its vast export potential for fresh Alphonso fruits (Subramanyam et al.1976; Gunjate et al,1982).

For identification of exact causes and control measures for complete erradication of this disorder, a lot of work has been done at Regional Fruit Research Station, Vengurla and College of Agriculture, Dapoli so as to find out correlations between the outbreak of disorder and specific factors responsible for the same. The occurrence of spongy tissue disorder has been linked with various factors which are of following types.

1. Horticultural aspects
2. Ecological aspects
3. Microbial spoilage
4. Nutritional aspects
5. Biochemical studies
6. Physiological studies

PRESENT STATUS OF RESEARCH

I) Horticultural Aspects :

The research work done during past to find out causes and control measures in relation to various horticultural aspects is described as below :

1. Varietal response : It has been observed that Alphonso mango is the most susceptible variety to spongy tissue in which the incidence goes upto 60 per cent depending upon various factors. In addition to this other varieties, Doodhapedha, Goamankur, Vellaikulamban, Suvarnarekha, Fernandin, Olour also develop spongy tissue in varying degree (Limaye et al., 1975). Pacchatiok variety from Gujarat is reported to be resistant to spongy tissue. The mango varieties like Pairi, Kesar, Neelum and a mango hybrid 'Ratna' developed by Konkan Krishi Vidyapeeth, Dapoli are observed to be free from spongy tissue under Konkan conditions.

2. Stage of maturity at harvest : The incidence of spongy tissue in Alphonso mango increased with advancing maturity. The lowest percentage (10%) fruits were affected by spongy tissue in the fruits harvested at 'A' stage (12 anna) and the maximum percentage (87.67%) was observed in the fruits harvested at 'D' state (Tree ripe). If the fruits are harvested at 'B' stage of maturity (14 anna) the occurrence of spongy tissue was at considerably low level (23.33%) and the fruit quality of ripe fruits is also acceptable. Numerous reports do support the view that spongy tissue incidence was the

maximum when the fruits are harvested tree ripe as opposed to the fruits mature but unripe (Limaye et al. 1976; Joshi and Limaye, 1984).

3. Size and weight of fruit at harvest : The incidence of spongy tissue in Alphonso mango was increased with increasing fruit weight, the incidence being 18.1 (%), 25.4 (%), 36.4(%) and 44.5(%) for fruits weighing 200 g, 200-250 g 250-300 g and above 300 g, respectively (Limaye et al.,1976). The occurrence of spongy tissue was positively correlated with the specific gravity of the Alphonso mango fruits (Krishnamurthy, 1980; Joshi and Roy, 1985; Joshi and Limaye, 1986).

4. Age of the tree : It is observed in Alphonso mango that the incidence of spongy tissue is more in older trees as compared to younger trees. In one experiment, 70 year old Alphonso tree had 52.3(%) incidence of spongy tissue followed by 34.4(%) from 40 years old tree and 31.1(%) from 20 years old tree (Joshi and Roy, 1985).

5. Effect of rootstock : It was observed in the studies conducted at Regional Fruit Research Station, Vengurla that the rootstocks have significant influence on the occurrence of spongy tissue in Alphonso mango fruits. The minimum incidence (35.4%) was observed in Alphonso scion grafted on Vellaikolamban a less vigorous polyembryonic (dwarfing) rootstock, whereas the highest incidence was in Alphonso scion grafted on Alphonso seedling stock (57.3%). It appears that the vigour of rootstock influence the occurrence of spongy tissue because of differences in the root distribution pattern, root-activity and capacity to absorb various kinds of nutrients from soil (Joshi and Roy, 1985).

6. Effect of manuring : It is generally believed that the higher doses of nitrogen leads to increased incidence of spongy tissue as reported by Young (1957) in case of "Soft nose" in mango in similar physiological disorder. However, the

studies carried out at the Regional Fruit Research Station, Vengurla in mango manurial trial on Alphonso mango showed that there was no significant differences in the occurrence of spongy tissue as well as yield due to various levels of N, P, K and their interactions (Joshi and Limaye, 1984).

7. Effect of mulching : It was observed that the fruits harvested from sod culture and grass mulch had significantly low levels of spongy tissue, i.e. (34.5 and 21.62%) and (31.00 and 27.5%), respectively as compared to control (50 and 49%). The soil temperatures of sod cultured plots and grass mulched plots were lower by 6.68 and 10.42°C and 10.4 and 10.25°C, respectively. The reduced radiated heat from the mulched and sod culture plots appears to be responsible for reduced occurrence of spongy tissue in Alphonso mango fruit (Table 1). Burondkar and Gunjate (1989) and Sheth (1985) opined that the convective heat arising from soil influences the occurrence of spongy tissue therefore, mulching and vegetation reduces the incidence of spongy tissue.

II) Ecological Aspects :

The ecological factors like location of the orchard, season of harvest and climatic conditions prevailing during fruit development play important role in relation to development of spongy tissue.

1. Location : It was observed by Subramanyam et al. (1971) that the incidence of spongy tissue was higher for Alphonso mango fruits grown in coastal region as compared to other locations. It was reported by Joshi and Limaye (1986) that the trees located in plain areas exhibited more spongy tissue (56.6%) as compared to hill slopes (46.6%) and the top of hill (35.5%). It appears that the soil moisture and temperature have some relation with the spongy tissue development. The moisture level was observed to be low on the top of hill as compared to other locations.

2. Season of harvest : It has been observed that the early (15th April) harvested Alphonso fruits contained comparatively less spongy tissue affected fruits. The Alphonso mango fruits harvested after 15th May and rainfall occurring 1±2 weeks prior to harvest have higher incidence of spongy tissue disorder.

III) Microbial Spoilage :

1. Bacterial infection : There may be a pathogenic cause to the spongy tissue disorder yet no strong evidence to support this hypothesis has been provided. The research work carried out at Regional Fruit Research Station, Vengurla confirmed that no pathogen could be isolated from spongy tissue, in some cases it appeared to be sterile.

IV) Nutritional Aspects :

1. Mineral composition of spongy tissue : Gunjate et al. (1979a) reported that the calcium content of spongy tissue was lower than the surrounding tissue of spongy tissue affected fruit or completely healthy tissue of ripe Alphonso mango. According to Krishnamurthy (1981), there was no significant difference in calcium content but the spongy tissue had lower potassium levels as compared to healthy pulp of Alphonso mango. In the studies carried out at the College of Agriculture, Dapoli also indicated that there were lot of fluctuations in the values of calcium contnet from year to year. However, it is seen that except K and Na all other nutrients were higher in spongy tissue as compared to healthy pulp of Alphonso mango. In 'Carabao' mango, calcium levels were higher and potassium levels lower in spongy tissue as apposed to healthy tissue (Gautam and Lizada, 1984). Subramanyam et al. (1971) also observed that spongy tissue had lower levels of calcium and higher levels of phosphorus.

2. Nutritional imbalance : As a method of control, pre-harvest calcium dips applied to mango fruits increased the calcium content of fruits as well as reduced the occurrence

of spongy tissue in Alphonso mango. Calcium chloride was more effective than calcium nitrate. By contrast post-harvest dips containing calcium did not significantly reduce the incidence of spongy tissue (Gunjate et al., 1979b). The application of calcium sprays is not always successful on mango as Krishnamurthy (1982) showed that application of pre-harvest spray and/or post-harvest dips of calcium chloride and/or boric acid failed to reduce the incidence of breakdown or enhance the calcium levels in the fruit of Alphonso mango.

V) Biochemical Aspects :

From the analysis of the healthy ripe Alphonso mango fruits, unaffected part of affected fruits and the spongy tissue, it is revealed that the normal ripening of the mango fruit is retarded at the localised spot of spongy tissue.

1. Biochemical changes associated with spongy tissue : In the studies conducted at College of Agriculture, Dapoli by Gunjate et al.(1982) and Ratkar et al.(1984) in Alphonso, it can be observed from (Table 1) that the spongy tissue contained higher levels of acidity (0.68 - 0.84%) as compared to healthy pulp (0.31 - 0.34%). Higher levels of starch content (7.96 - 8.24%) were observed in spongy tissue which was absent in healthy ripe pulp. The polyphenolic inhibitor content was observed to be higher in spongy tissue (1.15 - 1.98 mg/g) as compared to healthy pulp (0.45 - 0.68 mg/g). The levels of ketoglutaric acid and pyruvic acid are also reported to be low. In contrast with this the spongy tissue had lower pH (3.8 as compared to 4.55 in healthy pulp); lower carotenoid contents (5001 ug/g as compared to 8669 ug/g in healthy pulp); lesser amount of total sugars (8.87% as compared to 15.58 % in healthy pulp) lower ascorbic acid content 9.80-12.18 (mg/100 g) as compared to (28.59 - 41.17 mg/100 g) in healthy pulp; and lower amounts of soluble proteins (0.53 mg/g) as compared to healthy pulp (1.54 mg/g).

2. Enzymological studies associated with spongy tissue :

The data on the activity of various enzymes studied by Gupta et al.(1985) in spongy tissue and healthy pulp of Alphonso mango have been presented in Table 2, 3, 4, 5.

a) Amylase and invertase activity : The spongy tissue exhibited about 16 times lesser amylase activity and 2.5 times higher invertase activity as compared to healthy pulp. Similar observations have been reported by Chhatpar et al.(1968-69) for amylase and Amin et al.(1974) for invertase activity in spongy tissue. These observations are also in accordance with the findings that the sucrose level in spongy tissue is very low as compared to healthy pulp (Gunjate et al., 1982).

b) Ascorbic acid oxidase activity : The activity of ascorbic acid oxidase was found to be seven times higher than in the healthy pulp. Similar results have been reported by Amin et al.(1974). The lower amount of ascorbic acid in spongy tissue of mango reported by Gunjate et al.(1982) and Patkar et al.(1984) is perhaps due to the presence of higher ascorbic acid oxidase activity in the spongy tissue.

c) Peroxidase and Catalase activity : The activity of both the enzymes peroxidase and catalase was found to be much less in spongy tissue as compared to healthy tissue. It was 5.5 times less in case of peroxidase and 2.5 times less for catalase. The peroxidase have been known to be involved in ethylene biosynthesis which has an important role in fruit ripening (Gupta et al., 1985).

d) Glutamate Dehydrogenese (GDH) and Glutamate oxaloacetate transaminase (GOT) activity : It is also noticed that the spongy tissue exhibited much lower activity of GDH and negligible activity of GOT. Both the enzymes GDH and GOT have been shown to play important role in aminoacid biosynthesis in ripening fruits. The decreased protein contents observed in spongy tissue may be due to rapid breakdown of protein or inhibition of protein synthesis. The polyphenol levels in spongy tissue were very high. The phenolic compounds have been known to exert inhibitory effects on several enzymes (Gupta et al., 1985).

Therefore, spongy tissue disorder in mango is essential the result of imbalances in metabolism induced by some factor or factors in the pre-harvest or post-harvest environment that leads to the tissue breakdown or flesh breakdown during the course of ripening.

VI) Physiological Aspects :

The knowledge of metabolic changes causing the spongy tissue, a physiological ripening disorder in Alphonso mango is limited. The following studies on the physiological aspects have been done to find out the physiological basis for development of spongy tissue in Alphonso mango.

1. Post harvest sunlight exposure : Gunjate et al. (1982) studied the effect of post-harvest exposure of Alphonso mango fruits to sunlight. It can be seen from the data in Table 6 that as the exposure period increased, there was a marked increase in occurrence. The occurrence of this breakdown was maximum at 120 minutes (100%) and 240 minutes (100%) of exposure of fruits to sunlight. Such internal breakdown of fruits after exposure of fruits to sunlight might have been resulted from inactivation of ripening enzymes due to heat or accumulation of phenols or other types of inhibitors of mango pulp. Though, the mechanism of development of spongy tissue in ripe fruit is not understood, the farmers could be advised to avoid the inadvertent exposure of fruits to direct sunlight after harvest.

2. Post-harvest high temperature exposure : In the studies carried out at the College of Agriculture, Dapoli, it was observed that the occurrence of the spongy tissue disorder in the mature Alphonso mango fruits exposed to 45°C for 30 and 60 minutes after harvest was the same as that of the untreated fruits. However, 100 per cent of fruits exposed to 55°C for 60 minutes developed the disorder. These appears to be relation ship between ripening temperature on the development of internal breakdown which needs to be worked out in details.

3. Ripening temperature of fruit : In the experiment carried out at the College of Agriculture, Dapoli, it was noticed that the incidence of spongy tissue is lower in the fruits ripened at 37°C (12.5%) as compared to the control (normal ripening 25%). The increase in temperature by 5°C resulted into substantial increase (85%) in the incidence of spongy tissue (Table 7). The fruits ripened at 47°C were almost spoiled and showed 100 per cent incidence of spongy tissue. When the experiment was repeated in next season with an addition of pre-cooling treatments, it was observed that fruits dipped in water at 10°C for 18 hrs. did not show spongy tissue incidence, while the fruits exposed to 20°C for 5 hrs. showed as much incidence as observed in control.

Thus, data suggests that post-harvest exposure of fruits to low temperature 15°C to 10°C for a period of 10-18 hrs. followed by ripening as usual in wooden crates might prove beneficial for the control of spongy tissue disorder.

4. Post-harvest Ethephon application : Lad et al. (1985) have studied the effect of post-harvest Ethephon dipping of fruits (for 15 minutes) on the occurrence of spongy tissue disorder in Alphonso mango. It is observed from the data in Table 8 that post harvest dipping of fully mature Alphonso mango fruits in 500, 750, 1000 ppm solution of ethephon minimised the occurrence of spongy tissue disorder. The treatments also enhanced ripening of fruits by 2-3 days as compared to control. It is probable that ethylene released by ethephon inside the fruits might be interacting with the ripening inhibitors inside the fruit which are responsible for the enzymes catalase, peroxidase, amylase during the process of ripening (Mattoo et al., 1968). It has been also reported that the high CO_2 concentration and temperature / 35°C during ripening retard the rate of ripening by blocking the ethylene biosynthesis. The additional application of ethephon enhance the rate of

ripening of mango fruit and reduces the occurrence of spongy tissue without much increase in the ripening temperature of fruit.

FUTURE LINE OF RESEARCH WORK ON SPONGY TISSUE

The spongy tissue, a ripening disorder in Alphonso mango appears to be widespread and occurs at levels that cause appreciable economic loss due to deterioration in the fruit quality. There are many manifestations and these depend upon the various pre-harvest and post-harvest factors including location, climate, cultivars, cultural practices and post-harvest handling practices (Fig.1 and 2).

Eventhough, the lot of research work has been done in this problem the identification of exact causes for the occurrence of spongy tissue and the specific factors responsible for the same has not been possible so far (Kane et al., 1976; Wainwright and Burbage, 1989). However, the following aspects showing a particular trend needs to be further studied by carrying out the fundamental research.

1) Why tree ripe fruit of Alphonso mango develops spongy tissue disorder ?

   a) Inhibitor accumulation in fruit
   b) High temperature during fruit development/ripening.
   c) Low moisture level, high soil temperature stress.

2) Imbalance of which nutrient causes spongy tissue disorder ?

   a) Calcium deficiency
   b) Potassium deficiency
   c) High nitrogen (from urea) toxicity
   d) High chlorine (from MOP) toxicity
   e) Al^{+++} Mn^{++} toxicity or BO_3^-, Zn^{++} deficiency

3) How radient heat from soil influence the occurrence of spongy tissue disorder ?

   a) High soil temperature stress
   b) Low soil moisture, low nutrient uptake

4) How high temperature during ripening affect respiration, ethylene biosynthesis and spongy tissue ?

a) Imbalance in amylase enzyme which causes ripening of fruit.

b) Inhibition of ethylene biosynthesis

5) How Neutron Magnetic Resource Imaging (NMRI) technique can be used for non-destructive detection of spongy tissue in ripe mango fruits ?

This technique has been successfully used for non-destructive detection of physiological disorders in fruits like Apple, Peach, Pear etc. (Wang and Wang, 1989).

CONCLUSIONS

The spongy tissue incidence increased with increasing fruit size, fruit weight, specific gravity and post harvest exposure of fruits to sunlight. The incidence of spongy tissue was maximum when fruits are harvested ripe as apposed to mature but unripe and in the middle of harvesting period or late in the season.

The cv. Alphonso was the most susceptible, the occurrence of spongy tissue disorder but varieties like Pairi, Neelum, Totapuri and mango hybrid Ratna were not susceptible. The incidence of spongy tissue was higher in Alphonso mango grafted on Alphonso mango seedling rootstock but it was minimum in case of Vellaikolamban a polyembryonic dwarfing rootstock. The location altitude, latitude, season are also associated with the occurrence of spongy tissue. The reduced radiated heat from the mulched plots and sod culture plots appears to be responsible for reduced occurrence of spongy tissue in Alphonso mango.

Spongy tissue contained higher levels of acidity, pyruvic acid, ketoglutaric acid, starch and polyphenols but it had lower pH, carotenoids, total soluble solids, ascorbic acid

and soluble proteins. The enzyme activities of amylase, glutamate dehydrogenase, glutamate oxaloacetate transaminase, peroxidase and catalase were all low in spongy tissue whilst, those for pectin esterase, malic enzyme, invertase and ascorbic acid oxidase were lower. These evidences suggest that the imbalance in the metabolism of fruit during ripening causes development of spongy tissue.

Pre-harvest dipping of Alphonso mango fruits in calcium chloride solution significantly increased the calcium content of fruit and also reduced the occurrence of spongy tissue in Alphonso mango suggesting that the spongy tissue disorder might be caused due to calcium deficiency. However, increase in the incidence of spongy tissue by post-harvest exposure of fruits to sunlight and increased ripening temperature (47°C) but post harvest dipping of fruits in Ethephon solution reduced the incidence of spongy tissue suggests that it is an abnormality in ripening developed due to hinderance in ripening of fruits.

Identification of the exact causes has not been possible as there are poor correlations between the outbreak of spongy tissue disorder and the specific factor responsible for the same. The modification of a single factor can not completely control the incidence of this disorder, therefore, there should be an integrated approach for the control of spongy tissue disorder.

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Table 1. Effect of mulching on occurrence of spongy tissue

Treatment	Incidence of spongy tissue (%)	Soil Temperature (^{o}C) (of open space between two trees)	Soil temperature (^{o}C) (around tree based)	Tree canopy temperature (^{o}C)
1	2	3	4	5
1. Mulch	31.0 (33.55)*	37.57	32.29	32.72
2. Sod culture	34.5 (35.77)	41.29	32.83	33.18
3. Control (clean culture)	50.0 (45.21)	47.97	34.85	33.94
S.E. ±	3.046	0.103	0.32	0.141
C.D. at 5%	9.242	0.31	0.97	0.42

*(Figures in parenthesis indicates arcsin values)

Table 2. Enzyme activity in healthy and spongy tissue of ripe Alphonso mango fruits

Sr. No.	Sample	Enzyme activity (units/mg protein)						
		Amylase	Invertase	Glutamate dehydrogenase	Glutamate oxaloacetate transaminase	Peroxidase	Catalase	Ascorbic acid oxidase
1.	Healthy pulp	4.62	62	0.27	10.60	2.74	3.55	1.80
2.	Healthy pulp from spongy fruit	3.92	67	0.26	10.04	5.44	6.10	0.70
3.	Spongy tissue	0.28	155	0.12	00.04	0.52	1.36	12.80
4.	Sun-induced spongy tissue	1.16	289	0.07	Nil	4.96	1.13	11.60

Gupta et al. (1985)

Table 3. Rate of hydrogen peroxide decomposition by catalase enzyme from healthy and spongy tissue in ripe Alphonso mango fruit

Sr. No.	Time in minutes	Rate of H_2O_2 decomposition			
		H	SH	S	SS
1.	10	3.65	7.02	1.26	1.26
2.	20	3.79	5.20	0.84	0.84
3.	30	3.23	0.68	1.13	1.13
4.	40	1.69	0.30	0.85	0.85
5.	50	0.54	0.10	1.70	1.00

H = Healthy pulp from healthy fruit S = Spongy tissue

SH = Healthy pulp from spongy fruit SS = Sun-induced spongy tissue

(Gupta et al., 1985)

Table 4. Soluble proteins and polyphenols in healthy and spongy tissue of ripe Alphonso mango fruit

Sr. No.	Sample	Proteins (mg/g tissue)	Polyphenols (mg/g tissue)
1.	Healthy pulp from healthy tissue	1.54	0.45
2.	Healthy pulp from spongy fruit	1.87	0.47
3.	Spongy tissue	0.53	1.15
4.	Sun-induced spongy tissue	0.99	0.51

(Gupta et al., 1985)

Table 6. Effect of post harvest exposure of 20 fruits to sunlight on the occurrence of internal breakdown in Alphonso mango

Sr. No.	Exposure treatment	Average affected fruits (%) year 1980	Average affected fruits (%) year 1981	Average inside fruit temperature °C
1.	Control	15 (19.92)*	10 (13.28)*	34.5
2.	5 minutes	20 (26.56)	20 (26.56)	37.5
3.	10 minutes	35 (36.06)	30 (32.90)	39.5
4.	20 minutes	35 (36.06)	50 (45.00)	41.5
5.	30 minutes	45 (42.12)	60 (50.77)	43.5
6.	40 minutes	45 (42.12)	60 (50.77)	45.0
7.	60 minutes	60 (50.77)	70 (57.11)	49.0
8.	120 minutes	100 (90.00)	100 (90.00)	49.0
9.	240 minutes	100 (90.00)	100 (90.00)	49.0
	S.E. ±	2.07	2.23	
	C.D. at 5%	6.04	6.48	

* Figures in parenthesis indicate arcsin values

Table 5. Chemical composition of healthy and affected fruits of Alphonso mango

Sr. No.	Sample	Acidity (%)	Starch (%)	Reducing sugars %	Non-reducing sugars %	Total sugar (%)	Ascorbic acid mg/ 100 g	Carotenoids dig/ 100 g	Polyphenols (mg/g tissue)
1.	Healthy pulp	0.34	0.00	6.64	10.04	16.68	28.59	8669	0.68
2.	Unaffected part of affected fruit	0.52	0.00	5.98	7.33	13.31	21.80	8445	1.30
3.	Spongy tissue	0.84	7.96	3.67	5.02	8.69	12.18	5001	1.98
4.	Affected tissue of sunlight exposed fruits	1.84	10.56	2.99	4.05	7.04	13.58	4000	0.85

Table 7. Effect of ripening temperature on the incidence of spongy tissue in Alphonso mango

Sr. No.	Treatment (Ripening Temperature)	1985-86		1986-87	
		No. of fruits studied	% incidence	No. of fruits studied	% incidence
1.	37°C	16	12.5	33	23.7
2.	42°C	20	85.0	80	33.8
3.	43°C	50	100.0		
	Cold water treatment followed by ripening as usual				
4.	10°C : 18 hrs			50	Nil
5.	15°C : 15 hrs			50	2
6.	20°C : 5 hrs.			50	20
7.	Pre-cooling followed by ripening at 37°C			46	15.2
8.	Ripening at cooling temperature (15-20°C)			20	10
9.	Control			30	20

Table 8. Effect of post-harvest Ethephon treatment on occurrence of spongy tissue in Alphonso mango

Sr. No.	Treatment	Percentage occurrence of spongy tissue	
		Year 1982	Year 1983
1.	Ethephon 250 ppm	10.00 (18.19)*	11.66 (19.79)*
2.	Ethephon 500 ppm	6.66 (15.00)	8.33 (16.59)
3.	Ethephon 750 ppm	8.33 (16.60)	10.00 (18.19)
4.	Ethephon 1000 ppm	5.00 (11.25)	8.33 (16.59)
5.	Control (without treatment)	23.33 (28.84)	25.00 (30.46)
	S.E.	2.46	2.12
	C.D. at 5%	7.56	6.52

* (Figures in the parentheses indicate the arcsin values)

(Lad et al., 1985)

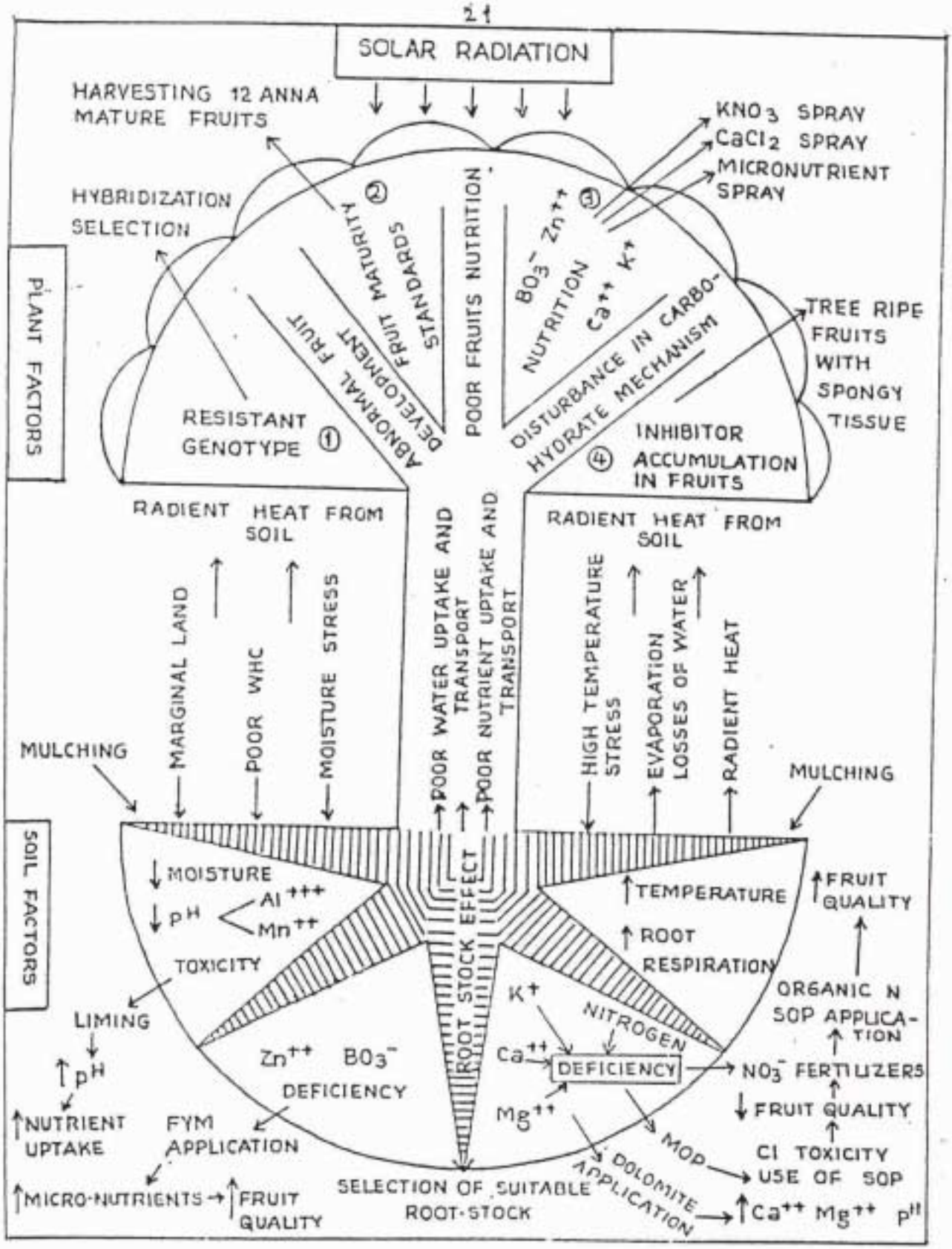

FIG.1. PREHARVEST FACTORS INFLUENCING THE OCCURRENCE OF SPONGY TISSUE DISORDER IN ALPHONSO MANGO.

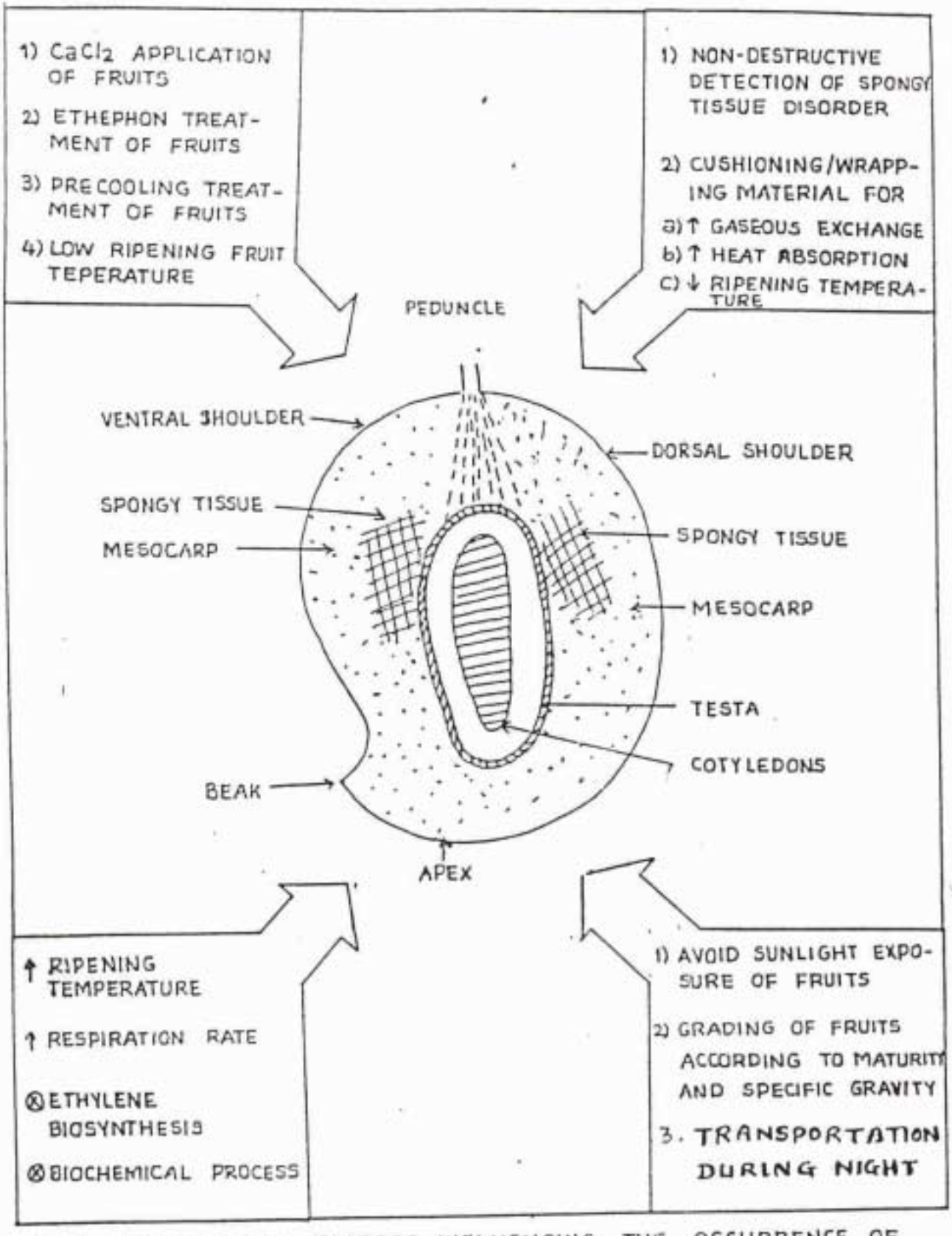

FIG. 2. POST-HARVEST FACTORS INFLUENCING THE OCCURRENCE OF SPONGY TISSUE DISORDER IN ALPHONSO MANGO.