**MEETING**

ABSTRACTS OF PRESENTATIONS ON PLANT PROTECTION ISSUES AT

# THE FIFTH INTERNATIONAL MANGO SYMPOSIUM

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*A: PEST CONTROL*

## An Analysis of the Pest Management Situation in Mango Agroecosystems

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Mango, like most fruit tree crops, is usually attacked by two or three pests, several secondary pests, and a large number of occasional pests in localized areas where it is grown. Of approximately 260 species of insects and mites that have been recorded as minor and major pests of mango, 87 are fruit feeders, 127 are foliage feeders, 36 feed on the inflorescence, 33 inhabit buds, and 25 feed on branches and trunk. Attempts to develop integrated pest management programs for mango must be based on sampling, economic thresholds, and take into account the effects of cultural control practices, horticultural sprays and disease control on pest and natural enemy interactions.

In general, mango pest management is largely dependent on the use of pesticides. Pesticides that are used in integrated pest management programs must have selective toxicity. The current trend is the development of chemicals that are highly effective for a limited group of insects. For example, cyromazine has been suggested as a means to reduce fertility of *Anastrepha obliqua*, and oils for control of scales in mango; however, most of the recommendations from other countries are based on highly toxic or illegal, nonregistered persistent chemicals. Control of mango fruit pests by chemicals alone has been complicated by development of insect resistance and resurgence and elevation of minor pests to major pest status.

Biological control has great potential as a tactic for regulating pest populations in integrated pest management programs in mango orchards; however, it will be difficult for biological control alone to reduce a pest attacking fruit from an economic to a completely noneconomic status. A combination of augmentative releases of parasitoids and the use of sterile insects, has been considered to be more effective for fruit flies than either method applied alone, at least theoretically. Biological control should be highly effective for indirect pests, and numerous studies have been conducted in many mango-producing countries to promote the use of parasites and predators for this type of pest.

Tolerance of mango to pests is mentioned for *Saissetia mangiferae, Noorda* sp. and *Idioscopus* sp., resistance to *Milviscutulus mangiferae* has been recorded, and also different degrees of susceptibility of mango cultivars to *A. obliqua*. Most of the research, however, needs to be assessed further. *Mangifera altissima* does not seem to be affected by mango pests, *i.e.*, leafhoppers, tip borers and seed borers, in the Philippines. There is little doubt that wild mangoes have potential value in breeding.

Recent developments in the identification and synthesis of sex pheromones have resulted in their possible use for pest management in mango orchards. Food attractants, however, are the most common monitoring tools. Trapping techniques can be utilized to reduce pesticide use by improving timing of sprays as a result of better monitoring of pest populations. It remains uncertain if trapping techniques can be used to predict infestations by fruit feeding pests and if they can be used for direct control (by mass trapping) over several years.

The evolution of research concerning pest control in mango during the past few decades, from the unilateral use of pesticides to integrated control, has developed out of necessity. Greatly increased regulation of pesticides, heightened public awareness of environmental contamination, pesticide resistance problems in pests, and the high cost of chemical pest control have resulted in increasing reliance on integrated pest management control as an important strategy in sustainable agriculture. Integrated insect control programs on mango are unsatisfactory for many pests, due to inadequate sampling techniques (the inability to relate the results of sampling to levels of damage in many cases) and the absence of sound economic injury levels. *(L)*[*]

## The Present Status of Mango Pests in Israel

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Since the first mango tree was planted in Israel in 1929 and the first fruits were picked in 1935, several surveys of mango pests have been conducted. The number of pests has increased, but the number of economically important pests has remained low. The status of three economically significant pests: the mango shield scale, *Milviscutulus mangiferae* (Green); the mango bud mite, *Eriophyes mangiferae* (Sayed); and the mango thrips, *Scirtothrips mangiferae* (Priesner), is the same today as in 1993. The new developments in the pest situation are related to the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann); the oriental red scale, *Aonidiella orientalis* (Newstead); and the western flower thrips, *Frankliniella occidentalis* (Pergande).

Limitation of aerial sprays against *C. capitata*, large-scale experimental use of newly designed traps for monitoring and mass trapping, and additional use of mineral oils to control the oriental red scale, led to the restoration of the biological equilibrium regarding this pest and to the appearance of many natural enemies. Those activities were conducive as well to an increase of the population of natural enemies of the mango shield scale. *Compariella lemniscata* Compere and Annecke (Hymenoptera: Encyrtidae) – a parasitoid of *A. orientalis*, and two predatory coccinelid beetles – *Chilocorus circumdatus* Gyllenhil and *C. baileyii* (Blackburn), were introduced into Israel from Australia. These natural enemies are reared commercially in Australia for control of the oriental red scale on papaya. Their present status of acclimatization is not known and research is needed to evaluate the establishment of these natural enemies in Israel.

[*] *L* = lecture sessions; *P* = poster (market place) sessions.

### Integrated Management of *Bactrocera (Dacus) dorsalis* in Mangoes

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Studies conducted at Pantnagar to develop an integrated management schedule for control of the oriental fruit fly, *Bactrocera dorsalis* Hendel, indicate that harvesting of fruits at physiological maturity reduced damage to 4.6% as compared with 10% in fully ripe, dropped fruits of 'Dashehari' on 22 June, and from 8% to 4% in 'Bombay Green'. Four methyl eugenol (0.2%)–baited yellow traps/acre run for 18 weeks (2 April to 30 July) reduced damage by 83.3% in physiologically mature fruits of Dashehari and by 37.5% in fully ripe, dropped fruits. The highest trap catch of 233 male flies/week was between 18 June and 25 June. Adult emergence was zero when fully mature larvae were allowed to pupate at 30 cm soil depth, followed by 20%, 65%, 5%, 45% and 30% at 20, 10, 5, 1 and 0 cm depths, respectively, indicating the suitability of 30-cm depth for burying the damaged fruits. Mango juice 5% was the most effective bait in reducing the damage to fruits (36.6% in physiologically mature and 17% in dropped fruits). 0.002% Deltamethrin gave 83.3% reduction in damage of physiologically mature and 78.8% reduction in dropped fruits; this was at a par with 0.01% fenvalerate. *Biosteres dacussii* (Cameron) was found to be the most important parasite of *B. dorsalis*; the parasitization was, however, very low. *(P)*

### Effect of Height of Traps in the Capture of Fruit Flies of *Anastrepha* and *Ceratitis* spp. in Mango Trees in Venezuela

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With the purpose of determining the optimal height for placement of traps on mango trees to capture the fruits flies *Anastrepha* spp. and *Ceratitis* sp., a test was conducted in a mango orchard located at Maracay, Aragua State. The trees used were divided into three imaginary heights: lower, middle and upper. A randomized block design was applied with six repetitions and three treatments for lower, middle and upper height. The trap used was the McPhail glass type. The lure used was Torula Yeast Borax (TYB), five pellets in 500 cc of water. The traps were checked weekly for 10 weeks, with renewal of the liquid lure every week. The data on the capture of flies were analyzed after being uniformized through the expression $\sqrt{X + 05}$; afterwards an analysis of variance was made. A significant difference between captures at the three positions was found. To determine which position was best, a Tukey test was conducted showing that the best one was the upper height of the tree. In order to confirm there results, an analysis of regression was made, indicating that at the upper height the capture of flies increased significantly. These results suggest that McPhail traps for the capture of fruit flies of the *Anastrepha* and *Ceratitis* spp. should be placed in the highest part of the trees. *(L)*

### Field Evaluation of Various Wrapping Materials against the Mango Fruit Fly, *Bactrocera dorsalis*

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Four wrapping materials, namely nonwoven fabric; standard newsprint; sugar bag wrappers; and sandwich bags, were used as wrapping materials for the pullet-egg-size developing fruits of 'Manila Super Mango'.

Complete protection from insect pests was observed in the nonwoven-fabric-wrapped fruits in addition to its being reusable in the succeeding season. With standard newsprint there was some incidence of ant and mealybug penetration of the wrapper.

The nonwoven fabric bag proved to be the best wrapping material, followed by standard newsprint. The sugar bag wrapper and the sandwich bag ranked third and fourth, respectively. The unwrapped or control treatment showed the highest insect pest infestation and disease infection.

Considering all the attributes of the different bagging materials, the nonwoven fabric utilized in conjunction with presprayings of insecticides and fungicides was the best wrapping material. *(P)*

### Resistance against Hoppers in Mango

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More than 100 varieties of mango were screened against hoppers, under both natural infestation and artificial release conditions. Nylon screen bags and polystyrene bags sleeved at both ends were used for releasing the hoppers on panicles. Observations were recorded on the hopper population inside the bags and hopper survival/development and multiplication, and fruit set were recorded. Observations were also taken on hopper population and fruit set outside the bags on panicles as well as on the trunk.

Results of the trials conducted during 1992/93 and 1993/94 indicated that very few varieties could tolerate hopper infestation. Varieties Pulhora, Amin, Kakaria Amin, Kala Hapus, Ramkela, Pau, Annanas, Kalank Goa and Kesher Basti were resistant to hoppers. Tolerant varieties included Dudha peda, Goff of Havasari, Padiri, Azwain, NX Humayuddin, Tamancha, Eruvadi Banglora, Malihabadi, Neelum, Mallika, Banglora, Panja Pasand, Langra Rampur, etc., whereas the varieties N x Chausa, Hapus, Himsagar, Rahiri, Panchadrakalsa, Eruvadi Romani, Kodurchinnarson, Gulab khas, Green, Vanraj, Kalapaddy, Mithua Malda, Sonakullu, Nilyora, Hathizhool, Kazalio, N x Panchadrakalsa, Cecil, Asadio, Baramalda, Ladavio, Rajapuri, Pathar, Naspati, Bijoragarh, Maharaja of Mysore, Popatpari, Fakira, Keshar, Chinnaswaranarekha, Vellakachi, Cherumani, Malgoa, Hazoor Pasand, etc., were susceptible. *(P)*

*B: MANGO DISEASES*

### Mango Breeding for Resistance to Diseases and Pests

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The mango breeding program for resistance to disease and pests of the Instituto Agronômico de Campinas (IAC) has two main objectives: (i) To obtain polyembryonic rootstocks resistant to the fungus *Ceratocystis fimbriata*, which causes the mango wilt; the goal is to distribute at least ten resistant rootstocks in order to avoid genetic vulnerability. (ii) To obtain mono- or polyembryonic varieties for utilization as crown, with good qualities, mainly productivity and fruit taste, plus resistance to the mango wilt, anthracnose and fruit fly. The first cultivar derived from this program, named IAC 100 Bourbon, was distributed to farmers in December 1989. It is a resistant mutant of the popular table variety Bourbon, which had been almost eliminated by the mango wilt. Two rootstocks resistant to the mango wilt, IAC 101 Coquinho and IAC 102 Touro, were distributed in January 1994. Four new varieties, two crowns – IAC 103 Mococa and IAC 105 Campinas, and two rootstocks – IAC 104 Dura and IAC 106 Jasmim, are scheduled for distribution in January 1998.

Three other crown varieties, IAC 107 Tietê, IAC 108 Pindorama and IAC 109 Votuporanga, are being prepared for distribution. It has been relatively easy to obtain mutants with resistance to mango wilt from susceptible polyembryonic varieties. The distributed varieties are not resistant to all diseases and pests. The precocious table varieties (IAC 103 Mococa and IAC 107 Tietê) have sufficient natural resistance against fruit fly damage, but the late varieties (IAC 105 Campinas and IAC 109 Votuporanga) require control measures against this pest. This research was supported by FAPESP and CNPq. *(P)*

## Mango Decline: Research in Florida on an Apparently Widespread Disease Complex

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Decline syndromes are recognized in virtually all mango-production regions. Symptoms are diverse and include all or some of the following: dieback, defoliation, gummosis, vascular discoloration, marginal chlorosis and necrosis of leaves, foliar nutritional deficiencies, and root degeneration. Fungi are the most commonly described agents, and in most situations a single species is indicated. Abiotic factors, such as poor host nutrition or water stress, are also reported to predispose the host.

In Florida, the etiology of mango decline is confused. Prior to the present study, fungi (*Botryosphaeria ribis* and *Diplodia* sp.), a nematode (*Hemicriconemoides mangiferae*), and nutritional deficiencies (especially of Mn and Fe) had been suggested to be causes. To clarify this issue, we addressed the following objectives: (i) identify fungi associated with declining trees in south Florida; (ii) determine the virulence and symptoms caused by the isolated fungi; and (iii) investigate the role played by host nutrition.

During survey work in 1994 and 1995, internal colonists recovered from symptomatic tissue included, alphabetically: *Alternaria alternata, Cladosporium* sp., *Colletotrichum gloeosporioides, Dothiorella dominicana, Fusarium* spp., *Lasiodiplodia theobromae, Penicillium* sp., *Pestalotiopsis* sp. and *Phomopsis* spp. The relative abundance of the isolated species varied by sample source and date. On 'Keitt', *A. alternata, C. gloeosporioides, D. dominicana, L. theobromae* and two species of *Phomopsis* caused all or some of the following decline symptoms: bud necrosis, tip dieback, gummosis and vascular discoloration. Thus, mango decline appears to be a disease complex in Florida involving several different fungi. Although plants inoculated with *D. dominicana* developed significantly greater vascular discoloration when they were deficient in Mn and Fe, other nutrition X pathogen interactions were not evident. *(L)*

## Mango Malformation – Visualization of *Fusarium subglutinans* in Infected Flowers and Branches by GUS Transformants

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Although more than 100 years have elapsed since mango malformation was first described, the development of *Fusarium subglutinans* – the causal agent of the disease – within malformed tissues is still obscure. The reason for such lack of information is due partly to the dispute among researchers concerning the identity of the causal agent. The unusual nature of the disease, characterized by a unique disease syndrome, reflects drastic hormone-like changes, which contribute to the dispute. In order to trace and follow the fungus in mango tissues, the GUS ($\beta$-glucoronidase) reporter gene was used. Virulent wild-type isolates of *F. subglutinans* were transformed with a plasmid containing both GUS and the hygromycin reporter genes. The transformants did not lose their virulence and after artificial inoculations typical disease symptoms developed. The fungus was viewed microscopically in flowers and in developing vegetative buds, cleared by chloral hydrate. The presence of the pathogen in different plant organs, and its preference for colonization around certain sites, were demonstrated and discussed. *(L)*

## Mango Malformation in Egypt

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Mango 'malformation' has become a limiting factor in mango production. Three main symptoms of this phenomenon were recorded in Egypt: malformed and stunted growth of seedlings in the nursery stage, vegetative growth malformation and inflorescence malformation in the bearing trees. Fundamental changes in the morphological structure and sex ratio occur in the malformed panicles. This phenomenon has not been reported to be translocated by grafting.

The commercial mango cultivars were classified into three groups according to their susceptibility to this abnormal phenomenon: highly susceptible, moderately susceptible and nonsusceptible cultivars. However, the incidence of the phenomenon can differ from tree to tree of the same variety within an individual orchard. Zonal variation has been reported for individual varieties.

In the light of the previously mentioned facts about mango malformation, it could be suggested that other factors may be responsible for the disorder. It might be due to rootstocks used for mango grafting in other cultivars. However, there have not yet been any convincing reports on the effect of mango rootstocks on this phenomenon.

The various constituents, minerals and biochemical components such as carbohydrates, amino acids, phenolic compounds and nucleic acids of the malformed panicles, were shown to vary in comparative studies using malformed and healthy inflorescences and other mango tree tissues. However, these differences might be a consequence of malformation and not a direct cause of it.

Cultural practices like pruning, fertilization program, irrigation, spray with some micronutrients and growth regulators, may be minimizing factors of the mango malformation disorder. However, no cultural practices succeeded to prevent absolutely mango malformation. *(L)*

## Infection Pathway of the Stem End Rot Fungus, *Dothiorella dominicana*, in 'Kensington' Mango

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*Dothiorella dominicana (Dd)* is one of several pathogens causing stem end rot of mangoes in Australia and other countries. *Dd* is also recovered after triple sterilization from symptomless seedlings grown from infected fruit, suggesting endophytism. This experiment aimed to trace the infection pathway of the pathogen from the inoculum placed onto the cut stem end of the fruit to the seedling. 'Kensington' mangoes obtained from the Northern Territory were inoculated with *Dd*. Fruits were surface-sterilized and isolations made from 18 points in the fruit and seed at 0, 1, 2, 4, 6, 8 and 11 days after inoculation. Uninoculated controls were assayed on days 0, 4, 8 and 11. The fungi grew down the vascular tissue into the peduncle (day 2) and pedicel (day 4), and under the skin (day 6). Colonization preceded lesion development, which began on day 8. The seed was infected first through the funiculus (day 6) and seed coats (day 8) and then into the seed (day 8-11), where it caused decay. *Dd* was not detected in the control fruit. Seedlings grown from inoculated fruit showed highest recovery of *Dd* in the connective tissue between the seed and seedling and the hypocotyl zone. These results have implications for the control of the disease and are part of a study into the endophytic infection of mango by *Dd*. *(P)*

## Biology and Control of *Nattrassia mangiferae*

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*Nattrassia mangiferae* has been associated with various diseases in a number of different crops. In South Africa it is the causal organism of several diseases occurring in mango: blossom blight; and the postharvest diseases, soft brown rot and stem-end rot. It is thought that *N. mangiferae* infects the inflorescence at an early stage during flowering. After infection, it spreads systemically through the inflorescence into the fruit, where it remains latent until the fruit begins to ripen. The aim of the present study was to formulate effective control measures. In order to do so it was necessary to confirm that *N. mangiferae* was the causal organism of the above mentioned diseases, and to determine the sources of inoculum and the time of infection. Commercially, blossom blight is currently controlled effectively by sprays of the systemic fungicides flusilazol or pyrazophos. In the current study various other chemicals were also tested for effectiveness in controlling soft brown rot and stem-end rot occurring on the fruit after harvest. These included both pre- and postharvest applications. Of all the fungicides tested, monthly preharvest applications of copper oxychloride during the period from fruit set until harvest resulted in significantly improved disease control. *(L)*

## Semi-Selective Medium for Isolation of *Nattrassia mangiferae*

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*Nattrassia mangiferae* is the causal organism of various mango diseases in South Africa. These are blossom blight and the postharvest diseases soft brown rot and stem-end rot. In epidemiological studies it is necessary to make numerous isolations from tissue which may be infected by the specific organisms. The isolation of *N. mangiferae* from branches, fruit and panicles by plating onto agar media, is severely hampered by the presence of saprophytic fungi. The development of a selective medium was therefore necessary. Ten chemicals were screened for their effect on the radial growth of *N. mangiferae*. Growth of *N. mangiferae* was the least inhibited by benodanil (100 ppm), rose bengal (50 ppm) and tannic acid (3000 ppm). These three chemicals were then tested at different concentrations and combinations for their effect on the radial growth of seven saprophytic fungi isolated commonly from mango tissue, as well as on *N. mangiferae*. A selective medium consisting of tannic acid (4000 ppm) and benodanil (100 ppm) provided a superior medium for the detection of *N. mangiferae* in isolations made from mango branches, blossoms and fruit. *(P)*

## Bacterial Black Blight of Mango in Israel

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Bacterial black blight is one of the mango diseases unknown in the optimal mango-growing regions. The disease appears in Israel during late winter – early spring, causing a black branch and leaf blight. The necrosis in the branch is confined to the bark tissues. Leaf petioles and the basal portion of leaf blades turn black as well. After unusually cold winters, all the young growth (one-year-old branches) is necrotic in affected trees. Pure cultures of *Pseudomonas syringae* pv. *syringae* can be isolated from branches and leaves with black blight symptoms. When mango branches are inoculated with those bacteria during summer months, disease is not incited. However, symptoms appear following inoculations performed during the winter months. Koch's postulates were fully established. The disease is highly damaging during cold winters accompanied by frequent wind and hail storms. Most commercial varieties grown in Israel are susceptible to the disease; sources of resistance do, however, exist. In years with mild winters, good disease control can be achieved by preventive sprays of Bordeaux mixture; in years with severe winters, the control is unsatisfactory. To achieve better control, studies to identify the initial inoculum sources were conducted and were discussed. *(L)*

### Mango Disease Losses: Balancing Economy and Ecology

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The damage and losses caused by mango pathogens are unacceptable to orchardists, marketeers and consumers. But what is the evolutionary significance of the magnitude of the losses? In nature, and in terms of tree survival, the losses are *not* of major significance.

Pathogen biology and disease ingress are influenced by host/ecosystem traits resulting from natural selection operating on an evolutionary time scale in regions to which *Mangifera indica* (and related spp.) was endemic. However, natural (loss-minimizing) balances have also been compromised (and damage tolerance thresholds lowered) by the artefacts of orchard cultivation and exotic/depauperate ecosystems, as well as the demands of harvesting, transport and storage.

What facets of host genome, environment, and micro- and macroflora and fauna could be manipulated, improved or reassembled to adjust the balance, so that disease losses are minimal and product quality is maintained at the level dictated by commerce?

What do we know about these factors? What more do we need to know? How can the information be exploited?

How can nature's gifts be resurrected, enhanced or supplemented? *(L)*

*C: POSTHARVEST PATHOGENS AND THEIR CONTROL; QUARANTINE MEASURES TO PREVENT DISEASE AND OTHER BLEMISHES*

### Hot Water Brush: A New Method for the Control of Postharvest Disease Caused by Alternaria Rot in Mango Fruits

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*Alternaria alternata* is the main postharvest pathogen attacking mango fruits in Israel. The pathogen penetrates the fruit through lenticels during fruit growth and remains quiescent until harvest. After harvest, while the fruit ripens, the pathogen renews its development and black spot symptoms of decay appear on the fruit, resulting in a reduction of fruit marketability. No preharvest treatments are applied in Israel to prevent postharvest diseases. However, postharvest treatments are applied depending on the relative humidity conditions at the grove location. Fruits from groves located in relatively dry regions, where the postharvest incidence of decay is low, are only water-washed. However, fruits from groves located in humid regions, where the incidence of decay is very high, are treated with 900 $\mu$g/ml prochloraz. A simple postharvest treatment that involves hot water spray at temperatures of 50–60°C while the fruits are brushed (hot water brush), was developed. The treatment significantly reduced decay development by *A. alternata* to levels similar to the prochloraz treatment in several mango cultivars stored for 3 weeks at 14°C. When fruits were stored for longer periods of time, the fungicide was more effective than the hot water brush. The possible use of this simple treatment in the postharvest mango industry, to reduce the use of fungicides, was discussed. *(P)*

## New Options for the Prevention of Postharvest Disease in Mango Fruits

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Postharvest diseases caused by *Colletotrichum gloeosporioides* and *Alternaria alternata* attack mango fruits during fruit growth and remain quiescent until the fruit is harvested. Susceptibility of mango fruits to postharvest diseases increases after harvest and prolonged storage as a result of physiological changes occurring in the fruits that enable pathogen development. In the past, resistance of unripe mango fruits was suggested to be related to a decrease in concentration of the preformed 5-substituted resorcinols in the peel of unripe fruits. New antifungal compounds of similar structure have been identified in the peel of unripe fruits and their relation to fruit susceptibility has been determined. The possible relation between levels of antifungal compounds and new biological and physical treatments that prevent postharvest diseases was investigated. Postharvest decay development was delayed by: (i) Co-inoculation of *C. gloeosporioides* with a strain of *Colletotrichum magna* (nonpathogenic on mango); (ii) exposure of some mango cultivars to a $CO_2$-enriched atmosphere; (iii) hot water dip at 55°C; and (iv) hot water brush. Hot water brush represents a new, simple and efficient method for the control of postharvest decay development in mango. The importance of each method as a postharvest treatment was discussed. *(L)*

## Hot Water Quarantine Treatment and Water Cooling of ‘Haden’ Mangoes

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A part of Mexican-grown mangoes must be subjected to a quarantine treatment by hot water immersion (46°C, 90 min) before shipment to export markets (Work Plan for Mexican Mango Preclearance Program, USDA-APHIS-IS/SARH-DGSV, 1994). The effects of this heat shock stress can be attenuated by cooling. The purpose of this study was to determine the impact of water heating on respiration, histological structure and conservation of the quality of ‘Haden’ mangoes as well as the effect of water cooling (21°C, 30 min) and refrigeration on the recovery of the fruits. Physiologically mature Haden mangoes produced in Mexico (18°32′ N; 99°52′ W) were used. The treatments were applied in the packinghouse and the fruits were stored at 25° or 13°C, at 85–90% relative humidity. The parameters evaluated were: respiratory activity, appearance and thickness of the cuticle, SSC, titratable acidity, flesh firmness, flesh color, % physiological weight loss, and sensory evaluation tests. Statistical analyses (ANOVA $\alpha$=0.05) indicated that water heating increased respiratory metabolism, expanded the cuticle, and induced the formation of small fissures and widening of pores, thereby causing a decrease of the storage life. Water cooling partially reversed the effects of the water heating: respiratory activity tended to return to normal, and the thickness and appearance of the cuticle recovered partially. Refrigeration also reversed the effects of water heating, but to a lesser degree. Neither treatment had a conspicuous effect on quality and sensorial parameters. It was concluded that water cooling should be recommended for hot-water-treated mangoes.

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### The Response of Mango Stem End Rot Pathogens to Heat

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In Australia, stem end rot of mango is caused by *Dothiorella* spp., *Lasiodiplodia theobromae*, *Phomopsis mangiferae* and other fungi. *D. dominicana* is the major cause of mango stem end rot in Queensland. Previous studies have shown that in cv. 'Kensington Pride', stem end rot is less effectively controlled by heat treatments (*e.g.* hot water and vapor heat) than is anthracnose (*Colletotrichum gloeosporioides* and *C. acutatum*). To investigate the reasons for this, the *in vitro* heat tolerance of selected *D. dominicana, L. theobromae* and *Phomopsis* sp. was studied. Mycelial suspensions of each isolate were immersed in hot water (at temperatures ranging from 46–55 °C for periods of up to 60 min), rapidly cooled and then plated onto potato dextrose agar. Isolates of *D. dominicana* were found to be the most heat-resistant of the three species, and *Phomopsis* sp. the least heat-resistant. In mango fruit (cv. Kensington Pride) inoculated with *D. dominicana* or *L. theobromae*, however, vapor heat treatment (fruit seed surface temperature of 46.5°C for 10 min) controlled stem end rot caused by *D. dominicana* more effectively than that caused by *L. theobromae*. The significance of these findings was discussed. *(L)*

### Heat Transference in Mangoes by Hot Water Dip and Forced Hot Air

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Quarantine treatments involving heat have been used to treat fruits destined for export. Knowledge about transference of heat in the pulp of fruit is basic information needed for the fast and rational development of new treatments.

We compared the heat gain in different depths of unripe 'Tommy Atkins' mangoes of 400 and 650 g weight submitted to two treatments: hot water dip and forced hot air at 46°C for 75 min. The temperatures were recorded from the start of the experiment at 5-min intervals at depths of 1, 2 and 3 cm. The heat transference in both treatments can be described by an asymptotic regression, $y = a + b.exp(-cx)$.

The data were submitted to null hypothesis test and resulted in significant differences between mangoes of the same weight treated with either hot water or hot air [$15.0 < F > 94.5/F_c(3;174)$ to 0.001 + 5.7] and between mangoes with different weights submitted to the same treatment [$11.2 < F > 73.6/F_c(3;174)$ to $0.001 + 5.7$].

The final temperature in mangoes of different weights did not differ in relation to treatment, because there was heat saturation in the pulp of the mangoes. *(L)*

## Use of Hot Water Treatment to Enhance Natural Resistance of 'Carabao' Mango against Anthracnose Disease

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'Carabao' mango fruits were inoculated with spores of *Colletotrichum gloeosporioides* ($10^6$/ml spore suspension) at various time intervals after hot water treatment (HWT). HWT did not appear to inhibit disease development in inoculated fruits when disease severity was plotted against time in days. However, plotting severity against peel color index (PCI) gave lower rates of development of anthracnose in fruits subjected to HWT. This can be attributed to the acceleration of ripening by HWT. In one trial, the inhibition was most pronounced in fruits inoculated 48 h after HWT. These results indicate the possibility of an antifungal compound formed in response to HWT.

To relate the above response to recommendations for the application of HWT, naturally infected fruits were subjected to HWT at various times after harvest. Results showed that treatment at 12 h after harvest delayed the onset of disease such that, on the average, fruits exhibited symptoms only when almost fully yellow (PCI 6). In contrast, those treated at 6 h or more than 12 h after harvest, showed symptoms of anthracnose at the yellow-with-green-tip stage (PCI 5). However, all treated fruits showed slight disease development. Mango peel was sampled for extraction with ethanol and subsequent analysis for antifungal compounds. *(P)*

## Application of Shortwave Infra-Red Radiation to Control Postharvest Decay of Mangoes

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A postharvest treatment of mangoes consisting of a 5-min hot water dip (50°C) followed by a 20-sec ambient temperature prochloraz dip is the conventional method used to ensure adequate control of postharvest diseases. This treatment is time consuming and represents a bottleneck in the packinghouse. Shortwave infra-red (IR) radiation has long been recognized as being a highly efficient form of heating. The effect of IR radiation was therefore compared with the commercially used hot water treatment, for the control of postharvest diseases on mango. A 3-min exposure to IR was found to be as effective as the commercially used 5-min hot water treatment, in controlling anthracnose (*Colletotrichum gloeosporioides)* and soft brown rot (*Nattrassia mangiferae*) on seven mango cultivars. There were no significant differences between IR and hot water treatments as far as fruit quality was concerned. The IR treatment is, however, cheaper and faster than the hot water treatment. *(P)*

## Evaluation of Phosphonate for Control of Postharvest Mango Pathogens

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Field trials were carried out over two seasons in an orchard in southern Queensland, Australia, to investigate the effect of preharvest trunk injection and soil drenches of phosphonate on postharvest disease levels in mango cv. 'Kensington Pride'. In the first trial, trees were injected when fruits were 'hen egg' size. Injection of a 400 g/*l* formulation of potassium phosphonate (15 ml/m canopy diameter) significantly reduced stem end rot levels in fruit after storage at 22°C for 20 days. There was also a reduction in the isolation frequency of endophytic stem end rot pathogens from inflorescences, ∼6 weeks after injection. In the second trial, injections and soil drenches were applied earlier in fruit development (flowering/fruit set stage). There was no reduction in fruit stem end rot levels.

Results of the first trial suggest that further trials should be undertaken to investigate the potential of phosphonate for the control of postharvest mango pathogens. *(L)*

## Effect of Hydrocooling and Bavistin (Carbendazim) Dip on the Shelf Life and Quality of Mango during Storage under Various Environmental Conditions

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The present investigation was undertaken to study the effect of hydrocooling and Bavistin (carbendazim) dip on the shelf life and quality of mango during storage under various environmental conditions. For this purpose, the fruits of three mango varieties, 'Kesar', 'Totapuri' and 'Vanraj', were harvested with stalk (2.5 cm), hydrocooled at 12°C, and given a postharvest dip in Bavistin (1000 ppm) and stored under two conditions: room temperature 24° to 35°C, and 48 to 80% r.h., in a low-cost, low-energy-input, easily installable cool chamber (22 to 26°C and 92 to 95% r.h.). It was found that the shelf life of Kesar, Totapuri and Vanraj could be extended up to 25, 36 and 31 days, respectively, when stored in the cool chamber. In contrast, the shelf life of these varieties was barely 17, 21 and 19 days, respectively, when stored at room temperature. It was observed, too, that in the hydrocooled and Bavistin-treated fruits lower physiological weight loss was recorded and higher organoleptic score when stored in the cool chamber, compared with at room temperature. The cool-chamber-stored fruits looked fresh, firm and attractive. The untreated fruits were found to be infected with *Colletotrichum gloeosporioides* and *Diplodia natalensis*. *(P)*

## Effect of Method of Harvesting on Postharvest Loss Reduction and Extension of Shelf Life of Mango

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The present investigation was undertaken to study the effect of the method of harvesting on postharvest loss reduction and extension of shelf life of mango grown in an arid zone. For this purpose, the mango fruits of cv. 'Kesar' were harvested with stalk (2.5 cm), using various harvesters such as Dapoli, CIHNP, IIHR, and IARI mango harvesters, along with manual harvesting without stalk. The fruits were then graded and packed in corrugated fiber board boxes and stored at ambient conditions (24 to 38°C and 42 to 81% r.h.). It was found that with the help of the Dapoli harvester, the maximum number of fruits could be harvested (182 fruits/h), followed by CIHNP, IIHR, IARI harvesters, and manual harvesting. Kesar mango with stalks intact had exhibited delayed ripening as well as delayed shrivelling. The fruits harvested by any of the harvesters had a shelf life of 15 days, as against 11 days following manual harvesting. The fruits harvested by using these harvesters had a minimum physiological weight loss of 12–13%, as against 17% with manual harvesting. The spoilage of manually harvested fruits was 13% after 16 days of storage. The mango fruits were found to be infected with *Colletotrichum gloeosporioides* and *Diplodia natalensis*, when harvested manually. *(P)*

## Detrimental Effects of Detergent in the Development of Mango Skin Browning

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The term mango skin browning covers a range of postharvest blemishes affecting mango fruit. Skin browning is a major fruit quality problem, causing the downgrading and rejection of the product on Australian markets. Etching and lenticel spotting are two of the more prevalent forms of browning. Etching consists of numerous small dark flecks and lenticel spotting is a dark halo of tissue around the lenticels.

To determine which points in the harvesting and postharvest handling operations contribute most to these blemishes, mango handling systems were investigated on several Australian farms during the 1994 and 1995 seasons. The operations that contributed most to etching and lenticel spotting were those associated with wetting of the fruit by detergent, whether by harvest aid or on desapping racks in the packinghouse. Fruit wetted with detergent showed greater levels of skin browning, lenticel spotting and postharvest diseases.

Laboratory investigations into the effect of detergent on mango skin, showed that detergent alone at commercial rates could cause etching and lenticel spotting. Etching appeared to be caused by the aided entry of aqueous solutions into the epidermis and underlying cells through small fissures in the cuticle. These fissures usually occur in the center of cuticular platelets as they subdivide, or at the junctions between platelets.

It seems that detergents can be a major contributor to lenticel spotting and forms of browning such as etching. The presence of detergent in the harvest/postharvest handling system may be causing as much harm as benefit to mango fruit quality. *(L)*