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Integrated nutrient & disease management in citrus

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Abstract

Citrus is considered highly nutrient responsive crop. Maintaining health of citrus plants by nutrition management and disease management demands to deal citrus as a tree plant that has growth in shifts. Site specific nutrient management studies find a greater weight age over conventional but classical progressive fertilization response studies, if constraint specific fertilization is to be worked out. Simultaneously use of integrated strategies viz., soil application of macronutrients (NPKS) and foliar application of micronutrients (Fe, Mn, Zn & B); fertigation and INM using rationale of organic manures fortified with microbial consortium based microbial reactor through isolation and characterization of native and dual purpose microbes and fertilizers have produced encouraging responses to improve production dividends underlying their undeniable utility. But, fertilizer requirement experiments have generated a vast variation in their recommendations depending upon orchard age, soil type and climatic features besides very limited information on micronutrients requirement. There is a need to chalk out nutrition programme by keeping in mind growth as well as phonological cycles of the plant because every shift of growth in association with phonological and growth cycles needs special attention to decide fertilization programme. There is a need to develop well established production technology to increase the production of this crop substantially by using non-conventional approaches alone or in combination with conventional approaches. The use of multi-nutrient plant growth regulator formulation amended with appetizer is a new and innovative approach to develop a cost effective foliar spray "Micro Power" for improving citrus yield.

Keywords: Integrated nutrient, disease management

Introduction

Plant nutrient management can influence flowering, fruit set, fruit size and the amount of vegetative growth and other plant characteristics. By carefully choosing the components of fertilizer programme, the grower can nudge a crop toward earlier, heavier fruit set (Ibrahim *et al.*, 2004; Abd-Allah, 2006; Alva *et al.*, 2006) [27, 1, 5]. This might be due to increase in photosynthetic activity and transport of photo-assimilates and production of endogenous growth regulatory substances by the applied bio-inoculants leading to production of more number of flowers, increased fruit set percentage in the plants.

Microbial Biofertilization

Biofertilizers in citrus has yet not received the priority, it deserves, with the result, soil physical, chemical and microbiological health have deteriorated irrecoverably in many commercial citrus belts. Use of microbial biofertilizers: on one hand, and the utilisation of Arbuscular mycorrhizae (AM) fungias bioprotector, bioregulator, and biofertilizers in citrus, on the other hand, is likely to bring a desirable change in the quality production, besides beneficial impact on soil health. The Arbuscular Mycorrhizal Fungi might have increased the availability and absorption of all essential nutrients which led to more uptake and accumulation of potassium in leaf tissues, thereby improving photosynthetic efficiency, translocation and accumulation of carbohydrates, resulting in increased fruit weight and size. Increased fruit weight might be also due to the increased accumulation of dry matter and also efficient partitioning of photosynthates towards the sink by biofertilizers and bio-inoculants. Besides bio-inoculants, inorganic fertilizers also help in apparent increase in fruit weight. This finding is in confirmation with the reports of Bhattacharya *et al.* (1973) [9] in acid lime, Jawaharlal *et al.* (1989) [29] in acid lime, in mandarin, Lal (1998) [36]

in Kinnow mandarin and Monga *et al.* (2002)^[40] in sweet orange. Supply of adequate quantities of nutrients is very essential for sustainable high yields and for good quality fruits over a long period of time. In the initial 4-5 years of vegetative growth and later during reproduction growth stage of crop, the nutritional requirements are different and must be met with as per their needs.

Foliar feeding has been used as a means of supplying supplemental doses of minor and major nutrients, plant hormones, stimulants and other beneficial substances. Observed effects of foliar fertilization have included yield increases, resistance to disease and insect pests, improved drought tolerance and enhanced fruit quality (Havlin *et al.*, 2005; Omaima Metwally, 2007; Tariq *et al.*, 2007)^[26, 46, 60]. In citrus yield reduction due to poor soil, crop and fertilizer management practices, poor quality (fruit with nutrient deficiency & disease symptoms) and poor management during harvesting, transportation, packaging and storage (Khattak, 1991; Tariq *et al.*, 2007)^[60, 31] Previous studies on nutrient management have shown that proper nutrient placement and timing (Koo, 1980; Koo *et al.*, 1984; Obreza and Rouse, 1993; Obreza *et al.*, 1999a; Kusakabe *et al.*, 2006; Obreza and Tucker, 2006)^[5, 33, 34, 35], application rate and frequency (Koo *et al.*, 1984; Lamb *et al.*, 1999; Paramasivam *et al.*, 2000; Mattos *et al.*, 2003b)^[34, 37, 48, 39] and fertilizer application method (Alva *et al.* 2003; 2006b; 2006c)^[4, 6, 5] can substantially affect nutrient uptake, yield, yield quality and environmental quality in citrus.

Citrus production in Florida is ranked first in the United States. Success of the citrus industry in the state relies heavily on sound water and nutrient management practices. Recently, citrus production has been declining due to the escalating prevalence of the citrus greening (*Liberibacter asiaticus*) and canker (*Xanthomonas axonopodis*) diseases. One option being explored is the manipulation of nutrient management scenarios to increase and enhance tree productivity. The paper presents a review of the management, analytical and application methods of three major nutrients Nitrogen (N), Phosphorus (P), and Potassium (K) on Florida's sandy soils with low organic matter (OM) and high leaching potential due to heavy annual rains (~1200 mm). The NPK management options for Florida citrus are compared with those of other citrus producing regions around the world. Also, the critical tissue and soil nutrient concentrations for optimal and high citrus production are discussed. The review paper should provide important nutrient management guidelines to citrus growers in Florida and other regions with similar climatic and soil conditions. (Srivastava and Shyam 2009)^[55].

Soil physical properties related constraints (clay gradient in soil profile, drainage/irrigation/water logging) and soil fertility constraints induced by soil pH, salinity (specific ion- and cumulative osmotic pressure effect), calcareousness (pedogenic or non-pedogenic CaCO₃), besides increasing menace of nutrient mining, are the important pedological factors contributing to citrus decline. But, the orchards established on later two soil orders confronted with subsurface constraints in form of argillic (clay rich horizon with acidic or alkaline pH and varying intensity/forms of calcareousness) and spodic horizonation (organic hardpan

with very acidic pH), in addition to multiple soil fertility constraints. Soil condition-based rootstock alternatives, site specific nutrient management coupled with variable rate application, and integrated soil management systems representing different modules of INM, are the viable means of combating an untimely decline in citrus orchards' productivity. (Srivastava and Shyam 2008)^[55].

Application of some nutrients (not all) through foliage can be from 10 to 20 times as efficient as soil application. However, this efficiency is not always achieved in actual practice due to weather extremes, application of the wrong spray mix, or of the right mix at wrong time (Alva *et al.*, 2006)^[6].

Nutrient Application Methods and Sources

Fertigation

Fertigation is a practice of applying solution fertilizer concomitantly with irrigation water, typically through a microsprinkler or drip system. This practice was developed in Israel for horticultural production to cope with an arid climate with the aim of conserving reclaimed water.

Advantages and Disadvantages of Fertigation

Fertigation has the potential to reduce NO₃ leaching and subsequent groundwater contamination. Water, fertilizer placement and frequency of application are managed more efficiently compared with a dry fertilization program. Kusakabe and co-workers (2006)^[35], however, noted in their study that it was the N rate, rather than the fertigation frequency that affected concentrations of residual NO₃. Thus a careful consideration of nutrient concentrations in fertigation programs is also required to contain nutrient levels within acceptable contaminant limits.

Disadvantages of using fertigation as follows

1. Complexity in fertilizer application uniformity and coverage because these depend on proper design, Installation and maintenance of the irrigation system.
2. Need for extra equipment (injection device, tank, and backflow prevention system) to the irrigation system, thus incurring extra expenses;
3. Soluble fertilizers are expensive than granular fertilizers on an equal nutrient basis;
4. Fertilizer injected into an irrigation system may contribute to emitter plugging.

Dry Granular Fertilization

Dry granular fertilization (DGF) in citrus production involved water soluble fertilizer application by banding or broadcasting. Dry granular fertilizers include Ammonium nitrate, urea, Potassium nitrate and others.

Advantages and Disadvantages

Dry granular fertilization (DGF) is reported to be the easiest and cheapest way of applying fertilizer in citrus and has been in use for a long time in Florida and other parts of the US (Obreza and Rouse, 1993)^[5]. However, problems associated with use of dry granular fertilizer include root injury and reduced water uptake. This method is also labor-intensive compared with other fertilizer application methods.

Table 1: NPK deficiency, causes and correction in citrus

| Nutrient | Deficiency | Cause | Correction |
|------------|---|---|--|
| Nitrogen | Light yellowish-green leaves New leaves are small, thin, fragile and light green in color Stunted trees with a thin canopy, irregular and very short twig | Lack of available N due to 1) leaching caused by heavy rain or over-irrigation in highly porous soils; 2) water-logging which cause anaerobic conditions leading to denitrification | Apply supplementary N frequently Use low-biuret urea as a foliar spray |
| Phosphorus | Reduced growth Leaves are small and narrow, with purplish or bronze, lusterless discoloration Leaves develop necrotic areas Limited flower development, reduced fruit set and fruit yield Delay in fruit maturity Poorly branched, stunted roots | Lack of available N due to 1) leaching caused by heavy rain or over-irrigation in highly porous soils 2) water-logging which cause anaerobic conditions leading to denitrification | Apply supplementary N frequently, Use low-biuret urea as a foliar spray |
| Potassium | Yellowing of the tips and margins, Necrotic areas and spotting develop on the leaves Slow growth, small leaves, fine branches, compact tree appearance, reduction in fruit size, very thin peel of smooth texture, premature shedding of fruit | Leaching on acid sandy soils, Lack of soil moisture Nutrient imbalances (N and P higher relative to K) | Apply KCl or K ₂ SO ₄ to the soil, Foliar application of KNO ₃ or mono-potassium phosphate on fine-textured, saline or calcareous soils |

1. Koo *et al.* (1984)^[34]; Zekri and Obreza (2003)^[5]; Obreza *et al.* (1999b; 2008b)^[43, 44].

2. Koo *et al.* (1984)^[34]; He *et al.* (2003); Zekri and Obreza (2003)^[5]; Obreza *et al.* (1999b; 2008b)^[43, 44]; Alva *et al.* (2006b, 2006c)^[5, 6].

3. Koo *et al.* (1984)^[34]; Zekri and Obreza (2003)^[5]; Obreza *et al.* (1999b; 2008b)^[43, 44].

Molybdenum (Mo) is a micronutrient that catalyzes a range of reactions, such as phytohormone synthesis, sulfite detoxification, purine degradation and nitrogen (N) assimilation by plants. Increasing the nitrogen (N) use efficiency of fruit trees to enhance fruit yield and decrease N rate and fertilization losses in the field is intensively discussed. Noteworthy, molybdenum (Mo) demand is likely to increase in high yielding citrus orchards. Although fertigation with calcium nitrate enhances sweet orange fruit yields, Mo-deficient plants present low NRase activity, what could limit their ability to attain maximum production efficiency. In plants, NO₃⁻ is reduced to NH₄⁺ before it is incorporated into organic forms by two distinct sequential reactions, catalyzed by different enzymes. The first reaction occurs in the cytosol of root and/or leaf cells and is mediated by NRase that reduces NO₃⁻ to nitrite (NO₂⁻).

Due to high pH and calcareousness of soil, the availability of micronutrients is affected (Talibudeed, 1981)^[59] and growing citrus on such soils frequently shows deficiency symptoms like yellowing of young growth, interveinal chlorosis and dieback of branches. These are typical symptoms of iron (Fe) and zinc (Zn) deficiencies. Some short duration studies were conducted on micronutrients indicating their response specifically to Zn (Khattak, 1994; Siddique *et al.* 1994)^[31, 53]. The soil conditions are such that applied nutrients may not give immediate impact on yield in perennial plants like citrus due to their limited root system and hairs on roots absorbing nutrients from surface soil (Cohen, 1976)^[14].

Foliar application of zinc sulphate @ 0.5 gave maximum yield and quality in citrus fruits which was given by Babu *et al.* 2007^[7] in kinnow mandarin, Supriya and Bhattacharya (1993)^[58] in Assam lemon. Whereas, Yadav *et al.* (2007)^[63] concluded that foliar application of zinc sulphate 0.75% gave maximum plant growth, fruit yield and minimum fruit drop. Combined application of zinc sulphate and iron sulphate gave good response to yield and quality of citrus fruit Such as foliar application of ZnSO₄ @ 0.5% and FeSO₄ @ 1.0% improved fruit yield in kinnow mandarin (Dixit *et al.* 1977)^[17], ferrous sulphate @ 0.5% and zinc sulphate @ 0.5% given maximum fruit yield in sathgudi orange (Durgadevi *et al.* 1997)^[18], zinc sulphate 0.4% and boron 0.2% given maximum fruit yield in sweet orange (Tariq *et al.* 2007)^[60], 1.0% of ZnSO₄ and 0.5% of FeSO₄ was the most effective

treatment (Dixit *et al.* 1977)^[17]. Whereas, Haque *et al.* (2000)^[25] concluded that foliar application of micronutrients (Cu, Zn and B) alone and their combinations significantly increased number of fruits per plant, total fruit weight per plant, fruit diameter and yield of mandarin orange.

Major diseases associated with citrus crop and its management

Citrus Canker

The geographical origin of citrus canker is a matter of controversy. Lee (1918)^[38] reported that it may have arisen in southern China, and he assumed *Fortunella hindsii* to be the wild host plant. However, Fawcett and Jenkins (1933) reported that citrus canker originated in India and Java Symptoms: Citrus canker is not vectored by any organism but is spread by wind-driven rain. However, wounds caused by feeding of the Asian citrus leaf miner (*Phyllocnistis citrella* Stainton) may serve as an entry point for the bacterium if citrus canker inoculum is present. Leaf - typical citrus canker lesions on leaves will range from 2-10 mm in size and will have raised concentric circles on the underside of the leaf. Frequently lesions will be surrounded by a water-soaked margin and a yellow halo. As a canker lesion ages, it may lose its palpable roughness, but the concentric circles will still be visible with a hand lens (on the underside of the leaf). The yellow halo eventually changes to dark brown or black and the water-soaked margin surrounding the lesion may diminish. The middle of the lesion (on underside of leaf) will be corky in texture with a volcano or pimple-like point. With the exception of very young lesions, lesions always penetrate through both sides of the leaf. In the presence of damage, the lesion may follow the contours of the damage and therefore may not be circular. In older lesions, a saprophytic white fungus may grow over the center of the lesion. The center of a lesion may fall out producing a shot hole appearance. Fruit - typical citrus canker lesions on fruit will range from 1-10 mm in size. Larger lesions usually penetrate a few millimeters into the rind. Fruit lesions may vary in size and may coalesce. Fruit lesions consist of concentric circles. On some varieties these circles are raised with a rough texture on other varieties the concentric circles are relatively flat like the surface of a record. The middle of the lesion will be corky in texture with a volcano or pimple like point. The center of

a lesion may crack and has a crusty material inside that resembles brown sugar. Frequently on green fruit a yellow halo will be visible; however it will not be visible on ripened fruit. Lesions may have a water-soaked margin and the water-soaked margin is especially evident on smaller lesions. In the presence of damage the lesion may follow the contours of the damage therefore not being circular. In older lesions a saprophytic white fungus may grow over the center of the lesion, the basic strategies of the specific methods are to avoid, exclude, or eradicate the pathogen, to reduce the amount of inoculums available for infection, to minimize dissemination of the pathogen, and to protect susceptible tissue from infection (Civerolo, 1981) [13].

1. Using canker-free nursery stock,
2. Pruning all the infected twigs before monsoon and burning them,
3. 56 Citrus canker – A review periodical spraying of suitable copper-based bactericides (to reduce inoculums build-up on new flushes and to protect expanding fruit surfaces from infection) along with an insecticide (to Control insect injury),
4. Taking some precautions to reduce the risk of spread of disease in orchards and nurseries,
5. By evolving canker-resistant varieties suited to local environmental conditions (Das and Singh, 1999, 2001) [15, 16].

Paracer (1961) [47] recommended pruning of infected twigs before the onset of monsoon and spraying of 1% Bordeaux mixture at periodical intervals for an effective control of the disease. Two pruning along with 4 sprays of 5000 ppm copper oxychloride or 1% Bordeaux mixture is reported to be effective against the disease (Kishun and Chand 1987) [32]. Other chemicals found effective against the canker were perenox (Chowdhury, 1951) [1], Ultrasulphur (Nirvan, 1961), mixture of sodium arsenate and copper sulphate (Patel and Padhya, 1964) [49], Blitox and nickel chloride (Ram *et al.*, 1972) [50]. According to Rangaswami *et al.* (1959) [51], 500–1000 ppm streptomycin sulphate was effective when sprayed with 1% glycerine on acid lime. Six sprays of 1000 ppm streptomycin sulphate along with two pruning reduced the canker in acid lime (Balaraman and Purushotman, 1981) [8].

Citrus Greening

Citrus greening pathogen, now known as Huanglongbing is a phloem-limited, uncultivable gramnegative bacterium (Subandiyah *et al.* 2000; Weinert *et al.* 2004) [57, 62]. The genus is *Liberibacter* from Asia and Africa and two geographically distinct *Candidatus* species, *L. candidatus asiaticum* and *L. candidatus africanum*, are widely distributed (Garnier *et al.* 1984; Jagoueix *et al.* 1996; Akhtar, Ahmad 1999) [21, 28, 3]. The size of this bacterium ranges from 350–550 × 600–1,500 nm and its thickness is 20–25 nm. They are generally rigid rod-like, and are pleomorphic bodies during growth (Su 1998) [56].

Symptoms

On Tree: Greening disease has different names according to their symptom expression in different areas of the citrus growing regions of the world. “Yellow shoot” (Huanglongbing) and “yellow dragon” are the names, describing the symptoms of leaf yellowing that may appear on a single shoot or branch (Chung, Brlansky 2005) [12]. This disease is called “decline” (likubin) in Taiwan, “dieback” in India, “leaf mottle” in Philippines, “vein phloem

degeneration” in Indonesia and “yellow branch”, “blotchy mottle” or “greening” in South Africa, based on the symptoms (Vichitrananda, 1998) [61].

On Leaf: Characteristic symptoms are mottling and chlorosis of leaves. Mottling resembles zinc deficiency symptoms, which are characteristic for the CGD (Elizabeth *et al.* 2005) [19]. A citrus life is on average five to eight years in the Asian region where the disease prevails in the endemic form and displays its symptoms in warm temperature. Root systems are poorly developed in both forms of greening. Roots start decaying from the rootlets.

On fruits: Some fruits are under-developed, lopsided and poorly coloured. Grayish-white waxy marks appear on the rind surface when pressure is exerted with a finger. In the case of African greening, fruits remain immature and green and seeds are aborted and stained.

Management

Different management strategies are needed to avoid a potential threat of greening disease.

Legislative control. Legislative control has been made to prevent the spread of pathogen. Following legislative control is needed to be established (Kawano 1998) [30].

1. Regulatory plants: Rutaceae. *Poncirus trifoliata*, *Fortunella* spp., and living plants of citrus genus (excluding fruits and seeds).
2. Regulatory pathogen and insect: citrus greening bacteria and citrus Psylla.
3. Protection of mother stock: Mother plants should be regularly checked for citrus greening and should be kept under isolation to prevent the plants from insect.

Thermotherapy. Another approach found to be very effective in the control of citrus greening. Graft wood is heated to 48–50°C for several minutes (Graca 1991) [22]. Elimination of yellow shoot disease was reported by Lin in 1964, giving a saturated hot air treatment to graft wood at 48–58°C.

Chemotherapy. Tetracycline hydrochloride showed good results in reducing leaf symptoms (Martinez *et al.* 1970). Penicillin carbendazin gave complete control (Cheema *et al.* 1986). Schwarz and Van Vuuren (1970) showed the best results through the injections of tetracycline hydrochloride. The best time for injection is in the spring season.

Eradication and replacement. Young trees (less than four-year old) and those not bearing fruits and showing symptoms should be eradicated and replaced, whereas trees with fruit should be pruned. Trees infected up to 50–70% should be eradicated.

Control of vector. Attempts have been made to control the vectors through different approaches e.g. by means of cultural, chemical or biological measures. The parasite (*Tamarixia radiata*) was found effective against the disease. Systemic insecticides like dimethoate and monocrotophos controlled *D. citri* (Graca 1991) [22]. Methomyl or melathion sprays on citrus trees at 10–12-day intervals from March to May were not effective against citrus greening. Sometimes 44% Dimethoate EC, 50% melathion EC and 40.64% carbofuran FP showed economically good control of the *Psylla* (Chiou-nan Chen 1998) [10].

Citrus tristeza virus: Citrus tristeza virus (CTV) is a major cause of the decline and eventual death of trees on sour orange rootstock. Causal agent- is cluster virus with long flexuous particles 2000 nm long and 12 nm wide with a single-stranded RNA.

Damage

Tristeza represents one of the biggest threats to citrus production around the globe (Pauline & Harty, 1992). Tristeza affects practically all kinds of citrus but mostly orange, grapefruit, and lime (Agrios, 1978). In 1981, the total world loss attributed to this disease was estimated at 50 million trees (Nawaz *et al.*, 2008). Tree decline results from necrosis and death (blockage) of the conductive tissue (phloem), resulting depletion of sugars/starch in the feeder roots leading to the death of the tree (Nawaz *et al.*, 2008).

Trees grafted on sour orange rootstock usually show

Dieback and defoliation, stunting and in many cases complete decline, stem pitting and low yields with small and poor quality, pinholes below the bud union in the inner face of the bark, leaf chlorosis and curling

Vectors of Citrus virus tristeza

1. Aphids (Aphids feeding): *Toxoptera citricidus* (most efficient vector) *Aphis gossypii* - less efficient but still effective *Aphis spiraeicola*- less efficient. *Aphis aurantii* -
2. Infected plant material is the most important means of *tristeza* spreading

Control

Tolerant rootstocks - CTV is controlled by the using of tristeza tolerant rootstock. There is no such thing as perfect rootstock. Selection is matter of determining which stock will perform best in your situation

Rootstocks should be selected for their

Ability to perform under your soil and climatic conditions:
Resistance to pest and diseases. Compatibility with the variety you are plant and positive impact they have on fruit yield and quality (Lacy & Foord, 2005).

Rootstocks commonly available

Troyer and Carrizo Citrange: Both rootstocks are cold hardy. Produced vigorous trees and perform well on most soil types, though they will not grow well in calcareous soils or under saline conditions. They tolerant to CTV, nematode, root rot, but susceptible to severe strains of exocortis viroid. Both rootstocks compatible with most common varieties.

Trifoliata (*Poncirus trifoliata*): Trifoliata performs best on heavier clay loamy soils, but not well suited to sandy soils. Trifoliata is cold hardy, but has poor drought tolerance and poor suited to saline and highly alkaline or acidic soil conditions. This rootstock is resistant to citrus nematode, CTV, root rots, but susceptible to the exocortis viroid. Trifoliata is incompatible with some minor varieties (Eureka lemon and others). Others tolerant rootstocks to CTV- Swingle Citrumelo (grapefruit), Volkameriana, Rough lemon (*C. jambhiri*), Cleopatra Mandarin, Sweet orange, C-35.

Cross protection

Mild Strain protection: In the recent years much effort has been devoted to mild strain cross protection research. Cross protection works on the basis that if you inoculate trees with

mild CTV isolate and later infect with a severe isolate, the symptoms of the severe isolate would not be expressed. This approach at the present appears promising in the controlling stem pitting symptoms in trees tolerant rootstocks varieties. It has not been effective in controlling of decline trees on sour orange rootstocks. However this method has many difficulties and in practical is only efficient in Brazil and South Africa

Program for virus-free nursery plants

Scion groves or mother trees with protective measures to prevent infection with pathogen by insect virus. These citrus provide virus-free bud wood for citrus nurseries. Bud wood is cut from one of the registered scion trees. The rootstock is grown from seed. Grafting or budding virus-free bud wood onto rootstock from seed produced almost 100% virus-free plants.

Recommendations

Using only certified scion - from the local confirmed mother trees (Examined every year to the CTV presence by ELISA and indicators tree (Mexican lime and Citron). Mother trees should be grown in nurseries under controlled conditions and treated with chemicals against aphids. Use compatible tolerant rootstock to CTV with suitable scion cultivar (Field experiments). Destruction of all affected trees with CTV. Survey-in Israel is done mostly for the detection of CTV in mothers trees because the presence of the only mild strains. Establishment- of local nursery for certified wood bud production.

Recommendations (Eppo quarantine pest).

Strict quarantine measures are necessary to avoid introduction of CTV into countries where the virus is not present or introduction of severe strains in areas with only relatively mild strains. Continuing the maintenance of CTV- free trees of important commercial cultivars in an aphid- proof screen house. Using tolerant rootstocks and tristeza-free propagation material. It is also necessary to spray nursery plants of young trees to control aphids to prevent re-infection with the virus. Large-scale surveys using the ELISA technique with monoclonal antibodies. Any new outbreak should be eradicated quickly to avoid virus spread. Fruit from infested countries should be free from leaves, peduncles washed and waxed or fumigated. Certification programmes should be established in all citrus- growing to guarantee that CTV is not spread with bud wood used for commercial propagation.

Citrus gummosis or leaf fall and fruit rot of citrus

Phytophthora palmivora, *P. parasitica* and *P. citrophthora*
This disease is found almost all citrus growing part of India; it is prevalent in many parts including Gujarat, Maharashtra, Karnataka. Assam and Tamil Nadu. Sweet varieties are more susceptible than the sour ones.

Symptoms: Gummosis occurs mainly at the basal part of the trunk and later spreads to the thicker branches also. Usually, infection starts from ground level. The earliest symptom is the appearance of water-soaked patches in the basal part of the stem, followed by oozing out of a brownish, gummy exudate. The disease spreads up the trunk and down to the roots. When the stem portion above the ground level is attacked, droplets of gum trickle down the stem to the base. Exudation of gum is not conspicuous always, as it is washed down during the rains and the exudates near the ground get mixed up with the soil. However, during the summer months, the bark shows brown

staining and hardened masses of gum on the surface. In course of time, longitudinal cracks develop in the bark, which peels off leaving the wood exposed. Heavy clay soils high soil moisture temperature ranging from 24°-25°C are conducive for disease occurrence.

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