Citrus foot rot disease (*Phytophthora* spp.) control in Indonesia using good agricultural practices efforts green agroindustry

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**Abstract.** Foot Rot (*Phytophthora* spp.) is an important disease in Indonesia and in the world. Around 35% of citrus plantations have been damaged by the complex of foot rot disease and Diplodia disease (*Botryodiplodia theobromae*), mainly in swamps and irrigated fields. The spread of the disease is fast, but the knowledge of citrus farmers is still limited, causing rapid death in production plants. This paper purpose is to provide an overview of the citrus root disease control from research studies supporting the efforts of Good Agricultural Practices in Indonesia. Usually farmers only rely on systemic pesticides to control disease, but it is not always successful. Control by means of healthy cultivation is highly recommended in supporting green agroindustry and saving nature. Integrated and rational control strategies, require knowledge of the ecology and epidemic of diseases ranging from seedlings to gardens. Propagule pathogens can survive in seeds, tree stumps, soil, even in alternative hosts. Therefore, to control the disease it must be directed not only to oranges but also to alternative hosts as well and to destroy pathogenic retention sites. The recommended integrated control strategy is to use disease-resistant plants, making sewers, garden sanitation, and optimal maintenance. This method is very effective and environmentally friendly.

1. **Introduction**
Citrus occupies an important place in Indonesia's horticultural and economic wealth as the third largest fruit industry after mangoes and bananas, with a total production of 1,999,000 tons in 2016 [4]. Indonesia is currently developing tangerines, considering that imports of these oranges are still increasing. In 2012 citrus imports reached 170,000 tons or Rp.1.6 trillion. Even though Indonesia has around 85 varieties that have not yet been fully developed. Although technically, financially, and socially, citrus farming is feasible to be developed, it does not mean that this farming is without obstacles. Among these obstacles, is a disease that interferes with the production and quality of fruit.

*Phytophthora* stem rot is one of the most important diseases carried by the soil. This disease causes the death of newly planted plants and slow plant development, as well as causing yield losses in productive plants. Foot rot, root rot, root neck rot and, crown rot, this is caused by *Phytophthora* spp. [21,38]. This pathogen exists in almost all citrus areas in Florida, Brazil and damage in Florida is estimated to be 8% to 20% in the garden and causes 50% loss of lateral roots [9]. Losses due to *Phytophthora* spp. difficult to judge accurately[24,25] because the relationship between root damage and loss of yield is disproportionate [38]. However, yield losses in Florida from root rot and stem rot are estimated to range from 3% to 6% per year, or $30-60 million, without treatment control and it is
estimated that there is an interaction between Phytophthora and beetles[23]. This loss does not include yield loss due to fruit rot, which varies widely with weather conditions from year to year. About 46% of the citrus crop and citrus industry in California and about 12.9 million dollars per year in losses due to disease attacks reached 88.89% in India [38]. Surveillance results [9] state that yield losses due to Phytophthora on annual plants in Indonesia are 6-12% with an average loss of US 23,400,000, while the Directorate of Horticultural protection reports that the average citrus loss of production due to Phytophthora, Diplodia and Huanglungbin in Indonesia in 2001-2003 was 60,960 tons or Rp. 236,926,500,000 [3].

Some effective chemical control practices are available for the management of this disease epidemic but to support environmentally friendly agriculture that preserves nature, it is necessary to include aspects of sustainable healthy cultivation management in controlling the disease. Several potential biological agents and botanic plants have been investigated to control Phytophthora's disease. The use of healthy plants and resistant rootstock, soil solarization, planting in mounds in wetland or swamp area, sanitation, regulating drainage, biological agents, mycorrhizae and aamenten in severely attacked plants combined with rational pesticides. This control has good prospects in the future because it can reduce the highcost benefit ratio and preserve the environment [11,13,17,35].

2. Symptoms of Phytophthora disease in Indonesia citrus plantation

2.1. Damping-off
Damping-off of seedlings in nursery bed is a widespread problem of the citrus industry and frequently occurs in citrus orchards where phytosanitary conditions are difficult to maintain. More than 20% seedling mortality has been observed in central India due to Phytophthora infection,[22]. Damping-off of Citrus seedlings is caused by *Phytophthora parasitica*, *P. citrophthora* and *P. palmivora*. Typical symptoms of damping-off result when the soil-borne fungus penetrates the stem just above the soil line and causes the seedling to topple. *Phytophthora* spp. also causes seed rot or pre-emergence rot. Infected seedlings are killed rapidly when moisture is abundant and temperatures are favorable for fungal growth [37].

2.2. Foot rot and Gummosis
Foot rot lesions developed as high as 60 cm from the ground level on the trunk and extended below the soil on crown roots as crown rot. On scraping the dead bark of the lesion, a brown discoloured, slippery area was observed. Such active lesions started oozing gum which observed on the trunk as brownish-black oozing known as gummosis. In dry season, the dead bark becomes firm, break away from healthy bark, curled and splitted. In severe cases, when foot and significant portion of root system was damaged, the large branches of the same side of the affected plants were killed due to the rot of conducting tissues near the bark. It attacks citrus species right from damping-off in nursery beds to fibrous root rot, crown rot, premature leaf fall, foot rot and gummosis in mature orchards and infect almost every part of citrus plants. This oomycete infects and induces the gum exudations from the trunk, giving the branches a bleeding appearance. The expansion of the lesions upwards affects secondary branches, and downwards it affects the trunk ultimately resulting in a dieback of infected limbs or trees. During infection, the pathogen establishes intimate relationship with their hosts by forming haustoria, redirecting host metabolism and suppression [2].

2.3. Fibrous root rot
Fibrous root rot is caused by infection of *Phytophthora* spp. to the root cortex which starts decaying of fibrous roots. The cortex turns soft, becomes somewhat discoloured and appears water-soaked. After severe infection cortex of fibrous roots gets destroyed leaving only the white threadlike stele, which gives the root system a stringy appearance. Root rot can be especially severe on susceptible rootstocks in infested nursery soil. Root rot also occurs on susceptible rootstocks in bearing orchards where damage causes tree decline and yield losses. In advanced stages of decline, the production of new fibrous roots cannot keep pace with root death. Under these conditions tree is unable to maintain
adequate water and mineral uptake and nutrient reserves in the root as roots are depleted by repeated severe attack of fungus. This results in the reduction of fruit size and production, loss of leaves and twig dieback of the canopy.

2.4. Die back
Dull chlorotic foliage is the first symptoms of such affected plants where mid rib, main lateral veins and bands of leaf tissue bordering them became yellow-leaved rest of the leaf normal in colour. The diseased plants thus had comparatively fewer fibrous roots than healthy plants. In severe cases, where regeneration of feeder root did not cope with the rate of destruction, the affected plant shown, starvation, less canopy volume with naked branches, die back and slow decline symptoms [27].

2.5. Brown rot of fruit
When fruits are infected by Phytophthora, it produces a decay in which the affected area is light brown, leathery and not sunken compared to the adjacent rind. Under humid conditions, the white mycelium grows on the rind surface. In the orchard, fruits near the ground become infected when splashed with soil containing the fungus. The disease spreads to fruits throughout the canopy, if favourable conditions of optimum temperature (75-82°F) and long periods of wetting (18 plus hours) continue. Most of the infected fruits soon abscise, but harvested fruits may not show symptoms until they have been kept in storage for a few days. If infected fruit is packed, brown rot may spread to adjacent fruits in the container. In storage, infected fruit has a characteristic pungent, rancid odour. Brown rot epidemics are usually restricted to areas where rainfall coincides with the early stages of fruit maturity [25]. In continuously wet weather conditions about 24 hrs or more, Phytophthora splashed along with rain drops to low hanging fruits and caused a typical brown rot of fruits and leaf fall [27].

3. Species of Phytophthora on citrus plants in Indonesia
In Indonesia, 3 species of Phytophthora were found in citrus plants, which were morphologically identified [33, 17] namely P. parasitica, P palmivora, P. citrophthora (Table 1) and from molecular identification [42], who studied the phylogenetic relationship using the Polymerase Chain Reaction of citrus Infected of Phytophthora sp in Jawa Timur Indonesia. The result showed that dendogram isolates from Banyuwangi, Jember, Ponorogo, Blitar and Tulungagung had 100% similarity coefficient, while the 2 isolates from Banyuwangi had a similarity of around 82%. Isolates from Ponorogo numbers 3, 4, and 5 have a 100% similarity coefficient. This isolate with 21 other isolates had the smallest similarity (28%).

Table 1. Phytophthora Morphological Identification [17]

| Sample origin from | Form of Sporangium | Size of Sporangium (µm) | Form of colony | Ø of colony (cm) | Morphological Identification Results |
|--------------------|--------------------|------------------------|----------------|-----------------|-------------------------------------|
| Banyuwangi         | Papilate, Ovoid    | 21.47-32.6 x 21.48-29.88 | Cottony Stelate | 6.32            | P. parasitica                       |
| Jember             | Papilate, Ovoid    | 14.74-30 x 13.98-30,09 | Cottony        | 6.55            | P. parasitica                       |
| Ponorogo           | Papilate Globuse   | 19.28-33.10 x 17-30     | Cottony        | 6.85            | P. parasitica                       |
| Blitar             | Papillate, ovoid   | 17.02-28.3 x 14.46-28.9 | Cottony        | 4.9             | P. parasitica                       |
| Tulungagung        | Semi Papilate ellipsoid | 14.44-30.22 x 13.86     | Rossaceous-cottony | 6.35           | P. palmivora                        |
| Tekung             | Papilate Ovoid     | 38.25-43.56 x 33.22-50.00 | Cottony Stelate | 6.35            | P. citrophthora                      |
| Kraton, Pasuruan   | Semi Papilate ellipsoid | 19.32-40 x 17.28-35.5   | Rossaceous-cottony | 6.37           | P. palmivora                        |
4. Management strategies for Phytophthora diseases Control In citrus Using Good Agricultural Practices Efforts Green Agroindustry

Integrated control is considered effective and friendly environment, that is by combining several appropriate control techniques for the purpose of maintaining ecological balance, develop unwanted environmental conditions disease, and improve health and or plant resistance. that integrated control is designed for balancing and managing activities related to the citrus plant life cycle, improve the level of health and or plant resistance to foot rot/root rot disease. The integrated management of this disease integrated suggested to complete the activity minimal application of fungicides with good and correct cultivation practices (technical culture).

4.1. Use of healthy plants and tolerant rootstock

The use of healthy seeds with the blue label is an initial guarantee for the success of the orange business. Quality citrus seeds are defined as healthy seeds, similar to the parent (true to type) and the stages of supervision follow the applicable certification or labelling program. In the steps of monitoring the health of citrus seeds also examined the systemic disease of the base of the stem/root of Phytophthora. Currently Indonesian farmers are required to use blue labeled seeds and legally strengthened by Regulation of the Minister of Agriculture Number: 39 / Permentan / OT.140 /8/2006 concerning Production, Certification and Distribution of Seed Development Guidance for disease-free citrus seed regulations and Decree of the Minister of Agriculture of the Republic of Indonesia No.04/KPTS/SR.130/D/6/2019 concerning Technical Guidelines for citrus Seed Production.

Table 2. Resistance to citrus rootstock against Phytophthora sp. On the tidal land of Sei Kambat village, Barito Kuala Regency [13]

| Treatment          | Symptoms of phytophthora infection | Plant Resistance Criteria |
|--------------------|-----------------------------------|---------------------------|
|                    | leaf                              | Stem, branch              | root     |                   |
| Volkameriana (V)   | Light yellowing (N)                | -                         | -        | T                  |
| Rough lemon (RL)   | -                                 | -                         | -        | ST                 |
| Japanese Citroen (JC) | -                                | -                         | -        | ST                 |
| Troyer (T)         | Leaves fall lightly               | -                         | -        | AT                 |
| Emperor            | -                                 | root rot/die              |          | SR                 |
| Mandarin (E)       | Citromello (C)                    | wilted leaves, yellowing  | Light stem rot | AR       |
| Cleopatra mandarin (CL) | -                           | -                         | -        | ST                 |
| Poncirus trifoliata (PT) | -                             | -                         | -        | ST                 |

Notes: Very Resistant (ST) = healthy leaves, stems and roots; Resistant (T) = leaves (yellowing), healthy stems and roots; slightly Resistant (AT) = wilting/falling leaves, healthy stems and roots; slightly sensitive (AR) = symptoms of wilted leaves, loss, stem rot, healthy roots; sensitive (R) = symptoms of wilting/falling leaves, wound stems, root rot; Very sensitive (SR) = root rot, dead plants

Citrus seeds planted in endemic areas should have a grafting height of ± 60 cm above the surface of the soil and planting on a mound as high as 15-20 cm. The use of resistant rootstock can be selected from research results [13] in the tidal land of South Kalimantan, namely varieties of Rough Lemon, Japanese Citroen, Cleopatra mandarin, and Poncirus trifoliata which have very resistant, Volkameriana resistant (Table 2). There is potential for interstock, scion of lime combined with interstock from Volkameriana, Troyer citrange, and Kanci able to inhibit the development of pathogenic citrus stem root pathogens [16] so it needs to be investigated for their effects on foot root disease.

4.2. Soil Solarization

Controlling root rot and base of citrus stems with solarization has not been widely applied in Indonesia. Solarization of soil recommendations with HP plastic is usually preferred for pest control and control of citrus weeds. Soil solarization is generally effective for controlling high-temperature
sensitive types of pathogens, including various fungi that cause wilting plants such as *Verticillium* sp., *Fusarium oxysporum*, *Sclerotium* sp., *Pythium* spp., *Rhizoctonia solani*, *Phytophthora* sp., Nematodes (*Pratylenchus* and *Xiphinema*), as well as some bacteria such as *Agrobacterium*, *Clavibacter* sp., and *Streptomyces* [30,39]. Control with soil solarization, which is a potential control method, is recommended in locations with a lot of inundation, soil that has been infected with *Phytophthora* fungus, and unclean water. This method is environmentally friendly by manipulating the environment around the roots through soil solarization. Soil solarization is defined as the process of soil heating using sunlight energy to disinfect the soil, which causes pathogens in the soil to be impaired so that plant diseases do not develop. Solarization is implemented in the form of soil mulching using transparent polyethylene (PE) transparent plastic. The high temperature in the soil is an important factor in the process of solarization. Plastic mulch can increase temperatures up to 35−60 °C, especially in surface soils.

The color of the plastic affects the high temperature achieved in the solarization process. Transparent plastic can be penetrated by solar radiation with a very high percentage, 85−95% [31]. In addition to increasing soil temperature, plastic mulch is also able to maintain soil moisture, at the bottom of the plastic formed a lot of dew that is useful for improving plant growth. Solarization of soils under wet (moist soil) conditions is more effective in controlling soil infectious diseases than dry heating conditions [40]. In Indonesia, the time to install the mulch after the second fertilization. On average since 3 months after flowering, planters fertilize plants for the 2nd time. Installation for 6 months or 1-1.5 months before harvest. The size of the plastic mulch adjusts to the size of the stem and the age of the plant. At the age of not being productive enough to use mulch size is 1mx1m and if the age of 3 years is 2mx2m. Before installing plastic, the grass is shortened first if the weed is already high. This plastic mulch can be used up to 3 times the growing season or 3 years. PHP mulch can be used up to 3 times the growing season or 3 years. After use can be folded and tucked in the stem of the plant (Figure 1a).

**Figure 1.** a. Installation of soil solarization on citrus plants, with PHP plastic (silver black plastic) the size of a tree canopy. (doc. ICIFRI 2015), b. organic mulch of *Arachis pentoi*

4.3. Application of compost with chicken manure and organic mulch

Intermittent organic mulch application with soil solarization using plastics. Application of mulch and organic fertilizer are especially needed in soils that lack water, or in the dry season. Besides increasing soil microbial activity to induce antagonistic fungi. Likewise, the benefits of manure, ammonia elements and organic acids contained in the pile are decomposed into organic material that can kill phytophthora fungi, organic material residues provide nutrients for the soil for the growth of antagonistic fungi in the soil [41]. The important thing to watch out for in using manure is not to use a pile that is not yet ripe because it can damage the roots. Cover crops can reduce root rot, especially phytophthora. In ICISFRI began researching *Arachis pentoi* cover crop types by adopting from phytophthora control technology on cocoa (Figure 1b). Nitrogen fertilization is not recommended because it can increase the incidence of disease.
Mulch stimulates the growth of plant roots, increasing Nutrient uptake, reduce evaporation from the soil, increase groundwater containment capacity, reduce surface runoff, facilitate drainage, regulate soil temperature, and provide high levels of nutrients for soil microbes [5]. Compost with Manure can increase or suppress disease, depending on its nature. Phytophthora is inhibited by alfalfa flour, cotton waste, soy food, wheat straw, chicken manure and urea. Ammonia and volatile organic acids released by decomposed organic matter kill Phytophthora, and residual organic matter stimulates competitiveness and antagonistic microorganisms in the soil [32]. While these mechanisms suppress the growth of Phytophthora, they might also make phytotoxicity to plant roots, making it less attractive for colonization by pathogens [9]. All compost increases soil organic matter, total biological activity, and antagonist populations of actinomycetes, fluorescent pseudomonads, and fungi. Addition of compost is needed for disease development but not enough for biological control. Mulch can also reduce the effects of rotten Phytophthora root if used from the time of initial garden preparation or if the disease is not too far advanced.

4.4. **Planting in hill/mounds on wetland or tidal area**

Citrus on tidal land have planted either monoculture or intercropping with rice. Citrus cultivation in tidal swamps using the surjan system, that is planted with citrus mounds, while on the alley planted with rice paddies. Planting citrus in mounds is highly recommended in efforts to control soil-borne diseases. Grafting limits should not be buried in mounds, to avoid splashing water from contaminated soil contaminated pathogens, you should grafting at least 20 cm above ground level. Ground mounds around trees are recommended for good drainage management [10]. Plants are planted in rows to prevent beds water in direct contact with plants, by making waterways. To reduce the rate of increase inoculums, plants must be irrigated less often so that water flows [7]. In areas where rainfall is the main source of water, optimal horizontal and vertical drainage is needed to prevent standing water. Spraying water on tree trunks should be avoided because bark that continues to wet can encourage the development of disease.

4.5. **Sanitation**

The effectiveness of control strategies depends on the ability of an individual species of Phytophthora to survive, either as a saprophyte or as dormant spores. Generally, mycelium and zoospores survive for only a few weeks, while chlamydospores may survive for 6 years, and oospores for 13 years [10].

Sanitation of diseased or dead seeds or plants and infected fruit by total eradication until the roots, collecting and must be burned immediately, should not be buried in the ground. Parts of the skin that are diseased until removed at least 1 cm in contact with healthy skin, scars rubbed with a fungicide, collect the remains of plants and plants that die of disease are burned. Maintain cleanliness of agricultural equipment with 70% alcohol or 10% Sodium hypochlorite.

4.6. **Drainage and water management**

Excessive irrigation and high rainfall are considered the most important factor that increases the severity and spread of disease that triggers Phytophthora on pathogen-contaminated soil, leaves, infected fruit that falls to the ground. In the submerged conditions Propagul breed and infect[10]. In addition, zoospores, cysts and kladidospora move on the ground following irrigation water, rain runoff. The farm must have good drainage and not be flooded. Therefore, the sloping ground is better. Ideally, the soil should be dried to a depth of 1.5 meters. Drainage and water management in paddy fields or tidal land is aimed so that rainwater and watering water should not pool in the vicinity of the base of the trunk by making bumps and trenches so that water can flow completely. Inundation and layers of pyrite in tidal swamps are a severe limitation for citrus plants if land management is not done properly. The most important aspect that must be considered in the management of tidal swamps is to protect the roots of citrus plants from tidal inundation and pyrite layers and their negative effects. Under natural conditions, peatlands are always water-saturated (anaerobic). On the contrary, most of the cultivated plants require aerobic conditions. Efforts to overcome this contradictory matter, then made the creation of drainage channels to reduce the surface of the ground water is only limited to
create aerobic conditions in the plant root zone so that plant roots are not submerged and plants can grow optimally.

4.7. Biological control

Biological control can be interpreted using biological agents and botanical agents. Many experiments are carried out with biological agents of Phytophthora in vitro, pot experiments, but rarely in the field. Research on large-scale biological control has been carried out in screening efforts without seeking further understanding of the interactions between biological control agents and Phytophthora. If disease management will be highly based on biological control, research efforts in this area will need to be significantly increased, because there are very few choices for biocontrol agents for Phytophthora or effective techniques for implementing them. However, biological control does provide attractive and environmentally friendly options for controlling or suppressing the development of Phytophthora disease. The latest developments in biological control for orange Phytophthora in Indonesia include: Developments in biological control for stem rot, stem roots and roots of citrus plants in Indonesia include: the use of organic material / compost / manure containing Trichoderma harzianum, T. viride, T. hamantum, T.koningii [6] T asperellum [1,15], Mucor sp. [37].

Mycorrhizae can also provide biological control over orange phytophthora. [34] reported that the average level of FMA infection in the Rhythm of SoE tangerines infected with Phytophthora was 21.76%. Glomus sp. has the potential to increase the resistance to root disease in increasing the resistance of citrus plants to Phytophthora sp. [14,17]. A single CMA and a combination of yeast + CMA are recommended for controlling citrus rot disease [29] while abroad successfully controlling this disease with Actinomycetes [43] Penicillium funiculosum [14] Gliocladium spp. [8, 10, 28] and Chaetomium globosum [10] All of these agents have all the distressed growth of P.cinnamomi, mostly by hyphal lysis, but can also promote host growth[18].

The latest development of environmentally friendly controls that have begun to develop is Secondary Metabolites originating from Biological Control Agents or so-called MS APH is an organic compound that can be utilized for pest control. The function of MS APH is to inhibit the germination of pathogenic spores, protect early growth, clean the environment, protect and strengthen tissues, provide nutrient supply, stimulate the formation of growth regulators. MS APH is soluble in water, leaves no residue, does not evaporate, is easily applied, can be combined with fertilizers and pesticides, is effective and efficient for controlling pests. T Harsianum and T. Asperellum have started to be produced by MS APH and have been applied in community citrus plantations in Kendari and South Kalimantan and have shown quite good results (Figure 2,3).

Botanic agents pesticides that have been tried for citrus phytophthora are clove waste [12] which is applied by immersing it in the soil around the roots. In cocoa, citronella oil has proven to be effective for controlling Phytophthora pamilovora [26].
4.8. Aannten in severely infected plants

In the case of citrus plants which are severely infected by the root or base of the stem but are still productive, an attempt is made to carry out aannten (suckling with some new rootstocks on the diseased tree) [12]. Infected plants side grafted with several rootstocks above the affected stem (Figure 4). Then after the connection is made and strong enough to support the upper trunk, the diseased rootstock is dismantled to its roots, the soil is left exposed and given a systemic fungicide. This method can extend the life of productive plants whose roots are damaged.
4.9. Combined with rational pesticides
Fungicides specifically recommended for root and stem rot diseases in citrus plants do not yet exist. However, from searching for references to phytophthora disease, it is known that there are some effective pesticides to control disease-causing pathogens [10, 20, 21] the Oomycetes class, including phytophthora (Table 3). Besides that, there are currently several fungicides that might be able to effectively control phytophthora in a semi-laboratory setting.

![Image](image_url)

**Figure 4.** Aannten or Breastfeeding with some new rootstock on the diseased tree above the infected stem on seedling, b). on plant, c) plant resulting from breastfeeding products well

| No | Common name of fungicide | Chemical | Trade name |
|----|--------------------------|----------|------------|
| 1. | Karbamat                 |          |            |
|    | - Prothiocarb            | S-ethyl(3-dimethylamino propyl) thiocarbamate | Previcur 70 SCW |
|    | - Propamocarb            | Propyl 3-(dimethylamino) propylcarbamate | Previcur N |
| 2  | Cyanoacetamide-oximes    |          |            |
|    | - Cymoxanil              | 1-(2-Cyano-2 methoxy methyl) minoacetetyl – 3 -ethylurea | Curzate WP |
| 3  | Ethyl phosphonat         |          |            |
|    | - Fosetyl                | Ethylhydrogen phosphate aluminium salt | Alliette WP |
| 4  | Phenylamides             |          |            |
|    | - Metalaxyl              | Methyl N – (2-methoxyacetyl)-N (2,6-xylyl)-DL-alaninate | Ridomil WP, G |
| 5  | Asam Fosfit              | -        | Forlisfos, AS |

**Table 3.** Fungicides for controlling foot root and rot root diseases

**Future Directions citrus phytophthora research**
Future research that needs to be further developed and strengthened are: 1). Study the nature and diversity of Phytophthora in citrus and plan national programs to obtain new high-yielding varieties that are resistant through breeding selection programs, 2). Study the disease epidemic in detail, 3). Study the production process and mass production of effective APH consortium MS products, 4). Downstreaming of integrated phytophthora disease control technology, 5). Regional collaboration through the establishment of phytophthora working groups for Southeast Asian countries sharing phytophthora issues.
Conclusion
Phytophthora is a pathogen that has begun to be recognized as harmful to citrus plants. This pathogen attacks seedlings, stem roots, roots and fruit. Stem rot is very difficult to control because pathogens can generally survive as mycelium and chlamydospores (thick-walled resistant spores) on infected plant material such as roots, stem cancer, mummy fruits, or in the soil for long periods of time. Integrated control by combining various technological components for the management of available diseases, such as the use of healthy seeds, tolerant rootstock, planting in mounds, soil solarization, mulching, water management, garden and plant sanitation; biological control with biological and botanical agents, anentens and fungicides if necessary.

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