TARO DISEASES

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Abstract

Although taro is susceptible to attack by at least twenty-three pathogens, only a few cause serious reduction in growth and production. Phytophthora blight (Phytophthora colocasiae) and Pythium root and corm rot (Pythium spp.) are the most serious fungal diseases of taro. Phytophthora blight is not yet found in Samoa, the Marquesas, the Society and Cook Islands. Dithane-M45 is available for control of Phytophthora blight. Pythium root and corm rot is found where ever taro is grown. Five Pythium spp. have been implicated as causal agents of the disease. Captan provides good control of the disease. Data to apply for metalaxyl registration on taro for control of Pythium root and corm rots are being collected. Phyllosticta leaf spot (Phyllosticta colocasiophila), Sclerotium blight (Sclerotium rolfsii), Black rot (Ceratocystis fimbriata), Rhizopus rot (Rhizopus stolonifer), Phytophthora root rot (P. palmivora) and Fusarium dry rot (Fusarium solani) are other fungal diseases which may be locally important. Hard rot (unknown etiology) is a major problem in wetland taro culture where it can cause substantial losses. Erwinia spp. may cause bacterial soft rots. Root-knot nematodes (Meloidogyne spp.) cause root galls and corm malformations.

Introduction

Yield loss of taro due to disease is not well known. Individual fields may suffer from little yield loss to as much as 30 percent loss due to Phytophthora colocasiae leaf blight (Trujillo and Aragaki 1964) and up to 100 percent from Pythium root and corm rot (Plucknett, de la Peña, and Obrero 1970). Most yield losses in the wetland taro crop may be traced directly to diseases. On the other hand, in dryland taro cultivation, water, and insects may be more important primary factors in limiting potential yield.

Fungal Diseases

Phytophthora Leaf Blight (Phytophthora colocasiae Rac.)

In the Pacific Basin, Pythium corm rot (Trujillo 1967; Plucknett, de la Peña, and Obrero 1970) and Phytophthora leaf blight (Trujillo 1967; Jackson and Gollifer 1975c) are the most serious diseases of the crop. Raciborski (1900) described Phytophthora colocasiae causing leaf blight in 1900 from Java. The pathogen probably spread from Java to the North Pacific; from Java to the Central Pacific; and from Java to the South Pacific (Trujillo 1967). Movement on the northern route went from Java to Taiwan, where Butler and Kulkarn (1913) reported it in 1911. From Taiwan it is believed to have moved to Japan and then to Hawaii, arriving probably in the early 1920s.

The first observation of the disease from the Philippines was in 1916 (Gomez 1925). Movement into Micronesia then probably came from the Philippines (Trujillo 1967). The most recent spread extends into the South Pacific through New Guinea, Australia, the Solomons, and Fiji, where Parham (1949) reported it present in 1948. The disease has not been reported from Samoa, Tonga, the Cook Islands, the Society Islands, or the Marquesas Islands.

Epidemics of leaf blight may occur throughout the year during rainy, overcast weather when night temperatures are between 20-22 °C and temperatures during the day are from 25-28 °C. Entire fields may be blighted in five to seven days under these conditions (Trujillo 1965; Trujillo and Aragaki 1964).

The early stages of the disease are characterized by small circular water-soaked lesions 1-2 cm in diameter, generally dark brown or purple. A clear amber fluid exudes from the center of the lesion. This liquid turns bright yellow or dark purple when it dries. The lesions rapidly enlarge and take on a zonate appearance. The zonation is the result of the temperature-related growth response of the fungus, with rapid growth during the warm days followed by slow growth during the cooler nights. The sporangia appear as a white fuzz on both sides of the leaf. The ring of sporangia are particularly prominent in the morning before the leaves dry. After initial establishment lesion development is rapid until the leaf is entirely colonized and collapses. Under severe conditions the fungus destroys the leaf petiole as well as the lamina and enters the corm causing a firm cream to brownish rot, with little or no odor. The difference between healthy and diseased tissue is well-defined.

The corm rot phase, although not a problem in Hawaii, limits production in the Marianas and the Caroline Islands. Phytophthora colocasiae is probably the principal cause of storage rots in the Solomon Islands and other islands in Melanesia and Micronesia. Up to 70 percent of the rots in the Solomons are attributed to this fungus (Jackson and Gollifer 1975b). It is not a cause of storage rot in Hawaii.

Copper fungicides applied with low volume spraying equipment are effective in Hawaii for control of this disease. A back-mounted knapsack mist blower can cover up to 12.5 meters horizontally with its valve fully opened and motor accelerated to maximum air speed. For each tank mix 227 g of basic copper to 7.6 liters of water and 14 ml of spreader sticker is used. The spraying should be done on days when wind velocities are less than 8 kph, with the spray directed downwind. Spraying should begin when the taro is 4 months old, with application every week during the rainy weather and every two weeks during the dry weather. Fungicide application should continue until the plants are 9 months old[1].

Copper oxychloride applied weekly at a rate of 2.24 kg ai/38 l/ha with a mist sprayer provided control superior to manzeb and captafol in the Solomon Islands (Jackson and Gollifer 1975a). While captafol provided excellent control of Phytophthora leaf blight, it is phytotoxic to taro and therefore dangerous to use (Berquist 1972, 1974). Manzeb provided good control and had a high residual effect without the phytotoxicity of captafol (Berquist 1972, 1974). Chemical control as developed for Hawaiian conditions is not effective in the wet tropics[2].

Dithane M-45 for control of Phytophthora leaf blight may be applied at 7 to 14 day interval until danger of infection is past at a rate of 1.5 to 2 lbs per acre in 50 to 100 gallons of water with enough Triton B-1956 for through wetting. No more than 25 application to a single crop are permitted and application must be discontinued when plant are 9 months old.

Deshmukh and Chibber (1960) reported the variety Ahina to be resistant to the blight. Paharia and Mathur (1964) found the variety Poonampat to be immune and Sakin V to be resistant to blight in their tests. No resistance has been reported elsewhere in the Pacific Basin (Parris 1941; Hicks 1967).

Increasing planting distance from 46 cm to 75 cm reduces blight incidence in Hawaii (Parris 1941). Sanitation by pruning and removing infected leaves biweekly appears to help reduce disease incidence in the Solomons (Jackson and Gollifer 1975a). Exclusion through quarantine will protect areas still free of the pathogen.

Pythium Rot (Pythium aphanidermatum Fitzpatrick, P. graminicola Subramaniam, P. splendens Brown, P. irregulare Buisman, P. myriotylum Drechsler, P. carolinianum Matthews, P. ultimum Trow.)

Pythium root and corm rot is probably the most widely distributed disease of the crop. Soft rot has been reported from New Caledonia, New Hebrides (Dumbleton 1954), Hawaii (Sedgwick 1902; Carpenter 1919; Parris 1939) Samoa, and Palau (Trujillo 1967), the Solomon Islands (Jackson and Gollifer 1975a), and Puerto Rico (Alvarez-Garcia and Cortes-Monllor 1971). This disease was probably spread with the introduction of the crop. Pythium aphanidermatum, P. graminicola, and P. splendens have been observed to cause losses of up to 80 percent in Palau, Samoa, and Hawaii (Trujillo 1967). Bugnicourt (1954) has reported heavy losses in New Caledonia due to P. irregulare. Jackson and Gollifer (1975a) find P. myriotylum persistently associated with soft rot in the Solomons, while Ooka and Uchida (1985 reported it from Hawaii and Kertz-Moehlendik et al. (1983) found it in Western Samoa. Ooka and Yamamoto (1979) have noted a prevalence of P. carolinianum in soft rotted material in Hawaii.

Conditions required for the occurrence of epidemics of corm soft rot are still only vaguely understood. Warm and stagnant water in the paddies of wet-grown taro as well as poor field sanitation have been suggested as important factors contributing to the high incidence of soft rot (Parris 1941; Plucknett and de la Peña 1971; Plucknett, de la Peña, and Obrero 1970).

The normally firm flesh of the corm is transformed into a soft, mushy, often malodorous mass. In wetland culture, the root system is destroyed except for a small fringe near the apex of the corm. Diseased plants are easily removed from the soil by hand. The plants become stunted, with leaf stalks shortened and leaf blades curled and crinkled, yellowish and spotted. Upon the demise of the main corm the lateral cormels develop roots and remain clustered around the cavity left by the disintegration of the main corm. The skin of the diseased corm usually remains intact until complete disintegration of the corm interior has taken place. When the corm is cut open there is usually a sharp line of demarcation between the healthy and diseased tissue. Newly planted huli may be killed before they are able to produce leaves or may be severely stunted.

Pythium rot caused by P. splendens is white, dry, and crumbling with a sharply defined, irregular boundary between healthy and decayed tissue. A zone of light brown undecayed tissue is often present in front of the rot.

The severity of soft rot may be reduced in soil by incorporating 112 kg Captan 50 WP/ha into the acid soils before planting. Captan is inactivated in alkaline soils. Huli should be selected carefully to avoid those showing any Pythium infection. The selected huli should then be dipped into a Captan suspension to provide them with protection for a few days after planting (Trujillo 1967). However, chemical control measures utilizing Captan are not always successful in reducing losses (Plucknett and de la Peña 1971; Plucknett, de la Peña, and Obrero 1970). Currently, Captan is being supported for registration by IR-4 for use on taro. Parris (1941) found that copper sulfate at doses effective for soft rot control was phytotoxic.

Resistance to Pythium rot occurs in the Hawaiian varieties Kai Kea and Kai Uliuli (Parris 1941). Others exhibiting some field resistance to soft rot are Piko Uaua and Lehua Maoli[3]. The cultivar Oga is tolerant to root attacks in the Solomons and is recommended for areas where Pythium root rot is known to be a problem (Jackson and Gollifer 1975b).

Phyllosticta Leaf Spot (Phyllosticta colocasiophila Weedon)

Phyllosticta leaf spot can often be seen on dryland taro in Hawaii, especially in the high rainfall areas of the islands. It is also known in American Samoa.

Cloudy, rainy weather for a protracted time (2-3 weeks) accompanied by cool winds is conducive to infection and disease development. The disease is limited by hot days and dry cool nights.

The spots on the leaves vary from 8 mm to 25 mm or more and are oval or irregular in shape. The young spots are buff to reddish brown. Older spots are dark brown with a chlorotic region surrounding the lesion. The centers of the infected area frequently rot out to produce a shot-hole type lesion. Phyllosticta spots generally resemble those caused by Phytophthora colocasiae, except for the absence of sporangia produced on Phytophthora colocasiae lesions.

No control is recommended unless Phyllosticta spot is continuously present and causing significant defoliation. Collecting and burning the diseased leaves seems to be of some value. The Hawaiian variety Manini Uliuli is resistant to fungal penetration through the unbroken epidermis (Parris 1941).

Cladosporium Leaf Spot (Cladosporium colocasiae Sawada)

Cladosporium colocasiae causes a relatively innocuous disease common on dryland taro in Hawaii (Parris 1941). Bugnicourt (1958) reports that C. colocasiae is frequently present in the planting of taro in irrigated terraces of New Caledonia. According to Trujillo (1967), it is present in the New Hebrides, Western and American Samoa, the Carolines, and the Marianas.

The disease attacks both wetland and upland taro and occurs mainly on the older leaves. On the upper surface the spot appears as a diffuse light yellow to copper area. On the lower leaf surface the spots are dark brown due to superficial hyphae, sporophores, and conidia of the fungus. The lesions are generally 5-10 mm in diameter.

Since no economic loss has been attributed to the disease, no control measures are needed (Parris 1941).

Sclerotium or Southern Blight (Sclerotium rolfsii Sacc.). Sexual stage: Pellicularia rolfsii (Curze) West (syn. Corticium rolfsii Curzi)

Sclerotium blight is generally a problem of dryland taro, although wetland taro is frequently infected. This disease has been reported in Fiji (Dumbleton 1954), the Philippines (Fajardo and Mendoza 1935), Hawaii (Parris 1941), and India (Goyal et al. 1974). This disease appears to be one of over mature corms and plant stress. Sclerotia abundantly produced on infected corms persist in the soil, causing serious outbreaks of the disease in warm, wet weather following a significant dry spell. They also float on the water of paddies, infecting the dead petioles of the taro when the opportunity presents itself and subsequently invading the corm and producing a rot in the field and in storage under some conditions.

Affected plants are usually stunted and the corms are rotted at the base where abundant sclerotia of the pathogen develop. The sclerotia are small, almost spherical lemon yellow to dark brown bodies resembling cabbage seeds. The rotted tissue is ocherous to brown and soft with a tendency to stringiness. A dense white mycelium may cover the tissue. In the wetland culture the rot frequently starts at the waterline on the corm rather than at its base.

Sclerotium rot of the corm is generally a shallow surface rot occurring below the external mycelial coating of S. rolfsii and occasionally penetrating deeply into the corm as a light pink soft rot with distinct margins. Sclerotia are produced in four to six days.

Sclerotium rolfsii may survive saprophytically on plant debris or as Sclerotia in the soil. When sufficient moisture is present sclerotia germinate and infect young or old roots, dead leaf petioles, and over mature corms. The disease is usually serious during warm wet periods. Flooding of paddy fields in early stages of disease development is an excellent cultural control method in Hawaii. For dryland taro, harvesting the taro before it becomes over mature will reduce losses to this disease. Burying plant debris after harvest by deep plowing is suggested for controlling this disease in other crops (Graham, Kreitlow, and Faulkner 1972; Brandes, Cordero, and Skiles 1959).

There are no chemicals registered for control of Sclerotium rot on taro in the United States (Trujillo 1967).

Spongy Black Rot (Botryodiplodia theobromae Pat.)

Botryodiplodia theobromae causes a spongy rot, occasionally becoming dry and powdery, ranging in color from cream to grayish brown and frequently becoming dark blue to black with an indistinct margin between healthy and diseased tissue. The fungus is capable of invading undamaged corms under conditions of high relative humidity.

Black Rot (Ceratocystis fimbriata Ell. and Halst.)

Ceratocystis fimbriata causes a soft dark to charcoal black rot with a fragrant banana odor, starting from natural or mechanical wounds in corms.

Rhizopus Rot (Rhizopus stolonifer Sacc.)

In Hawaii, Rhizopus stolonifer has caused serious losses in corms stored at moderate temperatures and high humidities while they were awaiting shipment.

Rhizopus rot is a white to cream colored soft rot ranging in consistency from cheesy to watery with a slight yeasty odor. The skin of the corm generally remains intact until the rot is very advanced. External development of mycelium is sparse, however, sporulation at breaks in the skin and wounds resulting from the removal of cormels are extensive, covering these areas with a black powdery layer.

Losses to this disease can be minimized through removal of the roots and soil from the corm, rinsing the corms well with clean water, and dipping them into a 0.5 percent solution of NaOCl for approximately one minute, air drying, and storing the corms in a cool, clean area of approximately 50 percent relative humidity (Ooka 1981).

Fusarium Dry Rot (Fusarium solani [Mars.] Syn. and Hans., Fusarium spp.)

Fusarium dry rot is a brown rot, mostly dry and powdery but sometimes becoming wet and soft in later stages, with a distinct margin between healthy and diseased tissues.

Viral Diseases

Dasheen Mosaic

Dasheen mosaic virus, a flexuous rod 750 nm, was initially described in 1970 as a polyvirus infecting members of the Araceae (Zettler et al. 1970). It has since been detected in taro in Florida (Hartman and Zettler 1972); Egypt (Abo El-Nil and Zettler 1976); Puerto Rico (Alconero and Zettler 1971); Venezuela (De Brot and Ordosgiotti 1974); Japan (Toyama 1975); the Netherlands (van Hoof 1971); the Solomon Islands (Gollifer and Brown 1972; Kenten and Woods 1973); Fiji (Abo El-Nil, Zettler, and Hiebert 1975); and Hawaii[4]. While it has not been documented as reducing yield in taro, it has been shown to adversely affect the growth of Caladium, Dieffenbachia, Philodendron (Hartman and Zettler 1974), and new cocoyam (Volin and Zettler 1976). The virus is well characterized (Hartman 1974; Zettler et al. 1970). Purification techniques for the virus and production of virus specific antisera have been developed (Abo El-Nil, Zettler, and Hiebert 1975).

It is a stylet-borne virus carried by aphids (Myzus persicae Sulzer, Aphis craccivora Koch., A. gossypii Glov.). The foliar symptoms include a dispersed and veinal mosaic pattern on the leaves. Leaf distortion is generally mild to moderate. Plants generally become asymptomatic three to four months after initial symptom expression. Symptom expression seems to be more pronounced during the cooler months of the year in Hawaii. Apparently this virus does not cause appreciable yield reduction in the varieties grown commercially, and the quality of the corm is not affected. Varietal resistance appears to be a good method for reducing the incidence of this disease in taro.

Alomae and Bobone

Gollifer and Brown (1972) described for the first time two virus diseases from the Solomon Islands. Alomae, a disease apparently caused by two bacilliform viruses, results in the death of susceptible cultivars (Kenten and Woods 1973; James, Kenten, and Woods 1973). At present this disease is confined to Papua New Guinea and the island of Malaita in the Solomons (Gollifer et al. 1975). The etiology of Alomae requires additional studies. A purification technique to get virus preparations suitable for production of virus-specific antisera as well as for use in biochemically and physically characterizing the particles needs to be developed. Vectors and host ranges, especially of the small bacilliform particles, need to be clarified.

Early symptoms of Alomae are a usually conspicuous feathery mosaic of the leaves. Young leaves are often crinkled and fail to open normally. Laminae of malformed leaves are thickened with hypertrophied veins. As the disease progresses, leaves fail to open and begin to die at the tip. Necrosis moves down the petiole and the plant dies.

Bobone is similar to Alomae except that the plants affected tend to be more stunted with curled, twisted leaves. The distorted foliage remains dark green. Recovery occurs in four to six weeks. Plant with Bobone contain only the large bacilliform virus.

These diseases are perpetuated by planting infected taro huli and possible transmission of the virus particles by insect vectors from older plantings to new plantings. It is suspected that the large bacilliform virus particle is transmitted by the taro planthopper, Tarophagus proserpina (Kirk); the smaller bacilliform particle could be transmitted by mealybugs.

Rouging plants infected with Bobone and Alomae to reduce the reservoir of pathogens and the use of resistant varieties appears to be the most practical approach to controlling these diseases.

Bacterial Diseases

Bacterial Soft Rot (Erwinia carotovora [L.R. Jones] Holland; E. chrysanthemi Burkholder, Mcfadden, and Dinock)

Bacterial soft rot is a strong smelling watery soft rot ranging in color from white to dark blue. Wounds and bruises caused by the feeding of insects and other animals and those inflicted at harvest are the most common infection courts for this disease. Abundant moisture is required for invasion of the bacteria.

Control measures therefore include careful handling of corms to minimize injury at harvest, air drying of corms, and storage at low temperatures of only the sound corms.

Bacterial Leaf Spot (Xanthomonas campestris pv dieffenbachiae)

The bacterial leaf spot of taro reported from India (Asthana 1946) and present in Hawaii is not important. It is characterized by yellow or brown-necrotic marginal and sub-marginal lesions of the leaf lamina with tan or pale yellow interveinal bleaching extending toward the piko of the leaf.

Nematode Diseases

While several nematode species are commonly reported on taro, little work has been done on the effect of these invertebrates on taro yield. The following nematodes have been reported on taro or dasheen in Hawaii: Pratylenchus sp. (Rabbe, Connors, Martinez 1981); Helicotylenchus sp. (Plant Disease Clinic [PDC] 1981); H. dihystera (Cobb) Sher (Holtzmann[5]); Rotylenchulus reniformis (PDC 1980, 1981; Holtzmann[6]); Meloidogyne sp. (Parris 1940; Rabbe, Connors, Martinez 1981; PDC 1980); M. incognita (Kofoid-White) Chitwood (Holtzmann[7]); M. javanica (Treub) Chitwood (Holtzmann[8]); Longidarus sylphus Thorne (Holtzmann[9]); and Tylenchorhynchus sp. (PDC 1981). Meloidogyne spp. (Byars 1917; Nirula 1959), Pratylenchus sp. (Kumar and Souza 1969), and Aphelechoides sp. (Tandon and Singh 1974) have been reported on taro or dasheen elsewhere.

Root-knot nematodes (Meloidogyne spp.) damage dryland taro when the crop is planted in infested soils. Galls on the root and swelling and malformations on the corm are characteristic of attack by this nematode. Severe attacks will stunt the plants and render it chlorotic.

Fumigation with dichloropropene, fenamiphos, of D-D (Nemafene) is desirable for control of root-knot nematodes in heavily infected soils. These chemicals are not registered in the United States for use on taro. Other root and corm feeding nematodes may also be controlled by soil fumigation. Treatment of dasheen corms with water at 50°C for 40 minutes kills the nematodes in the corms (Byars 1917). This treatment provides clean planting material.

Diseases of Uncertain Cause

Taro hard rot or "guava seed" is of unknown etiology and only reported from Hawaii where it may cause losses of up to 100 percent (Bowers 1967; HAES 1938; Parris 1941). Trujillo (1967) suggests that damage caused to feeder roots and large roots by Pythium spp. may be responsible for the problem. Hard rot incidence is high were the occurrence of Pythium corm rot is low and vice versa (Parris 1941; Trujillo 1967). It has also been reported that the use of planting material from infected corms increases the disease incidence in the subsequent crop (Parris 1941). This observation suggests a systemic biotic infection. Unfortunately, light microscopy and standard mycological isolation procedures have not produced positive indication of a fungal pathogen thus far (Takahashi 1953, Ooka[10]). Suboptimal levels of oxygen in the paddies have also been advanced as a cause of this condition (HAES 1920). However, taro in dryland culture sometimes exhibits similar symptoms in situations unlikely to be oxygen deficient (Ooka[11]).

The disease destroys the vascular system of the corm, starting with the root traces and working progressively inward. The healthy corm has a smooth skin. The skin of a diseased corm, on the other hand, is bark-like, 3 to 6 mm thick, deeply furrowed, crumbly, and coarse.

Affected areas of the corm are woody and appear dull. They are filled with walled off vascular elements tan to reddish brown in color, very much like the seed cavity of a cross-sectioned guava (Psidium guajava), thus giving the disease its local name "guava seed". In advanced stages of hard rot all that remains of the corm is a hardened, dark brown to black skeletal framework. Damage to roots by high salt concentration, whether through intrusion by salt water in paddies lying near sea level or induced by the application of commercial fertilizers may account for the stratification of the affected areas and the general limiting of the damage to the lower one-third of the corm.

Cultural practices to avoid root injury during corm development should be emphasized. There is some indication that liming of the fields is beneficial. Four varieties in the Mana group and Kai Kea are immune to hard rot. Kai Uliuli is resistant to both Pythium rot and hard rot (Parris 1941). Ooka[12] found Hapuu and Manini Kea to have little hard rot.

Abiotic Diseases

Physiological

Starch, present in normal corms, is deficient or absent in those with "loliloli", a term used in Hawaii to describe a physiological disorder of taro. While the normal corm is firm, crisp, and resilient to the touch, loliloli taro is soft and spongy and water exudes when affected parts are squeezed.

Loliloli taro is the result of withdrawal of starch from the corm. This starch is converted into sugar, which is used by the plant to develop new leaves and other parts. Any action that encourages resumption of vegetative growth in mature taro is likely to result in loliloli taro; therefore, use of nitrogenous fertilizers after the corm has formed or the natural growth-decadence of the plant has started should be avoided to reduce chances of loliloli taro occurring.

Notes

[1]. E.E. Trujillo 1975 personal communication.
[2]. E.E. Trujillo 1978 personal communication.
[3]. J.J. Ooka 1978, unpublished data, University of Hawaii, Honolulu.
[4]. J.J. Ooka 1980, unpublished data, University of Hawaii, Honolulu.
[5]. O.V. Holtzmann 1980: personal communication on nematodes.
[6]. Ibid.
[7]. Ibid.
[8]. Ibid.
[9]. Ibid.
[10]. Ooka 1978.
[11]. Ibid.
[12]. Ibid.

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