DISEASES OF THE GENUS *COLOCASIA* IN THE PACIFIC AREA AND THEIR CONTROL

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Colocasia esculenta (L.) Schott is one of the oldest cultivated crops. Chinese books mention taros (dasheen) as early as 100 B.C. and it was grown in Egypt before the time of Pliny (23—79 A.D.), for he mentions it as one of the established food plants of the country. The earliest European navigators saw it cultivated in Japan and as far south as New Zealand (29). Buck (2) suggests that the finest taros were carried from Indonesia to New Guinea and relayed by Melanesians to their eastern outpost, Fiji. From Fiji the finer taros were relayed to Central Polynesia via volcanic islands. The first relaying station in Western Polynesia was Samoa; from here taros spread to the Society Islands and as far north as Hawaii. Such movements might have occurred somewhere after 1 A.D. The different migrations of Indo-Malayan groups resulted in the spread of the crop to the Philippines and the Micronesian islands.

C. esculenta grows best in damp soils. In the Pacific Islands the swamp is considered by the natives as the crutch of life because of its suitability for taro culture. For the primitive agriculturist this swamp-loving plant collects the richness of the earth washed from the surrounding low hills and converts it into starchy food. Taro is grown today on volcanic islands both in "wetland" and "upland" culture. Wetland culture is practised in valleys with abundant water and easily flooded soils. For this type of culture the islanders have perfected techniques such as irrigating terraces or fields as in New Caledonia, Fiji, Western Samoa, and other islands. The paddy culture, originally oriental, is typical of Hawaii. Upland taro culture is practised in areas with annual rainfall above 70 inches and soils that drain easily. On low islands and atolls the crop is planted in pits meticulously carved in the coral and composted with abundant organic material.

The crop is subject to several diseases, some of which are of rather recent origin, while others probably are as old as the crop itself. Members of the family Pythiaceae are without doubt the most serious pathogens of the crop.

TARO LEAF BLIGHT

Phytophthora colocasiae Rac. was first described by Raciborski (24) in Java in 1900. Its occurrence in India as early as 1905 points to Southeast Asia as the centre of origin for the disease. From this part of the world the disease spread to the Pacific. Butler (3) reports it in Formosa in 1911, Gomez (13) in the Philippines in 1916. The disease reached Hawaii about 1920. It is known to occur in New Guinea and Australia. In 1946 Parham (19) found it in the British Solomons and in 1948 it was reported in Fiji (20) for the first time. The disease occurs in China (25) and Japan, also in the Caroline and the Mariana Islands. The disease has not been reported from Western or American Samoa or the Tonga, Cook, Society or Marquesas Islands. It appears likely that the disease has spread in recent times in three directions: from Java to the North Pacific (Hawaii) via Taiwan and Japan; from Java to the Central Pacific (Micronesia) via the Philippines; and from Java to the South Pacific via New Guinea, Australia, the Solomons and Fiji.

In the early stages the disease is characterized by purplish to brownish water-soaked circular lesions, measuring from 1 to 2 cm in diameter. A clear yellowish liquid exudes from the infected area. Lesions are zonate because of differences in growth rates during night and day, and sporulation during the night when temperatures are lower. As the lesions enlarge and coalesce the leaf shows irregular patches of dead tissue and eventually the whole lamina is affected. Epidemics develop when the night-day temperatures are 20-22°C, and 25-28°C, respectively, and humidities of about 65 per cent during the day to 100 per cent at night are accompanied by overcast, rainy weather. Under such conditions a taro field can be blighted in five to seven days (27). Epidemics can occur throughout the year. This disease is of such severity in the Solomons and Ponape that it is a limiting factor in taro production. In Hawaii and Fiji there is greater seasonal variation in temperatures and the disease is less destructive during the winter months when the night temperatures drop below 20°C. Low temperatures limit the sporulation of the fungus and reduce the possibility of epidemics despite high humidities and rain (27).

The taro plant is resistant to blight during the young stages of development because the leaf surface does not retain water droplets for a sufficiently long period. In young plants the leaf blade hangs at an angle which restricts water retention on the smooth surface. When plants are four and one half months old the luxuriant growth and overcrowding of the foliage hinder air movement and help to maintain high humidities. *Phytophthora* blight at that stage can be severe. In addition to the high humidities prevailing at that stage large numbers of leaves extend horizontally and the cup-shaped base of the lamina then retains rain water. Free moisture is necessary for germination of zoosporangia and zoospores and for subsequent leaf infection.

The disease has been successfully controlled in Hawaii by applications of copper fungicides when the plants are four to nine months old. Yield increases of up to 50 per cent have been recorded (28). The control of *Phytophthora* not only increases yield but also reduces the incidence of "Loliloli" taro a minor physiological disease. Bordeaux mixture and copper fungicides have been reported to provide adequate control of the disease (20, 22, 28), but varieties resistant to *P. colocasiae* should provide the most practical answer for native island agriculture. Deshmukh (9) has reported resistance in the var. Ahina. A comprehensive survey of the genus *Colocasia* and adequate testing of varieties for resistance are needed. Crosses and production of viable seed have been reported by Kikuta *et al.* (14). Therefore, it is probable that resistance can be incorporated into commercial varieties. On the other hand, it is advocated that since *Xanthosoma* spp. are similar in nutritional value and are resistant to *P. colocasiae* (12, 21), outstanding varieties of this genus should be introduced to replace the susceptible *C. esculenta*. Such an undertaking would involve changes in the habits and practices of the subsistence type agriculturist of the Pacific.

TARO ROTS

Soft Rot

The soft rot caused by *Pythium* is probably more widely distributed than any other disease of the crop. Soft rot caused by different *Pythium* spp. has been reported from many areas of the world where the crop is grown (6, 7, 8, 10, 23). *Pythium* spp. can be seed-borne and there is no doubt that this disease was spread with the original planting material introduced in the oceanic islands by Polynesians and other migratory groups.

Losses of up to 80 per cent caused by *Pythium aphanidermatum* (Edson) Fitzpatrick, *Pythium graminicolum* Subramanian, and *Pythium splendens* Brown, have been observed in Palau, Samoa and Hawaii. Bugnicourt (6) has reported heavy losses. in the New Hebrides due to *Pythium irregulare* (Buisman). The symptoms of soft rot are characteristic. The plant shows wilting and chlorosis and proliferation of roots at the base of the shoot. The corm becomes soft and mushy and the rot is usually accompanied by an acrid, putrid odour. When the disease occurs in new plantings the young shoots usually die and replanting is necessary.

Dry Rot

In many instances conditions are not ideal for soft rot development and the plants lose only a few roots. Temperatures below 25°C inhibit *Pythium* root rot, and soil and water temperatures apparently influence occurrence of soft rot. This suggests that the damage caused to feeder roots and large roots by *Pythium* spp. may be responsible for the disease known as dry rot or "guava seed". Parris (21) failed to reproduce dry rot under laboratory conditions and concluded that the disease is not attributable to a specific organism. However, he suggested that unfavourable conditions causing root death appear to be responsible for the disease.

Neither dry nor soft rot occurs in upland taros but both diseases are common in wetland taros. Apparently, resistance to soft rot and dry rot does occur. The Hawaiian varieties tested by Parris (21), namely Kai Kea and Kai Uliuli, were resistant to soft rot. The high-yielding varieties Piialii, Piko Uliuli and Piko Kea were highly susceptible. Four of the taro varieties in the *Mana* group and Kai Kea were immune to dry rot. Kai Uliuli combined resistance to soft rot and dry rot (21, 23). Again, breeding and selection of resistant varieties to soft rot should be fully explored if we are to upgrade the subsistence agriculture of the Pacific dweller. Dadant (8) reported that immersing the tubers for 30 minutes in a 0.2 per cent aqueous solution of Solusanigran before planting prevents *Pythium* rot. Tests conducted in Hawaii by the author with Captan as a soil drench and as a dip for planting materials have shown promise for acid soils. Captan is inactivated in alkaline soil and provides little or no control of the disease.

THE MINOR TARO DISEASES

Sclerotium Rot

This disease of upland taro has been reported from Fiji (10), the Philippine Islands (11), and Hawaii (21). Affected plants are usually stunted and corms are rotted at the base where abundant sclerotia of the pathogen develop. The condition is caused by *Sclerotium rolfsii* Sacc. Sclerotia of the pathogen persist in the soil and the disease is usually serious during warm, wet periods. It can be controlled effectively with Terraclor and Botran soil drenches at 10 to 20 lbs per acre.

Root-knot nematode damage

Meloidogyne spp. cause damage to upland taro whenever the crop is planted in soils infested with these nematodes. They produce characteristic galls on the roots and swellings and malformations on the corm. In Hawaii root-knot is particularly severe on dasheen (21), sometimes causing total losses. As the nematodes are spread with the tuber, dissemination over long distances is possible. However, it is possible to destroy the nematodes by treating the tubers in water at 50°C for 40 minutes (4). This treatment provides clean planting material. Fumigation with Telone, Nemagon, or DD is recommended for infested soils.

Cladosporium leaf spot

This disease occurs in Hawaii (21), New Caledonia (5), New Hebrides (15), Western and American Samoa, the Carolines and the Marianas. The distribution of this pathogen throughout the Pacific basin suggests that the disease is one of the earliest on taro. The disease attacks wetland and upland taros and occurs mainly on the older leaves (5). In the early stages the upper surface of the leaves shows light yellow to Havana green spots. On the lower surface are dark brown spots due to the superficial hyphae, sporophores and conidia of the pathogen. Apparently fungicidal control is uneconomic because the disease does not cause appreciable losses.

Other Diseases

Endoconidiophora sp. (17) and viruses (10, 16) have also been reported as pathogens of taro. The extent to which viruses are implicated in yield decline is not known. The whole subject clearly requires further study. Apparently there has been little research on the viruses attacking the Araceae family, and those reported on *Colocasia* have not been identified. The bacterial leaf spot of *Colocasia* from India (1) has not been recorded in the Pacific.

SUMMARY

Phytophthora blight and *Pythium* corm and root rot are the most serious diseases of *Colocasia esculenta* in the Pacific basin. Southeast Asia appears to be the centre of origin of *Phytophthora colocasiae* and its spread to islands in Micronesia, Polynesia and Melanesia is relatively recent. *Pythium* spp. and *P. colocasiae* are corm-borne and both diseases can be easily spread by infected planting material. Climatic factors, especially temperature, humidity and rainfall, determine the outbreak of epidemics caused by these pathogens. Successful chemical control is possible but costly. The development of resistant varieties would be more suitable for the subsistence agriculture practices of the islanders. Because resistance to both diseases is present within the genus *Colocasia* and related genera, a serious attempt to produce suitable resistant varieties by breeding and selection is advocated. Available information concerning nematode damage and leaf diseases other than that caused by *Phytophthora* is restricted to brief descriptions of pathogens and symptoms. A few reports of virus diseases appear in the literature, but as these are inconclusive they require further clarification.

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