Indian J. mycol. Res., 27(2), 107-119 (1989)
Printed in India

A COMPREHENSIVE ACCOUNT OF THE FUNGAL DISEASES OF *COLOCASIA ESCULENTA* (L) SCHOTT.

BY
SWAPAN KUMAR GHOSH AND SITANSU PAN
Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalay
Mohanpur, Nadia, West Bengal, 741252, India

Taro, *Colocasia esculenta* (L) Schott (commonly known as Taro), is grown either as stapel or subsistence crop in many parts of the world including India. The whole crop is not only used as vegetable but also has good medicinal and industrial values. The nutrition value of *Colocasia* is much superior to many other tropical tuber crops and potato in many constituents such as protein, minerals, fibre, phosphorus, iron etc.

Like other agricultural crops, *Colocasia esculenta* also suffers from the attack of large numbers of fungal, bacterial, viral and physiological diseases both in the field and storage. Among the diseases, the leaf blight *(Phytophthora colocasiae)*, dry rot of corn (*Fusarium solani* & *F. caeruleum*) soft root & corm rot (*Pythium* spp.) are the main fungal diseases.

The present paper deals with a comprehensive review account of the fungus diseases of Taro in India in particular and world in general.

Key words : Fungal diseases, *Colocasia esculenta*

INTRODUCTION

The name colocasia is an old Greek substantive name. This crop, belongs to the family Araceae, is a tuberous perennial herb with cordate peltate leaves. The tuberous under ground portion is called corm and upper portions are long petiolated leaves. The inflorescence is spadix with spathe.

The genus *Colocasia* has 13 spp. distributed in the tropical parts of South eastern Asia and Polynesia. Africa ranks first in area and production, followed by Asia and Oceania.

In India, *Colocasia* is cultivated throughout the country being grown under varied conditions such as swamps, moist hills, dry land and cold regions. It grows on all kinds of soils but thrives best in deep, well drained well manured and friable loams.

All parts of the *Colocasia* sp. are edible Tubers or corms are extensively used as food. The chemical analysis of tuber shows the following constituents per 100 g of corm viz., moisture, 73.1 g : protein 3.0 g ; Fat 0.1 g ; carbohydrate 22.1 g ; mineral 1.7 g ; calcium 0.04 g ; phosphorus 0.14 g ; iron 2.40 mg ;

carotene (calculated as vit. A), 40.0 I.U. : vitamine B, 80 I.U. ; vitamine C, trace (Anonymous, 1950).

'Poi', a preparation from corms is very popular in Hawai. The taro starch, mucilage and tissues posses good industrial value both in textile, paper and alcohol industries.

FUNGAL DISEASES OF TARO

Taro (*Colocasia esculenta*) is known to be attacked by a number of fungal pathogens both in the field and in storage. Among the diseases the leaf blight caused by *Phytophthora colocasiae* has been considered as a major deterrent for taro cultivation in all *Colocasia* growing countries.

Leaf blight

Distribution

The casual agent of leaf blight of Taro (*Phytohthora colocasiae*) was first reported from Java in 1900 by Raciborski. Subsequently, it was also reported from several other colocasia growing countries like India and Formosa (Butler and Kulkarni, 1913), Philippines (Gomez, 1925), China (Teug, 1932), Sri Lanka (Park, 1939), Langawl Island and Malaya (Thompson, 1939), Marinas, Carolines, Burma (Anonymous, 1943), British Solomons (Partham, 1947), Fiji (Parham, 1949), N. Borneo (Anonymous, 1963), Hong Kong (Johnston, 1963), Japan (Tamori, 1974), Indonesia, Malaysia, Sarawak, Africa and Caribbeans, (Anonymous, 1978).

Symptoms

The symptoms initially appear as small dark coloured round spots on the upper surface and with dark lesions on the under side. These spots soon enlarge in 5-7 days into circular, oval or irregular necrotic purplish to brownish spots measuring about 2.5 to 5 cm in diameter. Drops of yellowish to amber coloured liquid ooze from the dark yellow bordered lesions (Paris, 1941). The amber coloured liquids turn dark purple on drying. As the disease progresses, the spots coalesce and exhibit characteristic rings of yellow and brown zones (Ooka, 1983). If the weather conditions are favourable, the entire field can be blighted in 7-10 days (Trujillo, 1965 ; Trujillo & Aragaki, 1964). Otherwise, the infected tissues become necrotic, dry and fall off leaving short holes.

Epidemiology

Trujillo (1965) found that blight epidemics occur when night and day temperatures ranged between 20-22°C and 23-28°C respectively with a relative humidity of 65% during day and 100% at night and accompanied with overcast rainy weather. According to him low temperature below 20°C and high temperatare above 28°C prevented sporulation of the fungus and reduced severely despite high humidity and rain. The disease outbreak could occur when the temperature and relative humidity are optimum for 6-8 h for three consecutive days with light rain or dew in the morning.

Pathogen

Phytophthora colocasiae was first described by Raciborski (1900) from Java. The mycelium is hyaline, coenocytic, inter or intracellular with unbranched haustoria. The sporangiophores are slender, unbranched and extremely narrow at the tip and measure upto 50μ in length. The sporangia are elongated, lemon or pear shaped and measure 38-60 X 18-26μ, germinate directly or indirectly depending on the weather conditions. When they germinate indirectly (20-21°C) as many as 12 reniform, biflagellate zoospores are released, which germinate after 30 minutes (Trujillo, 1965).

The oogonium is spherical and yellowish in colour. The amphigynous antheridium persists at the base of the oogonium measures 99μ in diameter. Oospores are spherical, 20-28μ diameter and loose in oogonium.

Perennation

The perennation of the pathogen takes place through the mycelium present in the crop debris, corms present in the soil, seed corms (Gollifer *et al.*, 1980). Gollifer *et al.* (1980) observed that inoculum on detached leaf lesions or in soil remained viable for only a few days and that on petiole bases for 2 days if stored dry but for 14 days if planted in the field immediately.

The secondary spread in the field is mainly through the sporangia which are carried from diseased leaves to healthy one by wind or rain splashes (Parris, 1941).

Collateral hosts

Phytophthora colocasiae is known to infect many plant species of Araceae family. Several hosts such as *Alocasia* (Park, 1939), *Amorphophallus* (Paharia, Mathur, 1961), *Solanum tuberosum* L ; *Citrus aurontium* L ; *Artocarpus integrifolia* ; *Cocos nucifera* L ; *Areca catechu* L. *Theobroma cacao* L. ; *Lycopersicon esculentnm* Mill. ; *Hevea braziliensis* (Wild ex. Adr. de Juss) Mucll Arg. ; *Malus sylvestris* Hort non Mill ; *Ananas squamosa* L ; *Phaseolus vulgaris* L. (Butler and Bisby, 1960) ; and *Piper betle* L. (Tempany, 1932 ; Thompson, 1940 ; Bertus, 1943 ; Saksena & Mehrotra, 19 0) were listed as the hosts of this pathogen. However, the extent to which these hosts are responsible for the disease build up and perennation of the pathogen has not been worked out.

Other *Phytopthora* spp. on *Colocasia*

Besides *P. colocasie*, few other spp. of *Phytophthora* viz. *P. arecae* (Coleman) Pethybridge (Narasimhan, 1927) and Venkata Rao (1980), *P. palmivora* Butler

(Umabala & Ramarao. 1972), *P. parasitica* var. *parasitica* Dastur (Raghavendra Rao, 1982) have also been reported to cause infection on Taro. But information regarding their severity and extent of crop loss caused by these spp. are lacking.

Extent of damage

Losses in tuber yield have been estimated to range between 25-50% (Parris 1941, Johnston 1960, & Kay 1973 . Jackson & Gollifer (1975) found that infected leaves collapse within 20 days of unfurling as compared to 40 days in healthy leaves. They have also found 30-40% loss in tuber yield when the attack was recorded on 40-70 days old crop.

In India, the extent of damage of crop due to leaf blight pathogen (*Phytophthora colocasiae*) is yet to be worked out.

Control measures

Several control measures of leaf blight have been suggested.

Cultural control

Mundkur (1949) recommended the removal and destruction of infected leaves and crop rotation as control measures of the disease. On the contrary, Jackson *et al.* (1980) found that removal of diseased leaves did not help in reducing the disease incidence.

Chemical control

The disease has been claimed to be successfully controlled by application of copper fungicides in many places like Fiji (Parham 1949 , India (Mundkur, 1949), Hawaii (Parris, 1941 ; Trujillo. 1964 ; Bergquist, 1972 and 1974) and Solomon Islands (Jackson *et al* , 1980). Dithane M-45, Difolatan and polyram have been also found to be very effective in controlling this disease and increasing the yield (Anonymous, 1930 ; Bergquist 1972 and 1974). Benlate, Perenox and Dyrene gave poor control of the disease (Bergquist, 1972).

Rai (1972) observed that aureomycin was effective in reducing the growth of the fungus in culture.

Resistant/Tolerant varieties

Deshmukh & Chibber (1960) have identified the variety 'Ahina' as resistant. Out of twenty screened by Paharia and Mathur (1964), the variety "Poonam Pat" from Madras was recorded as immune followed by "Sakin—V from Ranchi as resistant and another seven varieties viz., Ahina, Bhadia, Kachu and Naga Kachu from Assam, 'Pusa' from Bihar, Sakin—II from Rachi and Simla from Himachal Pradesh as moderately resistant to blight.

In other *Colocasia* growing countries many scientists raised some resistant varieties of *Colocasia* (Parris 1941 ; Hicks, 1967 ; Gollifer & Brown, 1974 and Jackson & Gollifer, 1975).

Breeding for resistant

Trujillo (1967 suggested the development of resistant varieties through breeding and selection, as resistance is already present in pacific area within the Genus *Colocasia* and related group. But Bergquist and Aragaki (1971) faced certain technical difficulties in transferring resistance or immunity found in *Xanthosoma sagittifolium* Schoot and *Alocasia macrorrhiza* to *Colocasia esculenta.*

Patel *et. al.* (1983) in Solomon Island advised for breeding strategies for controlling diseases of taro because they observed resistance of leaf blight in a wild taro (*C. esculenta*) accession introduced from Thailand and designated Bangkok F_1 & BC, data from crosses between Bangkok and local cultivars indicated that resistance is controlled by a single dominant gene.

Biological Control

Although information on biological control of this disease is very little but Narula & Mehrotra (1987) made an attempt to control *Phythophthora colocasiae* with phylloplane microflora with different degrees of success.

Dry rot of corm

Distribution

The dry rot of corm of taro caused by *Fusarium caeruleum* was first reported by Tandon and Agarwal during 1956-57 from Uttar Pradesh of India. Subsequently a band of workers reported *Fusarium solani* as causal agent of dry rot of *Colocasia* (Michail *et al.*, 1969 and Michail & Salem, 1980 ; Gollifer & Booth, 1972 and Sharma & Upadhyay, 1977).

Symptoms

The infected corm shows a brown black dried and shrunken appearance with the deposition of white powdery or cottony fungal growth on the surface and the diseased corm become lighter in weight than the healthy one. The rotten tubers yielded mushy odour (Sharma & Upadhyay 1977), Michail & Salem (1958) observed that the large sized corms were less vulnerable to attack of *Fusarium solani* than the smaller ones due to their higher phenolics, poiyphenol oxidase and peroxidase content but lower carbohydrate levels.

Etiology

Sharma and Upadhyay (1977) obtained a good growth of *F. soloni* on Potato Dextrose agar (PDA) and Czapeck's Dox agar and similarly in character as described by Saccardo. Although the organism is primarily a wound perasite but is highly aggressive in causing the dry rot disease in tubers with a wide range of temperature adaptibility.

Collateral hosts

Tandon and Agarwal (1956) and Michail *et al.* (1969) reported that potato tuber can act as collateral host for both *Fusarium caeruleum* & *F. solani*.

Control measure

Tandon and Agarwal (1956) obtained a good control by treating the seed corms with 0,1% $HgCl_2$ or 5% formalin but treatment of soil with any fungicide had very little effect on the disease severity.

Pythium root and corm rot of Taro

Distribution

Wright (1930) first noted the association of *Pythium aphanidermatum* with rotten corms of taro in Gold Coast. Subsequently its occurence was reported from other colocasia growing countries like Hawaii (Smith, 1936 and Parris, 1941), Islands of Fernanedo, Gulf of Guinea (Gamez-Moreno, 1945), in South East Asia a Pacific Region (Anon, 1962 & Reddy, 19 0), Puerto Rico (Alvarez-Garica *et al.*, 1971), Fiji (Anon, 1980), Western Samoa (Kerz-Moehlendick *et al.*, 1983 & 1984, Fance (Anon, 1983), etc.

Symptoms

Soft rot of corm by *Pythium* shows mushy molodorous type decay (Smith, 1930). Park (1937) in Hawaii observed that *Pythium* causing soft rot of taro gains entry through the root particularly in the region of root hair development.

Parris (1941) observed that loliloi (water soaked) disease was characterised by softness of the corms that exude a watery substance and are deficient in starch content. Suckers from *Pythium* rotted plants that put out new leaves and develop individual root systems were also liable to produce similar symptoms.

The symptom of *Pythium* root rot usually originates at the base of the corm which thrus whitish yellow to grey blue or dark purple & may assume a parallel sided as bottle necked shape in contrast to the normal ovoid or oblong (Parris, 1941).

The roots infected by *P. ultimum* becomes mucilaginous and decayed rapidly, rhizome become soft and cheese like, petiole bases were water soaked & eventually the leaves collapsed (Alvarez-Garica *et al.*, 1971).

Other species of *Pythium* associated with corm and root rot of taro are *Pythium myriotylum* (Kerz-Moehlendick *et al.*, 1984), *P. gracile* (Sphepered, 1940), *P. irregulare* (Reddy, 1970) etc.

Etiology

The fungus (*Pythium* sp.) grows readily on all common synthetic media, producing abundant aerial mycelium. Chlamydospores occassionally developed in old culture grown on oat meal and Potato Dextrose Agar. Sporangia formed within 48-60 h at 28°C—30°C (measured 16-41.6μ by 12.8-33.6μ) were borned terminally on short side branches of a main hyphal strand, and cut off from mother hyphae by a septum. Free swimming zoospores were produeed within 20-30 minutes. A thin walled vesicle was extruded into which the protoplasm passed before the swarm spores become differentiated but no sexual bodies were observed (Paris, 1939).

Extent of damage

Pythium root rot is responsible for reduction of yield ranging from 10-100% at a conservative estimate of 25% ; this represents a loss of $ 50 to 75 per acre (Parris, 1941).

Control measures

Park (1939) suggested that the best method for the control of the disease is to adopt improved cultural practices, specially deep ploughing followed by drying of the land.

Among the varieties that were commonly grown in Wet land of Hawaii, Pilalii was more susceptible to *Pythium* root rot than Piko Uliuli, white Kai Kea & Kai Uliuli (Parris, 1941).

Alverez-Garica *et al*, (1971) recommended the use of healthy seeds, improved drainage and crop rotation as the means of control against the disease.

Kerz-Moehlendick *et al*, (1983-84) reported the varieties Tulsi lanumeamala to be most resistant and Ola da Vale mumu with some resistance against *P myriotylum.*

Other corm rot pathogens

Other corm rot pathogens on Taro are *Fusariella obstipa = Dendryphion obstipum* Pollock (Hughes, 1949) in China, *Cylindrocarpen lichenicola* (Usharani & Ramarao, 1980) in India, *Botryodiplodia theobromae* (D'souza & Moniz, 1968 ; Gallifer & Booth, 1973 ; Fajola & Nwufo, 1985), *Phytophthora colocasiae* in Jabalpur, India (Kulkarni & Sharma, 1970) and *Fusarium oxysporum* (Gollifer & Brown, 1973).

Other fungal pathogens which attack *Colocasia* sp. but cause minor crop damage include *Leptosphaeria colocasiae* & *Macrosporium neteroneum* (Unamuno 1920-1930), *Rhizoctonia = Corticium vaggum* or *C. sasakii* (Briten-Jones, 1925 ; Grover & Prusher, 1928 ; Roy, 1980), *Cladosporium colocasiae* (Hulsemann, 1926 ; Wright, 1930 ; Parris, 1941 ; Bugnicourt, 1955 ; Srivastava, 1977 and Singh, 1979), *Pleosphaerulina colocasiae* (Ragel, 1926), *Rosellinia bunodes* (Smith, 1928), *Sclerotium rofsii* (Bertus 1929, Goto, 1930 ; Auchinlock, 1934 ; Wright, 1936 ; Parris 1941, Graham, 1965 ; Goyal *et al* ; 1974 ; Anonymous, 1985), *Phyllosticta colocasiae* (Wright, 1939, Batista & Vital 1963, Graha 1965, Anonymous 1985), *Choanephora cucurbitamum* . & *Blakeslea trispora* (Sinha 1940), Mycorrhiza (Yousef. 19 6), *Ceratocystis fimbriata* (Mizukani, 1950 ; Kojma & Uritani, 1974 ; Kawakita & Kojma 1983), *Mycosph aerella colocasiae* (Kalsuki, 1955), *Macrophomina phaseolina= Rhizoctonia bataticola* (Grover & Prusher, 1968), *Oidium* sp. (Hirata, 1968) *Colleototrichum capsici* (Chauhan, 1972), *Vasculomyces xanthoomas* Anonymous, 19), *Alternaria teniussiuma* Solakure & Rao, 1972), *Khuskia oryza* (Tandon & Srivastava, 1979). *Drechslera colocasiae* (Tandon & Bhargara, 1980 and *Johensonia colocasiae* (Guha & Sengupta, 1982).

CONCLUSION

Taro *Colocasia esculenta*) is mainly grown for its corms used as food particularly by the financially weaker section of people of the society. Besides, the crop possesses both industrial & medicinal values and even superior to other tuber crops like potato cassava etc. In spite of tremendous potentiality of the crop for its many fold uses it has failed to draw a full fledged attentions of the scientists over the years and has suffered from an overall negligence. The crop thrives better under tropical climate. The environmental conditions under which the crop is grown make it vulnerable to suffer from a number of diseases of fungal origin. Besides, the literatures lack a comprehensive information on the overall control strategies for most of the diseases except only leaf blight caused by *Phytophthora colocasiae* Racib. which is even restricted to chemical control measures only and where over it is available it is not scientifically based on certain pertinent informations like epidemiology of the disease and perpetuation and spread of the pathogen s in the field. There is therefore, an urgent need to generate such valuable informations in these aspects so that more viable and scientific approaches could be made to formulate a well planned control strategies for combating the taro diseases suitably.

REFERENCES

Alvarez-Garica, L. A., Cortes-Menllas, A and Currtaca (1971). A Pythium soft rot of *Xanthosoma & Colocasia* spp. in Puerto Rico. *Journal of Agriculture. University of Puerto Rico*, 55 (1), 78- 4.

Anonymous (1936). Plant Pathology, Report of Hawaii Agriculture Experimental station. pp 33-40.

Anonymous (1943). Mycology Report. Department of Agriculure, Burma 1941-42 and 1942-43, 4-9.

Anonymous (1950). Plant Protection Work in India during 1949-50. Plant Protection Bulletin, New Delhi, 3, 31-43.

Anonymous (1950). *The Wealth of India*-A dictionary of Indian Raw Matarials and Industrial Products. Raw Material Vol II. C.S.I.R., New Delhi 1950, PP. 309-312.

Anonymous (1962). Quarterly Report for Jan.-March 1962 of Plant Protection Committee for the South East Asia and Pacific Region. F.A.O. Publ. Bangkok, Thailand, 12 pp.

Anonymous (1963). Quarterly Report for Oct.-Dec. 1962 Plant Prot. Comm. for the S.E. Asia and Pacific Region F.A.O. Publ. Bangkok, Thailand, 15 pp.

Anonymous (1972). Quarterly Report. F.A.O. Carribbean Plant Productfon Commission, 5(4), 1-5.

Anonymous (1978). CMI Distribution Map No. 466.

Anonymous (1985). New Records, Tuvalu. Taro disease Quarterly Newsletter. F.A.O. Asia and Pacific Plant Protection Commission (1985), 28(3), 29.

Auchinleck, G. (1934). Report on the Dept. of Agric. Gold Coast, for the year 1933-34, 18 pp.

Bergquist, R.C. (1974). Effect of fungicide rate, spray interval, timing of spray application and precipitation in relation to control of Taro. *Annals of Botany*, **38**, 213-221.

Bergquist, R.C. and Aragaki, M. (1971). Sources of resistance in *Colocasia esculenta, Alocasia macrorrhiza* and *Xanthosoma sagittifolium* to *Phytophthora colocasiae* (unpublished data).

Bertus, L.S. (1929). *Sclerotium rolfsii* in ceylon. Ann. Roy. Bot. Gard. Paradenity, xi (2), pp. 173-187, 2 pl.

Bertus, L.S. (1943). Mycology-Rep. Dep. Agric., Burma, 1342-43 pp. 4-9.

Briton-Jones, H.R. (1925). Mycological work in Egypt during the period 1920-22. Min. of Agric. Egypt. Tech. and Sci. Service, Bull., 49, 129 pp. 11 Pl.

Bugnicourt, F. (1958). Contribution a' l' e' tude de *Cladosporium colocasiae* Saccardo (A contribution to the study of *Cladosporium colocasiae) Rev. mycol.* Paris, **23**, 233-236.

Butler, E.J. and Bisby, G.R. (1960). The Fungi of India. Indian Council of Agriculture Research. New Delhi PP. 552.

Butler, E.J. and Kulkarni, G. S. (1913). Colocasia blight caused by *Phytophthora colocasiae* Racib. Memoirs of the Department of Agriculture in India, 5, 233-259.

Chauhan, S.S. (1972). A leaf spot disease of *Colocasia esculenta* Schott. *(Colletotri chum capsici)* Lab. dev. Jr. of Science and Technology, B 10 (2), 92 DAV Coll. Kanpur.

Deshmukh, M.J. and Chibber, K.N. (1960). Field Resistance to blight *(Phytophthora colocasiae* Rac*)* in *Colocasia antiquorum* Schott. *Current Science*, **29**, 320-321.

D'souza, T.E. and Monlz, L. (1 08). Root rot of *Colocasia antiquorum* Schott, caused by *Botryodiplodia theobromae* in Maharashtra State. *Indian Journal of Microbiology*, 8, 45-46.

Fajola, A.O and Nwufo, M·I. (1985). Control of corm rots of Cocoyam (*Colocasia esculenta* caused by *Botryodiplodia theobromae* and *Sclerotium rolfsii. Fitopatologia Bransileira*, **10**, 49-56.

Gollifer, D.E. and Booth, R.H. (1973). Storage losses of taro corms in the British Solomen Islands Protectorate. *Annals of Applied Biology*, 73, 349-359.

Gollifer, D.E. and Brown, J.F. (1973). Corm rot of *Colocasia esculenta* caused by *Fusarium oxysporum*. *Plant Disease Reporter*, 57, 701-703.

Gollifer D.E. and Brown, J.F (1974). *Phytophthora* leaf blight of *Colocasia esculenta* in the British Solomon Islands. *Papua New Guinea Agricultural Journal*, **25**, 6-11.

Gollifer, D.E., Jackson, G V.H. and Newhook, F.J. (1980). Survival of inoculum of leaf blight fungus *Phytophthora colocasiae* infecting Taro *(Colocasia esculenta)* in the Solomon Island. *Annals of Applied Biology*, **94**, 379-390.

Gomez, E.T. (1925) Blight of Gabi *(Phytophthora colocasiae* Raeb.*)* in the Philippines. *Philipp. Agr.*, **14**, 429-440.

Gomez-Moreno, M.L. (1945). Araceae of Fernando PO. Ann. Agric Terr, erp. Golfo do Guina 1942 pp. 737 (Received Feb. 1945).

Goto, K. (1930) On the perfect stage of *Sclerotium rolfsii* Sacc. produced on culture media. Preliminary report. *Journ. Soc. Trop. Agric*, **11**,165-175.

Goyal, J.P., Naik, S.M., Pathak, V.N., Sharma, H.C. and Prasada, R. (1974). Evaluation of some modern fungicides for the control of *Sclerotium rolfsii* Sacc. inciting the tuber rot of *Colacasia antiquorum* L. (Arvi.). *Beihefte aur Nava Hedwigia* **47**, 205-210.

Graham. K. (1965). Dalo diseases Fiji *Fmr.*, **1**, 54-57.

Grover, R.K and Prasher, R.D. (1968). *Rhizoctonia* rot of *Colocasia* in India. *Pl. Prot Bull. F.A O.*, 16, 6-7.

Guha Roy, H.S. and Sengupta P.K. (1988). A leaf blight of *Colocasia antiquorum* in India. *Indian Phytopathology* **35**, 340-341.

Hicks, P.G. (1967). Resistance of *Colocasia esculenta* to leaf blight caused by *Phytophthora colocasiae*. *Papua New Guinea Agric. Journ.*, **19**, 1-4.

Hirata, K. (1968*)*. Note on host range and Geographic distribution of the powdery mildew fungi. *Trans mycol. Sec Japan*, **9**, 73-88.

Hughes, S.J. (1945). Studies on micro fungi 1. The genus *Fusariella* Saccardo. Mycological Paper, Commonweal. mycol. Inst., 28, 11 pp.

Hulscaan (1 26). Der Einfluss der Kalis auf. Krakhei tse rschei nungen der Kultur planzen (The action of Potash on the manifestations of disease inicultivated Plants-*Ernohrung der flanza* xii (18), 217-219.

Jackson, G.V.H. (1977). Taro leaf blight. Advisory leaflet, South Pacific Commission No. 3,4 pp.

Jackson, G.V.H. (1980). Diseases and pests of Taro Nounnea, New Caledonia, South Pacific Commission 52 pp.

Jackson, G V.H. and Gollifer, D.E. (1975). Disease and Pest Problems of taro *(Colocasia eaculenta* L. Schott.) in British Solomon Islands. *PANS*, **21**, 45-53.

Jackson, G.V.H. and Gollifer, D.E. (1975). Storage rots of taro *(Colocasia esculenta]* in British Solomon Islands. *Annals of Applied Biology*, **80**, 217-230.

Johnston, A, (1960). A Preliminary Plant disease survey in the British Solomon Islands Protectorate 36 pp. Rome, Food and Agri. Organization of the United Nations.

Johnston, A.C. (1963). A Preliminary Plant diseases survey in Hongkonq. Plant Production & Protection Division, F.A.O., 32 pp.

Katsuki, S. (1955). Parasitic fungus flora of Yaku Island Kyushu, I. *Journal of Japan Botany*. **30**, 282-288.

Kawakita, K. and Kojima M. (1983). The isolation and Properties of a factor in taro tuber that agglutinates spores of *Ceratocystis fimbriata* black rot fungus. *Plant and call Physiology*. **24**, 41-49.

Kay, D.E. (1973). Root Crops. Tropical Prod. Inst. Crop. Prod. Dig., 2, 71-75, 168-179.

Kerz-Moehilendick, F.H., Fliege, F.H., Scholoesser E. (1983) Morphoiogy and pathogenicity of four *Pythium* spp. isolated with root and corm rot of taro, *Colocasia esculenta* (L) Schott. in Western Samoa. Alafua Agricultural Bulletin, 8 (3) 53-62.

Kerz-Moehilendick, F.H., Fliege, F.H., Schloesser, E. (1980). Susceptibility of 15 Samoan taro cultivars to root rot caused by *Pythium myriotylum* Drechsler. Alafua Agricultual Bulletin, 9(2), 36-41.

Koch, W. (1974). Tropical Tuber Crops and theirs Diseases. Tropische Knollenpflanzen undihre Krankheiten Nachrichblatt des Deutshee Pflanzen schutzdienstes, 26 (4), 129-135.

Linnemann, A.R. (1981). Preservation of Certain Tropical Agriculture, 7(1), 9-20.

Morae, W. (1934). Foot rot diseases of *Piper bette* L in Bengal. *Indian Journal of Agricultural Science*, iv, pp. 588-617.

Michail, S.H., Elarosi, H. and Khairy, E.A. (1969). Dry rot of *Colocasia antiquorum* in U.S.R. (Egypt). *Journal of Phytopathology* WAR 1, 23-26.

Michail, S. H. and Salem, M.A. (1981). Studies on dry rot of *Colocasia antiquorum. Phytopathologische Zeitschrift*, **100**, 157-161.

Mizukami, T. (1960). Comparison of Pathogenicity of *Ceratostomella fimbriata* and *Endoconidiophora* sp. caused fungus of Taro black rot on sweet Potatoes & Taroer. Scientific Bulletin. Fac. Agric. Kyushu University, **12**, 5-9.

Muller, H.R.A. (1936). Het *Phytophthora*—Voetrot van paper (*Piper nigrum* L.) in Nederland schelndie Maded. Inst. Plaziekt. Batavia, 88, 73 pp.

Mundkur, B.B. (1949). *Fungi and Plant Disease*. Macmilan and Co. Ltd. London, 246 pp.

Narasimhan, M.J. (1927). Wild Plants affected by Koleroga. Mysore Agriculture Calender, 36-37.

Narula, K. L. and Mehrotra R. S., (1987). Biocontrol Potential of *Phytophthora* leaf blight of *Colocasia* by Phylloplane microflora. *Indian Phytopathology*, **40**, 384-389.

Ooka, J.J. (1983). Taro diseases. In Taro, A Review of *Colocasia esculenta* and its Potentials. Ed. J.K. Wang. Univ. Hawaii Press. Honolulu (236-257) 400 pp.

Paharia, K.D. and Mathur, P.N. (1961). New host Plant of *Colocasia* blight (*Phytophthora colocasiae*, Racib). *Current Science*, **30**, p. 354.

Parham, B.E.V. (1949). Annual Report of the Economic Botanist for the year 1948. Coun. Pap. Fiji., 24, pp 31-35.

Park, M. (1939). Report on the work of Division of Plant Pathology. Adm. Rep. Dir. Agric., Ceylon. 1973, D, 42-48.

Parris, G K. (1941). Diseases of Taro in Hawaii. Circ. Hawaii Agric. Exp. Stat., 18, 29 pp.

Passam, H.C. (1932) Experiments on the storage of eddoes and tannias (*Colocasia & Xanthosoma* spp) under tropical ambient conditions. *Tropical Science*, **24**, 39-46.

Patel, M.Z., Saelea, J. and Jackson, G.V.H. (1984). Breeding Strategies for controlling diseases of Taro in Solomon Islands. In Proceeding, Sixth Symposium of the

International Society for Tropical Root crops, 21-26 Feb. 1983, Lima Peru, International Potato Center, 143-149.

Prasad, K.S. and Rao, P.P., (1979). Root and Corm rot of *Colocasia esculenta (Sclerotium rolfsii). Indian Phytopathology*, 32, 472-473.

Raciborski, M. (1900). Parasitic algae and fungi, Java Batavia Bulletin, New Work State Mus., 19, 189.

Raghavendra Rao, N. N. (1982). A collateral host for citrus *Phytophthora. Current Science*, 51, 200-201.

Rai, R. P. (1972). Studies on Parasitic fungi of medicinal plants. Ph.D. thesis BHU Varanasi, India.

Rama Rao, P. and Umabala, K. (1982). Survival of *Phytophthora palmivora* in soil. *Indian Phytopathology*, 35, 65-67.

—— and —— (1983). Evaluation of fungicides for the control of *Phytophthora* blight of *colocasia, Kavaka*, 11, 37-39.

Rangel, E, (1926). Fungus do Brasil, Novos on mal conhecidos (fungi of Brazil, New or little known). Bot. Inst. Brasileiro Sciencias, ii (10) pp. 333-335.

Reddy, D.B., (Editor), (1970). Quaterly Newsletter of the Plant Protection for South East Asia and Pacific Region. F.A.O. Publ. Bangkok, Thailand 13(1), 14 pp.

Roy A.K., (1980). Identification of strains of *Corticium sasakii* in India. *Journal of the Indian Botanical Society*, 59, 286-290.

Sharma, K.D. and Upadhyay, S.K., (1977). Dry not of *Colocasia esculenta* var *antiquorum*. *Indian Phytopathology* 30, 419-420.

Shephered, E.F.S., (1940). Cocoyam root rot in the Gold coast. Paper Third, W. Afr. Agric. Conf. 1938 (Gold Coast Sect.) pp. 83-86.

Singh, S.M., (1979). (Publ. 1980). Some new host records from India. *Indian Phytopathology*, 32, 295-297.

Singh, S., (1939). A wet rot of leaves of *Colocasia antiquorum* due to secondary infection by *Choanephora cucurbitarum* Thaxter and *Choanephora trispora* Thaxter. *Proc Indian Acad. Sc.* Section B x 1 (4), 167-175.

Smith, F.E.V., (1928). Plant diseases in Jamaica in 1928. Report of the Government Microbiologist. Annual Report on Department of Agriculture, Jamaica for the year ended December 1928.

Solankure, R.T. and Rao, V.G., (1979). *Alternaria* leaf spot of taro from India. *Indian Phytopathology*, 25, 457-459.

Srivastava, Y.N. and Bhargava, K.S., (1977). Fungi causing some new diseases of important crop plants in India. *Proceeding of the Indian National Academy*, B, 43, 198-200.

Symond, J.E., (1939) Report on Department of Agriculture, Gold Coast for the year 1937-39, 22 pp.

Tamori, M., (1974). Studies on the Genus *Phytophthora* and Pine heart-rot dfsease found in Okinawa. *Scientific Bulletin Univ. Ryukyus, Okinawa* 21, 1-72.

Tandon, R.N. and Agarwal, G.P., (1956). Dry rot of *Colocasia antiquorum* and Potato caused by *Fusarium caeruleum* (Lib) Sacc. Allahabad University Stud. Bot., 26 pp. 4 Pl.

Tandon, M.P. and Bhargava, V., (1980). *Drechslera colocasiae* a new sps. *Current Science*, 49, 75-76.

Tandon, M.P. and Srivastava, G., (1977). Some new host records of Phytopathogenic fungi. *Proceedings of the National Academy of Sciences*, India, B, 47, 69-70.

Tempany, H. A., (1932). Annual Report. Department of Agriculture, Straits Settlements and Federated Male States for the year 1931, 56 pp.

Teug, S. C., (1932). Some fungi from canton. Contrib, Biol. Lab. Sci. Soc. of China, Bot. Ser., **8**, 121-128.

Thomas K.M., Ramakrishnan, T.S., Soumini, C.K. and Balakrishnan, M.S.. (1947). Studies in the Genus *Phytophthora* 1. oospore formation and taxonomy of *Phytophthora palmivora* Bulter. *Proceeding Indian Academy Science*, Section B, **26**, 147-163.

Thomas, K.M. and Ramakrishna, T.S., (1948). Studies in the genus *Phytophthora —II*. *Proc. Indian Acad Sci. Sect.* B, **27**. 55-73.

Thompson A., (1939). Note on Plant diseases in 1937-1938. *Malaya Agriculture Journal*, **27**, 86-98.

Thompson, A., (1940). Notes on Plant diseases. *Malaya Agricultute Journal*, **28**, 400-407.

Trujillo, E.E. and Aragaki, M., (1964). Taro blight and its control. *Hawaii Farm Science*, **13** (4) 3-7.

Trujillo, E.E.. (1967). Diseases of the genus *Colocasia* in the Pacific Area and their control. Proceeding Institute Symp. Tropical Root Crops. Trinidad 1967 University West Indias, 13-18.

Umabala, K. and Rama Rao, (1972). Leaf blight of *Colocasia* caused by *Phytophthora palmivora*. *Indian Journal of Mycology and Plant Pathology*, **2**, 187-189.

Unamuno, L.M., (1920). Neuva datus para el estudio de los alrededores de Llance (Asturias) New data for the study of the mycological flora of the environment of Llanes (Austurias). Mem. R. Soc. Espanula Hist. Nat. xv(i), 345-354.

Uramuno, L.M., (1930). Neuva apastacion al estudio de la flora mycological concejo de Llanes (Asturies) New contribution to the study of the mycological flora of concejo de Llanes (Asturias). Bol. R. Soc. Espanula Hist. Nat, **30**, 179-187.

Venkata Rao, M.K., (1930). Annual Report Work done in the mycological section during the year 1928-29. Annual Report of Agriculture Department, Mysore for the year 1928-29 part—I, pp. 18-21.

Wright, J., (1930). Root rot of Coco-yams. Coast Department of Agriculture Year Book 1930 (Bulletin 23), pp. 184-197.

Yousef, H.M., (1947). The mycorrhiza of *Iris Germanica albicans* Lange and *Asparagus sprengeri* Regel. *Proceeding Egypt. Scienee*, ii (1046), 45-61.

(*Accepted for publication September 14 1989*)