Review of Literature

Betelvine is an important cash crop in India the major betelvine cultivating states includes Orissa, West Bengal and Tamil Nadu each having nearly 8,000 ha. Other important states cultivating this plant are Maharashtra, Kerala, Andhra Pradesh. Madhya Pradesh, Bihar, Uttar Pradesh, Karnataka, Assam and Meghalaya. Betelvine is perennial dioecious creeper and is usually grown under shade or in specially constructed houses for the purpose called Bareja. Betel leaves are used for chewing and is also considered as a good and cheap source of dietary calcium.

The most important and destructive fungal disease of betelvine reported from India is the foot-rot and wilt caused by *Phytophthora* spp, in 1885 this disease was commonly known as 'Chittabbari' to the local growers, which attracted the attention of the Revenue Officer of the Bengal Government *(Rep. Dep. Land Rev. & Agric. Bengal* 1985-86. *p.* 57). The disease was believed to be infectious owing to the practice of removal of diseased plants and the portion of the earth where the plant was growing. This may be the probable first report in disease management strategies of betelvine. Hector (1927) observed a species of *Phytophthora* and later identified as *P. nicotianae* var. *parasitica.* McRae (1928) also observed the same fungus and followed the nomenclature of Hector. Betelvine (*Piper betle* L.) is a perennial dioecious creeper of Malasyian origin, cultivated for its leaves. Daniel and Thulasidas (1976), have given the complete information of *Piper betle* regarding its botanical description, agronomic practices, economic, and nutritive value of the leaves. Gamble (1956) described the betelvine as, it is a creeping herb, usually aromatic and the branches are with swollen nodes. Betelvine is even grown in western ghats up to an altitude of about 900 m.

The leading states of betelvine cultivation in India are Karnataka, Tamil nadu and Kerala followed by Maharashtra, Andra Pradesh , Bihar , Uttar Pradesh and Assam. Betelvines are of several types differing in size, shape, color, taste, flavor and aroma (Table 2.1). The main varieties grown in Karnataka are Ambadi, Kanigale, Kariballi, Kumbalaballi and Nagaballi. (Vikas, 1995).

Epidemology and Yield loss due to soil borne fungi of betelvine.

Plant diseases of economic crops alone cause 13 to 20 percent annual loss in production representing US$ 50 x 10^9 (James, 1981). Even in the United States, with the most advanced disease management technologies, the extent of losses is ranged from 13 to 20 percent (Lewis and Papavizas, 1991). It was recorded by Wilson (1968) that about 90 percent of the 2000 major diseases of the 31 principal crops in the United States are caused by soil borne plant pathogens. Ten fungal genera have been recognized playing a major role in causing root and collar diseases variously named as root rot, collar rot, damping off, seedling blight, crown rot and wilt (Cook and Baker, 1983). In India it was assumed that about more than 50 percent of the crop loss is due to the soilborne plant pathogens, since these have wider host ranges covering all groups of plants and are problematic over world wide (Bineeta, 2000).

Betel leaves occupies an unique status in Indians, its religious value, social, economic and industrial value, the management of betelvine due to soil borne fungi has been the subject of very active interest. The diseases due to the betelvine is one of the main threat to betelvine industry, many workers during pre-independence have worked on the betelvine diseases, like McRae (1928) and Dastur (1935).

Dasgupta (1985), Singh and Shankar (1971), observed the fungal diseases of betelvine and recorded the losses due to diseases range between 20 to 80 percent in west Bengal and Uttar Pradesh respectively, while Chourasia *et al.,* (1987) observed 60 percent losses in Madhya Pradesh.

Deshpande and Tiwari (1991a) recorded 30 to 40 percent loss due to *Rhizoctionia solani.* Jain *et al.,* (1982), Deshpande and Tiwari (1991b and 1991c) recorded the collar rot disease of betelvine due to *Sclerotium rolfsii* and observed the losses due to *Sclerotium rolfsii* , that ranged between 5 to 50 percent losses in Madhya Pradesh. Sinha and Singh (1992), observed 30 to 50 percent losses caused by *Fusarium solani* in Erki, Gidhol of Aurangabad district. Borah *et al.,* (1993), recorded 45 percent losses due to the diseases of betelvine in Assam, the disease severity was observed peak during the months of June, July and August.

Foot rot of betelvine caused by *Phytophthora parasitica* var. *piperina* and their management is the main problem being faced by betelvine industry in the country. The total losses ranges between 40 to 100 percent every year (Chaurasia and Vyas, 1997).

Fungal Diseases of *Piper betle.*

Many species of fungi is causing various diseases like, leaf spot, leaf rot, anthracnose, foot rot and wilt. Among the above said diseases the soil borne diseases like wilt, foot root and root rot are very important and are threat to betelvine cultivation.

The fungal diseases of *Piper betle* was given in Table 2.1. The soil borne diseases were complicated to study and difficult to control or manage them (Irwin, 1997). Saksena (1967) and (1969a) had given a detailed account on root

Table 2.1 Fungal diseases of betelvine (*Piper betle*)

Diseases of ***Piper betle***			
Sl No	Fungal Pathogens	Disease	Authors
1	*Alternaria alternata*	Leaf spot	(Singh and Chand,1973a); (Singh and Chand,1973b);(Singh and Joshi,1974).
2	*Asteromia piperis*	Leaf spot	(Uppal, Patel and Kamat,1935).
3	*Cephalosporium acremonium*	Leaf Rot	(Singh and Joshi,1972).
4	*Colletotrichum capsici*	Anthracnose	(Dastur,1935).
5	*Colletotrichum piperis*	Leaf Spot	(Uppal, Patel and Kamat,1935).
6	*Fusarium equiseti*	wilt	(Singh and Joshi,1972).
7	*Fusarium moniliforme*	wilt	(Singh and Joshi,1972).
8	*Fusarium oxysporum*	wilt	(Singh and Joshi,1972).
9	*Macrophomina phaseolina*	Stem & root rot	(Dastur,1935).
10	*Oidium piperis*	Powdery mildew	(Uppal, Patel and Kamat,1935).
11	*Phytophthora palvimora var piperis*	Soft Rot	(McRae,1934).
12	*Phytophthora parasitica*	Leaf decay	(Dastur,1935).
13	*Phytophthora parasitica var. piperina*	Foot & leaf rot	(Dastur,1935).
14	*Pythium vexans*	Stem and root rot	(Dastur,1935).
15	*Rhizoctonia bataticola*	Root & stem rot	(Dastur,1935).
16	*Rhizoctonia solani*	Root rot	(McRae,1934).
17	*Sclerotium rolfsii*	Root rot	(Chowdhury,1943); (Chowdhury (1945) (Singh and Chand,1972); (McRae,1934).
18	*Stigmatea piperis*	Leaf spot	(Uppal, Patel and Kamat,1935).
19	*Trichothecium roseum*	Leaf decay	(Singh and Chand,1973a); (Singh and Joshi,1974).

infecting fungi, its biology, nature of survival in soil, pathogenesis and competition against native antagonists.

Venkata Rao *et al.*, (1969) worked on betelvine wilt in relation to the tempeature and recorded that higher percentage of plants wilted caused by *Phytopothora parasitica* Dast., in the Raja channel area of Salem district of Tamil nadu. They recorded that wilt sets during the end of October and steadily increases till January and then it declines. The falling temperature from October onwards are related with increase in wilt incidences. They later concluded that, rainfall does not influence the incidence but the number of days with cooler temperatures will be the criteria for the wilt of betelvine.

Maiti and Sen (1977) made comparisons of two isolates from *Piper betle* leaves with those reported for *Phytophthora nicotianae* var.*parasitica*, *Phytophthora parasitica* var.*piperina* and *Phytophthora palmivora* isolated from foot rot and leaf rot of *Piper betle* vines and came to the conclusion that those were more or less identical both in shape and dimensions. They suggested that all the isolates of *Phytophthora* from foot rot or leaf rot of affected betelvine called as *Phytophthora palmivora*. It appears to be more specific to perennial plants than to annuals which will affect various plants including roots, stem, foliage and fruits, causing severe rots and cankers (Rangaswami, 1982).

Phytophthora has protistan character like aseptate hyphae and biflagellate zoospores (Fig 4.29 and 4.31), There are 67 recognized species of *Phytophthora* infecting various plants (Waterhouse, 1963; Erwin *et al.*, 1983 & Erwin and Ribeiro, 1996). Many of the *Phytophthora* species were pathogenic on plants (Kale & Prasad, 1957; Nene *et al.*, 1980, Mehrothra, 1995a & Menge and Nemec, 1997).

The *Phytophthora* occupies an unique status in soil borne fungal diseases an has wider host ranges (Patel *et al.*,1949; Payak, 1949; Kale & Prasad, 1957 and Allen,1997). *Phytophthora* has a devastating potential because of its multicyclic nature and it can produce inoculum continuously after the initial infection, as long as conditions remain favorable (Mitchell, 1979).

Subbayya (1980) described the diseases of betelvine in Andra Pradesh and listed the important diseases, affecting the crop. Diseases includes, foot rot and wilt by *Phytophthora* spp, sclerotial wilt by *Sclerotium rolfsii*, root rot by *Rhizoctonia* spp. He also recorded the sudden out break of foot rot and wilt by *Phytophthora* spp, in Ponnur area of Andra Pradesh during 1979-1980.

Johri *et al.,* (1990) recorded three new diseases of betelvine, during their survey on betelvine plantations of Mahoba (Uttar Pradesh) they found that the fungi *Nigrospora sphaerica* (Sacc.) Mason, *Bipolaris spicifera* (Bainier) Subram, and *Fusarium lateritium*, causing marginal necrosis, Charcoal rot and stem tearing of betelvine respectively.

Anandraj and Sarma (1995) observed the blight disease caused by *Rhizoctonia solani*, root rot caused by *Phytophthora capsici*, and basal wilt caused by *Sclerotium rolfsii* in the nursery of *Piper nigrum.*

Hillocks and Waller (1997a) had given a detailed account regarding the nature of soil borne diseases, their biology, constrains of 'Soil borne fungal diseases'. They have stated that, soil inhabiting fungi like *Rhizoctonia solani, Pythium* spp, *Phytophthora* spp, *Fusarium* spp and *Sclerotium rolfsii* usually have wide host ranges, higher competitive saprophytic abilities, they can easily colonise dead plant tissues. They have stated that *Rhizoctonia solani* as soil inhabiting fungus causing damping off and root rot diseases, *Fusarium oxysporum* f. sp. *lycopersici* as soil invading fungus which causing vascular

wilts in plants. They have found the wide distribution of *Fusarium* spp, in the agro-ecological zones like, semi-arid, sub- humid, humid. The distribution of *Phytophthora* spp, in sub- humid and humid zones, the distribution of *Pythium* spp in Sub- humid and humid zones, the distribution *Rhizoctonia solani* in semi-arid, sub-humid and humid zones and the distribution of *Sclerotium rolfsii* in sub-humid and humid areas.

They also described that the non-specialized soil inhabiting fungal pathogens like *Rhizoctonia solani, Fusarium* spp, *Sclerotium rolfsii* causing similar symptoms like damping off, root rots. Garrett (1956) classified the soil borne pathogenic fungi as soil invading or root inhabiting (specilaized parasites) that includes *Fusarium oxysporum* (and many formae) and soil inhabiting (Non specialized parasites), which includes *Rhizoctonia solani, Pythium* spp, *Phytophthora* spp, *Fusarium* spp and *Sclerotium rolfsii.* Egan *et al.,* (1997) listed the soil borne diseases of sugarcane which includes the stem rot was caused by *Fusarium moniliforme* and *Pythium* root rot was caused by *Pythium arrhenomanes.*

Hillocks (1997) isolated the soil borne fungi from the diseased cotton seedlings which includes *Fusarium moniliforme, F.oxysporum, F. solani, Macromina phaseolina, Pythium aphanidermatum, P. irrigulare, P. ultimum, Rhizoctonia solani* and *Sclerotium rolfsii.* Jhamaria and Daftari (1970) recorded *Oidium piperis,* which causes powdery mildew disease on the leaves of pan (*Piper betle* L.).

Simons (1997) studied on soil borne diseases of tropical root and tuber crops. The root rot of cassava (*Manihot esculenta*) was caused by *Fusarium solani, Rhizoctonia solani, Phytophthora drechsleri* and *Sclerotium rolfsii.* The root rot of Sweet potato (*Ipomea batatus*) was caused by *Fusarium solani, Fusarium oxysporum, Rhizoctonia solani* and *Sclerotium rolfsii.* The tuber rot

of potato (*Solanum tuberosum*) caused by *Fusarium* spp, *Phytophthora* spp, *Pythium* spp, *Rhizoctonia solani* and *Sclerotium rolfsii.*

Liddell (1997) has given the constrains of a biotic factors like soil moisture, temperature, soil fertility and effect of herbicides on soil borne fungi. Whereas the little moisture is directly affect the population of soil fungi like germination of *Pythium* and *Phytophthora.*

Govinda Rao and Koteswara Rao (1956) described *Phytophthora parasitica* var. *nicotianae* as the hyphae usually measure 3.1μm thick but rarely they are up to 4.7 μm thick. The sporangia are borne terminally on long, slender and unbranched sporangiophores arising on both surfaces of the spot. The sporangia measure on average 39-233μm x 2.3-3.1μm. The sporangia are colorless thin walled, smooth and generally elliptical or pear shaped. Some are either elongated or round; at the free end there is always a broad, blunt papilla. The sporangia measure 40 x 25 μm (28-59 x 19-31μm).

Hunter and Kunimoto (1974) found that *Phytophthora palmivora* causes an aerial blight of *Carica papaya* L. The sporangia of *Phytophthora palmivora* were dispersed by wind- blown rain is an ideal spore release and dispersal mechanism for the survival of this species.

Ramachandran *et al.,*(1986), investigated the spatial distribution of *Phytophthora palmivora* MF4 propagules in the root zones of both diseased and apparently healthy vines of *Piper nigrum.* The intensity of fungal population was estimated in soil samples at 0, 30, 60 and 90 cm distances from the base of the vines and at depths of 0-10, 11-20 and 21-30 cm at each distances using pepper leaf discs as baits. Based on the number of infected baits, the spots in the root zones were classified as spots with low and high levels of fungal population. They found that the spots with high levels of population around

the base of infected plants up to a distance of 30 cm from the base and in the upper layers of soil up to the depth of 0-10 cm and the population decreased with increase in depth and distance. Khare *et al.,* (1988) described the current status of *Phytophthora parisitica* on betelvine with an outline of the history and geographical distribution of the disease, nature and extent of the damage, pathogen characteristics and taxonomy, disease cycle, factors influencing disease development, the effect of manures on the disease, host resistance and disease management.

Sastry and Hegde (1989) studied the variability of *Phytophthora* species found in plantations of Karnataka. They even studied the different characters of *Phytophthora* isolates with reference to colony characters and sporangial production on different solid media. Shastry and Hegde (1991), successfully isolated *Phytophthora* from infected tissues, they observed morphological, cultural characters to identify *Phytophthora* species. On the carrot agar medium they observed the mycelium, the sporangia which were elongate, caducous with long pedicels (20-240μm), biseptate with umbellate or fan shaped arrangement, 34-89 x 10.32 μm , length breadth ratio 1.7-3.0 : 1. They found that temperature 25-30 °C was found optimum for the growth of the fungus, from the zoospore suspensions they observed that the pathogen has successfully established the pathogenic nature revealing as the causative organism for quick wilt of *Piper nigrum* is *Phytophthora palmivora* (Butler) Butler MF4. Marimuthu (1991) recorded that *Phytophthora palmivora* MF4 is also causing wilt of susceptible betelvine cultivar Karpoori in Tamil Nadu. Ashok aggarwal *et.al.,*(1995) made a detailed studies on three isolates of *Phytophthora* from different parts of Madhya Pradesh and confirmed their identity as *Phytophthora nicotianae* var. *parisitica* and not *Phytophthora palmivora* .

Misra (1996) studied the secondary spread of disease through zoosporogenesis of *Phytophthora colacasiae* Raciborsky, which is causing leaf blight of *Colocasia esculenta*. He observed that zoosporangia and zoospores were being carried by rain splashes between the plants. The secondary inoculum is produced in abundance and is capable of causing infection.

Sushma nema and Sharma (2000) studied the characters of *Phytophthora* spp. causing leaf blight of *Dieffenbachia picta* and *D. amonae*. They observed the morphological characters of *Phytophthora* like coenocytic, hyaline broad tuberculated mycelium, sympodial branching and recorded the dimensions of sporangia, chlamydospore, oospore, optimum temperature, cultural characteristics, with all these characters they identified the pathogen as *Phytophthora nicotinae* var. *parasitica* Van Breda de Haan.

Sinha and Singh (1992) recorded *Fusarium solani* on betelvine causing wilt of betelvine in Erki, Gidhol and Erua villages in Aurangabad district of Maharashtra state and Handia village in Nawada district of Bihar during 1985-1987.

Deshpande and Tiwari (1991a) newly recorded the leaf blight and petiole rot of betelvine caused by *Rhizoctonia solani*. They observed the petiole rot and the leaf spot on the mother leaves the symptom appeared as circular to irregular brownish spot with dark brown margin.

Prathibha Sati and Sinha (1999) observed studied the survival of *Rhizoctonia solani* in soil under different soil conditions. They observed that the fungus survived in infected plant debris for 150 days and in the form of sclerotia. They also observed that *Rhizoctonia solani* survived for 150 days in infected crop debris incubated at 10-40 C and for 120 days at 0 C.

Anamika and Khare (2002) observed the different conditions of *Rhizoctonia solani* regarding the induction of imperfect and perfect stages. And observed that the fungus *Rhizoctonia solani* produces both imperfect stages like hyphae and sclerotia and also perfect stages like basidiospore in soil.

Vineeta *et al.*, (2002), studied 46 isolates of *Rhizoctonia solani* from Bijnore, Uttar Pradesd, they observed that all the isolates shared typical characteristics with that of *R. solani* like right angle branching near the distal septum of the cells in young vegetative hyphae. Sclerotia not differentiated into rind, cortex and medulla. Sharma *et al.*, (2004), observed maximum growth and sclerotial production of *Rhizoctonia solani* on PDA medium than the rest of the nutrient medium like, Brown's medium, Maltose medium, Richard's medium, and Czapeck's – Dox medium respectively.

Isolation of soil borne fungal pathogens

Papavizas *et al.,* (1980) had given a selective medium to isolate *Phytophthora capsici* from soils, like P5VPP-BH medium which make the maximum recovery of Phytophthora from soils, this medium includes important ingredients like Pimaracin, Pentachloronitrobenzene, vanomycin, Penicillin, benomyl and Hymexazol.

Manoharachary (1981) isolated many fungi of Peronosporales including *Pythium* from soils by baiting technique, they used baits like boiled hemp seeds, Maize grain, pollen grains, grass blade, fruits like mango, apple, tomato and seeds of *Crotolaria, Brassica.*

Padmanabhan and Alexander (1982) developed a baiting technique for selective isolation of *Pythium* from soil and infected roots of sugarcane seedling. They took sugarcane leaf laminar bits of size 5- 10 cm^2 were boiled in distilled water for 15 minutes. The leaf bits were floated in infected soil

solution and were incubated at room temperature (22-28°C) for 8 hours. Then the leaf bits were washed under sterile water and then placed on oats agar medium and incubated at room temperature (22-28°C) for 24 hours. They found that all the leaf bits were colonized by *Pythium.*

Rama Rao and Manoharachary (1990) studied the soil fungi of Andra Pradesh, they have isolated more than 156 species of soil fungi and they even described these isolated fungi in detail. They have followed many methods of isolating soil fungi like, dilution plate method, soil plate method and baiting technique.

Irwin (1997) pointed out the complexity of the soil environment and discussed the methods of isolation of soil borne fungal pathogens from plant tissue and soil, inoculation procedures. He isolated the *Phytophthora* spp, from soil by the baiting technique, where the suspected diseased tissue or infested soil is placed in contact with bait and the pathogen is subsequently isolated from the advancing margin of the lesion in the bait. He also stated that the soil plating and serial dilution technique were the common methods used for isolation of soil pathogens.

Pandey *et al.,* (1999a) used wheat straw and sugar beet hypocotyls as biological baits to isolate and to observe the saprophytic behavior of *Rhizoctonia solani* and *Rhizoctonia bataticola.*

Iyengar *et al.,* (1959), studied on the preservation of fungal cultures and found that the fungi belonging to Eu-basidiomycetes were found to be viable even after seven years of storage under mineral oil at 5-10°C. They also found that the Sclerotia of *Sclerotium rolfsii* that were stored under the above said conditions were not viable when tested after 4 years.

Pathogenicity tests for soil borne fungal pathogens

Anandraj *et al.,*(1996) isolated *Phytophthora* capsici from *Piper nigrum* and was cultured on carrot agar medium for 48h and 1cm diameter mycelial discs were cut from the growing edges placed in petri plates with few drops of sterilized distilled water and incubated in light for 24h to induce sporulation. Ten such sporulating discs were used as inoculum for each vine; they placed inoculum in the rhizosphere of the vines to test for its pathogenicity.

Bisht *et al.,*(1997) carried out pathogenicity tests in a glass house using pasteurized soil and incubated at 22-24 °C. Pre sterilized pots of 25cm diameter were supplemented with 15 mycelial discs of size 1cm in diameter of *Pythium* species, to study the seed and seedling rot of tomato plants.

Anamika and Khare (2002), done pathogenicity tests on seven days old mungbean at 96-100%humidity and at temperature 28-30°C in green house. They inoculated collar portion of seven days old mungbean plants grown in sterilized soil in pots and was inoculated with 5mm discs of *Rhizoctonia solani.*

Botanical control of soil borne fungal pathogens

Shekhawat and Prasada (1971) studied the extracts of forty-one plant species belonging to twenty-eight families. *Oscimum sanctum, Solanum xanthocarpum, Datura stramonium, Melia azedarach, Lausonia alba, Allium cepa, Allium sativum* and *Mentha piperita,* were showing antifungal properties against *Alternaria tenuis* Nees, *Curvularia penniseti* and *Helminthosporium* spp. Deshpande and Tiwari (1991c) have made experiments in pots to study the effects of soil solarisation during summer, on *Sclerotium rolfsii.,* which is a causal organism of collar rot of betelvine. Their results revealed that all

betelvine cuttings were free from collar rot which were planted in the pots infested with *Sclerotium rolfsii* which were previously solarised for 15 days.

Dipak *et al* .,(1999) evaluated many fungicides and antibiotics by poison food technique. Johri *et al.,* (1992) found that the fungicidial activity of coumarins of plant origin like calophyllolide, xanthotoxin and karanjin was evaluated to help prevent crop losses of *Piper betle.*

The disease was caused by *Colletotrichum capsici* and *Phytophthora palmivora.* Methoxsalen showed activity similar to that of synthetic fungicides copper oxy chloride and streptocycline. Johri *et al.,* (1994) worked on botanicals for management of betelvine diseases. They extracted saponins from *Mimusops elangi* and *M. littoralis* seeds and also from *Ammi majus* and found that these were 86-100% effective against *Phytophthora palmivora* .

Mandal *et al.,* (1994) found that incidence of diseases such as *Phytophthora nicotianae var. parasitica, P. nicotianae, Colletotrichum capsici* and *Xanthomonas campestris* was lowest in plants treated with neem seed cake, and highest in the untreated plants.

Anandraj and Leela (1996) worked on toxic effects of plant extracts on *Phytophthora capsici* causing foot rot of black pepper. They used leaf extracts from *Azadirachta indica, Chromolaena odorata, Lantana camara, Piper colubrinum* and *Strychnos nuxvomica* and tested against vegetative and reproductive phases of *Phytophthora capsici,* incluces mycelial growth, sporangial production, zoospore production were completely inhibited by *Chromolaena odorata* and similar results occurred with *Azadirachta indica.* They concluded that the water soluble toxic extracts of *Azadirachta indica* and *Chromolaena odorata* are ideal for developing into fungicides.

Bansal and Rajesh (2000) evaluated the leaf extracts of *Azadirachta indica, Atropa belladonna, Calotropis procera, Oscimum bacillium, Eucalyptus amygdalina, Ailanthus excelsa* and *Lantana camera against Fusarium oxysporum* by poisoned food technique and found that among seven leaf extracts *Azadirachta indica* proved highly toxic to *Fusarium oxysporum.*

Biocontrol of soil borne fungal pathogens

Bakshi and Singh (1956) described *Trichoderma viride* Pers. Ex Fries, as the colonies of *Trichoderma viride* are fast growing, growth rate 4.9 cms. White at first soon turning light green, which represent conidial areas. Conidiophores not distinct from vegetative hyphae, indefinite in length, di or tri-chotomously branched, phialides, 5-11.6 x 1.7-2.6 μm, conidia borne in groups of two to four held together in mucilage in persistent heads which are 6-8 μm in diameter, some times the adjoining heads fuse together to form a large head, pale green – brown tinge, sightly thick walled, smooth globose, 2.4-3.7 μm or more commonly ovoid, 3.2-4.6-3μ m.

Mehrothra (1980) has given a detailed account of Phytophthora wilt on betelvine (*Piper betle.*L) the causal organism of foot rot and wilt was *Phytophthora parasitica* var.*piperina* Dastur. The disease is severe during rainy and cloudy seasons. While the infection may also from the contaminated ponds. He also pointed out the role of infected plant cuttings, which was responsible in the dissemination of *Phytophthora.* He recommended that the dipping of plant cuttings in a suspension of *Trichoderma viride* prior to planting would control the disease.

Anandraj and Sarma (1994) described the symptoms caused by *Phytophthora capsici* on above ground and below ground plant parts of *Piper nigrum* and the use of biocontrol measures, biocontrol agents against

Phytophthora capsici, integration of biocontrol in the management of *Phytophthora nigrum* disease, control by ecological means, growing cultivar mixtures, chemical control and biological control organisms were briefly discussed.

An integrated approach in which antagonists such as *Gliocladium virens* and *Trichoderma spp.*, are used to suppress soil populations of *Phytophthora capsici*, together with sprays of Bordeaux mixture, metalaxyl or phosphoric acid against aerial infection, provides the best prospect for minimizing losses.

Hillocks and Waller (1997b) deduced the relationship between soil borne fungal pathogens and soil-inhabiting microorganisms. The direct interaction exists when microorganisms compete for space or nutrients, these will antagonize one another by producing toxic metabolites. The Trichoderma is having more potential as a biocontrol agent.

Rodriguez-Kabana and Kokalis- Burelle (1997) they stated that the use of *Trichoderma* spp. for control of damping-off and root rots caused by species of *Phytophthora*, *Pythium* and *Rhizoctonia solani.*

Abraham and Gupta (1998) evaluated seven biocontrol agents *Chaetomium globosum, Coniothyrium minitans, Gliocladium virens, Laetisaria aravilis, Trichoderma hamatum, T.harzianum* and *T. viride* against *Rhizoctonia solani* Kuhn. *Rhizoctonia solani* which was causing root rot of French bean (*Phaseolus vulgaris* L.) was studied under *in-vitro* and glasshouse conditions. *In-vitro* evaluation of biocontrol agents by dual-culture method revealed that, *T.harzianum* caused maximum inhibition, followed by *Trichoderma hamatum, T. viride, Gliocladium virens*. In the pot experiments *G. virens* and *T.harzianum* proved superior to other antagonists in reducing pre-emergence root rot to 6.7 and 13.3%, respectively, as compared to 36% in control. *T.harzianum* was also

effective to reduce post-emergence root rot, and they also observed that pre-inoculation of antagonists is found to be superior method to check post-emergence root rot.

Shanmugam and Sukunara (1999) isolated native organisms from the rhizosphere of healthy ginger plants in the rhizome affected fields. They screened in vitro for their antagonistic effects against the pathogen *Pythium aphanidermatum* by dual culture and cell free culture filterate studies. *Aspergillus niger, A. fumigatus, A. flavus* and *Trichoderma viride* were found to be potential antagonists. Among the fungicides tested, methoxy ethyl mercuric chloride, copper oxy chloride, mancozeb and Bordeaux mixture, mancozeb was found compatible with all the four antagonists.

Ram *et al.,* (1999) found that rhizome rot of ginger caused by either *Pythium myriotylum* and *Fusarium solani.* They isolated resident biocontrol agents (BCA) like *Trichoderma harzianum* and *Pseudomonas spp.* Combination of both BCAs resulted in better germination and plant stand, reduced disease, and increased yield. The soil application of *Trichoderma harzianum , Pseudomonas spp* with fungicides like Bavistin and Ridomil were also effective. Anith and Manomohandas (2001) revealed that *Trichoderma harzianum* has significantly reduced the incidence of *Phytophthora capsici* causing rot disease of *Piper nigrum.*

Joe *et al.*, (2000) conducted farm trials with Trichoderma, they added 10 and 5 kg ha^{-1} at pre and post monsoon periods respectively they mixed it with 500 kg of compost and revealed that this method is helpful in controlling root rot and wilt causing by *Rhizoctonia solani, Phytophthora* spp and *Phytophthora capsici* disease of Pepper (*Piper nigrum*).

Manoranjitham *et al.*, (2001) found that damping off tomato caused by *Pythium aphanidermatum* was reduced by the application of the talc based formulation of *Trichoderma viride* and *Pseudomonas fluorescens* in nursery beds before sowing. Besides reducing the pre and post emergence damping off, these antagonists significantly reduced the population of *Pythium aphanidermatum* in the soil.

Kannan and Revathy (2002) conducted field experiments to know the efficacy of powdered formulations of *Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus subtilis* they mixed with farm yard manure (FYM) in controlling *Phytophthora capsici,* causing foot rot and wilt in pepper (*Piper nigrum*). The highest control of foot rot and wilt was recorded with *Trichoderma viride* mixed with FYM + Bordeaux mixture.

Rajan *et al.*, (2003) isolated *Trichoderma* and evaluated the efficiency of isolates both in vitro and in vivo and found that isolates *Trichoderma virens*-12 and *Trichoderma harzianum* –26 were effective in controlling the *Phytophthora* foot rot of black pepper.

Control of soil borne diseases of betelvine under field conditions

Kousalya and Jeyarajan (1990) have mass multiplied *Trichoderma* spp. in various substrates like, Tapioca rind, wheat barn, ground nut shell, Paddy chaff, rice barn, sugarcane bagasse, wheat straw, sheep manure, poultry manure, shelled maize cob, paddy straw and chick pea. They also used sorghum grain as base substrate for mass multiplication of *Trichoderma harzianum* and *Trichoderma viride.*

Peter (1990) has stated that formulation of *Trichoderma harzianum* at 1500 kg ha^{-1}, will suppress *Rhizoctonia solani* and *Sclerotium rolfsii.* 10^5 propagules g^{-1} of Trichoderma is necessary for obtaining effective control of soil borne fungal pathogens.

Sangeetha and Jeyarajan (1993) have mass multiplied *Trichoderma* spp., by using different substrates like rice barn, wheat barn, peat soil, farm yard manure (FYM) and rice straw. In all the substrates they have got good colonization of *Trichoderma viride* and also *Trichoderma harzianum.*

Mukhopadhyay (1994) stated that biological control of plant diseases is fully justified, it includes using of biological methods to control harmful organisms causing plant diseases without disturbing the ecological balance and he reported that *Trichoderma harzianum* successfully controlled *Sclerotium rolfsii.*

Indu and savant (1996) have mass multiplied *Trichoderma harzianum* on the organic wastes like coffee waste, poultry manure from these substrates they achieved higher cfu $g^{-1}$of substrate like 92 x 10^{12} & 4.3 x 10^9 respectively. Whereas Najam and Singh (2004), have mass multiplied *Trichoderma harzianum* on cow dung, they observed maximum growth at 30 percent moisture level of air dried cow dung and obtained 2.46 x 10^{12} cfu g^{-1} of air dried cow dung.

Narasimhan *et al.,*(1975) have studied agronomic control practices to control diseases of betelvine like growing the crop in narrow beds without allowing water to stagnate around the base of crop, will effectively check the disease caused by *Phytophthora* spp. Palti and Katan (1997) have stated the influence of cultivation practices and cropping systems on soil borne pathogens, the composts will improve plant nutrition and soil structure and it also suppress

the soil borne pathogens. The flooding irrigation wet all the surface of the soil, while irrigation by furrows and dripping irrigation will reduce infection.

Haj Hoitink and Boehm (1999) stated that broad spectrum biological control of diseases caused by soil borne plant pathogens such as *Pythium*, *Phytophthora* and *Rhizoctonia solani.* These fungi may be introduced into sources of organic amendments for sustenance of biocontrol agents. The composts serve as an ideal food base for biocontrol agents and offer an opportunity to introduce and establish specific biocontrol agents into soils, which in turn leads to sustained biological control based on the activities of microbial communities.

Prasad and Rangeshwarn (2000) amended the soil with granular formulation of *Trichoderma harzianum.* They conducted micro plot test under field conditions to evaluate a modified wheat barn-kaolin granular formulation of *Trichoderma harzianum,* which is an effective biocontrol agent as it can parasitise many soil borne fungal pathogens especially *Rhizoctonia solani* and *Sclerotium rolfsii.* They observed greater reduction in the population of *Rhizoctonia solani.* Rathore and Pathak (2002), observed significant and the lowest systemic infection due to soil borne pathogen *Peronospora alta,* in the FYM amended plots.