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RHIZOCTONIA: A GENUS OF ORCHID SYMBIONTS

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Abstract

The present paper deals with the study of genus *Rhizoctonia*, the orchid symbiont which includes the pathogenicity as it is the main causal organisms of various crop plants like alfalfa, soyabean, lima bean, peanut, papaya, cucumber, corn and eggplant. Besides its pathogenic nature it is mycorrhizal with many plants specially with orchids. The seeds of orchids are very minute without any reserved food and the fungus helps them in germination. The fungi provide phosphate, minerals, vitamins, exogenous carbon sources and other growth factors showing the dependence on mycorrhizal partner for completing the life cycle. Identification features, classification and cultural characteristics of various species of *Rhizoctonia* have also been described here.

Introduction

RHIZOCTONIA IS the name given to a collection of basidiomycetacious fungal taxa that includes plant pathogenic and mycorrhizal species. The genus *Rhizoctonia* which was erected by deCandolle in 1815 to accommodate the non-sporulating root pathogens contains over 100 species. Unfortunately the lack of more specific characters has led to the classification of a mixture of unrelated fungi as *Rhizoctonia* species (Moore, 1987; Parameter and Whitney, 1970). The genus has geographical spread from the sub-arctic to the tropics. *Rhizoctonia solani* [teleomorph *Thanatephorus cucumeris* (Frank) Donk], the most widely recognized species of *Rhizoctonia* was originally described by Julius Kuhn on potato in 1858.

The members of family Orchidaceae are widely associated with the different species of *Rhizoctonia* which aid orchid seed germination in nature.

Rhizoctonia solani does not produce any asexual spores (conidia) and only occasionally produces sexual spores (basidiospores). Unlike many basidiomycete fungi, the basidiospores are not enclosed in a fleshy, fruiting body. The sexual stage of *Rhizoctonia solani* has undergone several name changes since 1891, but is now accepted as *Thanatephorus cucumeris*.

Rhizoctonia solani is called a 'species complex' because it contains many related but genetically isolated sub specific groups (Adams and Butler, 1979; Anderson, 1982; Ogoshi, 1987). Major sub specific groups of *Rhizoctonia solani* traditionally have been identified on the basis of hyphal anastomosis reaction and are called anastomosis groups (AG) (Carling, 1996; Carling *et al.*, 1999). Fungi in the *Rhizoctonia* complex can be divided into two groups *i.e.* the multinucleate and the binucleate taxa. The multinucleate genera include *Thanatephorus* and *Waitea*, and the binucleate, *Athelia*, *Botryobasidium*, *Ceratobasidium, and Uthatobasidium.* Although all species of *Thanatephorus* and *Waitea* belong basically to the multinucleate group (Flentje *et al.*, 1963), the number of nuclei in cells vary from species to species and even among isolates (Butler and Bracker, 1970; Parmeter *et al.*, 1967).

Rhizoctonia solani: A Plant Pathogen

Rhizoctonia solani is a major pathogen of cereal and pasture crops causing several diseases, the most serious of which is the bare patch disease. This disease is characterized by patches of stunted growth, yellow leaves and reduced root system (Weller *et al.*, 1986). The fungus exists in various pathogenic forms that are able to cause disease on a wide number of plant species. It causes diseases named damping- off in radish, wheat and cotton (Ichielevich-Auster *et al.*, 1985). This disease has also been reported in longleaf pine, soybean and peas too (English *et al.*, 1986; Liu and Sinclair, 1991; Shehata *et al.*, 1981).

Rhizoctonia solani (AG-1) causes sheath and web blight disease of rice in most growing countries (Ogoshi, 1987; Zuber and Manibhusanrao, 1982). Isolates of AG-2 cause root canker in crucifers (Anderson, 1982). A number of isolates from AG-2 are reported to cause crown and root rot in soyabean (Liu and Sinclair, 1991). Seed and hypocotyls rot disease caused by *Rhizoctonia solani* (AG-4) isolates are serious diseases of leguminous plants (Anderson, 1982). *Rhizoctonia solani* primarily attacks below ground plant parts such as seeds, hypocotyls and roots, but is also capable of infecting above ground plant parts (Petkowski and deBoer, 2001).

Several species of *Rhizoctonia* have been reported as pathogens on ornamentals. Ornamental diseases caused by *Rhizoctonia solani* include pre-emergence

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and post-emergence damping-off, web blight, stem rot and foliar blight. Disease development starts from the soil debris of the plant, survival of sclerotia and mycelium of *Rhizoctonia solani* grows rapidly and utilizes the organic matter which plays a key role in disease development.

Very less information is available on characterization of ornamental isolates. Chase (1991) studied 309 isolates of *Rhizoctonia* sp. from ornamentals in Florida, U.S.A and found 129 multinucleate and 180 binucleate isolates; 36%multinucleate isolates were from roots, 24% from stems, and 40% from leaves.

Some of the ornamentals infected by *Rhizoctonia solani* belong to the genera, *Acacia, Aconitum, Ageratum, Aloe, Amaranthus, Avena, Asparagus, Bauhinia, Brassica, Bougainvillea, Calendula, Capsicum, Cassia, Cissus, Citrus, Coffea, Crotalaria, Cycas, Cymbidium, Dahlia, Datura, Equisetum, Euphorbia, Ficus, Helianthus, Hibiscus, Ilex, Ipomoea, Jasminum, Laeliocattleya, Lantana, Limonium, Lotus, Mentha, Nerium, Ocimum, Phalaenopsis, Punica, Saxifraga, Salvia, Solanum, Tagetes, Taxus, Thuja, Valeriana, Viola* and *Zingiber.*

Rhizoctonia Species Associated with Orchids

Link (1840) was the first person who recorded the hyphal structures in the cells of an orchid seedling. Reissek (1847) also made an attempt to illustrate the presence of fungi in orchid roots. A functional relationship (mutualistic) between orchid nutrition and the presence of endophytic hyphae was first suggested by Frank (1891). However, the importance of fungi in orchid seed germination was realized following the the pioneer work of Bernard (1903), who successfully germinated orchid seeds by infecting with suitable fungus.

Orchid seeds are microscopic and have no reserved food material thus in nature, orchids utilize the mycorrhizal fungi to initiate the seed germination and for the growth of seedling (Andersen and Rasmussen, 1996; Currah *et al.*, 1997; Kaushik, 1988; Peterson *et al.*, 1990; Vij, 1986). The fungi provide phosphate, minerals, vitamins, exogenous carbon sources and other growth factors showing the dependence on mycorrhizal partner for completing the life cycle (Smith and Read, 1997).

A large number of fungal partners in orchid mycorrhizae belong to the genus *Rhizoctonia* (Burgeff, 1936; Warcup and Talbot, 1967, 1980) .These includes *Rhizoctonia goodyerae-repentis* isolated from *Goodyera repens* and *Rhizoctonia solani* from *Dactylorchis purpurella* (Downie, 1957, 1959; Masuhara *et al.*, 1993) . Fungi in *Rhizoctonia* do not have asexual spores but they share some unique vegetative characteristic (Mordue *et al.*, 1989); sclerotia have been observed in culture in some strains, but moniliod cells that are considered to be the precursors of sclerotia are always present.

Saksena and Vaartaja (1960) carried out the study on the forest nursery plants and isolated four new species *Rhizoctonia dichotoma, Rhizoctonia endophytica, Rhizoctonia globularis* and *Rhizoctonia hiemalis).* In another research, they reported another six species (*Rhizoctonia callae, Rhizoctonia repens, Rhizoctonia lilacina, Rhizoctonia rubiginosa, Rhizoctonia solani*, and *Ceratobasidium praticola*)from the forest nursery plants (Saksena and Vaartaja, 1961) .

Wolff (1926) and Burgeff (1932, 1936) *Rhizoctonia repens* from *Laeliocattleya canhamina*. *Rhizoctonia lanuginosa* from *Odontoglossum grands*, *Rhizoctonia mucoroides* from *Phalaneopsis amabilis*, *Rhizoctonia neottiae* from *Neottia nidus-avis, Rhizoctonia aerea* from *Taeniophyllum*, *Rhizoctonia floccose* from *Orchis maculata*, *Rhizoctonia asclerotica* from *Ophyrs apifera*, *Rhizoctonia gracilis* from *Oncidium sphacelatum*, *Rhizoctonia robusta* from *Oncidium cavendishianum*, *Rhizoctonia sclerotica* from *Ophyrus muscifera*. *Rhizoctonia stahlii* from *Platanthera chlorantha*, and *Rhizoctonia subtilis* from *Lycaste skinneri.*

Hyphomycetes that were able to produce conidia have also been isolated from orchid roots (Currah *et al.*, 1987, 1990; Richardson *et al.*, 1993). Among many bracket fungi that have been reported are *Armillaria mellea*, *Favolaschia dybowskyana, Fomes* sp., *Hymenochaete* sp., *Marasimus coniatus, and Xerotus javanicus* (Burgeff, 1932,1936; Hamada, 1940; Hamada and Nakamura, 1963; Jonsson and Nylund, 1979; Kusano, 1911). Kusano (1911) and Ramsbottom (1922) studied details of orchid mycorrhiza. Mehra and Nath (1974) studied mycorrhiza in the roots of *Zeuxine strateumatica* L. and also proved experimentally that the association of mycorrhiza was essential for germination of orchid seeds.

Vij and Sharma (1983) surveyed 39 North Indian orchid species and reported that these harboured an endotrophic and intracellular fungus in one or more of their organs in the adult phase. Roots were the most frequently infected organs ; the fungi repeatedly entered the roots through epiblema (velamen) cells and penetrate the deeper tissues through comparatively thin walled cells by developing fungal pegs. In *Aerides multiflorum*, the fungus enters the root through root hairs as well. Ten fungus species were isolated 8 belonging to *Rhizoctonia* and 2 to *Fusarium*. Kaushik (1983) also obsereved formation of intracellular pelotons in *Cephalantheropsis gracilis* velamen and cortical cells and intercellular hyphae in roots of several other orchids

Rajkumar and Kaushik (2007) attributed the penetrative ability of *Rhizoctonia solani* to all three composents of cellulose complex causing solubilization of the host cell wall.

Currah *et al.* (1987) isolated pure cultures of endophytic fungi that were obtained from the mycorrhizae of some native Alberta orchids. *Amerorchis rutundifolia, Calypso bulbosa, Coeloglossum viride, Corallorhiza maculata, Platanthera dilatata, P. hyperborea, P. obtusata* the fungi isolated by them were *Rhizoctonia repens, R. anaticula, Ceratobasidium obscurum* and *Leptodontidium orchidicola* respectively. One conidial isolate was identified as *Trichocladium opacum* two isolates resembling *Rhizoctonia* in cultural features, sporulated and are described as *Trichosporiella multisporum.*

Kaushik *et al.* (1987) reported species of *Rhizoctonia* as fungal endophyte from four different orchids *i.e. Epipactis, Calanthe, Aerides* and *Vanda* former two are terrestrial and latter are epiphytic. *Rhizoctonia solani, R. dichotoma, R. repens* and *R. dichotoma* are the endophytic fungi associated with above orchids.

In another research Currah (1987) isolated new species of *Thanatephorus pennatus* from the mycorrhizal roots of *Calypso bulbosa, Thanatephorus pennatus* is easily distinguished from other species in the genus by characteristics of the basidia, globose basidiospores and growth pattern on agar medium. Currah *et al.* (1990) studied the seasonal development and mycorrhizal fungi of the mycorrhizae of orchids *i.e. Coeloglossum viride, Platanthera hyperborean, P. obtusata, P. orbiculata.* Fungal endophytes belonging to the taxa were *Ceratorhiza goodyerae repentis, Epulorhiza anaticula* comb. nov., *E. repens,* and *Leptodontidium orchidicola.* A series of isolates bearing clamped moniliod cells and belonging to an unidentified species of *Sistotrema* was found in *Platanthera obtusata.* This is the first report of a *Sistotrema* species from orchid mycorrhiza.

Warcup and Talbot (1966, 1967, 1971 and 1980) identified large numbers of teleomorphs of *Rhizoctonia* species associated with orchids. The Fungi isolated are *Ceratobasidium angustisporum, C.cornigerum, C. globisporum,C. sphaerosporum, C.obscurum, C. papillatum, Thanatephorus cucumeris, T. orchidicola; T. sterigmaticus, Tulasnella allantospora, T. asymmetrica, T. calospora, T. cruciata, Tulasnella violea, Ypsilonidium anomalum, Y. langleiregis, and Y. sterigmaticum.*

Roberts (1999) lists out fifteen species with *Rhizoctonia* anamorphs that are known to be orchid symbionts. Five species of *Ceratobasidium*, three species of *Thanatephorus*, one species of *Serendipta* (*Sebacina*) and *Oliveonia* and five species of *Tulasnella*. Then all belong in Heterobasidiomycetes. Agaricanae are represented among orchid symbionts by *Armillaria* (Cha and Igarishi, 1996; Lan *et al.*, 1994; Terashita, 1996) and *Mycena* (Fan *et al.*, 1996; Lan *et al.*, 1996). Hericianae and Thelophoranae are represented by Russulaceae and Thelephoraceae (McKendrick *et al.*, 2000; Taylor and Bruns, 1997) and Hymenochaetanae by *Erythromyces* (Umata, 1995).

Rhizoctonia: Mycorrhizal Association with other Plant Species

In the family Gentiaceae most species host mycorrhizal fungi, and many species show similarities to the orchids with regard to seed size (Harley, 1969). Neumann (1934) investigated the mycorrhiza of some Gentiana species and concluded that the mycorrhiza was of orchid type and the fungus isolated belonged to *Rhizoctonia.* Species belonging to the Burmanniaceae and Triuridaceae have been reported to form mycorrhiza with *Rhizoctonia* (Harley, 1969). Stahl (1949) isolated a number of *Rhizoctonia* strains from the moss, and referred them to the taxa as described by Burgeff (1932, 1936). Fungi *Rhizoctonia pini-insignis* isolated from roots of *Pinus radiata* Don., may be involved in a mycorrhizal relationship as it improved growth of the plants. In bryophyte *Aneura* (Rayner, 1927; Stahl, 1949) in this both acholorophyllous and green species form mycorrhiza with *Rhizoctonia.* It would be worthwhile to clarify that *Cryptothallus mirabilis* known to be the only achlorophyllous bryophyte (a liverwort) has recently been transfered to *Aneura mirabilis* because of molecular and morphological features.

Classification and Identification of *Rhizoctonia*

The genus *Rhizoctonia* was established by de Candolle, by including *Rhizoctonia crocorum* DC: Fr. The isolation and identification of orchid mycorrhizal fungi are of importance to the understanding of the orchid fungus relationship. Unfortunately the lack of more specific features led to the classification of a mixture of unrelated fungi as *Rhizoctonia* species (Moore, 1987; Parmeter and Whitney, 1970).

The most widely studied species of *Rhizoctonia* is *Rhizoctonia solani* Kuhn which is associated with a teleomorph *Thanatephorus cucumeris* (Frank) Donk (Talbot, 1970; Tu and Kimbrough, 1978). The most useful system for classification of fungi in the *Rhizoctonia solani* complex is based largely on anastomosis grouping (AG) (Carling, 1996; Ogoshi, 1987).

Bernard (1909) referred the orchid endophytes to *Rhizoctonia* in describing the three species *Rhizoctonia repens, R. mucoroides* and *R. lanuginosa.* Other anamorphic species occurring as orchid endophytes were described by Burgeff (1932, 1936); Costantin and Dufour (1920) and Curtis (1939).

The genus represents an assemblage of taxonomically diverse groups that differ in many features like anamorph and teleomorph stages (Curtis, 1939; Currah *et al.*, 1987). The current species concept stipulates that isolates of *Rhizoctonia solani* stand distinguished in having,multinucleate cells in young vegetative hyphae; dolipore septa;branching near the distal septum of cells in young vegetative hyphae; hypha has some shades of brown; and constriction of hyphae and formation of septa at a short distance from the point of origin of hyphal branches (Parmeter and Whitney,1970).They however, lack pigments other than brown; conidia; clamp connections; differentiated into rind and medulla; and rhizomorphs.

Classification

The classification of *Rhizoctonia* species has evolved mainly from the studies of isolates that are isolated from the plants that are suffering from diseases. *Rhizoctonia* species consists of a large variety of teleomorphs that belong to different families, classes and orders. The teleomorphs of *Rhizoctonia* are referred to the Subdivison- Basidiomycotina, Class- Hymenomycetes, Subclass-Holobasidiomycetidae or Phragmobasidiomycetidae (Sneh *et al.*, 1991).

The conventional method of identifying these fungi has been based on their cultural characteristics like colony colour, chains of moniliod cells, mycelium characteristics and sclerotia (Curtis, 1939; Currah *et al.*, 1987). Moniliod cells are also known as monilia (Burgeff, 1932, 1936), moniliod cells (Butler and Bracker, 1970; Duggar and Stewart 1901), chlamydospores (Sappa and Mosca, 1954; Saksena and Vaartaja, 1960) spores (Curtis, 1939), pseudospores (Crandall and Arillaga, 1955) or doliform cells, barrel shaped cells, short cells or sclerotia cells (Butler and Bracker, 1970).

Ruhland (1908) took special note on the moniliod cells of a *Rhizoctonia* like fungus from Germany and erected a new genus *Moniliopsis* to include the fungus under the name *Moniliopsis aderholdi. Moniliopsis* was later considered identical with *Rhizoctonia solani* (Duggar, 1915; Schultz, 1937) and it was proposed that the genus *Moniliopsis* be merged with *Rhizoctonia.*

Morphologically *Rhizoctonia* can be classified on the basis of nuclei present in young cells (Sneh *et al.*, 1991). The important plant pathogenic species complex include *Rhizoctonia solani* (teleomorphs: *Thanatephorus*, Ceratobasidiales) and *Tulasnella* (Tullasnellales). The uninucleate strains occur in anamorphs of *Ceratobasidium* (Hietala *et al.*, 2001) but have rarely been reported (Hietala, 1997). Multinucleate, binucleate and uninucleate cells occurs. *Rhizoctonia solani* has multinucleate cells. *Ceratobasidium* and *Tulasnella* possess binucleate cells. Anamorph *Ceratobasidium* has uninucleate cells.

Anastomosis grouping (AG) is a way to classify these fungi. When two isolates belong to the same AG their hyphae are able to fuse. The *Rhizoctonia solani* (Multinucleate) AGs known to be associated with orchids are AG-6 and AG-12 (Carling 1996; Carling *et al.*, 1999). Uninucleate *Rhizoctonia* species include only one AG. Binucleate *Rhizoctonia* species has 21 AG and multinucleate *Rhizoctonia* species has 13 AGs. AG has been identified in relation to many diseases.

Isolates of certain AG was found to infect many host plants, while those of other AG has rather limited host range. AG-1 and its subgroups infect many different crops. The most important disease caused by isolates of the AG-2 and its subgroups infect sugar beet, rice and corn. Isolates of AG-3 causes the black scurf disease on potato tubers. AG-4 group has wide host range like onion and cotton. AG-8 causes the bare patch disease on wheat and barley. Isolates of other anastomosis groups may be weakly pathogenic on several plants or not pathogenic at all, such as AG-6 which is non-pathogenic. Certain isolates are capable to form mycorrhizal association with orchids (Ogoshi, 1996).

AG-5 and AG-6 have been isolated from orchids and it has been shown that all AG of *Rhizoctonia solani* can potentially form mycorrhizal association (Masuhara *et al.*, 1993). Several new isolates of multinucleate *Rhizoctonia* may be found to be involved in orchid mycorrhizal association.

Moore (1987) assigned doliporous *Rhizoctonia* like fungi into the groups namely *Ceratorhiza, Epulorhiza* and *Moniliopsis* according the cell nuclear and septal pore apparatus and teleomorph. The members of *Rhizoctonia* complex are assigned to the Ascomycetes. Characteristic features are transparent septa with large central pores and the presence of woronin bodies. Holobasidiomycetes have dolipore septa with parenthesomes that are perforate. Basidiomycetes have three layered septa. The four main genera represented are *Ceratobasidium* Rogers (e.g. *Rhizoctonia endophytica* var. *endophytica* Saksena and Vaartaja and *Rhizoctonia cerealis* E.P. Hoeven),*Thanatephorus* Donk (includes the teleomorph of e.g. *Rhizoctonia solani*), *Tulasnella* J. Schrot (e.g. *Rhizoctonia repens* Bernard) and *Waitea* (Warcup and Talbot, P.H.B. (e.g. *Rhizoctonia zeae* Voorhees). A major taxonomic feature of the anamorph that separates the former and latter two genera is the respective presence of multinucleate and binucleate cells in young vegetative hyphae (Sneh *et al.*, 1991).

The perfect stage is known for a few species. The history of the taxonomy and synonymy of the perfect stage, *Ceratobasidium filamentosum*, of *Rhizoctonia solani* and *Rhizoctonia microsclerotia* is given by Rogers (1943) and Olive (1957). *Rhizoctonia crocorum* is shown to be the imperfect form of *Helicobasidium purpureum* (Tul.) Pat. Some strains of *Rhizoctonia bataticola* (Taub.) Butl. produce the pycnidia of *Macrophomina phaseoli* (Maulb.) Ashby (1927).Parmeter *et al.* (1967) isolated a number of fungi of genus *Rhizoctonia* that are associated with orchid root. They describe that *Rhizoctonia solani* comprised of number of taxonomic species showing the various teleomorphic states. *Rhizoctonia crocorum* is the anamorph of *Helicobasidium brebisonii. Thanatephorus cucumeris* is the teleomorph of *Rhizoctonia solani. Tulasnella* is the teleomorphs of *Rhizoctonia repens* the anamorph of *Ceratobasidium* assign to the new genus *Ceratorhiza. Macrophomina phaseolina* is the perfect stage of *Rhizoctonia bataticola* Tassi (Goid).

Roberts (1999) summarized the *Rhizoctonia* forming fungi and assigned *Sebacina* and *Opadorhiza* to Exidiales. *Tulasnella* to Tulasnellales, and *Thanatephorus, Ceratobasidium* and *Waitea* to Ceratobasidiales and *Helicobasidium* (*Thanatophytum)* to Platygloeales.

Epulorhiza one of the most common genera forming mycorrhizas with terrestrial orchids but it is least studied (Currah and Zelmer, 1992). Five species of *Epulorhiza* have been identified on morphological and cultural characters like shape and dimension of moniliod cells. Species are *Epulorhiza repens* (Moore, 1987), *E. albertaensis* (Currah *et al.*, 1990; Currah and Sherburne, 1992), *E. anaticula* (Currah *et al.*, 1990), *E. calendulina* (Zelmer and Currah, 1995) and *E. inquilina* (Currah *et al.*, 1997). Besides these six species of *Tulasnella* with a *Rhizoctonia* anamorph have been found to be orchid mycobiont. *Sebacina vermifera* (Warcup, 1988), *Tulasnella allantospora, T. assymmetrica, T. calospora, T. cruciata, T. irregularis* and *T. violea* (Warcup and Talbot, 1971).

The genus *Rhizoctonia contains nearly 87 species.* These are *R. alba, R. allii, R. alpina, R. anaticula, R. anomala, R. apocynacearum, R. arachnion, R. asclerotica, R. aurantiaca, R. batatas, R. bataticola, R. betae, R. bicolor, R. brassicarum, R. callae, R. candida, R. carotae, R. cavendishiana, R. centrifuga, R. crocorum, R. dauci, R. destruens, R. dichotoma, R. dimorpha, R. endophytica* var. *endophytica, R. endophytica* var. *filicata, R. ferruginea, R. floccosa, R. fragariae, R. fraxini, R. fuliginea, R. fumigata, R. fusca, R. globularis, R. goodyerae-repentis, R. gossypii* var. *anatolica, R. gracilis, R. grisea, R. lanuginosa, R. leguminicola, R. lilacina, R. lupini, R. macrosclerotia, R. mali, R. medicaginis, R. menthae, R. microsclerotia, R. moniliformis, R. monteithiana, R. mucoroides, R. muneratii, R. muscorum, R. napi, R. neottiae, R. orobanches, R. oryzae-sativae, R. papayae, R. pini-insignis, R. potomacensis, R. praticola, R. quercina, R. quercus, R. radiciformis, R. ramicola, R. rapae, R. repens, R. robusta, R. rubi, R. rubiginosa, R. silvestris, R. solani, R. solani* var. *cedri-deodarae, R. solani* var. *fuchsiae, R. sphacelati, R. stahlii, R. strobi, R. strobilina, R. subtilis, R. tabifica, R. tomato, R. tricolor, R. tuliparum, R. violacea,* and *R. dauci*. Cultural characteristics of some of *Rhizoctonia* and allied species are as follows:

Ceratobasidium obscurum

On PDA medium, growth rate approx 0.2 mm/h. Mycelial mat low, plane, pale cream yellow becoming pale orange yellow and densely cottony after several months hyphae 4-6 μm, diameter, thin walled with dolipore septa, lacking clamp connections binucleate (Rogers, 1935).

Epulorhiza anaticula

Hyphae hyaline with constricted branch points, 2.5-7 μm diameter. Submerged growth in PDA, CMA. Ellipsoid or globose or irregular moniliod cells, 10-20 μm, colony creamy white to pale tan or orange rubbery or leathery in appearance and texture (Currah, 1987).

Moniliopsis anomala

On PDA medium, colonies 8 cm diameter, after 10 days. After 48 days mycelium partly submerged, aerial mycelium pale brown to white scattered, felted tufts, center dark reddish in brown. Sclerotia numerous in scattered clusters (Burgeff, 1936).

Rhizoctonia anaticula

On PDA medium, aerial mycelium thin, dense, cream, margin submerged, appearing glabrous, growth. On CMA mycelium submerged, sparse, white, runner hyphae, sclerotia minute. Moniliod cells thin walled, broadly ellipsoidal to clavate (Currah, 1987).

Rhizoctonia borealis

Mycelium at first light tan, later dark brown, sporodochia numerous, up to 3mm in diameter, distinct from the rapidly growing mycelium. Spores clostridium like 37-42 μm by 24-28 μm (Burgeff, 1936).

Rhizoctonia callae

On PDA medium, the colony is white, later cream yellow with low growth of colony aerial mycelium. Vegetative hyphae are septate hyaline becoming brownish, branching at near right angle. The hyphae are 3-4.5 µm wide and frequently anastomosed. The chlamydospores are hyaline, brown in mass, ovoid to doliform, 16-22 µm 11-15 µm (Castellani, 1934).

Rhizoctonia cerealis

Colonies are of white to light brown shade on the PDA, zonation absent. Moniliod cells 15-30 µm 7-12 µm. Sclerotia white to brown (Boerma and Verhoeven, 1977).

Rhizoctonia dichotoma

Mycelium is white in mats, hyphae branched, septate, walled smooth, moniliform, sporodochia white when young and becomes pale to brown during maturity, moniliod cells 20-24 µm by 8-12 µm (Saksena and Vaartaja, 1961).

Rhizoctonia globularis

Mycelium white in mats, hyphae branched, septate, walls smooth, aerial hyphae dichotomously branched, moniliform, sexual organs are not present. Moniliod cells measure 11.3-13.7 µm by 6.3-7.5 µm (Saksena and Vaartaja, 1961).

Rhizoctonia gracilis

Mycelium white. Sporodochium yellow, waxy, and elongate in shape, only slightly greater in diameter than the vegetative hyphae (Burgeff, 1936).

Rhizoctonia hiemalis

Mycelium is white in mats, hyphae branched, thin, septate, walls smooth, aerial branches moniliod at maturity, sporodochium of many short, branched moniliod hyphae, chlamydospores hyaline, thick walled, 3-8 in each hypha, full of granular material at maturity, sexual reproductive bodies are absent (Saksena and Vaartaja, 1961).

Rhizoctonia lanuginosa

Mycelium is white, sporodochium yellowish, waxy, spores elongate, widest beyond the middle (Burgeff, 1936).

Rhizoctonia monilioides

Cottony aerial hyphae appear on agar medium. Sporodochia absent. Spores in chains 10-14 µm by 7-10 µm. Growth in liquid culture similar to that of Rhizoctonia repens (Burgeff, 1936).

Rhizoctonia neottiae

Sporodochia are dark red brown, large, open textured. Hyphae coarse, 9-10 µm in diameter. Spores elongate 74-80 µm by 19-22 µm (Burgeff, 1936).

Rhizoctonia oryzae-sativae

White to yellowish colonies come on PDA, moniliod cells 21- 37 µm to 6-11 µm, sclerotia irregularly globose in shape (Mordue, 1989).

Rhizoctonia ramicola

Olivaceous grey to purple brown colonies are formed on PDA, moniliod cells and sclerotia are absent. Hyphae measures 3.7-9.9 µm (Tu and Kimbrough, 1975).

Rhizoctonia repens

On PDA medium, colonies are 5-7cm diameter, margin submerged, entire, glabrous, and white to cream. Vegetative mycelium mostly growing beneath the surface of agar media. Aerial mycelium sparse forming in irregular, low, cream to yellowish patches. On CMA mycelium nearly completely submerged white to cream. Sclerotia minute undifferentiated loosely arranged clusters of moniliod cells. Vegetative hyphae septate hyaline, constricted at branch points. Moniliod cells thin walled, hyaline, and ellipsoidal to nearly spherical (Bernard, 1909).

Rhizoctonia sclerotica

Mycelium white when young, light brown at maturity, basal hyphae branched, septate, smooth, aerial hyphae rich in granular contents (4-8 µm), moniliform at maturity. Sporodochium comprised of loosely or compactly arranged moniliod hyphae, white when young, and brown at maturity. Conidia are not formed (Burgeff, 1936).

Rhizoctonia stahlii

Aerial hyphae are white, abundant. Sporodochia yellow, large, open textured, not waxy, mostly 1 mm. or less in diameter. Spores elongate 26-34 µm by 14-18 µm (Burgeff, 1936)

Rhizoctonia subtilis

Mycelium at first light tan, later becoming uniform light brown, recumbent, smooth, glistening. Sporodochia small confluent over surface of mycelium. Spores in irregular pattern (Burgeff, 1936).

Rhizoctonia solani

On PDA medium, the colony is brown with felty and cottony, brown, aerial hyphae. The vegetative hyphae are septate, hyaline at first, later brown, branching at right angles with a constriction at the point of branching and the first septum a few microns beyond the point of origin (Rajkumar and Kaushik, 2007; Saksena and Vaartaja, 1961).

Thanatephorus pennatus

On PDA medium, growth rate is slow, mycelial mat sparse and hyaline at first growing out in a feather like pattern, becoming camel brown, plane with abundant white to pale brown aerial hyphae in irregular floccose tufts. On CMA hyphae forming at the margin of the plate after 6-8 weeks incubation on CMA in the light, loose, white sclerotia 1-2 mm diameter (Currah, 1987).

Tulasnella cucumeris

Have large basidia (15-18 μm by 8-10 μm) and oblong to ellipsoid basidiospores. The vegetative phase has a much faster growth rate and its formation of dark brown sclerotia (Downie, 1957).

Tulasnella praticola

Hyphae are upto 9 μm in diameter, mycelium in culture which later greyish brown, basidiospores 7-9 μm by 4-6 μm, subhymenial branching often racemose (Sneh *et al.*, 1991).

Sebacina sp.

On PDA medium, colonies measured 1.4 cm in diameter, aerial mycelium, felty downy, margin submerged, runner hyphae 5 μm by 7.5 μm diameter, quickly giving rise to short swollen segments that become moniliod cells. Sclerotia numerous cream, submerged (Currah *et al.*, 1990).

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