CHAPTER-2

REVIEW OF LITERATURE
2. REVIEW OF LITERATURE

In any breeding programme involving resistance there are two important entities, first is host and other one is a parasite. In an initiation of breeding programme information on genetics inheritance of resistance is obligatory to be worked out. Review of literature on host and parasite greatly helps in the success of the project on resistance breeding. A review, therefore, on the host and parasite in the present context apart from genetics of resistance is given here as under:

1. **Host: Cowpea** *(Vigna unguiculata (L) Walp.)*

1.1 **Classification**

<table>
<thead>
<tr>
<th>Benthom &amp; Hooker (1862)</th>
<th>Engler and Prantl (1899)</th>
<th>Hutchinson (1959)</th>
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<tbody>
<tr>
<td>Division</td>
<td>Phanerogamia</td>
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<td>Leguminosae</td>
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<tr>
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<tr>
<td>Species</td>
<td>unguiculata</td>
<td>unguiculata</td>
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</table>

Takhtajan (1980) classified the family leguminosae in the order, Fabales but Cronquist (1981) reaffirmed its position to be in the order, Rosales.
1.2 Botanical descriptions:

The cowpea (*Vigna unguiculata* (L) Walp. [2n = 2x=22]) is an annual herbaceous legume. It has well developed tap root system and spreading lateral roots in the surface soil. Root possesses large globular nodules, sometimes, clustered containing nitrogenfixing bacteria. Stem is weak cylindrical and fistular, tendrillous at the apex at late stage. Leaves are *trifoliate*, leaflets are relatively smooth and shining, ovate rhomboid in shape, entire but occasionally lobed, acute apex up to 16 x 11 cm, lateral leaflets oblique, peticolate and imperipinnately compound. Petioles are short, 5-15 cm long and grooved. Stipule are semicordate and irregularly toohned at the base. Inflorescence is solitary axillary, raceme, with few flowers up to 4 at the tip, peduncles, stout, grooved, often approaching length of leaf up to 12 cm long. Flower is pedicellate, bracteate, zygomorphic, hermaphrodite, complete, hypogynous, superior ovary, Flower are borne in pairs in short racemes. Within the flower sepals are five gamosepalous, green in colour and a valvate aestivation. Petals are five, white or violet in colour sometimes a dirty yellow, approximately 2.5 cm long, posterior petal is largest from a boat shaped structure called keel. Thus the flower becomes zygomorphic with descending imbricate aestivation. Stamens are ten, diadelphous, anthers uniform, dithecous and basifixted, filaments long dithecous, gynoecium is monocarpellary, unilocular, ovary superior and marginal placentation. Fruit, pod (legumes), pods are smooth, 8-12 inches long, cylindrical and somewhat curved. They are usually yellow, but brown or purple. The seeds are either uniformly coloured or multi-coloured. The multi coloured seed may be
variously spotted, specked or marbled. Hilum is white, surrounded by a dark ring in pole varieties. Growth habit of cowpea is erect, semi bushy of spreading depending upon varieties. Vegetable vendors after the green pods as a novelty vegetable that suffices for a meal. Good forage cowpea varieties are vigorous, erect, prolific and disease resistant, bear the pods, well above the ground and retain their leaves late in the season. Early maturity is important in order to increase crop intensity and tailoring the varieties in different cropping system. Early varieties may mature crops in three months and later varieties may take up to five month.

The plants initiate flowering about a month after sowing. A flowering period was followed by a non-flowering period to be succeeded in turn by a second and even a third flowering period. From the frequency curves, they found that the first flowering period had a mean of 23 days and the non-flowering period of 12 days. The latter corresponded with the development and growth periods of the pods, i.e. about 12-15 days. A large number of flowers sheel providing no chance for pod formation.

Krishnaswamy et.al., (1945) Coimbatore conditions, found that it look 11-15 days for the flower initial to develop and bloom for detailed observations conducted on two varieties they found that the flowers open between 7:00 and 9:00 a.m. Much fluctuation has also been observed in a single variety, some times flowers opening at 6:00 a.m. or as late as 10:00 a.m. On cloudy days the flowers were found opening even in the afternoon.

Though the flowers open late in the morning, the dehiscence of the anthers is much earlier. Krishnaswamy et.al. observed the time of dehiscence of anthers may very from 10:00 p.m. to 0:45
a.m. and that this fluctuation was closely influenced by environmental factors, like presence of moonlight, a clear sky and dry warm atmosphere. They found that artificial light of sufficient intensity (60 cp) induced early dehiscence of anthers and even under these conditions the lunar effect was noticed. During dark night, the dehiscence tended to be delayed while moonlight hastened the same.

1.3 Cytogenetics

Darlington and Wylie (1955) mentioned three basic number this genus viz. \( x = 10, 11, 12 \). They listed the number of nine species: ambacensis \( (2n = 20) \), capensis, glabra, canceolata Lesteola, awahuensis and unguiculata \( (2n = 22) \); sinensis and sesquipedalis \( (2n = 24) \).

Cytotaxonomical studies by Sen and Bhowal (1960) on 14 species revealed that the most frequent number was \( 2n = 22 \) and two wild species had \( 2n = 20 \). The number \( 2n = 24 \) recorded for the cultivated species could not be confirmed in their studies. The species investigated by them were Sinensis, ablongifolia, wilmsii, schimperi, marine, Luteola gracios, vexillata and davyi \( 2n = 22 \); heterophylla, membrancea \( 2n = 20 \).

Based on the evidence of the occurrence of \( 2n = 22 \) in majority of the species of the allied genera Phaseolus, Dolichos and Vigna of the tribe Phaseoleae they favour eleven as the basic number in Vigna and that the \( 2n = 20 \) group is derived from the 22 forms.
The complement in all consisted of long medium and short pairs of chromosomes. The chromosomes length varied from 3.7 μm to 1.6 μm.

The eleven wild type species of cowpea were classified into four groups (Rangaswami, 1970).

**Group – 1**: Corolla typically zygemorphic; Keel and style curved, but nub twisted and with out pouchked keel; posterior two repals fused to give false appearance of a four sepals. Fls. Small, seeds, ablong, small with caruncle (5 species).

**Group – 2**: Seed reniform, caruncle absent, Fls. Yellow, climbers (3 species).

**Group – 3**: Fls. Large, corolla irregular, keel with pouch like structure, keel and style twisted (2 species).

**Group – 4**: Resembling group 2 in flower size, zygomorphic, spur in keel and non tuberous, not erect fruits and group 3 in slight twisting of keel and style, large calyx sepals free (1 species).

The three cultivated species on account of their similar karyotypes and compatibility in hybridization deserve to be included in a single specific name with three sub-species. These species have considerable similarity with the group 2 and *V. luteola* may have had some role in their origin.

Sen and Bhowal (1949) induced polyploidy successful by treating apical buds with 0.5% aqueous solution of colchicine. The 4n plants were slower in growth, thicker stemmed with broader, thicker, darker green leaved, larger flower, fruits smaller and fruit set fewer and the seeds larger than the diploids. A number of
meiotic abnormalities, usual in the induced autotetraploids were also observed. Sterility was also noticed to be higher.

1.4 Uses:

In India, cowpea is used mostly as a pulse, either whole or as dal and also as flour after husking or with husk. The pods are used as vegetable when tender. The seed retain their virability for two year. Usually seed from the previous year is used. The sale is much restricted, since the total production, oftenly is not in surplus and therefore, confined to local markets. Cowpea is one of the principal pulses in common use in India. However, it is not a sufficiently important pulse as recorded in the crop consensus of the country. Nevertheless, it is used during auspicious ceremonies by Hindus in India.

Cowpea hay that has been well cured is considered equal to red clover hay in nutritive values. Cowpea is utilized for soil improvement in the Southern States. This may be successfully grow in the less fertile soils as well where in soybeans generally do not flourish.

Apart from its being a member of pulse cafeteria and one of the potent sources for soil improvement it is a very important fodder crop of the rainy season and contributes quality fodder for improvement of animal feed in various mixtures of fodder crop and grasses. These are grown in the form of mixed and inter cropping patterns of farming systems. Among crop combinations involving cowpea as one of the components cowpea + maize and cowpea + sorghum are the best combinations. The adaptability of former is the most extensive in length and breadth of the country. Quality-wise it is one of the important legumes and regarded as a member
of core legume fodders and known as a potent milk multiplier, when fed to milch cattle and bovine.

2. Parasite (*Macrophomina phaseolina* (Tassi) Goid & *Rhizoctonia solani* Kuhn.)

### 2.1 Classification of *Rhizoctonien* spps.

<table>
<thead>
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<th>Plantae</th>
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<tr>
<td>Sub Kingdom</td>
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<tr>
<td>Division</td>
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<td>Spharerioidaceae</td>
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</table>

(a) **Dry root rot**

- **Genus** *Macrophomina*
- **Species** *phaseolina*

(b) **Collar rot**

- **Genus** *Rhizoctonia*
- **Species** *solani*

### 2.2 Occurrence

*Rhizoctonia solani* Kuhn. is common and complex soil borne plant pathogenic fungus. *R. solani* is currently composed by several anastomosis group (AG) distinguished by hyphal anastomosis. The propagules hypae and sclerotis of *R. solani*. Survive in soil independently and in association with organic matter and host tissues (*Castro et.al.*, 1989).

*R. bataticola* (*Macrophomina phaseolina*) (Maubi) Goid, its amongst the most universally distributed soil borne fungi
with high competitive saprophytic ability high lethal pathogenicity and wide host range that make the fungus economically important (Byodgi and Hegde, 1987).

2.3 Morphology

Common Rhizoctonia fungus, Thanatephorus cucumeris (Frank Dank)

Mycelial stage: Rhizoctonia solani, Kuhn

Synonymy:

Rhizoctonia napaeae, (West)
Rhizoctonia rapae, (West)
Rhizoctonia betae, (Eidam)

Basidial stage:

Hypochnus filamentosus (Pat)
Hypochnus solani (Prill & Del)
Corticium botryosum, (Bres)
Corticium solani (Prill & Del, Bourd & Galz)
Corticium praticola, (Kotila)
Botryobasidium solani (Prill & Del, Donk)
Corticium microsclerotia, (Weber)
Corticium areolatum, (Stahel)
Pellicularia felamentosa (Pat. & Rogers)
Thanatephorus praticolus (Kotila, Feintje)

Donk (1954), affirmed the position of the species in Thanatephorus under the specific name T. cucumeris (Frank) Donk. Kotila (1929) described a second species of Rhizoctonia
and gave it the specific name *Corticium praticola Katila*. Flentje *et al.* in 1963 transferred this species to *Thanatephorus as T. praticolus* (Kotila) Flentje, but later studies led them to reject specific distinction of *T. praticolus*.

*T. cucumeris* grows well on culture media. The mycelium is colourless when young, becoming brown when old, occurring as visible brown strands on the host substrate. Branches when young are inclined in the direction of growth and are constricted at the junction with the main hypha, but as they grow older, they assume a right angle relation to the latter. Under certain conditions and on certain substrates the mycelium becomes justified, dividing into short ovate cells and eventually developing into brown *sclerotia*.

Basidial stage appears as a flaky pellicle on soil and on the surface of host stems or leaves under condition of high relative humidity. The basidia, borne on small imperfectly symmetrical cymes are barrel shaped, obpyriform or clavate (12 to 18 by 8 to 11 μ), bearing four sterigmeta which arise as blunt knobs and later become horn-shaped (5.5 to 12 by 1.5 to 3.5μ). Basidiospores are ellipsoid or oblong ellipsoid, flattened on one side, 7 to 12.5 by 4 to 7 μ. The thallus is multinucleate becoming, binucleate in the hymenium. Fusion of two nuclei occurs in the basidium and meiosis follows to form four nuclei each of which passes into a basidiospores. Some times three nuclei occur in the basidium and sometimes two nuclei migrate from the basidium into one spore. In the center of the septum is a septal pore through which mitochondria and possibly nuclei pass from cell to cell. As the
mycelium grows old the pore becomes occluded and protoplasmic contunity between cells is lost Charles (1969).

The fungus invades the host both inter and intra cellularly. It grows rather fast covering large areas of the host tissues and eventually killing them in short time. It produces numerous sclerotia bodies on the host tissues, which measure about 110-130 μ in diameter. Often the conidial or pycnidial stage is produced on the host. The pycnidia are dark brown ostiolate and of varying size, depending upon the host. The pycnidioospores are elliptical, thin walled single celled, hyaline and measure 10-24 x 6 -10 μ.

Sclerotia from mycelial threads can grow toward the plant when cellophane bags are placed around the roots of plants, hyphae aggregates are formed on the cellophane surface Kerr (1956) indicated the attraction of the hyphae by the roots, similar aggregates are formed on cellophane or membranes of mixed ester of cellulose that are placed over seedling. These aggregates should not be confused with infection cushion because they lack specific characteristics of infection cushion formation such as directed growth and the formation of T shaped branches. Under various experimental conditions it has been shown, that mycelial growth is stimulated various experiment conditions it has been shown that mycelia is stimulated by plant exudate (Kerr and Flentje,1957; Flentje et.al., 1963; De Silva and Wood, 1964). The growth stimulation rate correlates with higher and organic acid concentrations present in the exudates of younger plants as compared to older plants( Nour, et.al 1964; Matinson, 1965; Reddy, 1980).
*Rhizoctonia solani* Kuhn is a widely distributed plant pathogen. Its isolates vary considerably in pathogenicity and culture characteristics. Recently progress has been made in taxonomic studies on *Rhizoctonia* spp. (Ogoshi, 1975) and they are known to have general characters such as, branching near the distal septum of cells in young vegetative hyphae, formation of septum in the branch near the point of origin, constriction of the branch, dolipor septum, no clamp connection, no conidium, except monilioid cells, no *Rhizomorph*, sclerotium not differentiated into rind and medulla, *Rhizoctonia solani* that has three or more nuclei per cell and larger hyphae (6-10 μ) is the imperfect stage of *Thanatephorus cucumeris*.

The pathogen, *Rhizoctonia solani*, exists primarily as a sterile mycelium that is colourless when young but turns yellowish or light brown with age. The mycelium consists of long cells and produces branches that grow at approximately right angles to the main hyphae are slightly constricted at the junction and have a cross wall near the junction. The branching characteristics are usually they only ones available for identification of the fungus as *Rhizoctonia* sp. Under certain conditions the fungus produces sclerotia like tufts of short, broad ovate triangular shaped cells that function as or eventually, the tufts develop into rather small, loosely formed brown to black sclerotia which are common on some hosts such as potato. The perfect stage forms under high humidity and appears as a thin mildew like growth on soil, leaves and infected stems, just above the ground line. The basidia are barrel shaped are produced on a membrane layer of mycelium and have four steriginate each bearing on ovoid basidiospore.
Resistant bodies of a more complex nature are formed competitively by many plant pathogenic fungi, particularly those which are soil borne. These bodies, known as sclerotia, consist of aggregation of hyphae and are formed in various ways by the repeated branching and on anastomosis of the consistent hyphae Townsend and Willetts, (1954). The individual cells of these hyphae often round off so that in section the sclerotium looks like a true tissue. Some sclerotia e.g. those of Rhizoctonia solani are more or less uniform in structure, the through out all the constitutuent cells being similar and thick walled. This type may be better considered as a mass of chlamydospores than a true sclerotium. More frequently sclerotia show an outer protective zone of thick walled cells, usually dark coloured and an inner mass of cells with thin hyaline walls and dense contents. Reserve foods, including oil and glycogen, are accumulated in sclerotia so that structure is well adopted for survival over a period of adverse conditions. Some sclerotia germinate by putting out masses of vegetative hyphae but many produce specialized stomata on or in which sexual spores are borne. Fungi, which produce sclerotia are often to survive for long periods in the absence of the host plant and are often as cause of root rot and difficult to be eradicated from the soil.

In culture, sclerotia may range in size from barely detectable up to 6 mm in diameter and may coalesce into crusts of few centimeters in diameter. They may be irregular, globase, lattered and the bottom and rounded on the top or formed into crusts. They may be light tan to dark brown colour, Butter and Braker (1970). Hyphae of Rhizoctonia solani have a characteristic spitenkorper in
their growing tips and a cell shape described by the mathematical hypoid equation. A mild disturbance of hyphae growing in a slide culture chamber on a microscope stage caused the spitzenkorper to move away from its usual position next to the apical pole and move briefly inside the apical dome. Hyphal elongation rate declined abruptly and the apex became rounded and increased in deam. As the spitzenkorper migrated back to its pole position, rapid cell elongation resume and the contour of growing hyphae tip returned to the typical hypoid shaped. The brief dislocation of spitzenkorper left a permanent bulge in the hyphae project. This morphogenetic the computer simultaneous mimicked sequence based on the hypoid equation, which relates the generation of hyphae shape to the linear displacement of a vesicle supply centre (VSC). The VSC was programmed to retrace the observed movement of the spitzenkorper during sequence. The resulting similarity of shape between real and computer simulated cells reinforced the mathematical prediction that the spitzenkorper act as a VSC and that is continuous linear advancement generates a typical hyphae tube with the characteristic hyphoid provided a possible hypothesis to explain the cellular basis of polarized growth of fungal hyphae (Barknicki - Garcis et.al. 1995).

Protoplast regenerated culture derived from Rhizoctonia solani mycelia collected from infected wheat roots at a site in western Australia exhibited major variations in cultured morphology and in pathogenicity, each field isolates yield 3 or 4 distinct morphological type protoplast cultures. The presence of the new morphological phenotypes was attributed to the selection of homokaryons arising from protoplast with single nuclei. Highly
pathogenic field isolates produced protoplast cultures with higher virulence than those from weakly virulent pathogenic that the parental field isolate (Yang, et al. 1994).

The effect of atmospheric temperature and rainfall in India on the incidence of char-coal rot of maize by *Macrophomina phaseolina* was studied under artificial epiphytotic conditions in field of the gangetic plains and West Bengal. *In vitro* studies of *Macrophomina phaseolina* showed that max, linear growth and germination of sclerotia occurred at 35 °C. The importance of RH was not well defined, but good growth and germination of sclerotia at levels of 50-100% RH. Results from the field indicated that the incidence of charcoal rot maize increased at high temperature (35-39 °C) and in water stressed condition from the flowering stage onward (Singh, et al. 1992).

Growth and sclerotia production in root rot fungus of cotton. *Rhizoctonia bataticola (M. phaseolina)* groups on cotton root extract agar, PDA, Richards agar and Sobourand's agar showed sclerotia production to be excellent on the last three media (Kulkarni, et al.1992).

Inoculation techniques to identify cowpea germplasm resistance to charcoal-rot *Macrophomina phaseolina* (Tassi) Goid. Three methods for inoculating cowpea with *Macrophomina phaseolina* are describe the toothpick inoculation method, inoculation using dry sclerotia of *Macrophomina phaseolina* and inoculation using rice seeds colonized by *Macrophomina phaseolina* sclerotia. It is concluded that the result obtained using these technique may vary in the field and in the green house due to the different environmental conditions (Higerera et al. 1991).
2.4 Mode of infection

The remarks here will be confined to common *Rhizoctonia* disease, since little research has been carried out with violet root rot. The fungus lives from season to season in the soil or as sclerotia on propagative plant parts e.g. potato tubers Baker (1947) has shown it to be seed borne the fungus invading the seeds of pepper, egg plant, tomato and *Linnia*. Leach and Pierpont (1956-58) showed seed transmission in *Phaseolus vulgaris*, *P. lunatus* and *Agrostis tenuis*.

The fungus has an optimum temperature for growth on culture media of 25 °C - 30 °C with a minimum of about 8 °C and maximum of 31 °C - 35 °C. *Sclerotia* germinate over a range of 8-30°C with an optimum at 23°C, the optimum for germination of basidiospores is 21-25°C. Richards (1923) studied the relation of temperature to development of stem lesions on potato, pea and bean. In each case the optimum temperature was about 18°C. Flentje and Hagedorn (1964) working later in the same region studied tip blight and stem rot of pea and found the disease severe only at temperature above 18-20°C. Hemmi (1923) found the fungus most active at 16-24 °C in damping off of garden cross. Walker (1943) reported sore shine on cotton most severe at 17-23 °C. Roth and Riker (1943) stated an optimum for post emergence damping off of red pine seedlings to be about 28 °C, while damping off of soybeans to be severe at 25-29 °C. It is evident that differences in temperature optima occur with the isolates and the host concerned. When the fungus is invading the dormant storage organs rather than the growing plants, the optimum temperature is closer to that of the organism on artificial media.
The two fungi are facultative pathogens capable of living saprophytically for many years on organic matter in soil. The predisposing factors for the disease onset and spread are a soil moisture percentage in the range of 15-20 °C, soil temperature above 35 °C during plant growth and certain soil types like alluvials and clays. Once the plants are vulnerable to infection the fungi dominate inside the roots, the hyphae multiply rapidly in the cortical tissues, extend up to the pith and sometimes enter the xylem vessels. In diseased plant roots there is an increased accumulation of calcium and iron and certain toxic substances are believed to play a role in wilt symptoms. The fungi remain saprophytically on host root in soil. They also multiply on several other hosts such as vegetable and oilseed crops, on which they are also pathogenic, when the cotton crop is sown again in the soil and if the predisposing factors are favourable the pathogen again become active and infect the plants. The role of the pycnidial and perfect stages of the respective fungi in perpetuation of the disease is unknown. (Rangaswamy et al. 1972).

Virulent isolates of *R. solani* and *R. bataticala* (*M. phaseolina*) from cowpea roots, were cultured in various media used to inoculate tomato, cowpea and lagenania, siceraria plant grown in sterilized soil in pats. *R. solani* caused 100% seedlings mortality in cowpea, 78.12 in lagenania siceraria and 69.25% in tomato. *M. phaseolina* caused 92.18 diseased in cowpea, 71.87% in tomato and 62.30% in *L. siceraria* variable seedling mortality was ascribed to alternations in the constituent of the media, *L. siceraria* as the carbon source and *L. asparagina* as the nitrogen
source modified the pathogenic behaviour of the fungi (Gupta, et.al.1992).

Samples of cowpea seeds collected from different sources in Karnataka, India were found to have high levels of infection by *Rhizoctonia solani* in pods near the soil surface. Study on naturally infected and artificially inoculated seeds showed that penetration occurred mainly through the hilum although direct penetration through the intact seed coat was occasionally observed. The fungus colonized all parts of all seed 144 h after pod inoculation (Sharma et al. 1988).

Comparison of soybean and cowpea cultivars in relation to their susceptibility to root-rot and wilt disease indicated that *Rhizoctonia solani* isolates, were pathogenic with varying virulence in pre and post emergence damping off soybean cultivars (S2), showed different degrees of susceptibility to infection to root-rot in wilt and were divided into three groups, least susceptible 25% dead plant, moderately susceptible 25-50% dead plants and highly 50% dead plants (Abou et al. 1987).

2.5 Hostrange

A total of 79 *Rhizoctonia solani* isolates from several plants and locations were cultured and tested for pathogenicity against cucumbers and *Phaseolus vulgaris* in the green house using infected soil. The sprout weight of *P. vulgaris* (recorded after 10-25 in infested soil) was a simple and effective measure of damage caused by infection. Dry storage of oat seeds inoculation with
*Rhizoctonia solani* preserved the isolates better than stored on malt agar (Walk *et al.* 1994).

Damping off of cauliflower caused by *Rhizoctonia solani* was reduced most effectively when a 1:1 mixed spore suspension of the antagonists was added to the soil prior to inoculation with the pathogen. The reduction in disease incidence was due to increased population of the spp. leading to a lower population of *Rhizoctonia solani* (Kundu *et al.* 1993).

The incidence of maize sheath blight caused by *Rhizoctonia solani* ranged from 2-80% in field at location in Korea Republic during the growing seasons of 1990-91. *Rhizoctonia solani* and R. *zeae* were isolated from maize plant identification as a *Rhizoctonia solani* and sheath blight of 468 isolates 421 *Rhizoctonia solani* isolates and the remainder as *R. zeae* of the 421 were identified as *Rhizoctonia solani* isolates, 382 were classified as anastomosis group AG-1, 10 as AG-2-2, 13 as AG-4 and 16 AG-5. All of *R. zeae* isolates were classified as WAG-2 of the 382 isolates of *Rhizoctonia solani* AG-1 only was grouped as cultured type 10 and the other as cultural type 1A. Pathogenicity tests revealed that *R. solani* AG-1(1A) was the most strongly pathogenic to leaf sheaths and stalks of maize followed by *R. solani* and *R. zeae* were weakly pathogenic *R. solani* AG-22 induced severe rot symptoms on roots of maize by soil inoculation, *R. solani* AG-1 (1B) weak rot symptoms and the other anastomosis groups of *R. solani* and *R. zeae* no symptoms reference were observed in the susceptibility of 4 maize cultivars to the anastomosis groups of *R. solani* and *R. zeae* (Kim *et al.* 1993).
*Rhizoctonia* has been reported to infected rice as sheath blight (*R. solani*) in Haryana and the Indian Punjab (Pillai *et al.* 1993).

As typical isolates of *Rhizoctonia bataticola, Macrophomina phaseolina* was discovered on pods and seeds of soybeans plants exhibiting ashy stem blight symptoms in the IARI Research Farm, New Delhi, India. The isolate has the smallest known sclerotia in the world (Vishwadhar *et al.* 1993).

Seeds of healthy *lagenaria* squashes, melons, cowpea, *Phaseolus volgurar* and *P. lunatus* and those infected by *Macrophomina phaseolina* were collected and stored in ambient conditions. The longevity of *Macrophomina phaseolina* ranged from 19-38 months in seeds of different hosts, lasting 38 months in *P. lunatus* (Mahalay *et al.* 1994).

A wilt (*Fusarium oxysporium, F. sp. ciceres*) sick plots was developed by growing a wilt susceptible chickpea line, JG-62, obtained from ICRISAT for 2 seasons, to screen 211, promising ICRISAT lines against wilt and root rot (mainly *Rhizoctonia bataticola (Macrophomina phaseolina)*), each entry and the susceptible control were grown in 4 cm long rows, 30 cm apart in 1987 and 1988 and wilt/root rot incidence was recorded at 15 days intervals. The mortality of the susceptible control in 1986-87 main season, 1987 off season, 1987-88 and 1988-89 was 50%, 80%, 95% and 95% respectively, indicating the uniformity of inoculum. Isolation from dead plants indicated that mortality was mainly due to wilt and dry rot. Among 48 entries which showed less than 20% mortality in the 1987-88 season, 46 lines again showed less than 20% mortality in the 1988-89 season, 22 lines of which 17 showed
less than 10% mortality were selected for an initial yield trial in 1989-90 (Ahmed et al. 1990).

*Rhizoctonia solani* and *Macrophomina phaseolina* were isolated from groundnut (*Arachis hypogea*) affected by pod rot in 1989. Following the observation of high disease incidence during trials in 1990-91, 21 Spanish type entries were scared for degree of infection at harvest. None of the entries were immune but cultivars ICGV-86885 and R 892 were classed as resistant. Of the remainder 6 were tolerant, 5 susceptible and 8 highly susceptible, Most high yielding selections with light green foliage, including Dharwad genotypes DH-39, DH-40, DH-41 and DH-42 were highly susceptible (Gopal et al. 1994).

Twenty five genotypes were inoculated during 1984-85 by germination and growth in soil infested separately with *Rhizoctonia solani, Fusarium oxysporium* and *Sclerotium bataticola (Macrophomina phaseolina)*. Highly significant differences among genotypes were observed in the percentage of infection by each pathogen in each season. Varieties B-50 and 1370-23-2 were the most tolerant of each pathogen and were significantly more so than the control variety Giza-25 (Bakheit et al. 1988).

Comparison of soybean cultivars in relations to their susceptibility to root rot and wilt disease *Cephalosporium sp.* *Fusarium moniliforme* (Gibberella fujikura), *F. solani, Macrophomina phaseolina* Rhizoctonia solani and *Sclerotium (cortieicum)* rolfsii were isolated from diseased soybean roots from Giza, Dakahlia and Kajr-el-sheikh Egypt. All isolates were pathogenic with varying virulence in pre and post emergence
damping off, Soyabean cultivars (S2) showed different degrees of susceptibility to infection to root rot and wilt and were divided into 3 groups, least susceptibility <25% dead plants moderate susceptibility 25-50% dead plants and high susceptibility >50% dead plants (Abou-zeid et al. 1987).

Beans are subject to the attack of many of the soil borne pathogens including, *Rhizoctonia* that attacks after pulses such as cowpea and soybean. This soil inhabiting fungus produces not only a root rot, a wilt associated with its attack on the root system, but in particularly favourable conditions it may also attack stems, leaves and pods (Standsted, 1969). The first system of the disease to appear is of water soaked spots on the stem just above ground and subsequently similar lesions in the upper portions of the stem. Under high humidities and temperature in the range of 16-21 °C the lesions may enlarge on the stem and kill the plant. Infected plants in high humidity develop a cotton weft of mycelium, producing brown water droplets. Sclerotia and produced by the mycelium may persist in the soil as resting bodies.

Apart from infecting groundnut and beans *Rhizoctonia* invades devastating pigeonpea, chickpea, horsegram and gardenpea. *Rhizoctonia bataticola* in particular is prevalent more often in pigeon pea, chick pea and horse gram white *Rhizoctonia solani* is known to be sporadic in garden pea (Smartt et al. 1976).
2.6 Physiological races

Physiological specialization has been defined on the occurrence of entities within morphologic species that differ from each other in one or more physiologic character including pathogenicity, host morphology, biochemical properties cultural variability spore germination and ecological relationship.

Pathogenic specialization is the most important criterion used in differentiating physiological races of pathogens. The existence of wide spread pathogenic races has been established in several species of smut fungi.

Many investigations have shown selective pathogenicity among isolates of *R. solani*. Isolate from sclerotia on potato tubers are often non-pathogenic on potato. Isolates form potato stem canker be non-pathogenic on cabbage and sugarbeet while isolates from sugarbeet may be pathogenic on potato. Flentje et al. reported further on the occurrence of races within *R. solani* (Wellman 1932). Root rotting fungi are not static. New races may arise by means of hybridization between races or by mutation. Differences in virulence of races are of great importance because they complicate the study of inheritance of resistance to root rot and the selection of varieties resistant to root rots.

New varieties may be resistant in one locality by susceptible in another because of the prevalence of different pathogen and the existence of different races of the pathogen in different regions. Moreover, root rot problems are continually changing because new pathogens are introduced from the other regions or countries. Sometimes, problems change because relatively minor root disease become major disease challenges in cropping systems and the
introduction of new varieties also may create new conditions. All new varieties therefore should be tested for resistance to root rot before they are made available to the growers. One of the best means of selection of varieties resistant to root rots is to test them in pathological nurseries and disease gardens in the region in which they will be grown.

Different species of fungi or different physiological races of some fungi may spread, in some defined seasons. If one wants to be certain of resistance, must test the variety in the disease garden for several years.

*Rhizoctonia solani* Kuhn *Thanatephorus cucumeris* (Frank) Donk is a soil borne pathogen with wide host range. As collective species or a species complex it is made up of divergent populations. The lack of understanding of the relationships among the populations with in the species has hampered other studies of the fungus including of disease control methods.

*R. solani* AG-2 consisting of economically important plant pathogens has been divided into two sub groups AG-2-1 and AG-2-2 on the basis of the frequency of anastomosis among its isolates. Two ecological types within AG-2-2, IIIB (rush type) and IV (root rot type). Isolates of *R. solani* are highly variable and groups of smaller isolates can be identified by anastomosis grouping. The use of AGs might be indicated as genetic selectives among populations of this fungus. The result from the present study demonstrated that population of R-50 within AG-2 could be differentiated into five genetically distinct subgroups on the basis of isozyme polymorphism and DNA restriction fragment analysis. This was the first time that genetic variation within an AG was
confirmed by using different molecular evidences. Because each isozyme band as independent characteristic analysis with maximum parsimony could be used. The use of allelic characters for isozyme analysis is considered a significant way of measuring evolutionary trends, although the use of locus status is debated with the uncertainty of the effect of environmental conditions on selection acquisition of an allelic may be more significant than subsequent modification of allelic frequency for clastic analysis.

The four enzymes purified from isolate No. 82, AG-4 (virulent an a wide range phasis) and designated as endopolygalacturanose I and II and -PG-I and end PG-II pectinosterone (PE) and endopectinlyase (end PL) were purified to homogenecity by a single chromatographic step and a cross linked ploypicetals calcium. They were identified also in 2 virulent isolates of *R. zeae* and 2 virulent binucleate *Rhizoctonia spp.* the end PG-I, endo PG-II and PE but not endo PL were identified in 3 hypovirulent isolates of *Rhizoctonia solani* and 2 of *R. zeae*. These enzymes were purified to homogeneity from R. solani (No 521; AG-4). The MW, pH opt; isoelectric point and optimum temperature for each enzymes were respectively endo, PG-I, 34000, 4.8-6.8, and 50 °C and PG-II 37000, 5.4 - 7.4 and 42 °C, PE 26000, 7.7, 6.2 and 48 °C and endo PL 45500, 8.4 - 8.1 and 53 °C (Marcus et al. 1986).

Isolates (114) of *M. phaseolina* from tissue of hosts in the Asteraceae, Euphorbiaceae, Fabaceae and Rosaceae and from cultivated and non-cultivated soils were tested for pathogenicity and ability to form pycnidia and chlorate utilization phenotype. Hyphal interactions of pairs of isolates from non-cultivated soils
were examined to address the possibility of genetic isolation of 2 geographically separated populations. Isolates from the poaceae were less pathogenicity and formed pycnidia less frequently as compared to isolates from dicot host tissue source. However, isolates that infrequently or never produced pycnidia were more likely to have chlorate sensitive phenotypes. Apparently, successful hyphal fusions were observed for 64.3% of conformation and no barrier to genetic interchange at this initial level of interaction could be observed. *M. phaseolina* is a heterogenous species that can not be partitioned into distinct subsepecific groups based upon function it appears that isolates colonizing the poaceae are more restricted in pathoenicity than the general population (Mehoil, *et al*. 1995).

Two *R. solani* strains were isolated from coffee seedling affected by lodging micro culture staining with sofarin and KOH showed the presence of hypae with multinuclear cells (58 nucli/cell). The strain were referred to anastomosis group (Gottam *et al*.1992).

Inhibition of seed germination by *Macrophomina phaseolina* is related to *Phaseolinone* production. The production of *phaseolina* a phytotoxic metabolite of *M. phaseolina* in *phaseolina* infected, *phaseolinone* plants was estimated by ELISA and HPLC. The degree of inhibition of seed germination correlated well with amount of toxin produced. An inhibition of 50% was observed at a toxin level of 2.1 μg/g of wet tissue. A comparison of the toxin producing ability of 9 isolates of the fungus obtained from different hosts and localities showed that strain MPK-83 produced a significantly larger amount of the toxin, both in liquid culture and
infected seeds. The virulence of the isolates was related to their ability to produce phaseolinone (Dhar et al. 1994).

Isolates of Rhizoctonia solani from rice and cowpea were similar in their pathogenicity to 14 test plants and both produced similar symptoms on rice. An isolate from Jack produces only very mild symptoms on rice and one from cotton was non pathogenic to rice. The cultivation of cowpea as follow crop in a rice cropping system could aggravate the problem of sheath blight caused by R. solani. Onion and cassava are previously unreported hosts for R. solani from Kerala (Lakshmanan et al. 1985).

2.7 Symptomatology

Seedling roots and shoots were assayed for mycoflora and rated for disease symptoms of selected fungi. Seedling and soil variables were analysed for possible correlations thirty eight fungal including 8 species of Fusarium were isolated from seedlings. F. oxysporium, R. solani, F. solani, Macrophomina phaseolina and T. viride were the most frequent isolates from roots, Alternaria alternate, Phornopsis longicalla, Phorna spp. and E. nigrum were the most frequent from shoots Correlation studies suggested that prior colonization of roots by certain fungi predisposed aerial tissue to other fungi. Correlations suggested also an existence of coinvasion on roots by F. solani, R. solani, F. oxysporium and Macrophomina phaseolina. In green house pathogenicity tests, F. solani from B and R. solani were pathogenic to seedlings (Killebraw et al. 1993).
2.8 Screening

A wilt sick plot was developed by growing a wilt susceptible chickpea JG-62 obtained from ICRISAT developed a wilt sick plot. To screen 211 promising ICRISAT lines against wilt and root rots, mainly *Rhizoctonia bataticola (Macrophomina phaseolina)*, each entry and the susceptible control were grown in 4 long rows, 30 cm apart in 1987 and 1988 and wilt/root rot incidence was recorded at 15 days intervals. The mortality of the susceptible control in 1986-87 main season, 1987 off season, 1987 and 1988 to be 50%, 80%, 90% and 95% respectively with an uniformity of isolation from dead plants indicated that mortality was mainly due to wilt and dry rot. Among 48 entries which showed less the 10% mortality were selected for an initial yield trial in 1989-90 (Ahmed et al.1990).

Of 33 genotypes of *V. unguiculata* grown in soil infested with *Macrophomina phaseolina* in 1980-81, 26/9/1, V-16, K-39, 25/8/2 and CO3 were moderately resistant to 6 fungicides the genotypes tested in the field and in the green houses. *Carbadoxium benomyl* and *phenymercury acetate* were the most promising as seed dressing for reducing the incidence of the disease (Singh et al.1986).

Of 141 cultivars tests 21 were resistant to anthracnose and 4 to *Macrophomina phaseolina* (Sohi and Rawal 1984).

Screening of cowpea to root rot disease of 31 lines tested under natural infection by *M. phaseolina*, 2 were moderately resistant one moderately susceptible and the remainder susceptible or highly susceptible (Sivapракasam and Anbalogan 1983).

A total of 1639 *V. unguiculata* germplasm lines were planted in 1980 in soil where *Phytophthora* stem rot not appeared the previous year. In addition 145 lines of the international cowpea disease nursery were planted in the same soil. Disease severity was high after 5 weeks and uniform spread of the disease was encouraged by spraying twice with a spore suspension. Lines K4 235 and TV4 386 were moderately resistant (Milgo, 1988). Of 31 lines tested under natural infection by *Macrophomina phaseolina*, two were moderately resistant one moderately susceptible and the remainder susceptible or highly susceptible.

One hundred and twenty types of cowpea were screened for disease resistance under natural conditions of infection. All the test lines were sown in double rows of 5 M length with a spacing of 45x15 cm sandwiching the test lines with highly susceptible check. Observations were recorded prior to harvest by following the method given below.

The lines giving resistant and moderately resistant reaction to the disease under natural conditions were further tested in sick plots prepared by in cooperating large amount of root rot infected cowpea material in the soil CO-2 variety of cowpea was grown as a check line in between each test line.
A wide screening variety for resistance to root rot was done by a group of scientists headed by a plant pathologist under. All India Coordinated Research Project on Forage Crops at Indian Grassland and Fodder Research Institute, Jhansi, U.P. and the Coordinating Centres during last five years (Pandey et al. 1995). Out of all different material of cowpea tested for resistance root rot under natural infection in the field conditions in the hot spots at Jhansi, Anand, Jabalpur, Pantnagar and Urulikanchan, some of the genotypes developed by different institutions showed resistance in varying degree. They were grouped as under:

**Resistant:** A Bundel lobia-CL-334, DFC-1, IFC-9201, 9301, 9303, 9304, UPC-93-2, 93-3, 9103, 9202 and RFC-8903.

**Moderately Susceptible:** CL-326, 330, 333, CS-55, 82, 90, 91, 94, 98, IFC-9102, UPC-9201 and RFC-84-2.

**Susceptible:** CL-321, 323, 324 and 329.

Combined infection by *Macrophomina phaseolina* and the nematodes in plants of soybean cv. Williams was best controlled using oldicarb (1.5 H/teddam) and seed treatment with captan (3 kg/seed). Among 11 treatments tested root rot caused by *Macrophomina phaseolina* was increased in the presence of the Nematode (Mohamed et al. 1990).

**Genetics**

In a study of inheritance of dry root rot (*Rhizoctonia bataticola*) resistance in chickpea the parental F1 and F2 populations from crosses involving two resistant (R) and two susceptible lines, together with 49 F3 progenies from one of the
RxS crosses were tested for reaction to *Rhizoctonia bataticola* (*Macrophomina phaseolina*) in green houses. F1 plants from R x S crosses were resistant and F2 fitted a 3R : 1S ratio indicating monogenic inheritance with resistant dominant to susceptibility F3 family segregation occurred in R x R or R x S crosses. *Rhizoctonia bataticola, M. phaseolina* (Rao and Haware 1987) was investigated with and without irrigation in altisols and vertisols, in Andhra Pradesh in India in 1989 and 1992-93. Some lines showed a promising degree of resistance. Seed ad seedling disease are caused primarily by *Pythium* and *Rhizoctonia* sp. the most important fungi causing root rots include *Aphanomyces, Phytophthora* sp and *Macrophomina phaseolina* (Kraft *et al.* 1994). As for genetic of resistance to these fungi is concerned no literature could be traced on the subject (Khan *et al.* 1989).

**2.9 Control**

The damping off stage, when it occurs in green house, hot beds, cold frames, and seedling nurseries is controlled by soil treatment. In field, rotation is of some value in special situations. In as much as the host usually grows into infection relatively rapidly after the early seedling stage, various means have been devised to protect the host or retard the pathogen during this period. For bean and lima bean Tetrachlor and Captan have been successful in controlling the damping off phase when applied as dust or drench in the furrow with the seed.

Providing best possible tilth for seeding is of importance because it encourages prompt growth when the nature of the soil permits, shallow planting of potato seed tuber reduces apical injury to shoots and stem cankers. In practice, seed pieces are dropped in
the usual trench with minimum covering the soil being worked to plants gradually in succeeding cultivations. Townsend worked out a control for bottom drop of lettuce through the application of 20-25 lb per acre of 2% ethyl mercury phosphate dust under the nearly mature plants. The use of mercury compounds for control of brown patch of turf grasses is a common practice.

When seeds such as those of tomato, pepper and eggplant infected, the usual chemical treatments are inadequate. A hot water treatment is satisfactory for this purpose. Treatment of potato seed tubers to rid them off the scab organism and the sclerotia of *R. solani* is an old practice. Its value is limited by the extent of soil infestation. In the case of *R. solani*, a second limitation lies in the fact that in the main sclerotia borne on tubers are those of mildly pathogenic or saprophytic strains. In many states seed tuber treatment for potatoes is no longer recommended generally.

The disease is found both on Indian and American cotton and attempt made to evaluate resistant varieties have not succeeded. Certain cultural practices have been recommended to provide unfavourable soil conditions for the pathogen. Adjusting the sowing dates so that the crop is not in the field when soil temperatures are high has yielded rich dividends. Mixed cropping to include shady plants with cotton to reduce the soil temperature has also helped in checking the disease intensity. Sorghum and *Phaseolus aconitifolius* L. are commonly used for this purpose (Rangaswami 1972).

In tests with 3 isolates of *R. solani* from cotton rice and cowpea respectively *Carbendazim* and *Thiophonate methyl* were the best of 7 seed treatment fungicides tested for control of
seedling mortality of *V. radiata* in inoculated soil (Singh *et al.* 1995).

*In vitro* evaluation of bacteria for the biological control of *Macrophomina phaseolina*. A total of 64 strains of *Rhizobium* and 7 other *rhizosphere* bacteria were evaluated by streak plate, double layer and spent cultures methods to determine their antibiotic activity against *M. phaseolina*. Expression of inhibition varied among strains and depended on growth media and screening method. The streak plate method with yeast extract/manitol was the best bioassay. Results indicated that root nodule bacteria have weak bio-fungicidal potential. *Pseudomonas cepacia* strui UPR - 5C consistently restricted fungal growth (Perdoma *F et al.* 1995).

A total 586 natural wine yeasts, belonging to different genera were tested for their antagonistic effects on fungal pathogens. A low percentage of yeast strains showed biocontrol activity which inhibited the pathogens growth. Biocontrol activity was found to be strain specific and did not solely depend on species or genus. Among the antagonists, 2 strain of *Saccharomyces cerevisae* and 1 of *Zygosaccharomyces* showed a broad spectrum of antagonistic activity against 10 fungal pathogens including (*Aspergillus niger, Botrytis squamosa [Sclerotinia squamosa] Cladosporium variable, Colletotrichum acculatum, Macrophomina phaseolina, Penicillum digitatum, Phomopsis longiealla, Rhizoctonia fragariae, Sclerotinia, sclerotiorum and Trichoderma viride* (Suzzi *et al.* 1995).

Conidia of two strains of *Glioelodum* virus that were strongly parasite to *Rhizoctonia solani* were irradiated with ultraviolet light and screened for mycoparasitism in dual cultural
with *Rhizoctonia solani*. Three mutants that showed no mycoparasitism were isolated from each strain. The selected mutants retained some antibiotics as the parents strains peat mass ezapek's culture of parent and mutant strains had similar efficacy as bio-control agents of cotton seedling disease induced by *Rhizoctonia solani* in soil. These results indicates that mycoparasitism is not a major mechanism in the biological control of *Rhizoctonia solani* incited seedling disease by *G. virens* (Howell et al. 1987).

Effect of straw oil cakes on ashy grey stem blight caused by *M. phaseolina* (Tassi) was studied. Of 4 different straws tested as soil amendments wheat was the best, reducing the disease index to 12.1% compared with 100% in the untreated inoculated control. Among oil cakes prepared from 6 different plants, Neem cake at 1.5% reduced the disease index to 5.5 and increased germination to 100% (Ratnnoo and Bhatnagar 1993).

Isolates of *M. phaseolina* obtained from 6 different plant spp. differed in cultural character, growth rate and morphology of the sclerotia. Pycnidial stage and pycnidiospore and virulence. Those from bean *Phaseolus vulgaris, Cicer arictinum* and cowpea grew well with maximum dry mycelial soyabeen isolates had moderate growth and isolates from Gliricidia grew very slowly. Pycnidial production was recorded only on bean and *C. arietinum* seedlings and showed variation in size and shape of pycnidia and pycnidiospore. Based on morphology, cultural character and pathogenic behaviour the G. isolates were classified into 3 groups. A-virulent, B- intermediate and C- mild. (Hegde and Byadgi 1985).
In vitro tests, *Rhizobium meliolote* inhibited growth of the soil borne root infecting fungi *Macrophomina phaseolina*, *Rhizoctonia solani* and *Fusarium solani*, while *Bradyrhizobium japonicum* inhibited *Macrophomina phaseolina* and *Rhizoctonia solani*. In field tests *R. melitati*, *R. leguminosarum* and *B. japonicum* used either as a seed dressing or as a soil drench reduced infection by *M. phaseolina*, *R. solani* and *Fusarium spp.* in both leguminous (soybean and mungbean (*Vigna radiata*)) and non-leguminous (sunflower and okra) plant and gave increase in shoot length and FW as compared with untreated controls (Ehteshamul and Ghaffain 1993).

Linear growth of an isolates of *M. phaseolina* from cowpea was inhibited by Carbendazium, quintozene and thiram. Carbendazium was fungicidal at 100 ppm Sclerotia production was totally inhibited by carbendazium and thiram and delayed by quintozene (Ramadass and Sivprakasham 1994).

Efficiency of certain fungicides in controlling *Rhizoctonia solani* damping off of bean was studied. Three isolates of *Rhizoctonia solani* from affected seedlings caused severe damping off in all 7 cultivars of *Phaseolus vulgaris* tested. In pot experiments, seed treatment with benomyl, moncerine, moncerine combi and quinolate increased survival of cv. contender seedlings growth in infested soil. In the field, all 7 test fungicides gave good protection against damping off of bean seedlings (Raffol 1992).

The fungicides carbandazium, quintozone and TMTD (Thiram) and 4 insecticides, carbosulfan, chloropyrisphoshasalone and Monocracoptas and combinations of these were evaluated for control of *Macrophomina phaseolina in vitro*. The fungicide
carbendazium produced the largest inhibition zone (50.64 mm), one of the insecticides alone inhibited *Macrophomina phaseolina* but acts synergistically in combination with the fungicide carbasalfan with cabendazium produced 56.06 mm inhibition zone. In germination tests this combination also resulted in the highest germination tests this combination also resulted in the highest germination rate 95.0% compared with 87.1% for the interacted control in general, the efficacy of seed treatment decreased after 3 months storage (Ramadass and Sivprakasam 1987).

The influence of *in vitro* substrates on pathogenicity of *Rhizoctonia solani* and responses to fungi toxicants used for disease control. There was no correlation between rates of mycelial growth on different substrates and pathogenicity to cowpea seedling. Disease incidence increased with the increase of carbon and Nitrogen concentration in media in which the inoculum was raised. Pathogenicity was max when the maximum used contained glucose and ammonium sulphate as C & N sources respectively. Disease control by carbendozium, quintozene and methoxyethyl-mercury chloride used as a seed treatment for cowpea was variable when inoculum raised in different C & N amended media (Gangopadhyay and Grover 1986).

Micronutrients applied to the soil in pot tests differentially altered the efficacy of a seed treatment fungicides against cowpea seedling rot caused by *Rhizoctonia solani*. Boron improved disease control by methoxyethyl mercury chloride, quintozene, chloride and carbonium, but 5 other micronutrients reduce the efficacy of fungicides to varying extents. NPK lowered the efficacy of all the fungicides tested except thiobendazole, but
carbendazim and benomyl gone max disease control in soil treatment with a mixture of 6 micronutrients and NPK. Implication of micronutrient fungicides interaction are discussed in the context of fungicides control of *Rhizoctonia solani*. Probable mechanism of inactivation of fungicides by micronutrients are indicated (Kataaria and Sunder 1985).

Efficiency of fungi toxicants on the control of root rot of cowpea caused by mixed inoculation of *Rhizoctonia solani, Rhizoctonia bataticola, Fusarium solani* indicated that seed treatment with carbendazim and soil treatment with carbendazim and thiophanate methyl gave good control of disease even when high inoculum levels of *Rhizoctonia solani, F. solani* and *Macrophomina phaseolina* were added to the soil.

The involvement of the fungi causing seedling mortality was greatly depended on inoculum rate and the fungi toxicant used. Thiophanate methyl gave the best control of 4 different soil moisture levels. At 40% moisture effectiveness of most of the fungi toxicants was greatly reduced. Control was much better at low temperature (25-30 °C) than at higher (35-40 °C). Fungicidal activity was reduced in clay soil and better in sandy soil seedling rot was maximum in soil at pH of 7. Quintozene and MEMC treatment gave maximum disease control at pH 7. Organic amendments reduced disease control efficacy complete control was obtained in soil with K amendments (Ganopadhyay and Grover 1984).

Control of seed borne *Macrophomina phaseolina* and *Fusarium equiseti* by hot water treatment of cowpea seeds were studied. In trials with cowpea seeds infected with *M. phaseolina*
and *F. equiseti* and dipped in hot water at 8 °C temperature in the range 42-50 °C for 5-20 minutes. Dipping in hot water at 46 °C for 20 minutes was the most effective treatment against both disease and gave the highest germination 74% compared with 52% in untreated seeds (Sinha and Khare 1977).