CHAPTER - II

REVIEW OF LITERATURE

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Pigeonpea (*Cajanus cajan* (L) Millsp.) is extensively cultivated in Asia and Africa, particularly in the Indian sub-contenent accounting for approximately 90% of the total pigeonpea production in the world (Nene and Shaila, 1990). India is the major pigeonpea producing country in the world where almost 90% of the world pigeonpea is cultivated (Rathore and Yadav, 2000). The world area, production and productivity under pigeonpea is 3.82 million hectares, 2.88 million tonnes and 753 Kg/hectare, respectively (Asthana and Chaturvedi, 1999). In India, pigeonpea grown on an area of 3.67 million hectares with the production of 2.36 million tonnes, however the national productivity of pigeonpea is only 642 Kg/hectare (Ag. stat. May, 2001).

Statistics pertaining to production and productivity of the crop in India are summarized in Table (C).

Table C: Area production and productivity of pigeonpea in defferent states of India (1999 - 2000), (Ag. stat. May, 2001).

S.N.	States	Area (Million hectares)	Production (Million Tonnes)	Productivity (Kg/hectare)
01	Maharashtra	1.04	0.87	834
02	Uttar Pradesh	0.43	0.55	1281
03	Madhya Pradesh	0.39	0.36	915
04	Gujarat	0.36	0.29	812
05	Karnataka	0.51	0.29	581
06	Andhra Pradesh	0.43	0.15	360
07	Bihar	0.07	0.10	1508
08	Orissa	0.14	0.07	507
09	Tamil Nadu	0.09	0.06	692
10	Haryana	0.01	0.01	Not available
11	Others	0.03	0.04	Not available

Pigeonpea suffers from above 60 diseases caused by biotic and mesobiotic agents (Reddy, *et al.*, 1993). Major diseases and causal agents are summarized in Table D.

Table D

S.N.	Diseases	Causal Organism
01	Collar Rot	*Sclerotium rolfsii*, Saccardo
02	*Phytophthora* Blight	*Phytophthora drechsleri*, Tucker f. sp. cajani (Erwin and Nene)
03	*Fusarium* Witt	*Fusarium udum*, Butler
4a.	*Macrophomina* Stem Canker	*Rhizoctonia bataticola* (Taub.), Butler. *Macrophomina* phaseolina (Tassi), *Goidanich*
4b.	*Phoma* Stem Canker	*Phoma cajani*, Khune and Kapoor
05	Anthracnose	*Colletotrichum cajani*, Rangel *Colletotrichum graminicola* (Ces.) Wilson
06	Bacterial leaf spot and	*Xanthomonas compestris* (pv.) *cajani*, Stem Canker Kulkarni, *et al.*, Dye
07	Powdery mildew	*Oidiopsis taurica*, Salmon
08	*Cercospora* leaf spot	*Cercospora cajani*, Henning *Cercospora indica*, Singh *Cercospora instabilis*, Rangel
09	*Alternaria* Blight	*Alternaria tenuissima*, Kunze *Alternaria alternata*, (Fries.) Keissler
10	*Phyllosticta* leaf spot	*Phyllosticta cajani*, Sydow
11	*Fusarium* leaf blight	*Fusarium semitectum*, Berkley & Rav
12	Rust	*Uredo cajani*, Sydow
13	Halo blight	*Pseudomonas syringae*, pv phaseolicola young *et al.*
14	Sterility Mosaic	*Tenui* virus
15	Yellow Mosaic	Vector-Bemisia tabaci
16	Phyllody	Mycoplasma-like organism (Vector. Not Known)
17	Root-Knot	*Meloidogyne incognita*, Chitwood *Meloidogyne jawanica*, (Treub) Chitwood *Meloidogyne arenaria* (Neal). Chitwood *Meloidogyne acronea*, Coetzee
18	Pearly Root	*Heterodera cajani*, Koshy

Among the diseases (Table D) wilt of pigeonpea caused by *F. udum*, is possibly the most serious and wide spread. It has been reported from 15 countries viz. Bangladesh, Ghana, India, Indonesia, Kenya, Malawi, Mauritus, Nepal, Nevis, Tanzania, Thailand, Trinidad, Uganda, Grenada and Venezuala (Nene *et al.*, 1989).

In India, pigeonpea wilt is prevalent throught the country, but causes maximum damage in the states of Utter Pradesh, Maharashtra, Madhya Pradesh, Bihar and Tamilnadu.

In a survey conducted during 1975-1980 by ICRISAT (Kannaiyan, *et al.*, 1984), the incidence of the disease was found to vary from 0.1% Rajasthan to 22.6% Maharashtra. In Bihar and U.P. the average wilt incidence was 18.3 and 8.2 percent, respectively.

The production loss was estimated to be about 32,000 tonnes in U.P., 44,000 tonnes in Maharashtra and 10,000 tonnes in Madhya Pradesh (Singh, 2000). In India the annual crop loss, due to wilt alone has been estimated to US $ 36 million, while in Eastern Africa annual losses have been estimated at $ 5 Million (Kannaiyan et al., 1984).

However, according to Upadhyay (1979) the symptoms of wilt may appear in early stages of plant growth i,e., When the plants are about 4-6 weeks old, the disease may at any stage of plant growth from young seedling up to podding and maturity. The typical symptoms of the disease appear in plants as gradual or sudden withering and drying of green parts exactly as if they were suffering from drought, even through there may be plenty of water in the soil (Butler, 1918). In the beginning, yellowing of leaves and blackening of stem portions starting from collar to the fine branches may appear which gradually result in drying of leaves, stems, fine branches and finally the death of whole plants. Partial wilting of plant is very common in the field during the advanced stages of plant growth (plate 1, Fig. 1, 2).

Fusarium wilt of pigeonpea a soil-borne disease was first reported in 1906 from Bihar, (Butler, 1906). The disease appears in young seedlings stage in August but the highest mortality invariably occurs at flowering and podding stages from November onwords. Although, the disease first appears in patches in a field but it may extend to the entire field if pigeonpea is repeatedly cultivated in the same field. The fungus can be isolated from apparently healthy 15 days old plants from a wilt sick plot (Nene *et al.*, 1980). The yield loss depends on the stage at which the plant wilt. It may approach 100% when it appears at the prepod stage, about 67% loss occurs at maturity, and 30% loss occurs at the preharvest stage (Kannaiyan and Nene, 1981).

The causal organism of wilt disease of pigeonpea is *Fusarium udum* (Butler, 1910) and its perfect stage is *Gibberella indica* (Rai and Upadhyay, 1982). *Fusarium udum* is pathogenic to pigeonpea only (Upadhyay and Rai, 1989) and is soil-borne facultative parasite which enters through roots and later on becomes systemic. It can be isolated from all parts of the host, from lateral fine roots to pedicel and pod hull (Nene *et al.*, 1979). The pathogen usually occurs more frequently with high recoverable population in the vicinity of the infested and wilted plant roots.

The fungus extends more rapidly from one place to another along the roots than accross the soil (Butler, 1910). It is dispersed through irrigation and / or rain water, and displacement of host debris within or between fields. Upadhyay and Rai, (1982) recorded spread of the propagules by termites that feed frequently on the dead wilted plants. The pathogen has also been found to be seed - borne in talerant cultivars(Haware and Kannaiyan, 1992). It survives in the infested soil for three years even in the absence of pigeonpea (Kannaiyan *et al.*, 1981). The pathogen show a great deal of variation in cultural characteristics (Reddy and Chaudhary, 1985).

The colonies of *Fusarium udum* develop profusely on nutrient medium. Mycelium is hyline and produces micro and macro conidia on simple or vertically branched conidiophore. The conidia are generally present in pinkish salmon coloured masses and are produced from the tips of phialides and are seen generally on collar region of the host (Rai and Upadhyay, 1982). They also recorded microconidia are small, elliptical or curved, unicellular or with 1-2 septa, and measure 5-15×2-4 µm. The macroconidia are long curved (fusaroid), pointed at the tip, and notched at the base, septate (3-4 septa), and measure 15-50X3-5µm. (Plate 2, Fig.4).

Slightly acidic to slightly alkaline soil containing 50% or more sand particles favour disease incidence in susceptible cultivars and it is also noted that higher proportion of sand in soil favours occurrence of wilt (Shukla, 1975).

Sadasivan (1965) emphasized that the competetion for available minerals between plant and minerals in the soil, mobilization of unavailable complex and their immobilization in to the system occurs in the rhizosphere region. Instances of microbialogically induced mineral deficiency especially for calcium, Maganesium and Potassium in higher plants are common (Sarojini, 1950; Leach *et al.*, 1954). The classical examples of the role of micro-organisms that play importent role in the mineral uptake by plants is located in ectomycorhizal association where entry of phosphate ions is accelerated by the fungal associates (Singh, 1996). Addition of solution of Boron, Manganese and Zinc develops resistance in the host against *Fusarium udum*. It has been suggested that zinc inhibits spore germination of pathogen and pathogen disappears quickly from the soil (Sarojini, 1950). Similarly, Subramanian (1956) reported that pre-treatment of seeds in Mn solution provids resistance to the plant against infection. The soil amendments at 100 and 200 ppm of Mn exclude fungal spores in the soil.

In general, the soil microflora have been recorded to increase after soil amendments with nitrogen, phosphorus and potassium. Some non-pathogenic microflora were observed to be stimulated without infecting common soil inhabitants (Sadasivan, 1965). He further observed partial disappearance of pathogenic soil Fusaria, their inability to sporulate well and their consequent inability to colonize organic matters in soil amended with trace elements. In addition to Boron, Zinc and manganese Sulochana (1952); Studied the saprophytic behavior of *Fusarium vasinfectum* and other Fusaria in the presence of Al, Co, Li. Mo and Ni. The amendments reduced saprophytism and colonization over long periods.

The successful management of soil-borne disease such as the pigenpea wilt caused by *Fusarium udum*, has always been a problem. The methods invariably tried for management of wilt incidence cultural practices, resistance, amendment of soil with decomposable organic wastes, oils and Bio-agents.

Crop rotation is undoubtedly one of the best ways of suppressing wilt of pigeonpea. However, since the fungus survives on deepseated roots of the host, below the depth of ordinary cultivation, the success of rotation will depend on field sanitation (removal of affected plants with their roots), hot weather cultivation (deep ploughing during summer), and similar practices. A 4-5 year rotation has been found to free the field completly of the wilt pathogen. The lenth of rotation can be reduced by ensuring removal of affected roots. Sorghum, pearl millet, Cotton and resistant pigeonpea cultivars are recommended as rotation crops (Singh, 2000).

Mixed cropping with sorghum (*Sorghum vulgare* Pers.) provides the most effective and practical solution of this problem. At Kanpur in U.P., experiments extended over several years during 1940 had shown that the incidence of wilt in pigeonpea was substantially reduced in mixed crop mixed with sorghum than in the pure pigeonpea crop. Several reasons were suggested for this reduction in incidence of wilt such as the chances of contact between host roots and the pathogen and the inhibitary effects of exudates of sorghum on pathogen (Singh, 2000). Natrajan *et al.*, (1985) studied and recorded the impact of cropping system on the disease. In continuous cropping of pigeonpea, the incedence was as high as 64-69 percent. A rotation of sorghum and fallow reduced it to 16-31 percent and 2 cycles of sorghum followed by pigeonpea reduced the incidence to 16 percent. In their opinion also the root exudates of sorghum had a suppresive effect on the pathogen in soil there by suppressing infection of pigeonpea.

Among several secondary metabolites of higher plants, the essential oils have been reported to be highly effective against different plant pathogens (Pandey and Dubey, 1992). Toxicity of the essential oil extracted from *Ageratum houstonianum* has been reported against *Fusarium udum* (Pandey and Chandra *et al.*, 1983).

Rathe *et al.*, (1982) have reported that the oil of *Nigella sativa* was fungitoxitic against soil-borne pathogen. The oil inhibited colony growth of *Pythium vexans, R. solani* and *C. capasici.* The oil of *Glossocardia bosvallia* was found to be inhibitory against *Phytophthora parasitica, Botryodiplodia theobromae, Fusarium salani,* and *Rhizopus nodosus* (Pathak and Dixit, 1984). The essential oils of *Azadirachta indica* completely inhibited the growth of *Alternaria alternata* (Dharamvir and Sharma, 1985). Kishore, (1985) reported that the oil of *Chenopodium ambrosioides* inhibited the mycelial growth of *Rhizoctonia solani.* Dwivedi and Dubey (1986) reported that the oil of *Azadirachta indica* and *Eucalyptus globulus* decreased sclerotia germination of *Macrophomina phaseolina.* The oil of *seseli indicum* was found to be fungitoxic against *Aspergillus flavus, A. niger* and *Fusarium oxysporum* (Chaturvedi and Tripathi, 1989).

Kishore and Dwivedi (1991) reported that the oil of *Tagetes erecta* controlled damping-off disease up to 50% and the oil of *Zingiber cassumunar* also inhibited the disease upto 85% (Kishore and Dwivedi, 1992). Kazami *et al.*, (1993) reported that the oil of *Anethum graveoleus* completly inhibited the growth of *Alternaria alternata, Aspergillus flavus, A. fumigatus* and *A. wentii.* Valarini et al., (1994) observed that the essential oil from the leaves of *C. citratus* completely cheeked the mycelial growth of *Fusarium salani* f. sp. phaseoli, *Sclerotinia sclerotiorum* and *Rhizoctonia solani.*

Amendment of soil with decomposable crop residues and oil-cakes has been recognised as most effective method of changing soil and rhizosphere environment, thereby affecting the quality and quantity of soil microflora and fauna. Soil amendment with oil-cakes has already been reported to reduce nematode infestation (Singh, 1965; Pandey and Singh, 1990; Gupta, 1993). Reduced disease intensity of fungal pathogen through soil amendment with oil-cakes has been reported by various workers (Das gupta and Gupta, 1989; Mukhopadhyay and Gupta, 1991). Rao *et al.*, (1989) reported the reduction of the foot and root disease of wheat caused by *Sclerotium rolfsii* by amending the soil with castor cake. They explained that the organic amendments in soil stimulated soil microflora including the antagonists and some of them ultimately controlled the soil-borne pathogens.

Rai and Singh (1996) studied the efficacy of certain oil-cake amendments on *Heterodera cajani, Fusarium udum* and the associated incidence of wilt of pigeonpea. Oil-cakes of neem, mustard, mahua, coconut, linseed and sesame were tested at different concentrations (0.25, 0.5, 1.0 and 2.0%) against radial growth of *Fusarium udum*. Neem, mustard and mahua oil-cakes were found most effective in reducing fungal growth and were used in pot culture to test their efficacy on *H. cajani, F.udum* and associated wilt of pigeonpea, with carbofuran as standard nematicide. The best growth of pigeonpea plants was recorded with mahua oil-cake but the neem oil-cake was most effective in controlling wilt incidence, caused by *F. udum* alone and in combination with *H.cajani.* Further, all the treatments adversely affected total nematode population, carbofuran being the most effective, followed by neem and mustard oil-cakes.

Azadirachta indica is well known for its medicinal use (Shah *et al.*, 1959). Its antiviral (Rao *et al.*, 1969), antibacterial (Murthy and Sirsi, 1957), antiprotozoal (Bhide *et al.*, 1958), antiinsecticidal (Krishnamurti and Rao, 1950), and antifungal (Singh *et al.*, 1980) properties have been reported. Dwivedi and Dubey (1986) have studied the effect of volatile and volatile fraction of neem and Eucalyptus on germination of sclerotia of *Macrophomina phaseolina.*

Though most phytopathological aspects of the disease have been studied yet no or little progress has taken place with respect to its management. In recent years, wealth of informations are available on the effect of fungicides on the control of soil-borne plant pathogens and their activities in soil (Ray and Das, 1987; Singh and Dwivedi, 1988). Sinha, (1975) observed a significant cotrol of the disease by soil drench of Bavistin at 2000 ppm. Efficacy of Phygon XL, Dithane Z-78 in reduction of wilt incidence has also been reported by Upadhyay and Rai (1981).

Haider *et al.*, (1978), reported disease control over three years by captan, Brassicol (quintozene) and Phenylmercury acetate. Kotasthane et al., (1987) reported that seed treatment with benlate + Thiram (1:3) considerably reduced the wilt incidence. Bashar (1990) studied effects of nine fungicides in vitro on radial growth of *Fusarium oxysporum* f. sp. *ciceri* causing wilt disease of chickpea and found that MeMc and Bavistin completly checked the grouth of the pathogen even at 5 ppm concentration. Bhatnagar (1992) has shown inhibition of the radial growth of *Fusarium udum* to different concentrations of fungicides like Blue copper, Foltaf, Shield-75 and Sulfex. However, the effect of the fungicide applied at the time of showing did not persist for the whole cropping season and thus, a single treatment did not provide a remedy for disease control.

Although a large number of reports exist on the use of pesticides in disease control, there can not be a total reliance on a such chemicals. Pesticides can cause environmental pollution and may induce resistance in pathogen (Larson, 1987; Cohen and levy, 1990). Pesticides are necessary at pressent but are not a long term solution to crop, human and animal helth (Mukhopadhyay, 1987). They are becoming more expensive and some are lossing their effetiveness because of development of resistant stains. Therefore, it is apparent that pesticides do not hoid well for the disease control and other methods of the the disease management should be explored and used.

Biopesticide have the potential to replace or augment conventional plant disease management based on the use of synthetic pesticides. It provides an ecofriendly means to control plant pathogens through the use of indigeneous or genetically modified organisms (Taylor *et al.*, 1994). Control of plant diseases through biopesticides is consistent with the goal of the sustainable agriculture and integrated disease management to minimize the use of chemical pesticides. Few areas of research, within plant pathology, which have attracted more attention during the past two decades, include the use of microorganism based pesticide for biological control of plant diseases.

Antagonists may function by suppressing the inoculum potential of pathogen (Baker and Drury, 1981). A successful biocontrol agent efficiently suppresses pathogens by such forms of antagonism as competition, antibiosis and/or exploitation. According to Mclaughlin *et al.*, (1990) an effective antagonist provides resistance to host indirectly by changing its chemical and/or osmotic environment which may favour antagonists over the pathogens. Several studies have demonstrated reduced incidence of disease after supplementing soils with non-phytopathogenic fungi, bacteria and actinomycetes (Chalutz and Wilson, 1990; Smith *et al.*, 1990; Mandeel and Baker, 1991).

Microorganisms antagonistic to *Fusarium udum* has been reported by (Gaur and Sharma, 1991). Microorganism isolated from the rhizosphere soil of pigeonpea were tested for their antagonistic action against *F. udum* on Czapek's sucrose nitrate agar medium. *Trichoderma viride* persent in the rhizosphere soil of resistant NP-15 as well as susceptable T-21 varieties of pigeonpea was most effective in controlling the disease followed by *Asporgillus niger, Streptomyces spp., Penicillium spp.* and *Bacillus spp.* An apparent correlation existed between the decrease in wilt disease incidence and magnitude of population of *F. udum* per gram soil and antagonists.

Smith *et al.*, (1990) reported a successful control of Phytophthora-rot and Crown-rot of apple by infesting soil with *Trichoderma and Gliocladium* spp. Upadhyay and Mukhopadhyay (1986) reported biocontrol of Sclerotium root-rot of sugar beet by soil application of *Trichoderma harzianum* preparations. Similarly, control of *Pythium* spp. in tobacco, sugarbeet and cauliflower was achieved by *T. harzianum* through soil application (Mukherjee *et al.*, 1989; Sawant and Mukhopadhyay, 1990). Recently extensive work on soil application of *Trichoderma* and *Gliocladium* has been done by scientists at USDA-Bettsville, USA for control of damping-off and blight of snap been (Sclerotium rolfsii), damping-off cotton and Rhizoctonia disease of potato (Lewis and Papavizas, 1992).

Disease of several ornamental plants caused by *Pythium* and *Rhizoctonia* could be controlled by soil application of *Gliocladium virens* (Lumsden *et al.*, 1990). Preplanting application of biocontrol agent *Coniothyrium minitans* resulted in control of botton rot of lettuce (Whipps, 1991; Budge and Whipps, 1991). A lot of work has been done on biological seed treatments for control of diseases using *Trichoderma spp.* and *Gliocladium virens* on crops like potato (Beri and Mukhopadhyay, 1988), Cauliflower (Mukherjee *et al.*, 1989), Chickpea (Kaur and Mukhopadhyay, 1992) and tomato (De and Mukhopadhyay, 1994). Biological control has been tried in several wilt causing *Fusarial* diseases and has been found to be partially successful management (Alabouvette *et al.*, 1985). Attempts to identify antagonist of *Fusarium udum* were made in past (Jariwala *et al.*, 1995).

Bacillus subtilis has been reported to possess strong antagonistic property against *Fusarium udum* (Podile *et al.*, 1985), which produces an antibiotic bulbiformin and is able to reduce the wilt incidence. Another antagonist reported to have potential for biocontrol of *F. udum* is *Micromonospora globosa* (Upadhyay and Rai, 1978) which kills and destroys *F. udum* even in its resting stage.

Harish *et al.*, (1998) reported that *Fusarium udum* is resistant to the mycolytic activity of a biocontrol strain of *Bacillus subtilis.* Fusarial wilt suppression and crop improvement through two rhizobacterial strains in chick pea growing in soil infested with *Fusarium oxysporum* f. sp. *ciceris* (Kumar, 1999). Upadhyay, (1993) reported ecology and biological control of *F. udum* in relation to soil fungistasis of antagonistic microorganisms. Bapat & Shah 2000 reported that the strain of *Bacillus brevis* may have potential as a biological control agent against fusarial wilt in pigeonpea.

A detailed study on antagonism between *Fusarium udum* and other saprophytic mycoflora, isolated from the pigeonpea field, was made by upadhyay and Rai (1987). They found *Aspergillus niger, A. flavus, A. terreus, Penicillium citrinum, Trichoderma harzianum, T. viride* and *streptomyces greseus* as potent antagonists for control of wilt disease of pigeonpea.

The integrated biological control of plant pathogen has been discussed by several workers (Lewis and Papavizas, 1991). The development of integrated control strategies depends on identification and integration of appropriate control objectives (Papavizal and Lewis, 1988). The major objectives are (1)reduction of populations of disease causing microorganisms to levels that do not limit crop production and (2) Utilization of more than one disease control component in reducing a disease below the economic injury threshold. Combinations of biocontrol fungi with broad spectum fungicides are more comman. The rationale to use biocontrol fungi in combination with reduced amounts of pesticides stems from the need to reduce pesticides use in disease control (Papavizal, 1987).

Baby and Mani Bhusan (1993) have reported control of sheath blight of rice through integration of two fungal antagonists i.e. *Gliocladium virens* and *Trichoderma longibrachiatum* with organic amendments (Neem oil-cake and Gliricidia leaf) under green house and field conditions. Kaur and Mukhopadhyay (1992) controlled chickpea wilt by integrating *trichoderma* with a fungicide. There has been little effort to adopt and follow integrated approach for managing pigeonpea wilt.

The integrated use of biocontrol agents with other disease management practices is a better prospect than either used alone. In recent years, much emphasis has been placed on integrated disease management of plant pathogens using different useful components.