CHAPTER 2

REVIEW OF LITERATURE

The present scenario of sustainable agriculture aims at increasing food grain production without any harmful effects on soil, plant and environment. Adequate food grain production for meeting the demands of ever increasing population is a global concern today. Plant diseases have been of great concern to the sustainable agriculture as evidenced from the history of plant diseases such as the Irish famine which occurred in 1845 due to late blight of potato caused by *Phytophthora infestans* and Bengal famine which occurred in 1943 due to severe damage caused by *Helminthosporium* leaf spot of rice were major human suffering caused by plant diseases. This led the scientists to develop appropriate disease control measures for plant diseases. There were few reports on the success stories of plant disease control and to name some of them are: Wheat stem rust (*Puccinia graminis tritici*), Wheat leaf rust (*P. recondita tritici*), Rice blast (*Pyricularia oryzae*), yellow vein disease of ladies finger and viral diseases of potatoes have been brought under control to a great extent.
*Fusarium* wilt of pigeonpea (*Cajanus cajan* (L.) Millsp.), caused by *Fusarium udum* Butler is widely prevalent in all the pigeonpea growing regions of the world. It is an important soil borne disease causing significant yield losses. The disease can cause 30-100% loss in grain yield (Kannaiyan and Nene, 1981). Of the various strategies available for disease management, the chemical based strategies have been so far dominating in the present situation. However non judicious use of chemicals caused serious imbalances in the diverse components associated with the agro ecosystems. Therefore, disease management strategy should be made economical as well as environmental safe. In this context, integrated disease management module which is economically viable and environmentally safe is highly essential. In pursuit of this, extensive researches were carried out for an effective management of the disease over the decades. There is a need to combine more than one disease management practices for effective management of the diseases. In pursuit of this enough literatures have been generated on the integrated management of diseases over the last many decades. However, only the literatures relevant for the present study on the management of wilt disease are summarized under the various heads such as, occurrence of the disease, symptomatology of disease, the fungus- *Fusarium udum* Butler- the causal organism of the disease, pathogenicity of the disease, epidemiology of the disease, effect of agronomic practices and effect of organic amendments on the occurrence of wilt disease, effect of rhizosphere microflora on wilt pathogen, effect of biofertilizers and biopesticides on wilt pathogen, effect of medicinal plant extracts on wilt pathogen (both *in vitro* and *in vivo*), etc.
2.1. Occurrence of the disease

Wilt disease of pigeonpea caused by *Fusarium udum* was first reported from Bihar state in India by Butler (1906). The disease was also reported from major pigeonpea growing areas of Asia, Africa and the Americas. The disease has now been reported from Bangladesh, Grenada, Indonesia, Mauritius, Myanmar, Nepal, Venezuela, Trinidad and Tobago (Kannaiyan *et al.*, 1984; Reddy *et al.*, 1993). Kannaiyan *et al.*, (1984) also reported higher incidence of the disease in eastern states of Africa and a minor disease in America. Recently, the disease was reported spreading in Southern Africa reaching areas in Mozambique (Gwata *et al.*, 2006). In India the *Fusarium* wilt disease has been reported from different parts of the country with variation in disease incidence and disease severity. Incidence of the disease was most serious and widespread in Maharastra (22.6%), Bihar (21.4%) and Uttar Pradesh (8.2%) as per the report of Kannaiyan *et al.*, (1981). In another roving surveys conducted by the same authors in nine states of India during 1975-1980, recorded the incidence of wilt in Andhra Pradesh (5.3%), Bihar (18.3%), Gujarat (5.4%), Karnataka (1.1%), Madhya Pradesh (5.4%), Maharastra (22.6%), Rajasthan (0.1%), Tamil Nadu (1.4%) and Uttar Pradesh (8.2%). Kotasthane and Gupta (1981) observed wilt of pigeonpea caused by *F. udum*, a serious disease in Madhya Pradesh. They noticed a close relationship among flowering period, wilt intensity and soil temperature. They found that an early maturing variety (AS-3) was better for reducing
losses due to wilt. Report of the occurrence of the disease is virtually not found. Chhetry and Devi (2014) only for the first time reported prevalence of wilt disease of pigeonpea in Manipur during a survey conducted at three districts viz. Imphal west, Imphal east and Senapati in relation to this work.

2.2 Symptomatology of the disease

*F. udum*, the fungus causing wilt disease of pigeonpea enters the host vascular system at root tips through wounds leading to progressive chlorosis of leaves, branches, wilting and collapse of the root system (Jain and Reddy, 1995) and the same has been observed in the present investigation. Although the infection occurs in the early seedling stage, characteristic symptoms are not visible until crop pass through various developmental stages (Reddy et al., 1990; Hillocks et al., 2000). Pande et al., (2012) reported the parasitic or saprophytic behaviour of mycelium of *F. udum* with the production of macroconidia (1-5 septate), microconidia (0-1 septate) and chlamydospores, thick walled round or oval spores, sometimes found in short chains. Although, many workers have reported on the symptoms of *Fusarium* wilt, the initial visible and characteristic symptoms are loss of turgidity in leaves and interveinal clearing as found in the investigation. Reddy et al., (1990) reported leaves showing slight chlorosis and sometimes becoming bright yellow before wilting. Black streaks in the vascular region and brown band or dark purple bands on the stem surface are the most characteristic symptom of the disease (Reddy et al., 1993; Pande et al., 2012). According to them, wilt symptoms usually appear in flowering and podding stage and sometimes at seedling stage. However, the most characteristic symptoms
are reported as browning or blackening of the xylem vessels and the purple band extending upwards from the base of the main stem. Partial wilting is also reported as an indication of Fusarium wilt. All these symptoms have been noticed in pigeonpea field in Manipur too during the course of investigation.

2.3 The fungus *Fusarium udum* (Butler) - the causal organism of the disease

*F. udum* is a soil borne fungus. The fungus can survive in plant stubbles for 2.5 years in Vertisols and 3 years in Alfisols (Kannaiyan *et al*., 1981). The perfect state, or the sexual stage of *F. udum* is reported to be *Gibberella indica* (Reddy *et al*., 1990). Several workers have reported the occurrence of physiological races of *F. udum* (Gupta *et al*., 1988; Reddy and Raju, 1993). Extensive works on wilt of pigeonpea have been done at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Studies carried out at ICRISAT Centre (Patancheru, India), and multi-locational testing of resistant genotypes in India, also pointed to the presence of physiologic races in *F. udum* (Reddy *et al*., 1990).

2.4 Pathogenicity of the disease

Information Bulletin of ICRISAT (1986) reported the use of root-dip and transplanting methods to inoculate seven-day-old seedlings of pigeonpea with *F. udum*. The inoculum concentration of $1 \times 10^6$ colony forming units ml$^{-1}$ in sterile water is ideal for inoculations (Reddy and Raju, 1993).
2.5 Epidemiology of the disease

The major infection of wilt disease occurs through the soil. Therefore, air and irrigation water plays an important role in rapid spread of the disease. Upadhyay and Rai (1983) reported that termites can spread wilt by carrying the fungus propagules from infested to healthy plants. Such infested termites can also cause the disease in pigeonpea plants grown in the sterilized soil. They found the important role of mycoparasitation on other fungi and host debris in the disease cycle. In other study, Hasan (1984) reported increased wilt incidence in nematode (Heterodera cajani) infested pigeonpea. Siddiqui and Mahmood (1996) also found higher wilting in combined infection of F. udum with H. cajani than with Melodogyne spp. alone. The importance of imperfect state, G. indica and perfect state for completing wilt disease cycle were established. However, the imperfect state of the pathogen is found to be more important. Spread of disease from plant to plant occurs through root contacts, irrigation, rainwater and termites (Upadhyay and Rai 1992). Further, infected seed may be the primary means of spreading F. udum over a long distance into new areas where it could become a primary source of inoculum (Haware and Kannaiyan, 1992). Pigeonpeas grown during the post rainy season suffer less from wilt and sterility mosaic than those grown in rainy-season (Sharma, 1980). In fact, development of perithecial stage of Fusarium udum is favoured by cloudy weather, high humidity and a combination of low and high temperature (Singh et al., 1980). Fusarium wilt is favoured by soil water holding capacity (30%) and soil temperatures between 20°C and 30°C (Singh and Bhargava, 1981). Slightly acidic or alkaline soils with 50% or
more sand favour the wilt (Upadhyay and Rai, 1989). The disease is not only more prevalent in early planted than late-planted crops, but is also more prevalent in irrigated than rain-fed crops (Chaudhary et al., 2001).

2.6 Effect of agronomic practices and effect of organic amendments on the occurrence of wilt disease

Organic amendments are known to favour native antagonists to suppress the soil borne diseases (Mukhopadhyay, 1994). The mode of action of organic amendments leading to plant disease control and stimulation of microorganisms is complex and dependent on the nature of the amendments (Akhtar and Malik, 2000). Development of disease suppressive soils by introducing organic amendments and crop residue management take time but the benefits accumulates in successive years leading to improvement of soil health and structure (Bailey and Lazarovits, 2003). The application of organic amendments, manures and compost that are rich in nitrogen, may reduce soil-borne diseases by releasing allelochemicals generated during product storage time or by subsequent microbial decomposition in course of time (Deepak, 2011). Mixed cropping, green manuring with Crotalaria juncea and nitrogen application in the form of farmyard manure will also help in reducing wilt incidence (Upadhyay and Rai, 1981; Verma and Rai, 2008). Inhibition of radial growth of F. udum in castor cake amended soil was also reported (Singh and
The best growth of pigeonpea plants was recorded with mahua oilcake but neem oil cake was most effective in controlling wilt incidence alone and in combination with Heterodera cajani (Rai and Singh, 1995).

Application of individual components of green manure and farm yard manure (FYM) had no influence on pigeonpea wilt incidence in sole and intercropping system (Bharathि et al., 2008). Higher pigeonpea grain yield with the combined application recommended dose of fertilizers and cultural mulch (Selvi et al., 2009). Chhetry and Mangang (2011) while studying the soil amendments effect for three years reported significant effect of organic amendments on Rhizoctonia rot and Sclerotina rot of frenchbean.

During disease survey in India, Kannaiyan et al., (1984) recorded low wilt incidence in pigeonpea fields intercropped with sorghum. Natarajan et al., (1985) found the importance of intercropping with Sorghum in the management of pigeonpea wilt. With higher initial levels of F. udum inoculum in soil, wilt incidence in sorghum- intercropped pigeonpea plots were significantly lower as compared to sole pigeonpea plots (Naik et al., 1997). However, under very high soil sickness with F. udum there was no significant response of sorghum or soybean or fingermillet intercropping on wilt incidence in pigeonpea (Madhusekhara et al., 2003). Bharathi et al., (2008) also reported less percent wilt incidence in pigeonpea intercropped with Sorghum than sole crop without any amendment. The maize-pigeonpea intercropping module has a high potential and the same are well adopted by farmers (Myaka et al., 2006) because pigeonpea matures on residual soil moisture after most farmers have
harvest their maize stocks, thereby bridging the hunger period and providing food security to the rural farmers. Interestingly Rani and Reddy (2010) recorded more seed yield in sole pigeonpea than intercropped pigeonpea. Thus, varying results on agronomic practices have been reported from time to time.

Soil solarization, a non-chemical disease management technology introduced by Katan (1981) in Israel to control weeds, nematodes and soil-borne pathogens is a process that uses sun’s energy to enhanced temperature of soil to that level at which most plant pathogens will be inhibited or reduced to achieved significant level of disease control (Shukla and Dwivedi, 2011). Arya and Mathew (1993) observed the effect of solarization on Fusarium incorporated soil and reported the absence of Fusarium colonies on potato dextrose agar petriplates after 45 days of solarization. Solarization of the field during summer period reduced Fusarium inoculum (Reddy et al., 1993). Rao and Krishnappa (1995) conducted field experiment to study the effect of soil solarization for the control of Meloidogyne incognita and Fusarium oxysporum f. sp. ciceri by covering the soil by transparent polythene sheet for 6 weeks during hot summer months. They observed that increase in soil temperature caused significant reduction of population of M. incognita and F. oxysporum f. sp. ciceri to 58% and 80.8%. Singh et al., (1996) also found suppression of wilt disease of pigeonpea in solarized soil of Uttar Pradesh. Chauhan et al., (1998) observed reduction of wilt incidence in solarized plot of pigeonpea under both irrigated and non-irrigated conditions. Gade et al., (2007) reported that solarization of pigeonpea field and seed treatments with thiram + benomyle (1:1) improved seedling emergence. They also
noticed delay of wilting in soil solarized plots. Shukla and Dwivedi (2011) studied the effect of soil solarization on population dynamics of two pathogenic soil fusaria i.e. *Fusarium oxysporum* f. sp. *ciceri* and *Fusarium udum*. They found that the populations of the pathogens were significantly reduced in solarized plots compared to control plots. However, in Manipur condition, the highest temperature recorded ranges from 33-35°C during June-July is not sufficient to inhibit the soil borne pathogens to desired level and even then solarization technique is sustainable one under organic farming system.

### 2.7 Effect of rhizosphere microflora on wilt pathogen

Among the microorganisms considered as biological control agents, the beneficial free-living bacteria referred to as plant growth promoting rhizobacteria or PGPR are often influences the soil pathogens (Kloepper *et al.*, 1980). Singh and Singh (1980) reported that *Bacillus subtilis* (cultures B4, B6, B18 and B19) and *B. cereus* (culture B12) were found to inhibit growth and spore germination of *Fusarium oxysporum* f. sp. *udum* and found to cause some lysis of the mycelium and germ tubes of the test fungus. Sunitha *et al.*, (1995) observed a wide zone of inhibition with the use of *Trichoderma harzianum* and *Bacillus subtilis* against *F. udum*. They also found that pigeonpea seeds coated with the antagonist microorganism germinated better than untreated seeds and produced longer shoots and roots when shown in either wilt infested or sterilized soil. Siddiqui and Mahmood (1996) found that simultaneous use of biocontrol agents viz. *Glomus mosseae, Trichoderma harzianum* and *Verticillium chlamydosporium* against wilt disease complex of pigeonpea caused by *Heterodera*
*cajani* and *Fusarium udum* gave better control than their individual applications in reducing wilting intensity. Seed treated with *T viride* isolate H reduced the number of *F. udum* propagules from $19.4 \times 10^2$ to $2.5 \times 10^2$ cfu/g soil and wilt severity ranged from 15.5% to 7.3%. Soil application of *T. viride* isolate H also significantly reduced the number of *F. udum* propagules and wilt severity (Somasekhara *et al.*, 1996). Nakkeeran and Devi (1997) found that seed borne fungi detected on pigeonpea seeds were effectively reduced by seed pelleting with *T. harzianum* and *B. subtilis*. Bidari *et al.*, (1997) recorded 27.62% reduction in wilt disease of pigeonpea caused by *F. udum* when seeds were treated with *T. viride*. They further reported that wilt susceptible pigeonpea cultivar GS-1 showed a 29.23% wilt reduction and the resistant cultivar BSMR 36 showed a 23.65% wilt reduction. Landa *et al.*, (1997) observed strong antagonism of *Bacillus* spp. and *Pseudomonas chlororaphis* against *Fusarium oxysporum* f. sp. *ciceri*, the causal agent of fusarial wilt of chickpea. They found that some selected antagonistic *Bacillus* spp. isolates suppressed disease caused by highly virulent *F. oxysporum* f.sp. *cicero* race 5 in cv. PV 61 chickpeas. However, the degree of protection was influenced by the host genotype and the inoculum concentration of the pathogen. Singh *et al.*, (1997) reported that *Trichoderma harzianum* showed mycoparasitism against *F. oxysporum* f. sp.*,ciceri*, causal agent of chickpea wilt and *T. viride* and *Epicoccum purpurascens* exhibited antibiosis. It was also observed that the growth of chickpea roots, shoots and leaves was enhanced in the presence of all the antagonists with maximum growth in soil inoculated with *T. harzianum*. Podile and Laxmi (1998) reported that cell free culture filtrate of a biocontrol PGPR strain of *Bacillus subtilis* AF1 showed a concentration dependent
growth and conidiation inhibition of *F. udum*. They further observed that *in vitro* interaction of cell free filtrate of AF1 induced bulb like structures in the hyphae of *F. udum*. Seed treatment with *B. subtilis* significantly reduced the incidence of pigeonpea wilt but not with the cell free culture filtrate of AF1. Singh and Rai (2000) found that a combination of *Aspergillus niger* and *essential oil from Aegle marmelos* inhibited the radial colony growth of *F. udum* upto 70%. They also observed maximum inhibition in radial colony growth of *F. udum* by the combination of *A. niger* and plant extracts of *Adenocallyma allicea* upto 75%. They found complete inhibition of the colony growth of *F. udum* by the combinations of *Aspergillus niger, Gliocladium virens, Penicillium citrinum* and *Trichoderma harzianum* with plant extracts of *Asparagus adscelidelis* and *Adenocallyma allicea* in combination with the fungicides Bavistin. They opined that the complete inhibition of radial growth of *F. udum* which might be due to the overall effect of metabolites of antagonist, phytotoxic compounds of plant parts and the fungicides and concluded that the integrated effect of *G. virens, A. allicea* and Bavistin was highly effective for controlling wilt disease of pigeonpea both in pot culture experiment as well as field experiment. Singh *et al.*, (2002) reported that the culture filtrates of test fungi *Gliocladium virens, Aspergillus flavus, Trichoderma harzianum, Penicillium citrinum* and *Bacillus licheniformis* (strain-2042) inhibited the radial growth of *F. udum* at varying degrees. The maximum inhibition (69%) was recorded in *G. virens, A. flavus and B. licheniformis, P. citrinum and T. harzianum* also showed marked inhibition against the test pathogen (50.6-60.6%). They also found that when the antagonist were amended in sterilized and unsterilized soil, *G. virens* was the most potent biological control agent against *F.*
udum showing disease control upto 96.6% in unsterilized soil and 100% in sterilized soil. Prasad et al., (2002) found that soil application of T. harzianum was more effective than seed treatment for suppression of pigeonpea wilt. They also found that even at the highest pathogen density (log 5.34 cfu/g of soil), soil amendment with T. harzianum at 10 g gave about 30% disease reduction. In seed treatment plots, achievements of disease control ranged between 4.36% and 13.7%. Gholve and Kurundkar (2004) found that combined inoculation of T. viride with Pseudomonas fluorescens isolates from mungbean showed the minimum growth of F. udum. Mahajan et al., (2008) tested the efficacy of fungal isolates obtained from the rhizosphere soil of different crops grown in Marathwada region against wilt of pigeonpea. They found that Aspergillus flavus (isolate 15), Paecilomyces varioti, Hormiscium sp. and A. fumigatus (isolate 8) delayed wilting of pigeonpea as compared to control. The combination of carbendazim seed treatment of pigeonpea @ 2g/Kg of seeds + soil application of P. fluorescens, T. viride each @ 2.5Kg/ha and FYM @ 50Kg/ha recorded least mean wilt incidence of 7.25% with mean yield of 1203.17Kg/ha (Mahesh et al.,2010).

2.8 Effect of biofertilizers and biopesticides on wilt pathogen

The legume- Rhizobium symbiosis is probably the major source of fixing nitrogen on a global basis. The success of the inoculant strain depends upon the efficiency and competitive dominance. Once a strain becomes established in the soil it is difficult to replace completely with a more suitable one (Dahiya, 1980). Rao and Dart (1980) reported that the distribution of cowpea group rhizobia in soils varied
within the same field and also with the soil type and depth. They concluded that seed inoculation at the time of sowing with an effective *Rhizobium* is a prerequisite for good nodulation especially in those soils having few rhizobia as well as those soils where the rhizobial populations were high. Many workers have reported on the influence of biofertilizers on growth and yield parameters of pigeonpea. Gupta (1980) found that inoculation of pigeonpea cv T-21 with rhizobial strain KA-1 and addition of phosphate increased grain yield by 167 to 175 kg/ha. Solanky *et al*., (2004) found that seed inoculation of pigeonpea cv. GT-1 with *Rhizobium* isolate SS-1 or PRN-3 or SR-1 without N fertilizer @ 200 g per 12 Kg per seeds were significantly superior for obtaining maximum green pod yield in South Gujarat. Reddy *et al*., (2011) conducted a field experiment to study the effect of fertilizers, farmyard manure and biofertilizers on growth and yield of pigeonpea and recorded significantly more number of branches (16.3/Pl.), pods (151.3/Pl.), higher grain yield (1358 kg/ha) in averages and net returns of Rs.15541 in 50% recommended dose of fertilizer (RDF) + seed treatment with *Rhizobium* @ 200g/kg seed. Osman *et al*., (2011) also observed that inoculation of pigeonpea with *Rhizobium* significantly increased nodulation, nodule dry weight, root dry weight, shoot dry weight, nitrogen and phosphorus content in shoot and seed yield of pigeonpea plants in comparison to the un-inoculated control. Gupta *et al*., (2005) found antifungal activities of lathyrus *Rhizobium* isolates against *Sclerotium rolfsii* a pathogen causing rotting in legumes. They observed that among twenty one lathyrus *Rhizobium* isolates collected from soils of Madhya Pradesh and Chhatisgarh, only *Rhizobium* isolate L-11 showed complete inhibition in growth of *S. rolfsii* and L-12 showed 89% growth inhibition after 96 h of incubation.
(2005) also conducted field experiment to evaluate promising isolates of *T. viride* and *Rhizobium* as bio-inoculants for controlling wilt complex fungi (*Fusarium*, *Sclerotium* and *Rhizoctonia*) of chickpea. They found that *T. viride* local isolate No. 2 was superior followed by *T. viride* TNAU isolate on the basis of plant height, plant population, nodulation, wilt incidence and biomass accumulation.

Bhatnagar (1995) found that addition of commercial biofungicide *Trichoderma* MTR-35 (Mukhteshim Chemical Works Limited, Israel) to the soil at 1.0% (w/w) concentration resulted in reduction up to 44% wilt incidence. He also found that increased in biofungicide concentration at 2.0 and 2.5% (w/w) resulted in almost complete suppression of the disease. Other worker also found that powder formulations of *Pseudomonas fluorescens* were effective in controlling wilt disease of pigeonpea but they reported that their efficacies varied depending upon the length of biopesticides storage (Vidhyasekaran *et al.*, 1997).

Many workers have used neem based formulations for eco-friendly management of certain diseases. Chandel *et al.*, (2007) studied the efficacy of the commercial formulations of neem namely Neemazal (1.0% effective concentration), Nimbicidine (0.03% effective concentration) and Achook (1.0% effective concentration) against gladiolus wilt under field conditions. Among the biopesticides, they found that Achook was significantly superior over other treatments with 31.93% disease incidence and Nimbicidine has proved least effective with a highest incidence of 43.52%. Bunker *et al.*, (2008) tested four neem based formulations namely, neem seed extract, neem oil, Azadirachtin and Achook each at 0.2% (V/V) against
**Exserohilium turcicum**, the causal agent of sorghum leaf blight both *in vitro* and *in vivo* conditions. They observed that neem seed extract showed maximum growth inhibition (88.9%) and sporulation (93.4%) followed by Achook. Under field conditions, foliar spray of individual neem formulation was more effective than their seed treatment. Pal et al. (2008) also found that foliar spray of Companion + Nimbidicine showed minimum disease incidence (23.33%) against *Alternaria* leaf spot of datepalm. They recorded 60.22% disease control over the untreated or water sprayed check. But *Trichoderma viride* was least effective in controlling the disease where disease incidence was 49.00% as compared to control (58.66%). Thus, various biofertilizers and biopesticides have been tested and recorded the mixed results at various time by different plant pathologists.

### 2.9 Effect of medicinal plant extracts on wilt pathogen (both *in vitro* and *in vivo*)

Literatures related to the effect of plant extracts are flooded. Singh et al., (1999) studied the effect of *Cyperus rotundus* rhizome extract on spore germination, percent germination and germination types of conidia of *F. udum* using different solvent. They recorded increased percent germination with increased in dilution of the extract and was maximum at extract dilution of 1:10 (extract : water). Mandhare and Suryawanshi (2008) studied effect of different plant extracts against the mycelial growth of *F. udum* using poisoned food technique. They found that the extract of *Ocimum sanctum, Eucalyptus* spp. and *Nerium indicum* completely inhibited the growth of *F. udum* in agar plates. Similarly, the growth of *F. udum* was completely inhibited in liquid medium containing extract of *O. sanctum* and *Eucalyptus* app. The
growth of *F. udum* was inhibited by 80, 75 and 71% with the extract of *A. indica*, *Flax lini* and *Hibiscus rosasinensis*. They also found the inhibition of *F. udum* by extract of *Vitex nigundo*, *Sorghum bicolor*, *Piper nigrum*, *Vinca rosea* and *Zea mays* by 60, 60, 63 and 62% respectively. They further reported that the dry mycelial weight of *F. udum* was 30.4, 66.9, 61.7, 88.6, 80.5, 76.2 and 86.6 mg with the extract of *A. indica*, *H. rosasinensis*, *F. lini*, *S. bicolor*, *Z. mays*, *V. rosea* and *P. nigrum* respectively. Singh *et al.*, (2010) reported that aqueous extract of *A. indica* was most effective in inhibiting mycelial growth (67.8%) of *F. udum* followed by *Datura festilosa* (61.2%), *Tagetes erecta* (52.6%), *Eucalyptus citridora* (52.2%), *Aegle marmelos* (47.9%) and *Mimusops elengi* (45.9%). Khandare and Salve (2011) found that the leaf extracts of *Vitex nigundo*, *Polyalthia longifolia*, *Vinca rosea*, *Adhatoda zylanica* and *Hyptis suaveolens* inhibited the radial growth of *F. udum* at 25% concentration of the extract. They also observed zero conidia per microscopic field per ml of suspension at 10% concentration of *V. negundo* leaf extract and leaf extract of *V. negundo*, *P. longifolia*, *V. rosea*, *A. zylanica* gave 100% control efficacy against pathogenic fungi in *in vivo* conditions.

Thus, these are not the exhaustive lists of literature related to pigeonpea vis-a-vis *F. udum*, but few of the existing relevant to my work plan which have been scanned to support our findings in the present investigation.