Chapter one

Introduction

Potato (*Solanum tuberosum*) is a starchy, tuber ouscrop from the perennial nights hade *Solanum tuberosum*L(*Singh et.al., 2004*). The word "potato" may refer either to the plant itself or the edible tuber. In the Andes, where the species is indigenous, there are some other closely related cultivated potato species. Potatoes were introduced outside the Andes region approximately four centuries ago, and have since become an integral part of much of the world's food supply. It is the world's fourth-largest food crop, following maize, wheat, and rice.(FAO,2007). Wild potato species occur throughout the Americas from the United States to southern Chile. The potato was originally believed to have been domesticated independently in multiple locations, but later genetic testing of the wide variety of cultivars and wild species proved a single origin for potatoes in the area of present-day southern Peru and extreme northwestern Bolivia (from a species in the *Solanum brevicaule*complex), where they were domesticated approximately 7,000–10,000 years ago. Following centuries of selective breeding, there are now over a thousand different types of potatoes(*Spooner,etal 2005*). Over 99% of the presently cultivated potatoes worldwide descended from varieties that originated in the lowlands of south-central Chile, which have displaced formerly popular varieties from the Andean highlands.The annual diet of an average person in the first decade of the 21st century included about 33 kg (73 lb) of potato(.*FAOSTAT,2015*). However, the local importance of potato is extremely variable and rapidly changing. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world,.(*Mohankumar,., et, al 2000,*)but the most rapid expansion over the past few decades has

occurred in southern and eastern Asia. China now leads the world in potato production, and nearly a third of the world's potatoes are harvested in China and India.(AOAD,2006).

In terms of global production, potato (*Solanum tuberosum* L.) is the fourth most important food crop after corn, rice and wheat. This crop is grown throughout the world. Present world production is some 321 million tons fresh tubers from 19.5 million ha.(*FAO,2007*).

In Sudan the area around Khartoum .the capital of the Sudan benefits from rich water resources (including the Nile and tributaries) and the fertile cultivable land along the River bank is avaluble natural resource. The land suitable for cultivation accunts for about 750.000ha.Of which 11 percent is allocted to urban and periurban agriculture .In Jebal Marra in the western part of the country is reported to be the second most important potato prduction area of Sudan .The Gash Delta in Kassala province is often mentinoned as a zone of high potential for potato production though figures on actual production in the area are lacking (Elsir M .Elamin 2005) .

The potato plays a strong role in developing countries with its ability to provide nutritious food for the poor and hungry. The demand for potato is growing as both a fresh and processed food. The decreasing availability of land for area expansion means that yields will have to be improved. Critical to achieving improved tuber yields will be access to an adequate water supply, including more efficient use of scarce water and costly fertilizer inputs. Potato is grown in about 100 countries under temperate, subtropical and tropical conditions.(AOAD,2006) The potato is basically a crop of temperate climates. Yields are affected significantly by temperature and optimum mean daily temperatures are 18 to 20°C. In

general a night temperature of below 15°C is required for tuber initiation. Optimum soil temperature for normal tuber growth is 15 to 18°C. Tuber growth is sharply inhibited when below 10°C and above 30°C. Improved varieties include Russet Burbank, Desiree, Yukon Gold and Nicola, among others. Potato requires a well-drained, well-aerated, porous soil with pH of 5 to 6. Compacted soils affect root penetration, water and nutrient uptake and tuber enlargement. *Fusarium solani*f.sp.eumartii can persist in the soil for several years. The spores and the mycelium are carried into the soil on tools and in bean straw manure. They may also be splashed by rain or carried by floods. The chlamydospores are the survival structure in the absence of a host plant. (Cho, *et al*, 2001).

The objective of the study :-

- Isolation and Identification of *Fusarium solani* f .sp .eumartii the causal agent of dry rot in potato.
- To explore the antifungal activityof Argel powder against *F.solani* f.sp eumartii in potato crop.
- To evaluatethe effects of fungicide (Apronstar 42) on fungal growth
- To explore the biological control by uses the Mycorrihzae fungal against *F solani* f. sp. eumartii.

Chapter two

Literature review

2.1 The crop

Potato (*Solanum tuberosum* L.) is one of the four major food crops of the world, the other three major food crops being rice, wheat and maize. It is an important crop and it can supplement the food needs of the country in a substantial way as it produces more dry-matter food, has well balanced protein and produces more calories from unit area of land and time than other major food crops (FAOSTAT,2015). The problem of malnutrition and under nutrition can be largely solved if potato is accepted as a major food and not merely as a vegetable in our country. It is a nutritious food containing practically all the essential dietary constituents. Like cereals, carbohydrates are the major constituents of potato. Besides, it contains essential nutrients such as proteins and minerals like calcium, phosphorus and iron, and vitamins (B1, B2, B6 and C). There is great potential of exporting potatoes from India both for seed and table purposes to our neighboring countries of South-East Asia and to Middle East countries (*Chadha,K.L. 2001*) Potatoes can even be exported to some of the European countries during March-May when fresh potatoes are not available in these countries.

2.1.1 Classification

Kingdom: plantae

Phylum : Asterids

Order : Solanales

Family : Solanaceae

Genus : Solanum

Species : Tuberosum

Scintific Name: *Solanum tuberosum* *(Spooner,et al,.2005)*

2.1.2**Area and production:**

Among the major potato growing countries of the world, China ranks first in area, followed by the Russian Federation, Ukraine and Poland. India ranks fourth in area in the world.(FAOSTAT, 2015) The present area under potato in India is about 1.4 million hectares. India produces a total of about 25-28 million tonnes of potatoes every year and ranks fifth in production also after China, Russian Federation, Poland and Ukraine. From each hectare of land, it produces about 16-19 tonnes of potatoes. In European and American countries the potato productivity is about 30-40 tonnes per hectare. The states of Uttar Pradesh, \Vest Bengal and Bihar account for nearly 3/4 of the area and 4/5 of the potato production in the country. The highest area and the production is in Uttar Pradesh followed by West Bengal and Bihar. The highest productivity of the crop is in West Bengal followed by Gujarat. Potato is one of the principal cash crops and it also contributes to Indian economy in several ways).

2.1.3Climate and soil requirements

Potato is basically a crop of temperate region but there is a large variation in the gene pool with respect to crop's response to thermo periods. Generally potato crop is raised in India when maximum temperatures are below 35°C and minimum temperatures below 20 ^{0}C (*FAO 2007 and 2008*) (with ideal tuberization temperatures between 16-22^{o}C).

2.1.4Soil

Potatoes can be grown in alluvial, hill, black, red and laterite soils having pH in the range of 5.5-8.0. Deep Alluvial soils of Indo-Gangetic plains with almost neutral soil reaction are the most suitable. Maximum area under potato is in alluvial soils, followed by hill, black and red soils. Saline, alkaline and soda soils are however, not congenial for potato production. Soil should be fine, loose and without compacted layers that hinders root penetration and deshapes tubers.. (Mohankumar, Nair 2000) Compacted layers also restrict drainage of water. Clods and stones present reduce root contact with soil and also cause deformation of tubers. Well-drained coarse or sandy loam to loamy soils, rich in organic matter are ideal for potato cultivation. Such soils ensure availability of sufficient oxygen for the growth of roots, stolons and tubers, retain moisture and are helpful in drainage of excess water that allows production of beautiful tubers.

2.1.5 Varieties and Hybrids

The early introductions and subsequent systematic attempts to introduce potato varieties mainly from European countries were not very successful.**(***Chadha, et, al, 1994*) These varieties were primarily bred for long-day and long-duration conditions of Europe where moderate temperatures prevail both at the time of planting and harvesting. Therefore, they did not do well under short-day, short growing conditions of sub tropical plains of our country where high temperatures prevail both at the time of planting and harvesting. Therefore, the major goal of potato breeding is to breed high yielding varieties suitable for the above conditions. Among the other goals/problems, late blight (*phytophthora infestans*)is the most devastating disease occurring regularly in epiphytotic form every year in the hills and very frequently in plains. The

widely present large numbers of viruses infecting potatoes through contact or aphid vectors is responsible for bringing down yields of potato stocks and are most important constraints in potato productivity. Bacterial wilt in mid-hills and pockets of Assam, Meghalaya, Maharashtra and Orissa, wart in hilly regions of West Bengal, cyst forming nematodes in southern hills and potato tuber moth in warmer plateau areas of Maharashtra, Karnataka and Madhya Pradesh are the other major diseases and pests of potato in the country. In recent years potato processing industries have come up in a big way needing varieties containing low sugars and high dry-matter for preparation of specific value-added products like chips, French fries, cubes and other dehydrated products.(*Singh, 2004*).

In the year 1949, the Central Potato Research Institute was established. This Institute began work on breeding of new potato varieties suitable for Indian conditions. The varieties bred by it always have the prefix name 'Kufri' denoting the name of the place in the Himachal Pradesh where actual hybridization work is done. The Institute starting from 1958 till date has released 41 improved potato varieties for different agro climatic regions of the country. Many of these varieties possess resistance to diseases like late blight (*phytophora infesting*) and wart and pests like cyst nematode. The earlier potato varieties were either the clonal selections from the then prevailing popular varieties that survived following introduction from foreign countries, e.g. Kufri Red from Darjeeling Red Round and Kufri Safed from Phulwa or had mainly foreign varieties in their parentage. Progressively there was a gradual shift in the choice of parents in favor of Indian cultivars and parental lines and currently the new varieties often involve an indigenous variety in their parentage. Many of the initially released varieties are no longer in cultivation simply because better varieties have been developed.

2.1.6 Cultivation Practices

Potato is planted directly in the field; however, true potato seeds (TPS) are raised in nursery. The seedlings of TPS raised in nursery beds may either be transplanted in the field or left in the nursery for producing seedling tubers. The planting density depends upon the location, method of planting, purpose for which the crop is raised, etc. Normally when mechanical cultivation is practiced a spacing of 60 cm between rows and 20 cm between plants is adopted which results in a planting density of 83,333 plants per ha.(*Orzelek 2010*)When manual planting and intercultural is adopted then the row-to-row spacing is reduced to as low as 45 cm. In the hills where animal drawn implements are used, row-to-row distance of 50 cm and plant-to-plant distance of 20 cm is adopted.

After pre-planting tillage operations, different methods are used for potato planting in various parts of the country. Ridge and furrow method is the most popular method carried out manually or mechanically. In manual method, the furrows are made with the help of curved/narrow-blade spade followed by fertilizer mixture application, covering it with soil and finally making of ridges. The seed tubers are dibbled on each ridge whereas in mechanical method, furrows are made with the help of tractor drawn 2-4 row marker cum fertilizer drills so as to apply fertilizer in one sequence. This is followed by planting of tubers with the help of 2-4 row planters cum ridge. In absence of fertilizer drill and automatic planter, ridges are made with tractor drawn ridge after application of fertilizers and tubers are dibbled manually 5-7cm deep on the ridges. In another method, the field is marked with the help of rope or marker and fertilizer is placed on the marked lines. Tubers are placed to the side of these lines and then ridges are made either with bullock-drawn implements or with narrow-blade spade manually. In the hills, after placement of fertilizer in shallow furrows drawn with hand tools (Khilna

or Kudal) tubers are placed and covered with soil to make ridges. In all these methods care is taken that seed tubers do not come in direct contact of fertilizers.(*Nancy 2011*).

2.1.7 Management of water, nutrients and weeds :

Potato responds well to manures and fertilizers as compared to cereals and legumes. The fertilizer requirement varies with the soil and previous crop. Recommended doses (kg/ha) of N, P_2O_5, K_2O are 180:80:110 for alluvial soils and 115:45: 50 respectively for black soils..(Mohankumar, Nair, *et al*, 2000) Nitrogen is the primary limiting nutrient in potato production directly affecting the tuber yield in all soil groups. It increases roots, foliage and tuber growth. Nitrogen is applied to the crop in two split doses, i.e. half at the time of planting and remaining half at the time of earthling up for effective utilization by the crop. Both calcium ammonium nitrate (CAN) and ammonium sulphate are good sources of nitrogen for potato crop. Urea though less efficient is the cheaper source and can also be applied either alone or in combination with CAN in 1: 1 ratio of N basis.

Phosphorus and potassium are the other two essential elements in potato production. Phosphorus increases tuber yield by increasing the yield and number of medium size tubers whereas potassium increases the number of large size tubers. The application of P and K in furrows in full dose at the time of planting gives the best results. Water-soluble phosphate fertilizers like superphosphate and DAP are most suitable for potato. Similarly potassium sulphate is a better source of K than muriatic of potash. The residual phosphorus and potash are generally adequate and nitrogen requirement is reduced by half in succeeding cereal crop. Farmyard manure has been found to be useful in potato production and its

application 30 tonnes/ha has been found to meet entire P and K needs of potato and succeeding cereal crop besides meeting micro-nutrient needs.

2.1.8Mulching :

Use of mulch helps in conserving soil-moisture, reducing soil-temperature and inducing quick germination in winter. It also suppresses weed growth. Plant material such as paddy straw, maize or jowar stalks or farm refuses acts as good mulch and is applied on ridges. In hilly regions, local available materials such as pine needles or leaf litter are quite effective in controlling run off loss and conserving moisture.(*Picard, Andre 2002).*

2.1.9Irrigation

Water is one of the essential components required for growth and development of crop. The total water requirement of crop varies between 350-550mm depending upon soil type, climate and crop duration. Pre-planting irrigation is advantageous for uniform germination. Second irrigation is given after about a week and subsequent irrigations as and when required. Light and frequent irrigations are better than heavy and less frequent irrigations. When irrigation water is in short supply, water is applied efficiently and economically at critical stages in crop development, i.e. at stolen formation, tuber initiation and tuber development stages of crop. Irrigation is stopped about 10 days before harvesting of crop to allow firming of tuber skin.(Orzolek 2010).

2.1.10 Weeds Management :

Weeds compete for nutrients, moisture, light and space and cause considerable loss in potato yields. They also harbor a few pathogens and act as host to a number of insects and pests. Important weeds of potato

fields in plains are *Anagallis arvensis, Chenopodium album, Trianthema monogyna, Vicia sativa, Cyperus rotundus, Spergula arvensis, Melilotus spp., and Oxalis spp. In the hills Amaranthus spp, Chenopodium album, Cynodon dactylon, Oxalis latifolia, Polygonum spp., Spergula arvensis, Digitaria sp* and *Setaria glauca* are the most common weeds in potato fields. Weeds are effectively managed by cultural or chemical methods or combination of both the methods. (*FAO 2008*) They are effectively controlled by hoeing and weeding when the crop is about a month old followed by earthling up. Among the herbicides pre-planting application of Fluchloralin and Pendimethalin and pre- emergence application of Alachlor, Linuron, Metribuzin, Nitrofen, Oxyfluorfen, Ametryn, Simazine, etc., are the most effective herbicides for weed control. Among post-emergence herbicides, Parquet at about 5% emergence is quite effective.

2.1.15 Harvesting and yield :

Harvesting of potatoes is done before the maximum soil temperatures rise above 26-30° C. It is completed by end of January in central and eastern plains and by 15 February in the western plains to avoid rotate of tubers due to high temperatures in March/ April. The crop is harvested 10-15 days following stoppage of last irrigation. This allows tuber skin to become firm and tubers do not get bruised on harvesting. Harvesting is done manually with the help of spade or khurpi or by bullock drawn single row digger/plough. It is also done mechanically with the help of 1-4 row potato diggers (Nancy 2011).

2.1.16 Post harvest Handling :

Nearly one fifth of the total potato production in the country is used as planting material in the following season. Therefore, post-harvest

handling particularly of seed stocks becomes very important. After harvesting, potatoes are kept in heaps in cool places for another l0-15 days for drying and further curing of skin. Heaps 3-4 meter long, wide at the bases and about 1 meter wide at the top are the best..(*Chadha, ,. 1994*) In hills the harvested potatoes are spread in well-ventilated rooms for drying. Before grading, all the cut, damaged and rotted tubers are removed. The tubers are then graded and packed in gunny bags according to sizes preferably in 4 sizes, e.g. small (less than 25g), medium (25-50g), large (50-75g) and extra large (above 75g). After grading potatoes meant for use as seed during the next year are treated with 3% boric acid solution for 30 minutes for protecting against soil-borne pathogens, e.g. black scurf, common scab, etc. before storing in bags. In the plains the seed potatoes after drying, curing and grading are stored in cold stores where temperature is maintained between 2°-4°C with high relative humidity. The low temperature checks sprouting and rotate, and high relative humidity reduces weight loss in tubers.

2.1.17 Pests and Diseases :

The potato plant and its underground tubers are afflicted by several diseases and pests. The important ones are late blight of potato, which affects the stems, leaves, and the tubers and causes heavy losses in tuber yield.(*Orzolek,et al,. 2010*) The disease appears in the crop in the hills every year and frequently in the plains also. Other leaf spot diseases affecting leaves and stems are early blight, phoma and leaf blotch. Among the diseases affecting tubers, the black scurf, common scab and wart are important. The black scurf (*Rhizoctonia solani*)and common scab diseases are present in all potato growing areas of the country in different intensities.These diseases do not affect the yield much; however, they disfigure the tubers and reduce their market value. The wart disease

affects both the plants and the tubers. It causes heavy losses in tuber yield. The disease has been confined to the Darjeeling hills of West Bengal by legalization (internal quarantine measures). The brown rot of tuber is another important disease of potato. This disease causes wilting of plants in the field and hence is also known as bacterial wilt disease. This disease is present mainly in the mid-hills in the country and in pockets of Assam, Meghalaya, Maharashtra, Karnataka and Orissa. Aphids and leaf-hoppers are the important vectors as they are responsible for transmitting and spreading a number of viral and mycoplasmal diseases. Among pests, the cutworms, white grubs, potato tuber moth and cyst nematodes(*Globodera spp*) are important. The cutworm damages the plants in field by cutting the stem at ground level and the white grub damages the underground tubers in the field. The potato tuber moth is present in the plateau region and in some pockets in the hills of Himachal Pradesh. It damages the plants in the field and the tubers in both fields and stores. The cyst nematodes are confined to the southern hills only. They affect the roots, hinder the movement of nutrients to the plant and thereby reduce crop yields(*Agrios, 1997*).

Effective control measures have been developed against most of the diseases. The integrated disease management (IDM) components that are employed in crop protection are deployment of short-duration varieties which may escape the disease and do not allow build-up of pathogen, e.g. for late blight, soil and tuber borne diseases and bacterial wilt

- use of agronomic practices like healthy seed, hot and cold weather cultivation, green maturing, irrigation, fertilizer application, storage and adoption of seed plot technique e.g. for viruses, aphids, late blight, potato tuber moth, etc.,

- use of bio-control measures like host resistance, bio- agents, plant products and sex pheromones for diseases like late blight, early blight and other foliar diseases, wart and pests like cyst nematodes and iv), use of chemicals e.g. fungicides, insecticides and other chemicals alone or in combination with other components for control of diseases like early and late blights and other foliar spots, soil and tuber borne diseases like black scurf and common scab, pests like potato tuber moth and cyst nematode. Many varieties released by CPRI have multiple resistant to *Fusarium solani*

2.1.18 *Fusarium solani* caused dry rot disease

Fusarium is a large genus offilamentous fungi widely distributed in soil and in association with plants. Most species are harmless saprobes and are relatively abundant members of the soil microbial community. Some species produce mycotoxins in cereal crops that can affect human and animal health if they enter the food chain. The main toxins produced by these *Fusarium* species are fumonisins and trichothecenes. (Howard, 2003)

2.4.1 Classification

Kingdom : Fungi

Subkingdom : dikarya

Phylum : Ascomycota

Subphylum : Pezizomycotin

Class : Sordaiomycetes

Order : Hypocrites

Family : Nectraceae

Genus : Fusarium

Species : solani

(Desjardins, 2006)

2.4.2 Biology

In solid media culture, such as potato dextrose agar (PDA), the different special forms of *F. solani* can have varying appearances. In general, the aerial mycelium first appears white, and then may change to a variety of colors - ranging from violet to dark purple according to the strain (or special form) of *F. solani*. If sporodochia are abundant, the culture may appear cream or orange in color (Smith, *et.al.*, 1988).

2.4.3 Symptoms

Generally produces symptoms such as wilting, chooses, necrosis, premature leaf drop, browning of the vascular system, stunting, and damping-off. The most important of these is vascular wilt (Ramsamy, *et.al.*, 1996)

Fusarium wilt starts out looking like vein clearing on the younger leaves and drooping of the older lower leaves, followed by stunting of the plant, yellowing of the lower leaves, defoliation, marginal necrosis and death of the plant. On older plants, symptoms are more distinct between the blossoming and fruit maturation stages (Agrios, 1988, Smith, *et.al.*, 1988).

2.4.4 Disease Cycle

Fusarium solani produces asexual spores (micro conidia and macro conidia). Its sexual state is *Nectria haematococca* (Ascomycete). It produces chlamydospores and overwinters as mycelium or spores in infected or dead tissues or seed. It can be spread by air, equipment, and water (Vincent, *et. al.,* 1971).

The fungus can persist in the soil for several years. The spores and the mycelium are carried into the soil on tools and in bean straw manure. They may also be splashed by rain or carried by floods. The chlamydospores are the survival structure in the absence of a host plant. (Cho,*et.al.*2001).

2.4.5 Hosts Rang

The fungal*Fusarium solani* affects a wide variety of hosts of any age. Tomato, tobacco, legumes, cucurbits, sweet potatoes and banana are a few of the most susceptible plants (Koenning, 2001).

2.4.6 Diseases

Fusarium wilts effect and cause severe losses on most vegetable and flowers, several filed crops such as cotton vegetable and flowers, and tobacco, plantation crops such as banana, plantain, coffee and sugar cane, and a few shade threes, Fusarium wilts are most severe under warm soil conditions and in green houses, most Fusarium wilts have disease cycles and develop symptoms (Agrios, 1997).

2.4.7 Environment

As previously stated *F. solani* is a common soil saprophyte that infects a wide host range of plant species around the world. It has the ability to survive in most soil- arctic, tropical, desert, cultivated and non-cultivated

though *Fusarium* spp. may be found in many places and environments, development of the disease is favored by high temperatures and warm moist soils. The optimum temperature for growth on artificial media is between 25-30°C, and the optimum soil temperature for root infection is 30°C or above(Koenning. 2001).

2.4.8 Importance

*Fusarium solani*is so widespread; it is a significant problem in many crops. It is economically damaging to the banana industry, and the threat of more virulent strains or mutations to damage previously resistant crops is of major concern. *F. solani* also causes damage to many crops from the Solanaceaefamily, including potato, tomato, and pepper. Other commercially important plants affected include basil, beans, carnation, chrysanthemum, peas, and watermelon. Woody ornamentals are infected, but are usually not killed by Fusarium wilt alone. Palms, (Dreistadt, *et. al.*, 2004)

2.4.9 Management

F. solani is a major wilt pathogen of many economically important crop plants. It is a soil-borne pathogen, which can live in the soil for long periods of time, so rotational cropping is not a useful control method. It can also spread through infected dead plant material, so cleaning up at the end of the season is important (Jones *et.al.*, 1982).

One of the control methods is to improve soil conditions because *Fusarium*spp spreads faster through soils that have high moisture and bad drainage. Other control methods include planting resistant varieties, removing infected plant tissue to prevent over win (Smith, *et. al.*, 1988).

Tering of the disease, using soil and systemic fungicides to eradicate the disease from the soil, flood fallowing, and using clean seeds each year. Applying fungicides depends on the field environment (Booth, 1971).

It is difficult to find a biological control method because research in a green house can have different effects than testing in the field, (Thomas. Zitter, 1998). The best control method found for *Fusarium* spp. is planting resistant varieties, although not all have been bred for every forma specialist.

2.2 Mycorrihzae

Roots of most terrestrial plants form symbiotic associations with fungi. These ubiquitous symbioses, called mycorrihzae, function as conduits for the flow of energy and matter between plants and soils.

The term "mycorrihzosphere" was coined to describe the unique properties of the rhizosphere surrounding and influenced by mycorrihzae (Linderman 1988). Mycorrhizal fungi frequently stimulate plants to reduce root biomass while simultaneously expanding nutrient uptake capacity by extending far beyond root surfaces and proliferating in soil pores that are too small for root hairs to enter. Mycelial networks of mycorrhizal fungi often connect plant root systems over broad areas. These fungi frequently comprise the largest portion of soil microbial biomass (Olsson *et al*., 1999; Högberg and Högberg , 2002). Thus, mycorrhizal symbioses physically and chemically structure the rhizosphere, and they impact communities and ecosystems. Excellent reviews of mycorrhizal biology (Smith and Read 1997; Varma and Hock 1998) physiology (Kapulnik and Douds 2000), evolution and ecology (van der Heijden and Sanders 2002; Read and Perez-Moreno 2003; Allen 1992) are available.

2.2.1 Convergent Evolution of Mycorrihzae

Throughout their evolution, plant roots have repeatedly formed symbioses with fungi. With remarkably few exceptions, plant roots have evolved to accommodate, utilize and control mycorrihzae fungi. Both molecular and fossil evidence indicate that the earliest land plants were mycorrihzae (Redecker *et al*. 2000). These bryophytic plants did not possess true roots but rather stem-like rhizomes that were colonized with fungi that appear similar to modern day arbuscular mycorrhizal (AM) fungi. (Pirozynski and Malloch, 1975) suggest that plants could not have colonized land without fungal partners capable of acquiring nutrients from the undeveloped soils that existed during the Silurian and Devonian. Once terrestrial plants became established and soil organic matter accrued, more mycorrhizal partnerships evolved as plant and fungal taxa radiated into the newly forming terrestrial niches rich in organic matter. These disparate symbioses have been grouped into six general types of mycorrhizas arbuscular (also called vesicular-arbuscular), ecto, ericoid, arbutoid, monotropoid and orchid (Smith and Read ,1997).

Mycorrhizas are highly variable in structure, yet they have evolved two common features: an elaborate interface between plant root and fungal cells, and extraradical hyphae that extend into the soil. This chapter will focus primarily on arbuscular, ecto-, and to a limited extent, ericoid mycorrhizas. However, a brief examination of the similarities and differences of all six types of mycorrhizas reveal points of evolutionary convergence and divergence of mycorrhizal symbioses.

2.2.2. Arbuscular mycorrihzae

Arbuscular mycorrihzae are widespread and abundant. They are formed by bryophytes, pteridophytes, gymnosperms and angiosperms, and are ubiquitous in most temperate and tropical ecosystems including

agricultural systems. The fungal partners in AM associations are remarkably abundant, accounting for 5 to 50% of the microbial biomass in agricultural soils (Olsson *et al.*, 1999). These fungi are members of the Glomeromycota, a monophyletic phylum containing 150 to 160 described species .

Arbuscular mycorrihzae are sometimes called "endomycorrhizae" because the fungal partner forms intraradical structures (i.e. inside plant roots). In AM associations, the interface between plant and fungal tissues that facilitates exchange of materials between plant and fungal symbionts takes the form of arbuscular or coils. Arbuscular and coils are modified fungal hyphae that provide a large surface area for resource exchange. Several genera of AM fungi also form intraradical vesicles that function as fungal storage organs. The extra radical hyphae of AM fungi lack regular cross walls allowing materials, including nuclei, to flow relatively freely within the mycelium. These hyphae can be very abundant; one gram of grassland soil may contain as much as 100 m of AM hyphae (Miller *et al*. 1995). The taxonomy of AM fungi is based upon the morphology of large (10-600 μm diameter) asexual spores produced in the soil or within roots.

2.2.3 Ectomycorrhizas

Ectomycorrhizas occur in certain families of woody gymnosperms (e.g. Pinaceae) and angiosperms (e.g. Dipterocarpaceae, Betulaceae) and are extremely important in many temperate and boreal forests. The fungal partners in ectomycorrhizal (EM) associations account for an estimated 30% of the microbial biomass in forest soils (Högberg and Högberg , 2002). These fungi are a diverse assemblage of at least 6,000 species of basidiomycetes, ascomycetes, and zygomycetes (Smith and Read, 1997). This estimate of EM fungal diversity is extremely conservative, and is likely to increase as more systems are examined (Cairney

1999).Ectomycorrhizal basidiomycetes are obviously polyphyletic, many EM fungi belong to large basidiomycete families like Amanitaceae, Boletaceae and Russulaceae (Brundrett 2002). Ascomycetes that form EM associations have four or more separate origins (LoBuglio *et al*.,1996), and a few species of zygomycetes in the genus Endogone form EM associations (Smith and Read ,1997). The oldest fossils providing clear evidence of EM associations date back 50 million years (LePage *et al*. ,1997), yet the association is hypothesized to have evolved 130 million years ago (Smith and Read ,1997). Molecular evidence indicates that the EM habit has evolved repeatedly from saprotrophic ancestors and that there have been multiple reversals back to a saprotrophic way of life (Hibbett *et al*,. 2000).

Structurally, ectomycorrhizas are characterized by the presence of a fungal mantle that envelops host roots and a Hartig net that surrounds root epidermal and/or cortical cells and provides a large surface area for resource exchange. Hormonal interactions between plant and fungus lead to dramatically altered root architecture including the suppression of root hairs. The external component of EM associations consists of hyphae with cross walls that partition cellular components. These hyphae sometimes coalesce into macroscopic structures called rhizomorphs that attach the mycelium to sporocarps or can be morphologically similar to xylem and serve in water uptake (Duddridge *et al*., 1980). The external mycelium of EM fungi may be more extensive than that of AM fungi (Jones et al., 1998), with as much as 200 m of hyphae per gram of dry soil (Read and Boyd, 1986). Ectomycorrhizal fungi also are frequently classified using the morphology of colonized roots and their sporocarps, such as the familiar mushrooms and truffles.

2.2.4 Mycorrhizas in the Ericales

The plant order Ericales contains a natural group of closely related families with worldwide distribution. Plants in this order form three distinctive forms of mycorrhizas: ericoid, arbutoid, and monotropoid . Ericoid mycorrhizas involve partnerships between ascomycetes and members of the Ericaceae, Epacridaceae, and Empetraceae families. In the ericoid mycorrhizas, the epidermal cells of small diameter roots lack root hairs and instead are frequently filled with fungal hyphae. Arbutoid mycorrhizas form between basidiomycetes and members of the Pyrolaceae and some genera of Ericaceae, most notably Arbutus and Arctostaphylos. Structurally, arbutoid mycorrhizas are similar to ectomycorrhizas as they possess a thick fungal mantle and a Hartig net, yet they are characterized by the formation of dense hyphal complexes within root epidermal cells. Monotropoid mycorrhizas are partnerships between certain non-photosynthetic members of the Monotropaceae and basidiomycetes. In these associations, the fungus transfers carbohydrates from a photosynthetic plant to its achlorophyllous (myco-heterotrophic) host plant. In addition to a fungal mantle and Hartig net, these mycorrhizas are characterized by a "peg" of fungal hyphae that proliferates within the epidermis of the root (Smith and Read 1997).

2.2. 5 Orchid Mycorrhizas

Members of the Orchidaceae form a unique type of mycorrhizas with some basidiomycetes Orchids differ from other plants because they pass through a prolonged seedling (protocorm) stage during which they are unable to photosynthesize and are dependent upon a fungal partner to supply exogenous carbohydrate (Smith and Read, 1997). Adult plants of most species of orchids are green and photosynthetic, but an estimated 200 species remain achlorophyllous throughout their life. These orchids are considered to be "myco-heterotrophic" because they acquire fixed

carbon heterotrophically through their mycorrhizal fungal partner (Leake ,1994). Orchid mycorrhizas are morphologically distinct as well, consisting of intracellular hyphae that form a complex interface between plant and fungal symbionts termed a peloton. (Smith and Read ,1997) and (Leake ,1994) question whether or not these associations should be even considered mycorrhizas because there is no demonstrated benefit of the association to the fungus.

2.3 Argel

2.3.1 Description

Argel is an erect perennial l that reaches up to 1.5-2 feet in heightwith numerous branches carrying opposite decussate leaves.

The leaves are lance lateto oblong –ovate with acute or sub-acute apex and cuncate base. The leaf petiole is thick .Fruit are solitary follicles,thick, ovoid,lance late,acuminate at the apex and they are very hard with dark purple color. Seed are turgid, ovoid and they are channel down at one face, they are minutely tuberculation bearing an apical tuft hair (Andrews,1952 and elkamali,1991).

2.3.2 Classifications

Class magnoliopida

Order gentianales

Family asclepiadaceas

Scientific name (S*olenostemma argel)* (Hayne,1825)

2.3.3 Distributions

Solenostemma argel is a desert plant,which is of wide spread in central and north's parts of the Sudan,Egypt,Libya,Chad,Algeria,Saudi Arabia and Palestine. However, Sudan is regarded as the richest source this planet (orange, 1982).

2.3.4 Localities

Slenostemma argel grows wild or cultivated in north Sudan,dongola,to barber andrubatab, whose capital town is Abuhammed, is famous for argel production and collection (Elkamali, 1991)

2.3.5 Chemical constituents of Argel

Elkamali (1991,) conducted photochemical screenining of Argel(*Solenostemma argel*) constituents of leaves ,stems and roots at the pre-flowering stage .results of phytochemicals screening showed the presence of a number of chemical groups flaronoides ,and saponins] the major constituents were spooning.

2.3.6 Insecticidal activity of *Solenostemma argel*

Hag-Eltayeb(2005),reported that aqueous extract was effective in control of the larvae of mosquitoes culex spp and Anopheles spp under laboratory condition.Argel water extract when tested under laboratory condition against Faba bean beetle Burchidius in carnatus at 2.5%,5% and 10% gane 60.1%,66.7 and 75.8%mortality of the adult insects respectively (Mohamed,2004).Sid Ahmed(2006) reported that,Argel aqueous extracts when tested under field conditions against the date palm white scale insect (*Parlatoria blacharadii*). At 1.2&3 ounes /6 L of water ~tree increased the mortality of *parlatoriablanchardii*siginificantly compared to the un treated control. In the Northern state of Sudan at

Shaygia area in Eshishi and Elbalel village to the south of Nouri town,farmers used Argel as traditional method to control insect pests on Okra especially the boll worms.The farmers put the vegetative parts of Argel plants in main irrigation canals.

The extract of Argel is leached with water to okra field where it'sabsorbed by roots and transolacated to all plant parts causing mortality of the feeding larvae (Sir Elkatim ,2005).

Chapter Three

MATERIALS AND METHODS

3.1-Introduction

The study were conducted in the laboratory and green house of the plantpathology Department of plant protection, College of Agricultural Studies, Sudan University of Science and Technology (SUST), Shambat, in November 2015.The aim of these study was to evaluate the effects of Mycorrhizae,Argel (*Solenostemma argel*) and Fungicide (Aprono star 42) against Fusarium *i n vivo*.

3.2 Collections of plant samples

Infected potato (tuber) showing symptom of the disease was obtained from Bahre vegetable market in November 2015 Random samples from infected potato field were collected to the laboratory for isolation and identification.

POTATO CROP

:form left to right

- F= *Fusarium. solani* f.sp. .eumartii
- H=Hargel
- H+F= Hargel + *Fusarium.*
- M= Mycorrihzae
- A+F= Abronstar + *Fusarium.*
- M+F= Mycorrihzae + *Fusariu*
- Control

3.3. Isolation methods

3.3.1 Isolation of *Fusarium solani* f.sp. eumartii;from plant materials;

Infected potato (tuber) showing symptom of the disease were obtained from Bahre vegetable market in November 2015 parts showing disease symptom were cut into small section (0.5-1.0), washed thoroughly with tap water, and surface sterilized by immersing 1:4 Clorox (NaOcl) for 5 miles, rinsed three time in changes of sterilized distilled water to remove the adhering Clorox and dried on sterilized filter papers ready for culturing .A culture medium Potato Dextrose Agar,(P D A) was used .The medium was supplemented with poured in 9cm Petri dishes . Five sections of the dried parts were as optically placed in Petri dish and incubated at 28c.Sub-culture were later prepared to get pure cultures. Slider were prepared from these pure cultures, and examined microscopically (x: 40).

3.4. VA Mycorrihzae Isolation:

Vesicular-Arbuscular Mycorrihzae VAM was isolated according to the wet sieving and decanting method.The soil was mechanically stirred and soaked in water over night. The suspension was stirred again and allowed to settle for few minutes and the suspension was then decanted through 250 ųm sieves to remove plant debris and large organic particles, and then thoroughly washed out 250ųm under a stream of water. The materials passed through a sieve were resuspended and decanted through 45ųm sieves(*Aerts 2002*).

Materials retained in the 45ųm sieve were washed in Petri-dishes. Spore sand their hyphae were examined under a binocular for rounded red – vacuolated spore and their hyphae. Spores were then poured in 1000

volumetric conical flask and stored at 4º C. This step was repeated several times until a 1000 mm volumetric flask was collected.

The VA mycorrihzae fungi strain (spores) collected ,were cultured and multiplied in pot cultures of sterilized Sudan grass seed (*sorghum bicolorvar. Sudanese*) using sodium hypochlorite 10% and grown in sandy claysoil (1:1 by weight) for 45 days. The soil was sterilized at 120°C for one hour using autoclaves to kill the indigenous mycorrihzae in the soil.

3.4. 1 VA Mycorrihzae Inoculations

The mycorrihzae soils i.e. whole of the soil in pot containing hostroot clippings were transferred to the field as VAM inoculums and applied uniformly before transplanting (Hartneet 1999). To emphasize the infection by VAM mycorrihzae, potato tubers were mixed with inoculums of soil and Sudan grass debris

3.5 Effects of botanicals

The aim of this experiment was to study the antifungal activities of plant against the growth of *F. solani*. The plants tested for the effects against the fungus, used Argel (*Solenostemma argel*).

3.5.1 Sample Preparation

3.5.2 Collection of plant samples

Leaves of Argel were obtained from the market .The plants were cleaned from dust and strange materials by hand. Leaves of Argel washed with tap water, air-dried under shade. The dried plants were crushed by a home crusher into coarse powder.

3.6 Green house experiments:

3.6.1 Evaluation of Biological control, fungicides and antifungal activities in pots

Effects of Mycorrihzae on growth of *F.solani*, Mass Culture was mixed with sterilized soil (ratio 1:3), ten days before addition of Fusarium culture. The inoculums of the test pathogen mass cultured on sand maize medium (1:1) was added to the soil placed in. earthen pots previously disinfected with 5% copper sulphate. Potted sterilized soil was no inoculated, or inoculated with the fungus(as control). All pots were sown to potato. Three seeds of the potato were sown when relevant, per pot.The seeds of the potato, dressed with fungicides Abronstar, each at 0,05g/kg seeds, were subsequently sown (3seeds/pot) in sterilized potted soil previously infected with the fungus. Fungus free-soils, similarly sown, were included as controls for comparison. Sterilized earthen pots (25 cm diameter) were filled with autoclaved potting mixture of soil: sand (1:1) and as per treatment details the potting mixture was amended with powders of leaves of Argel (at 50 g/ pot). The pots were subsequently, inoculated with the fungus (*F .solani*f. sp .e umartii 200 ml/3kg soil) with mass culture of test multiplied in sand: maize medium (1:1). Seeds of potato were sown (3seeds/pot). Treatments were arranged in Complete Randomized Block Design (CR BD) with four replicates. The pots were lightly irrigated and incubated at room temperature for one week Potting mixture inoculated with test fungus sown to untreated seeds was included as control.

3:7 Statistical Analysis Procedure

The data Obtained Was Statistically analyzed statistic according to Complete Randomizied Block Design (CRBD) analysis of variance (ANOVA), L.S.D test was used for means separation

.

Chapter Four

RESULTS

4.1 Laboratory and Green House Experiments

This study was conducted at the laboratory and Green House Experiments at Sudan University of Science and Technology during 2015/2016 .The study was evaluatedthe effects of Mycorrihzae Hargel (*Solenostemma argel*) and Fungicide (Aprono star 42) against the growth of plant and yield parameter in potato crop.

4.1.1 Isolation and Identification of the Pathogens:

The causal agent of potato dry rot disease was identified as isolate of *Fusarium spp*. Identification was performed depending on the cultural characteristics and conidial shapes as described by Booth(1971).

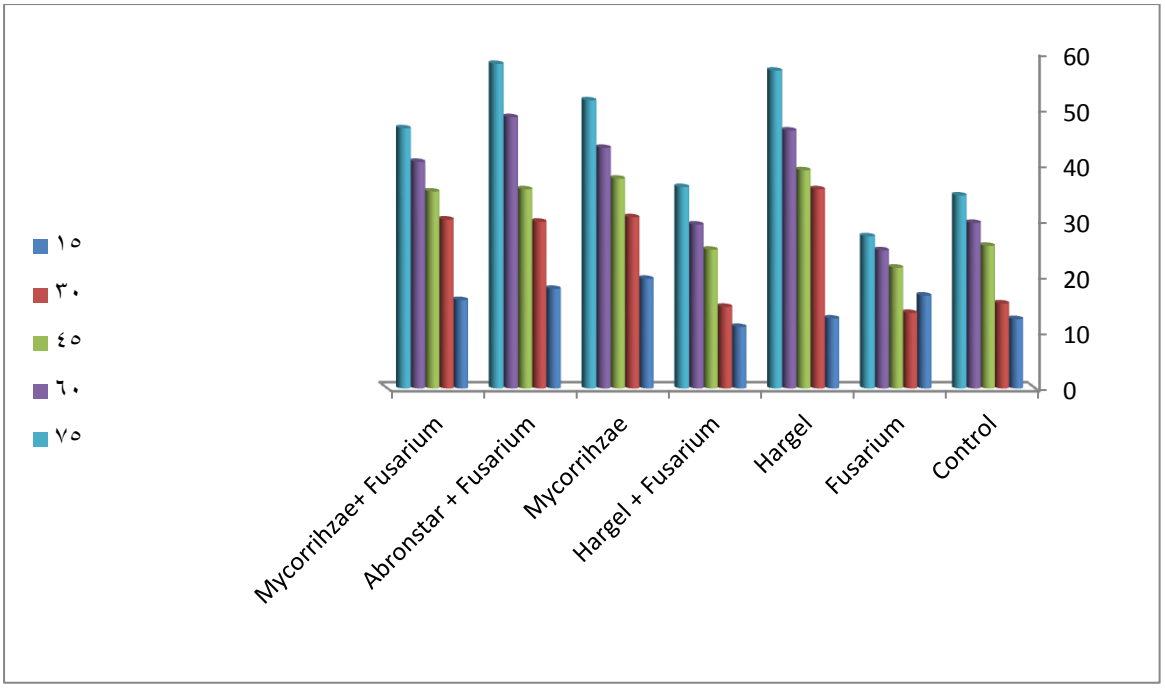
Condia Shape of fusarium

4.1.2 Effects of Mycorrihzae, Argel (*Solenostemma argel*) and Fungicide (Apron star 42) on Potato Heights

Significant differences were observed between treatments with and without Fusarium and between controls (treated and untreated). The mean height plant highest was (58), when soil was treated with fungicide (Apron star 42),with argel, (56.8) and Mycorrihzae (51.5) cm but the lowest plant height was attend when the soil was treated with Fusarium (27.2) and when the soil was untreated (34.5) (control) after 10 weeks of growing

Table 1 The Effects of Mycorrihzae, Argel (*Solenostemma argel*) and Fungicide (Apron star 42) on the plant height in potato crop.

TREATMENTS	PLANT HEIGHT (Cm)				
	15	**30**	**45**	**60**	**75**
Control	**12.4**	**15.2**	**25.5**	**29.6**	**34.5**
Fusarium	**16.6**	**13.5**	**21.6**	**24.7**	**27.2**
Hargel	**12.5**	**35.6**	**39**	**46.1**	**56.8**
Hargel + Fusarium	**11**	**14.6**	**24.8**	**29.3**	**36**
Mycorrihzae	**19.6**	**30.6**	**37.5**	**43**	**51.5**
Abronstar +Fusarium	**17.8**	**29.8**	**35.6**	**48.5**	**58**
Mycorrihzae+Fusarium	**15.8**	**30.2**	**35.2**	**40.5**	**46.5**
CV	**33**	**31**	**22**	**17.9**	**15.3**



4.1.3 Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apron star 42) on Potato shoot fresh weight

Table (2) shows the mean shoots fresh weight of potato Fusarium alone reduced potato shoots fresh weight by 3.0g.Significant differences were observed between treatments (with and without Fusarium) and between controls (treated and untreated). The mean shootsfresh weight was highest 14g, when soil was treated with Mycorrihzae, and 13g, when soil was treated with fungicide but the lowest 4g shoots fresh weight was attained when the soil was treated with Fusarium and Mycorrihzae.

4.1.4 Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apronstar 42) on Potato roots fresh weight

Table (2) shows the mean rootsfresh weight of potato Fusarium alone reduced potatoroots fresh weight by 5.5g.Significant differences were observed between treatments (with and without Fusarium) and between controls (treated and untreated). The mean root dry weight was highest 12g, when soil was treated with Mycorrihzae, and 10g, when soil was

treated with fungicide but the lowest 2g root dry weight was attained when the soil was treated with Fusarium and Mycorrihzae.

4.1.5 Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apronstar 42) on Potato shoot dry weight

Table (2) shows the mean shoots fresh weight of potato Fusarium alone reduced potatoshoots fresh weight by 0.5g.Significant differences were observed between treatments (with and without Fusarium) and between controls (treated and untreated). The mean shootsfresh weight was highest 3g, when soil was treated with Mycorrihzae, and 2.2g, when soil was treated with fungicide but the lowest .2g shootsfresh weight was attained when the soil was treated with Fusarium and Mycorrihzae.

POTATO CROP TREATMENT

FROM LEFT TO RIGHT

1/MYCORRIHZAE & FUSARIUM

2/FUSARIUM &FUNGICIDE

3/MYCORRIHZAE

4.1.6 Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apron star 42) on root dry weight of potato

Table (2) shows the mean rootsdry weight of potato Fusarium alone reduced potatorootsdry weight by 1.1g.Significant differences were observed between treatments (with and without Fusarium) and between controls (treated and untreated). The mean root dry weight was highest 3g, when soil was treated with Mycorrihzae, and 1.9g, when soil was treated with fungicide but the lowest 1g root dry weight was attained when the soil was treated with Fusarium and Mycorrihzae.

4.1.7 Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apronstar 42) on Potato yield (g)

Data in Table 2 showed that there were significant differences among the treatments. The highest yield was produced by the Mycorrihzae (23.0kg)compared to the control (12.0kg). However the lowest yield was observed by Fusarium (8.0kg).

Table 2: Effects of Mycorrihzae, Hargel (*Solenostemma argel*) and Fungicide (Apron star 42) on root dry weight of potato

TREATMENT	FRESH WEIGHT g		DRY WEIGHT g		Yield (kg)
	SHOOT	ROOT	SHOOT	ROOT	
Control	9	8	1.6	1.5	12
Fusarium	3	2	0.5	1.1	8
Hargel	10	5	1.9	1.2	20
Hargel + Fusarium	5	3	0.3	1.6	9
Mycorrihzae	14	12	3	3	23
Abronstar +Fusarium	13	10	2.2	1.9	21
Mycorrihzae+Fusarium	4	2	0.2	1	10

Randomized Complete Block ANOV Table for PH15D				

Source	DF	SS	MS	F	P
REP	3	7.5296	2.50988		
TREATMENT	6	47.4993	7.91655	3.51	0.0177
Error	18	40.5979	2.25544		
Total	27	95.6268			
Grand Mean 4.5607	CV 32.93				
Source	DF	SS	MS	F	P
Nonadditivity	1	4.9632	4.96316	2.37	0.1423
Remainder	17	35.6347	2.09616		
Relative Efficiency, RCB 1.00					
Means of PH15D for TREATMENT					
TREATMENT	Mean				
A+F	4.4500				
CONT	5.8500				
F	4.1500				
H	3.1250				
H+F	2.7500				
MYCO	4.9000				
MYCO+F	6.7000				
Observations per Mean	4				
Standard Error of a Mean	0.7509				
Std Error (Diff of 2 Means)	1.0619				

Randomized Complete Block AOV Table for PH30D

Source	DF	SS	MS	F	P
REP	3	1.607	0.5356		
TREATMENT	6	121.130	20.1883	4.08	0.0093
Error	18	88.996	4.9442		
Total	27	211.733			

Grand Mean 6.7250 CV 33.06				
Source	DF	SS	MS	F P
Nonadditivity	1	3.4760	3.47603	0.69 0.4174
Remainder	17	85.5197	5.03057	
Relative Efficiency, RCB 0.89				
Means of PH30D for TREATMENT				
TREATMENT	Mean			
A+F	7.6750			
CONT	8.3000			
F	3.3750			
H	8.9000			
H+F	3.6500			
MYCO	7.6250			
MYCO+F	7.5500			
Observations per Mean	4			
Standard Error of a Mean 1.1118				
Std Error (Diff of 2 Means) 1.5723				

Randomized Complete Block AOV Table for PH45D

Source	DF	SS	MS	F P
REP	3	1.730	0.5767	
TREATMENT	6	69.302	11.5504	3.07 0.0301
Error	18	67.795	3.7664	
Total	27	138.827		
Grand Mean 8.2214 CV 23.61				
Source	DF	SS	MS	F P
Nonadditivity	1	1.0399	1.03993	0.26 0.6134
Remainder	17	66.7551	3.92677	

Relative Efficiency, RCB 0.89				
Means of PH45D for TREATMENT				
TREATMENT	Mean			
A+F	8.9000			
CONT	9.1250			
F	5.4000			
H	9.7500			
H+F	6.2000			
MYCO	9.3750			
MYCO+F	8.8000			
Observations per Mean	4			
Standard Error of a Mean	0.9704			
Std Error (Diff of 2 Means)	1.3723			

Randomized Complete Block AOV Table for PH60D

Source	DF	SS	MS	F	P
REP	3	2.581	0.8604		
TREATMENT	6	70.495	11.7492	3.41	0.0200
Error	18	62.016	3.4454		
Total	27	135.093			

Grand Mean 9.7750	CV 18.99				
Source	DF	SS	MS	F	P
Nonadditivity	1	0.8279	0.82793	0.23	0.6376
Remainder	17	61.1885	3.59932		
Relative Efficiency, RCB 0.90					
Means of PH60D for TREATMENT					

TREATMENT Mean			
A+F 11.125			
CONT 10.150			
F 7.425			
H 11.525			
H+F 7.325			
MYCO 10.750			
MYCO+F 10.125			
Observations per Mean 4			
Standard Error of a Mean 0.9281			
Std Error (Diff of 2 Means) 1.3125			

Randomized Complete Block AOV Table for PH75D

Source DF SS MS F P				
REP 3 1.910 0.6365				
TREATMENT 6 93.009 15.5014 4.36 0.0069				
Error 18 63.983 3.5546				
Total 27 158.901				
Grand Mean 11.618 CV 16.23				
Source DF SS MS F P				
Nonadditivity 1 3.9803 3.98029 1.13 0.3031				
Remainder 17 60.0026 3.52956				
Relative Efficiency, RCB 0.90				
Means of PH75D for TREATMENT				
TREATMENT Mean				
A+F 13.250				
CONT 12.375				
F 8.750				
H 13.450				

H+F 9.000			
MYCO 12.875			
MYCO+F 11.625			
Observations per Mean 4			
Standard Error of a Mean 0.9427			
Std Error (Diff of 2 Means) 1.3332			

Statistic 8.0 4/15/2016, 2:07:39 AM

LSD All-Pairwise Comparisons Test of PH15D for TREATMENT

TREATMENT	Mean	Homogeneous Groups
MYCO+F	6.7000	A
CONT	5.8500	AB
MYCO	4.9000	ABC
A+F	4.4500	BC
F	4.1500	BC
H	3.1250	C
H+F	2.7500	C

Alpha 0.05 Standard Error for Comparison 1.0619

Critical T Value 2.101 Critical Value for Comparison 2.2311

Error term used: REP*TREATMENT, 18 DF

There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of PH30D for TREATMENT

TREATMENT	Mean	Homogeneous Groups
H	8.9000	A
CONT	8.3000	A
A+F	7.6750	A

MYCO 7.6250		A			
MYCO+F 7.5500 A		A			
H+F 3.6500		B			
F 3.3750		B			
Alpha 0.05 Standard Error for Comparison 1.5723					
Critical T Value 2.101 Critical Value for Comparison 3.3033					
Error term used: REP*TREATMENT, 18 DF					
There are 2 groups (A and B) in which the means					
are not significantly different from one another.					
LSD All-Pairwise Comparisons Test of PH45D for TREATMENT					
TREATMENT Mean Homogeneous Groups					
H 9.7500		A			
MYCO 9.3750		A			
CONT 9.1250 A		A			
A+F 8.9000 AB					
MYCO+F 8.8000 AB					
H+F 6.2000 BC		BC			
F 5.4000 C		C			
Alpha 0.05 Standard Error for Comparison 1.3723					
Critical T Value 2.101 Critical Value for Comparison 2.8831					
Error term used: REP*TREATMENT, 18 DF					
There are 3 groups (A, B, etc.) in which the means					
are not significantly different from one another.					
LSD All-Pairwise Comparisons Test of PH60D for TREATMENT					
TREATMENT Mean Homogeneous Groups					
H 11.525 A					
A+F 11.125 A					
MYCO 10.750 A					
CONT 10.150 AB					

MYCO+F 10.125 AB					
F 7.425 BC					
H+F 7.325 C					
Alpha 0.05 Standard Error for Comparison 1.3125					
Critical T Value 2.101 Critical Value for Comparison 2.7575					
Error term used: REP*TREATMENT, 18 DF					
There are 3 groups (A, B, etc.) in which the means					
are not significantly different from one another.					
LSD All-Pairwise Comparisons Test of PH75D for TREATMENT					
TREATMENT Mean Homogeneous Groups					
H 13.450 A					
A+F 13.250 A					
MYCO 12.875 A					
CONT 12.375 A					
MYCO+F 11.625 AB					
H+F 9.000 BC					
F 8.750 C					
Alpha 0.05 Standard Error for Comparison 1.3332					
Critical T Value 2.101 Critical Value for Comparison 2.8009					
Error term used: REP*TREATMENT, 18 DF					
There are 3 groups (A, B, etc.) in which the means					
are not significantly different from one another.					

Chapter Five

DISCUSION

Several species of genus Fusarium are ubiquitous fungal pathogens in a wide variety of crops.Potato dry rot is a result of infection by several species of Fusarium of which *F solani .eumartii*that infects tubers at wounded sites causing lesions on the surface that no extend deeply in the tuber tissue producing a visible rot. In fact, dry rot is an important post-harvest disease that affects tubers in storage and seed pieces after planting causing important crop losses.

Nowadays, dry rot is combated in the field with chemical fungicides. This therapeutic approach for killing organisms with synthetic chemicals has been the prevailing pest control strategy for over 50 years. However, due to the risk involved using synthetic pesticides, this initiated the integration of botanical and biological approaches as part of the disease management strategy for many crops. This is primarily due to its safe and effective use. Moreover, there is an increasing knowledge about effect of chemical pesticides on the environment, as many chemicals may no longer be available. Accordingly, the primary objective of this study was to develop an integrated management approach for potato dry rot. The investigation included the use of plant extracts, bioagents and fungicides. The three approaches were evaluated against *F. solani* in pot culture under greenhouse conditions

The results confirmed that the causal agent of potato dry rot disease was *Fusarium solani*. This was performed depending on the cultural characteristics and conidial shapes as described by Booth(1977).

The results also indicated that the use of Mycorrihzae enhanced the growth and development of the plant. This result was in line with(Smith

and Read1997) who reported that application of Mycorrihzae into soil through seed treatment could be an effective and useful approach against dry rot of potato.Moreover, the use of Mycorrihzaeresulted in better germination, increased root-shoot length, seedling vigor and wasmore efficient than others. Similar results were obtained by (*Ferrol et al., 2002).*

Similarly, the results showed that the use of Hargal powder significantly superior for in increasing germination and yield as well. These findings were in agreement with those of (*Fugro. 2000*) who reported that the addition of extracts from selected Medicinal and Aromatic ones to the soil in the form of organic sources besides, altering the soil structure, and other biochemical effects, also improves the chances of development of antagonistic microorganisms which through the phenomenon of competition, antibiosis or parasitism reduced population of inciting agents with the increase in microbial activities. added that the possible liberation of CO2 by soil saprophytes growing on dead organic matter and that in turn may suppress the activities of the pathogen.

The findings in this study illustrated that powder of Hargal can be used as natural fungicides to control pathogenic fungi and thus reduce dependence on the synthetic fungicides. In fact, in this study Hrgel was found to be the most efficient and it might be a promising material for controlling these fungi. These findings were also in line that these botanical is bio-degraded by different soil microbes to simpler nitrogenous compounds. Finally, this study is only a preliminary one. More studies are still needed in the future to test the antifungal activities of the studied plant extracts on other pathogenic fungi.

CONCLUSIONS

- Application of Mycorrihzae into soil could be an effective and useful approach. Use of Mycorrihzae showed better germination and resulted in increased root-shoot length and seedling vigor and was more efficient than others
- Hrgel was found to be the most efficient and it might be a promising material for controlling *F.Solani. f.sp.eumartii*. in Potato.

RECOMMENDATION :

- Use seed dressing by all fungicides resulted in reduced in disease incidence enhanced germination , height, dry weight (shoots and roots) and yield of potato.
- Use the chemical control method was found to be the best among all methods used against wilt disease of potato
- Use botanical Hrgel (*Solenostemma argel*) and biological control (Mycorrihzae Fungi) was found to be more effective against *F.Solani. f.sp.eumartii*
- The overall results suggest the development of an integrated management strategy where chemicals could be combined with botanicals and /or biological method .

REFERENCES

Aerts R (2002) The role of various types of mycorrhizal fungi in nutrient cycling and plant competition. In: van der Heijden MGA, Sanders I (eds) Mycorrhizal Ecology. Springer, Berlin, Heidelberg, New York, pp 117-134

Agrios, G,N(1997) vascular wilts caused by Ascomycetes and imperfect fungi. Plannt pathology 4 edition pp 342-346. Of dermatophytes. International Journal of Dermatology 19.285-287 .

Agrios, G.N. (1988). Plant Pathology, 3rd. ed. Academic Press, Inc.: New York. 803pp.

Allen MF (ed) (1992) Mycorrhizal functioning: an integrative plant-fungal process. Chapman & Hall, New York

Andrews, F.W (1952) . the flowering plants of the Anglo – Egyption – Sudan. Vol. 11: 397-404-T.Bucle and Co, Ltd.Arroath, Scotland .

AOAD (2006) Yearly statistical book .Arab Organization for Agricultural Development.Khartum,Sudan.

AOSTAT, faostat .fao. org. Retrieved 25 January 2015.

Booth, C. (1971) The Genus Fusarium Commonwealth Agricultural Bureaux. 146.

Brundrett MC (2002) Coevolution of roots and mycorrhizas of land plants. New Phytol 154:275-304.

Cairney JWG. 1999. Intraspecific physiological variation: implications for understanding functional diversity in ectomycorrhizal fungi. Mycorrhiza 9:125-135

Chadha, K.L. and Nayar,G.S. (Editors). 1994. Advances in Horticulture-Tuber Crops. Malhotra Publishing House, New Delhi.V-8. 714p.

Chadha,K.L. (Editor). 2001. Handbook of Horticulture. Indian Council of Agricultural Research. New Delhi. 1031p.

Cho, J. H., Rupe, J. C., Cummings, M. S., and Gbur, E. E. J. (2001) Isolation and identification of Fusarium solani f. sp. glycines from soil on modified Nash and Snyder's medium. Plant Dis. 85:256-260.

Desjardins, Anne E.(2006). Fusarium mycotoxins: chemistry, genetics and biology The American Phytopathological Society. St. Paul, Minnesota. APS Press PP 184-185.

Dreistadt, S.H., and Clark, J.K . (2004) Pests of Landscape Trees and Shrubs an Integrated Pest Management Guide ANR Publication 233.34.

Duddridge JA, Malibari A, Read DJ (1980) Structure and function of mycorrhizal rhizomorphs with special reference to their role in water transport. Nature 287:834-836

Elkamali, H.H(1991) . Botanical and chemical Studies on Solenostemma arggel (Del) Hayne grown in khartoum . M.Sc . thesis , Faculty of Agriculture, universty of khartoum, Sudan.

FAO (2007and 2008) The annual statistical report .Food and Agriculture Organization .Italy,Rome

Ferrol et al (2002) Enviromental and Micrbial Relation Ships (2nd Edition)

Fugro (2000) Recnt Advances in Diagnosis and Management of Plant diseases

Hag El tayeb , F.M.(2005). Evaluation of the larvicidal activety of Hargel Solenotemma argel Del. Hayne, and Usher Calotropis procera Ait, water extracts against the larvae of Anopheles arabiensis patton and culex guingue fas ciatus sey (Diptera: Culiciqdae) M.SC thesis , College of Agric. Studies , SUST . 80 pp.

Hayne.Friedrich Go Hob.1825Getreve Darstellung .

Hibbett DS, Gilbert LB, Donoghue MJ (2000) Evolutionary instability of ectomycorrhizal symbioses in basidiomycetes. Nature 407:506-508

Högberg MN, Högberg P (2002) Extramatrical ectomycorrhizal mycelium contributes one-third of microbial biomass and produces, together with associated roots, half the dissolved organic carbon in a forest soil. New Phytol 154:791-795

Howard, D.H. (2003). Pathogenic fungi in human, animal, .Via ,.Google Books ISB, No. 8247. 683.8.

Hartnett DC, Wilson GWT (1999) Mycorrhizae influence plant community structure and diversity in tallgrass prairie. Ecology 80:1187-1195

James A. D. (1983). Hand book of energy crops un published.

Jones, J.P., Jones, J.B. ., and Miller., W (1982). Fusarium wilts on tomato. Fla. Dept. Agric. & Consumer Serv., Div. of Plant Industry Plant Pathology Circular No. 237.

Jones MD, Durall DM, Tinker PB (1998) Comparison of arbuscular and ectomycorrhizal *Eucalyptus coccifera*: growth response, phosphorus uptake efficiency and external hyphal production. New Phytol 140:125-134

Kapulnik Y, Douds DD Jr (eds) (2000). Arbuscular mycorrhizas: physiology and function Kluwer Academic Publishers, London.

Koenning, S, (2001) Soybean Sudden Death Sydrome, Soybean Disese Information Note 7 Plant Pathology Extension, North Carolina State Univesity, Raleigh, NC.

Leake JR (1994) The biology of myco-heterotrophic ('saprophytic') plants. New Phytol 127:171-216

LePage BA, Currah RS,Stockey RA, Rothwell GW (1997) Fossil ectomycorrhizae from the middle Eocene. Am J Bot 84:410-412

Linderman RG (1988) Mycorrhizal interactions with the rhizosphere microflora: the mycorrhizosphere effect. Phytopathology 78:366-371

LoBuglio KF, Berbee ML, Taylor JW (1996) Phylogenetic origins of the asexual mycorrhizal symbiont *Cenococcum geophilum* Fr. and other mycorrhizal fungi among Ascomycetes. Molecular Phylogenetics and Evolution 6:287-294

Miller RM, Reinhardt DR, Jastrow JD (1995) External hyphal production of vesicular-arbuscular mycorrhizal fungi in pasture and tallgrass prairie communities. Oecologia, 103:17-23

Mohamed , E.H.B . (2004) . Effect of Vince rosea and Haragel Solenostemma argel Del . Hayne , Powder and aqueous extrats on the Faba been beetle adult Burchidius in carnates Boh (

Coleoptera : Bruchidae) , M.Sc. thesis Colleg of Agric.. Studies , SUST 64. PP.

Mohankumar, C.R., Nair, G.M., George, J., Ravindran, C.S. and Ravi,V. 2000. Production Technology of Tuber Crops. Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India. 174p.

Nunn, Nahan Qian, Nancy (2011) . The potato contribution to population and Urbanization Evidence form attisorical Experimment (PDF) Quarerly Joumal Economics 126(2)-593-650.

Okigbo, , R.N. (2004) .A revew of biological control methods for post harvest yams Dioscoreaspp.) In storge in South Eastern Nigern Ngeria KMITL Sci J.4 (1) : 207-215

Olsson PA, Thingstrup I, Jakobsen I, Bååth E (1999) Estimation of the biomass of arbuscular mycorrhizal fungi in a linseed field. Soil Biol Biochem 31:1879-1887

Orange, R.A.(1982) . Ecological and phytochemical Studies on Solenostemma argel growing in Sandi Arbia . J. of the collge of Science , king Saudi Unverstiy . 13 (1) : 17-24 .

Orzolek, M.D, creaser, G,L & Harper , . J.K. 2010. Commercial Vegetable prodction Guide . Penn State Cooperative Extenstion Agricultura Alternativees: The Pennsylvania State Universty .

Picard, Andre (July 6, 2002). "Todays fruits, vegetables lack yesterdays nutrition " Globe and and Mail . Retrieved February 16 .2015.

Pirozynski KA, Malloch DW (1975) The origin of land plants: a matter of mycotrophism. Biosystems **6**:153-164

Ramasamy, P., Rajan, P.R. Jay Kumar, R. Rani, S.and Brenner, G. (1996). Infection and its control in cultured larval Indean tiger prawn, Penaeus New York.

Read DJ, Boyd R (1986) Water relations of mycorrhizal fungi and their host plants. In: Ayres PG, Boddy L (eds) Water, fungi and plants. Cambridge University Press, Cambridge, pp 287-303

Read DJ, Perez-Moreno J (2003) Mycorrhizas and nutrient cycling in ecosystems - a journey towards relevance? New Phytol 157:475-492

Redecker D, Kodner R, Graham LE (2000) Glomalean fungi from the Ordovician. Science 289:1920-1921

Sid Ahmed . O.A.A. (2006) . Field control of the white Scale Insect Parlotoria blanchardii (Tarig) (Homptera : Diaspidiae) with agueous extracts of (Solenostemma argel) Del Hayne . M.Sc thesis, college of Agric studies , Sudan Unversity of Science and Technology .. 60. PP.

Singh NP, Bhardway Ak , Kumar A,Singh KM (2004) Modern Technology on Vegetable production . International book distrbuing co. India.

Sir ElKhatim, M.O.M (2005) Efficacy of Selected plant products on the control of Tribolium Castaneum (Herbst) (Coleoptera : Tene brionidae) M.Sc thesis , Fac .Agric., University of Khartoum , Sudan.

Smith SE, Read DJ (1997) Mycorrhizal Symbiosis. Academic Press, New York

Smith, I.M., Dunez, J. Phillips, D.H. Lelliott, R.A., and Archer, S.A. eds. (1988) European,handbook of plant diseases. Blackwell Scientific Publications: Oxford. 583pp.

Spooner, David M: Mclean, Karen, Ramsay , Gavin, Waugh, Robbile, Bryan Glenn J. (2005) "A single domestication for potato based on multilocus amplifed fragment length polymorphism genotyping " PNAS 102 (41): 1469499. Doi : 10.1073/pnas.0507400102. PMC1253605. PMID16203994.

Thomas A. Zitter, Fusarium Diseases of Cucurbits. Fact Sheet Page: 733.00 Date: 1-(1998) Thomas A Zitter, Department of Plant Pathology, Cornell University.

Van der Heijden MGA, Sanders IR (eds) (2002) Mycorhizal Ecology. Springer, New York

Varma A, Hock B (eds) (1998). Mycorrhiza: structure, function, molecular biology, and biotechnology. Springer, New York

Vincent, .W. C., and Jean., C. C. (1971). Chlamydospores inductionin pure culture in *Fusarium solani*, Mycologia. 63, 462-477.