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Management of some common insect pests and diseases of tomato (*solanum lycopersicon L*)

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ABSTRACT

Tomatoes are affected by several of the insect pests and diseases that wreak havoc on their productivity. Tomato Leaf Minor (TLM), *Tuta absoluta* (Meyrick), is the most common insect pest affecting tomato yields, while *Fusarium oxysporum*, early blight, and late blight are among the most common diseases wreaking havoc on tomato crops in many tomato-growing countries across the world. The most long-term solution is to implement an integrated system that includes cultural practices, fungicide spraying, and the adoption of broad-spectrum genetic resistance cultivars. Because single management practices may not be effective in the control of pests, integrated pest management is the best strategy to control these diseases and insect pests.
Keywords: *Fusarium* wilt disease, IPM, Late blight of tomato, *Tuta absoluta*

INTRODUCTION

Tomato (*Lycopersicum esculentum L.*) is often regarded as one of the world's most significant vegetable *crops*. This crop is affected by plenty of insect pests and diseases that inflict damage on its yield. Tomato Leaf Minor (TLM), *Tuta absoluta* (Meyrick), is a severe insect pest that attacks tomatoes in many tomato-producing locations across the world. It started in South America, quickly infiltrated several European countries and quickly spread across the Mediterranean Basin, including Egypt (Desneux N et al., 2010) It is regarded as a major agricultural danger to tomato production in Europe and North Africa. Gelichiidae, Order: Lepidoptera, Class: Insecta, Phylum: Arthropoda, Family: Gelichiidae, Order: Lepidoptera, Class: Insecta Phylum: Arthropoda *Fusarium oxysporum* f. sp. lycopersici (Sacc.) W.C. Snyder and H.N. Hans, a soil-borne plant pathogen belonging to the Hyphomycetes class, causes *Fusarium* wilt in tomato plants. More than 100 *Fusarium* vascular wilt illnesses have been identified worldwide (Bawa I., 2016.) They colonize the exterior cells of roots as innocuous endophytes after the pathogen has killed the root tissues and others dwell in the soil as saprophytes (Burgess LW., et al. 2008) Many factors influence tomato yield and quality, with illnesses playing a significant effect (Pritesh P et al. 2011) Early blight, anthracnose, bacterial wilt, bacterial canker, tomato spotted wilt, *verticillium* wilt, and *fusarium* wilt are the most frequent tomato illnesses (Winand H et al., 1999) The infection is caused by bacteria (*Pseudomonas spp.*) and fungi (*Verticillium* and *Fusarium* spp.). The wilt diseases are the result of this (Mardi D et al. 2022) tomato *Fusarium* wilt is one of the most common tomato diseases globally, affecting both field and greenhouse-grown tomatoes (Abdel-Monaim, MF, et al. 2012) Wilted plants, yellowed leaves and minimal/reduced or even missing agricultural yields are all symptoms of this fungus's illness. This article aims to summarize the various aspects of *fusarium* wilt disease and the various management options devised to tackle this destructive tomato disease. One of the most frequent foliar diseases is early blight, which is caused by *Alternaria solani* (Ell. and Mart.) Jones and Grout. It causes yield losses of up to 70%. (Glala AA et al. 2005) Multiple applications of chemical fungicides throughout flowering and fruiting are required to control this disease (Akila G et al. 2012) Furthermore, the use of synthetic pesticides to treat fungal plant diseases of food commodities is limited due to their probable carcinogenicity, high and acute toxicity, long degradation periods, and potential pollution of the environment. Because plant extracts are a rich source of bioactive substances such phenols, flavonoids, quinones, tannins, alkaloids, saponins, and sterols, they may be a viable alternative to chemical fungicides for suppressing phytopathogenic fungus (Islam Z et al. 2001). Since Since these extracts can be active against fungal phytopathogens, and are biodegradable to nontoxic.

Late Blight (LB), caused by the oomycete Phytophthora infestans de Bary, is one of the most damaging diseases of tomato and potato (*Solanum tuberosum L.*) in the globe, incurring enormous economic losses each year. The pathogen is well recognized for its part in the Irish potato famine, which resulted in the deaths of over a million people. If left unchecked, *P. infestans* can wipe out a tomato or potato crop in a matter of days. *P. infestans'* pathogenicity stems from its efficient asexual and sexual life cycles, as well as its extraordinary ability to overcome plant resistance genes quickly. Researchers have labeled *P. infestans* as a pathogen with "high evolutionary potential" because of this trait. The genome of *P. infestans* has undergone evolutionary and comparative analysis, revealing the unique architecture that enables the pathogen's rapid adaptability to host plants (Vleeshouwers, VG et al. 2011) *P. infestans'* ability to reproduce asexually and through sexual mating leads to rapid reproduction, quick epidemics, and enhanced genetic diversity and survival. The integration of cultural methods, fungicide sprays, and the adoption of resistant cultivars is required for long-term control of the LB disease (Nowicki M et al. 2012) The objectives of this article are to look at how to deal with some of the most frequent insect pests and diseases that affect tomatoes in Ethiopia (Figure 1).

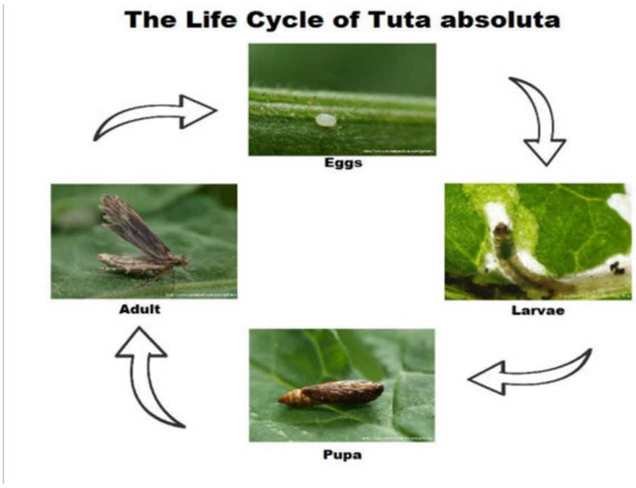

Figure 1: The life cycle of *Tuta absoluta*.

LITERATURE REVIEW

Tuta absoluta's Origin and Regional Spread

As it has spread into new countries during the last decade, its pest status has grown in importance. After establishing resistance to routinely used plant protection agents, the species is currently migrating south from the lower Mediterranean coastlines into Africa on different solanaceous crops. It is considered to have originated in Chile and moved to South America, Europe, and eventually South East Asia (Retta AN et al. 2015) they looked at all countries infected with *T. absoluta* from all over the world.

T. absolutes' rapid spread across large areas could be due to a variety of factors, including its high biotic potential, a wide range of host plants (improving its persistence in cultivated areas and overwintering potential), intra-continental dispersal facilitation due to human transportation, and the artificial selection of insecticide-resistant populations. In addition, the lack of co-evolved natural enemies may explain why pest population dynamics in recently invaded areas are faster than in native places, where natural enemies are more common (Desneux N et al. 2004)

Entry and pathways of *T. absoluta*

Tanzania was likely introduced to the pest through neighboring countries that were impacted first, such as Kenya, Ethiopia, Uganda, Mozambique, and Sudan. Porous East African borders and a lack of quarantine standards, among other factors, may have aided the rapid spread to Tanzania. Import of tomato fruits intended for consumption from countries where the pest is present; packing materials boxes, crates, pallets, etc. For import of tomatoes, eggplants, potatoes, tobacco, and peppers from countries where the pest is present; and planting material originating from countries where the pest is present (mainly tomatoes) are the most relevant pathways for *T. absoluta* entry.

Host Plants of *T. absoluta*

T. absoluta feeds, develops, and reproduces on a variety of other solanaceous plants, including potato, tobacco, eggplant, pepper, aubergines, black nightshade, and other related weeds like *jimson weed* (Pereyra and Sanchez, 2006). Other host plants include: *Solanum Lycopersicum* (tomato), *Solanum Tuberosum* (potato), *Solanum Melongena* (eggplant), *Capsium Annuum* (pepper), *Nicotiana Tabacum* (tobacco), *Solanum Nigrum, Datura Stramonium, Solanum Eleagnifolium, Physalis Peruviana, Solanum Nigrum, Datura Stramonium, Solanum Sapponaceum, Solanum Bonariense, Solanum Sisymbriifolium Datura Ferox, Lycium sp., Malva sp., Lycopersicum puberulum.*

If the pest is not correctly handled, a severe infestation of *T. absoluta* can cause significant harm by feeding on all aerial sections of the tomato plant, resulting in economic losses of up to 80-100 percent. The majority of the damage is seen on the leaves and fruits, but inflorescences and stems can also be impacted. *T. absoluta* eggs are laid individually or in small groups on leaves, and the larvae feed on leaves, stems, and fruits. *T. absoluta* larvae eat on the leaf's mesophyll, leaving just the epidermis with its feces intact, which then expands as the damaged tissue dries. The damaged leaves become yellow, wither, and senescence as a result of the attack; the fruits are destroyed; and and the plant is ultimately die (Maluf, W et al. 1997)

Management of *T. absoluta*

Biological control: The use of biological control employing natural enemies as a major component of any Integrated Pest Management (IPM) program for managing TLM would be a concentrated effort. Trichogrammatidae egg parasitoid species are regarded effective biological control agents and are commonly utilized commercially to suppress and control lepidopterous pests on a variety of crops (Agamy EA et al. 2003) Trichogramma species are used to treat about 32 million hectares around the world. They are simple to grow and release in open fields or protected crops (Chailleux, A et al 2012) with innudative releases being the most common method. The right Trichogramma species for a certain insect pest is critical to the efficacy of a biological control program.

Using predators: *T. absoluta's* natural enemies have been identified and reported from their source (South America). *T. absoluta's* enemies are commercially accessible and can be utilized to manage it. published a report that highlighted a list of commercially accessible predators that have shown to be useful. These may consist of: Predatory bugs like Macrolophuspygmaeus (also known as Macrolophuscaliginosus) and Nesidiocoristenuis have been identified as the most promising natural enemies of *T. absoluta* in Europe because they consume the pest's eggs in enormous quantities. The mired Dicyphusmaroccanus, the nabid Nabispseudoferusibericus, and the two phytoseid species Amblyseiusswirskiiand Amblyseiuscucumeris (these two mites in aubergine (eggplant)) have also been discovered as predators of *T. absoluta* (Retta AN et al. 2015).

By parasitoids: These are one of the natural enemies that can be employed to restrict T. absoluta population growth in greenhouses as well as open field tomato fields. In South America, where the pest originated, they are the most commonly employed natural enemies of *T. absoluta*. In the Mediterranean region of Europe, parasitoids have been discovered parasitizing *T. absoluta* larvae. In Spain and Italy, at least two Necremnus species have been discovered. Infested tomato plots in Spain have spontaneously sprung *Stenomesius spp*. and other unidentified species (mostly Braconidae), indicating that native parasitoids are adapting to the new host. *Trichogramma acheae* has been identified as a possible biological control agent of *T. absoluta* eggs and is presently being deployed in commercial tomato greenhouses (Chailleux, A et al 2012).

Use of entomopathogens: With the exception of *Bacillus thuringiensis var*. kurstaki, research by (Siqueira ÂA et al. 2000) found little data on the usefulness of entomopathogens in controlling *T. absoluta*. *Bacillus thuringiensis*, an *entomopathogenic bacterium*, has been used to manage tomato plant pests and has been described as a highly effective bio-insecticide by a number of writers. It has been extensively utilized to control the pest in crops where biological control IPM programs are used.

Effect of bio-pesticides on *T. absoluta* larvae: The effect of bio-pesticides on *T. absoluta* larvae revealed that there were significant (P=0.01) differences between the treatments in all evaluated districts. When compared to untreated control and standard check 2.09 percent and 94.74 percent, respectively, mean larval percent mortalities due to application of different bio-pesticides resulted in 0-96.19 percent mean larvae percent mortalities after 3 days. Vayego 200 SC had the highest percent mortality (96.19%) and *Nicotiana sp*. had the lowest percent mortality (39.35%), but both entomopathogenic fungi (*B. bassiana* and *M. anisopliae*) had no effect on *T. absoluta* within 3 days of treatment application, owing to the time it takes for fungi to establish in insect pest larvae.

The mortality percentage of *T. absoluta* on tomato fruit was better on the 5^{th} day of the trial than on the 3^{rd} day in all treatment plots and in all locations except the standard check (Coragen 200 SC) and Vayego 200 SC, which exhibited high percent mortality in all districts. After 10 days from the third day of the trial, the percent mortality of the other treatments gradually grew from 0% to 74.26 percent. Tetraniliprole (Vayego 200 SC), a chemical insecticide, had a very low toxic effect on *T. absoluta* after 10 days of treatment, and percent mortality was low in all areas when compared to other treatments, but highly significant (P=0.01) when compared to the untreated control.

Detection and identification: According to (Retta AN et al. 2015) using pheromone traps to detect the presence of *T. absoluta* is a reliable method. *T. absoluta* natural sexual attractants are used in pheromone traps, therefore the approach exclusively catches adult male moths. The sample is taken to the bug research facilities for identification once it has been caught. Pheromone traps are employed not only to detect the pest, but also to reduce the population of *T. absoluta* by disrupting mating and mass extinction. The data from pheromone traps provides early notice of an infestation and also alerts the user to low population levels before they become serious. Water traps, sticky rolls, and Delta traps are only a few examples of pheromone trapping strategies (Siqueira ÂA et al. 2000 and Megido R et al. 2013)

Sex pheromone-based control strategies: Pheromones are molecules secreted in bodily fluids that are thought to impact the opposite sex's behaviour, such as eliciting sexual attraction and excitement. Natural sexual attractants are pheromones. Sex pheromones are chemical signals emitted by an organism to attract an individual of the same species of the opposite sex, according to. The main component of the *T. absoluta* pheromone lure is (3E, 8Z,11Z)3,8,11-tetradecatrienyl acetate, with (3E,8Z)tetradecadienyl acetate as a minor component (Megido R et al. 2013).

Trap catches: The *T. absoluta* moth trap catches in pheromone traps put in the experimental field in Fayoum Governorate, Egypt in the tomato Nili plantation of 2014. Two pheromone traps were put in plot for monitoring the pest population by early September 2014, the start of the investigation in the permanent field. On September 9th, the first catches were discovered. As a result, additional traps were installed in plots to act as a monitoring and mass-trapping control approach. On September 12th, the initial reports of 3.75 and 7.75 moths/trap in different two plots, were reported. The moths were seen throughout the research period, from September 2014 to January 2015. The highest mean number of moth catches/traps was recorded in October (46.8 moths), followed by November (27.6 moths), and the lowest (16 moths) in September and December. The technique of mass pheromone trapping has been widely employed to manage a variety of insect species (Rodriguez-Saona, CR et al. 2009). These findings corroborate those of Ltd, who stated that mass trapping can be utilized to minimize *T. absoluta* populations and is especially effective in greenhouse tomato production. Water traps were also the most popular pheromone traps employed for mass catching of *T. absoluta*, according to Salas. They are easier to maintain and less dust-sensitive than Delta or light traps, and they also have a bigger trapping capacity. According to Cocco et al. mass trapping alone was ineffective in minimizing leaf and fruit damage in male *T. absoluta* populations.

On the 28th of September, 12th of October, 26th of October, 9/11, and 23rd of November, 2014, Fytomax N was released. Infestation rates began at (7.3 percent) in September, grew in subsequent months to (8.2 percent) in October, (16.3 percent) in November, and then decreased to (12 percent) in December. Except for the application practiced by early November, infestation rates were always lower after Biotrine application than after Fytomax application. Statistical investigation revealed a highly significant difference between the usage of Bio-rational solutions (t=0.00111**) and the control of mass trapping technology and *T. bactrae* release in TLM management. According to Abbes et al. 20 percent of leaves were infested in the IPM cropping system (mass trapping+release of *Nesidiocoris tenuis*) versus 98 percent in the conventional cropping system, and 18.2% of fruits were infested in the IPM cropping system versus 46.8% in the conventional cropping system. The control plot was treated seven times by the grower with three different pesticides: Nomolt 15% SC twice, Pleo 50% EC twice, and Oshin 20% SG twice (3 times). The following were the application dates: Nomolt 15% SC on 18/10 and 22/11/2014, Pleo 50% EC on 7 and 13/11/2014, and Oshin 20% SG on 22/10, 28/11, and 2/12/2014. The monthly mean rate of insect infestation jumped from 13.3 percent in September to 26.8 percent in October, 60.5 percent in November, and 29.3 percent in December. This means that utilizing Biotrine or Fytomax, or releasing parasitoids, resulted in 70-75 percent lower infection rates than using insecticides.

Cultural Control Methods

Best agricultural practices: Crop rotation with non-solanaceous crops (ideally Cruciferous crops), ploughing, proper watering and fertilization, removal of infested plants, and total removal of post-harvest plant debris and fruit are all good agricultural methods for controlling *T. absoluta*. It is also recommended that wild solanaceous host plants surrounding the growing region be removed, since these can house all stages of the pest, which can subsequently infect the growing crop. *T. absoluta* can be controlled through sound agricultural methods such as cultural practices, rotation with non-solanaceous crops, ploughing, sufficient fertilization, and irrigation, as well as the eradication of afflicted plants and post-harvest plant debris. For example, if fruit stalks are injured by *T. absoluta* larvae at any point during the growing cycle, the system will be overhauled. To prevent the bug from completing its cycle and spreading further, the entire plot was withdrawn and securely destroyed.

Planting matrial management: *T. absoluta* can be controlled by using pest-free transplants, according to Retta AN et al. When pest damage is minimal, remove any symptomatic leaves, stems, or fruits that have been impacted by larvae or pupae and deposit them in plastic bags to be destroyed. Remove any weeds that may be hosts for the bug in the area. Crop wastes should be destroyed as quickly as possible after harvesting.

Chemical control: A list of insecticides to control *Tuta absoluta* is available on the market, but most of these treatments have failed in the field because the pest has developed resistance to hundreds of pesticides (Haubruge, E et al. 2013) Because the larvae eat inside leaves, fruits, and stems, chemical control is difficult. Furthermore, pests with a high reproductive capacity and brief generations, such as *T. absoluta*, are more likely to evolve resistance. As a result, it's critical to avoid using a systemic approach and instead rely on experts to apply treatments based on insect population density and crop damage. It's also critical to switch between active drugs with various mechanisms of action (chemical group) Chlorantraniliprole and flubendiamide are two diamide insecticides. In Argentina resistance to abamectin, -methrin, and methamidophos was discovered, as was resistance to organophosphates and pyrethroid pesticides.

On a population of *Tuta absoluta* that is naturally present in the experimental plot tomato, insecticide treatments are applied. With the exception of the stage nymphal, all stages of the pest are monitored and observed. The active component and the dose used for each insecticide are listed in a tabular format.

Integrated pest management strategies: Some insects can be managed using a combination of techniques that are ineffective when applied alone. *T. absoluta* is one of those insects that require more than one method of control to be effectively controlled. As a result, numerous countries are developing Integrated Pest Management (IPM) strategies to combat *T. absoluta* infestations. To properly control the pest, all available control techniques must be used, including cultural treatments, biological control agents, and the proper application of licensed pesticides. In South America, IPM techniques are being developed to combat *T. absoluta*. Various active chemicals, in combination with bio rational control methods, can be used. Massive trapping before planting, clearing the soil of crop residues, application of imidacloprid in irrigation water 8-10 days after planting, application of either spinosad or Indoxacarb if occasional individuals of *T. absoluta* are observed, and elimination of the crop remnants immediately after the last fruits have been harvested are all part of the recommended integrated control method. Chemical and biological treatments must often be used in order for an Integrated Pest Management (IPM) program for arthropod pests to be successful. For the control of *T. absoluta*, an integrated pest management strategy (shown below) can be used:

- Clearing the soil and area of crop waste, fruits, and wild host plants.
- Mass trapping before or after planting.
- If occasional individuals of *T. absoluta* are observed, use sulphur, neem oil, *Bacillus thuringiensis* in combination with either, methrine, spinosad, Indoxacarb, or another recommended bio-pesticide.
- Elimination and burning of infected plants during the growing season and of the crop remnants immediately after the last fruits have been harvested.

Leaf miners can be controlled using a variety of strategies. To properly control the pest, all possible control measures must be used, including physical methods, cultural methods, biological control agents, and the proper application of licensed pesticides [15, 21].

Fusarium Wilt Disease of Tomato

Symptoms of *Fusarium* wilt disease on tomato: Attack symptoms include minor vein clearing on the outer portion of young leaves, followed by epinasty on older leaves (Mui-Yun W. 2003). This condition usually only affects one side of the plant or one branch. Before the plant reaches maturity, successive leaves become yellow, wilt, and die. Growth is usually slowed as the disease proceeds, and little or no fruit develops. Dark brown streaks can be seen going longitudinally across the main stem if it is cut. The browning of the vascular system is a symptom of the disease and can be used to identify it in most cases (Ajigbola CF et al. 2013) White, pink, or orange fungal growth can be noticed on the outside of afflicted stems, especially under moist situations (Ajigbola CF et al. 2013).

Biological control: The employment of hostile microorganisms is an alternate disease management technique for providing an environmentally friendly *Fusarium* disease control system (Lugtenberg, BJJ et al. 2009). Biological control agents may use direct, indirect or hybrid techniques to achieve their goals. The use of bioagents to combat *Fusarium* wilt disease on tomatoes has been reported to be extremely effective (Freeman, S, et al. 2002) Several isolates of nonpathogenic Fusarium spp. (*F. oxysporum and F. solani*) that efficiently controlled *Fusarium* wilt in greenhouse tests have been found, according to Momol et al. CS-20, CS-1, CS-24, and Fo-47 were among the isolates that were consistently effective when used at a high rate. After spraying with *Phytophthora cryptogea* zoospores followed by *Fusarium oxysporum* discovered that f. sp. lycopersici inoculation, tomato plants show no wilt disease. Akkopru and Demir found that *Arbuscular Mycorrhizal* Fungi (AMF) *G. intraradices*, as well as some Gram-negative and fluorescent Rhizobacteria (RB), *P. fluorescens*, *P. putida*, and *Enterobacter cloaceae*, isolated from the rhizoplane of solanaceous plants, were effective against *Fusarium oxysporum f. sp*. ly *Peudomonas flourescens, P. putida, P. chlororaphis, Bacillus subtilis, Streptomyces pulcher, S. corchorusii*, and *S. mutabilis* are bacterial biocontrol agents with promising biocontrol effects against *Fusarium oxysporum f. sp. lycopersici*, according to Monda, Rhizobacteria can operate as biofertilizers and biostimulants by producing plant growth hormones such indole acetic acid, gibberelin, cytokinin, ethylene, and dissolved minerals, as well as indirectly preventing harmful microbes by producing siderofore and antibiotics (McMilan,S 2007 and Sarma, MV et al. 2009)

Use of natural products: Despite numerous research attempts to find alternative and environmentally friendly strategies to control plant diseases, the use of plant products for the control of *Fusarium* wilt in crops remains limited Hanaa et al. investigated the effect of 10 percent aqueous extracts of *Azadirachta indica* (Neem) and *Salix babylonica* (Willow) on *Fusarium* wilt disease in tomato, finding that the percentage of disease incidence was reduced to 25.5 percent and 27.8 percent after 6 weeks of infection, respectively.

Use of resistance: Where resistant cultivars are available, the most cost-effective and environmentally friendly means of control is to use them. The use of resistant cultivars is the best disease control method [9], as well as one of the most effective alternative approaches to wilt disease control. According to Pritesh et al., identifying and using disease-resistant tomato plant cultivars is a viable alternative to the usage of chemicals.

Chemical control of tomato wilts disease: In tomato, seed treatment with synthetic fungicides significantly reduces the occurrence of wilt. However, their use is both costly and harmful to the environment (Song F et al. 2001). Prochloraz, propiconazole, thiabendazole, carbendazim, benomyl, thiophante, fuberidazole, and all benzimidazoles are examples of these compounds. Using the root dip treatment approach, Nel et al. found that benomyl was only partially effective against *F. oxysporum f. sp cubense*. When carbendazimal was used on tomato seedlings affected with *Fusarium* wilt, this approach resulted in a 24 percent increase in yield (Khan, M.R et al. 2002) Prochloraz and carbendazim were chosen to investigate their greenhouse control effects on tomato *Fusarium* wilt in a hydroponic production system based on the results above.

Cultural control: Cultural control refers to procedures and farming strategies that help to improve crop quality and quantity while also reducing pest and disease impact. It entails non-mechanical manipulation of the environment to control plant pests and diseases. It entails changing farming practices to make the environment unsuitable for disease viruses and pests to thrive in. It can also refer to the intentional manipulation of a garden or farm's growing, planting, and nurturing of plants in order to reduce plant disease, insect damage, and pest numbers. It has been demonstrated that proper application of cultural approaches to reduce soil borne pathogens results in enhanced soil structure and, as a result, lower occurrence (Neshev, G 2008)

Integrated disease management of *Fusarium*: In poor nations, Integrated Disease Management (IDM) is acknowledged as an efficient strategy for enhancing agricultural output and combating environmental degradation (Waiganjo, MM et al. 2006) Crop rotation, organic matter additions, and the use of high-residue tillage equipment are all practices that can help to build healthy soils. Pest and disease reduction through the use of compost products has been the subject of extensive research around the world. Composts can provide natural biological management of soil-borne illnesses that harm collars, roots, and plant foliage, according to the findings Recycled Organics Unit. Incorporating green manures and cover crops into a rotation is a great method to boost fertility, control weeds, and break up insect cycles (Jeff, G. 2009).

Including a variety of crop species in a cycle, as well as manures and/or compost, ensures a diverse source of organic matter. This diversity results in a more minerally balanced soil and a pool of nutrients that slowly become available over time, decreasing leaching, waste, and toxicity that can occur when inorganic fertilizer applications are made instantly available (Jeff, G. 2009). Crop rotation with non-similar crops such as cabbage and cauliflower for at least 4-5 years, disease resistant cultivars, natural antagonistic organisms, particularly bacillus-based Biological Control Agents (BCAs), farm hygiene, and the use of chemicals such as prochloraz and methyl bromide are some of the integrated control strategies for *fusarium* wilt of tomato. Finally, good soil fertility management is critical because the soil and surrounding air environments are almost intertwined, and the formation of a functional and stable system in one environment can have far-reaching consequences in the other (Dishon MN et al. 2012).

DISCUSSION

Late Blight of Tomato

Tomato pathogens have been identified as more than 200 pests and illnesses that impede output. Among these are fungus, oomycetes, bacteria, viruses, and nematodes, which cause a variety of diseases.

Historical significance of the disease: Late Blight (LB) is a serious tomato and potato disease that has been regarded as one of the most damaging plant diseases of all time. Because of LB infection, an unprotected tomato field can lose up to 100 percent of its output. *Phytophthora infestans*–literally "plant destroyer" in Greek–is thought to have originated in the same Andean region as tomatoes and potatoes. Isozyme and DNA studies, as well as pathogenicity similarities among Peruvian, US, and European isolates of *P. infestans*, have recently confirmed a common origin for both the host and pathogen populations. Which was first suggested in the nineteenth century shortly after the Irish potato famine of *P. infestans*. In 1843, the disease caused the first documented case of potato LB in Philadelphia and New York City, both in the United States. Winds dispersed the dehiscent pathogen sporangia to neighboring states because of weather patterns, extending the region impacted by LB. By 1845, LB had spread from Illinois to Nova Scotia and from Virginia to Ontario, wreaking havoc on crops. In 1845, a cargo of contaminated seed potatoes crossed the Atlantic Ocean from the United States to Europe, spreading the illness. When *P. infestans* arrived in Ireland, a society that relied heavily on potatoes as a primary source of food and was susceptible to negative political, social, and economic circumstances, widespread potato LB nearly wiped out the crop. One million people died as a result of this, and another million were displaced, many of them immigrated to the United States. Following the pathogen's continued expansion in future years, LB had spread worldwide by the turn of the twentieth century, wreaking havoc on potato and tomato crops all over the world. Recent observations support the pathogen's aggressiveness against potato, as well as tomato: When *P. infestans* infects an unprotected crop (field, greenhouse, and/or plastic-cover cultures) the entire crop can be destroyed in seven to ten days (Foolad, MR et al. 2008)

The disease cycle and development: The pathogen's severe economic and social consequences piqued scientists' interest in LB research. Understanding of tomato LB has benefited by discoveries in disease biology made because of potato-driven research. *P. infestans* can be especially damaging in regions where both tomatoes and potatoes are produced year-round, such as in Africa's highland tropics, the Americas, Asia, and Europe. *P. infestans'* unhindered success as a pathogen stems from its efficient asexual and sexual replication. During the season, the asexual form is responsible for the majority of vehicle driving outbreaks. *P. infestans* develops thousands of sporangia per lesion on sporangiophores in this form. Sporangiophores are undefined structures that aid in sporangia air dissemination *via* wind, rain, or wind-blown rain transportation. The disease cycle starts when sporangia land on host plant tissue, which must be coated with a thin layer of water to allow motile, germinated spores to migrate towards a penetration site. Germination of Sporangia happens either by direct expansion of germ tubes or through zoosporogenesis. Cool and damp circumstances boost the latter, which is essential since it broadens the range of meteorological conditions in which infections might arise. Direct germination of sporangium on host tissue occurs between 8 and 48 hours at temperatures over 21°C (optimally at 25°C). At temperatures over 15°C, the sporangium germinates immediately and quickly begins mycelia development Up to eight biflagellate zoospores are discharged from the sporangia at temperatures below 21°C, with optimal zoospore production occurring at 12°C. Motile zoospores break through the aqueous film, detach their flagella, and encyst until germ tubes form. This happens after around two hours at the ideal temperature (12 to 15°C). Appressoria form from germ tubes and infiltrate the host through the leaf cuticle or, less frequently, the stomata. The ideal temperature for germ tube development is between 21 and 24 degrees Celsius. Intercellular hyphae generate biotrophic feeding interactions in the mesophyll by developing and traveling within the host between cells utilizing haustoria. Between 22 and 24°C, rapid colonization begins. Hyphae spreads, and sporangiophores emerge from stomata at some point. Following five to 10 days after immunization, LB symptoms appear. Sporulation results in the formation of 2N sporangia, which then release zoospores, which aid in the spread of LB through the air and keep the disease cycle going. When temperatures rise beyond 35 degrees Celsius, illness growth stops, but *P. infestans* can persist in living host tissue and the disease can progress when conditions improve. Large peripheral vesicles, encystment vesicles, kinetosomes, and flagella are among the organelles seen in Sporangia that are missing in hyphae. The multinucleate sporangial cytoplasm is cleaved by nucleusenveloping membranes during zoosporogenesis. Following that, flagella are assembled, the sporangial papilla is dissolved, and uninucleate zoospores are expelled. Several of the early induced genes encode vesicle-movement players, which may contribute in the formation of these structures. More than 70 flagella-associated genes, as well as a thrombospondin-like encystment protein, are among the early-induced genes that encode components of spore-specific vesicles or organelles.

Disease symptoms and progression: *P. infestans* can damage tomato and potato crops at any stage of their development. In five to ten days, the entire plant might collapse. LB can infect all aboveground sections of the plant, causing leaf and stem necrosis, fruit rot, and final plant death. Tomato seed and potato tubers can also be infected by the disease. Initial infection symptoms, such as tiny lesions on leaf tips and plant stems, appear after three to four days and can be as small as 1 to 2 mm in diameter in certain cases. Water-soaked lesions that are purple, dark brown or black often have a pale yellowish-green border that merges in with healthy tissue. In wet weather, fluffy white sporangia might appear on the lower (abaxial) leaflet surface. Plant leaflets shrink and die as the disease proceeds, and the disease spreads to the rest of the foliage, resulting in severe defoliation. Late Blight of tomato dark brown LB lesions occur at the top of the stem or at a node and may spread down the stem. Tomato fruit lesions that are firm, dark, and greasy are common at the stem end and sides of green fruit, rendering it unmarketable. Secondary pathogens can infect infected tomato fruit, causing soft-rot disease.

Late Blight Disease Control

Host plant defense: Pathogen detection is precisely tuned in plants. They are able to detect infections' chemical and physical signals and respond quickly to infection attempts (Hardham, AR et al. 2010) Plant responses to oomycetes range from invaded cells with no visible response to more localized reactions that prevent pathogen intracellular structures from forming, to Hypersensitive Response (HR) and programmed cell death, the latter occurring only after pathogen growth has progressed to the formation of a clearly identifiable haustorium. Resistance against penetration at the leaf surface is the first line of induced defense in tomato plants against *P. Infestans*. This is a highly effective defense technique that host plants deploy quickly in response to attempted penetrations. Recent research has shown that plasma membranebound receptor proteins play a direct role in the identification of apoplastic pathogen elicitors and the activation of host defences. Furthermore, the invading penetration peg's physical pressure may operate as a signal to plant surface detecting systems.

Tomato and potato LB have a large financial impact on growers and consumers around the world, costing an estimated $5 billion each year in disease control and crop losses. In 2009, total yield losses in the freshmarket and processed tomato industries in the United States were $46 million and $66 million, respectively. Up to half of these costs could be ascribed to LB-related crop losses. In unprotected fields, fruit infection can vary from 41 to 100 percent, while in plots treated with systemic fungicides, fruit infection can range from 12 to 65 percent. Over the last few years, Poland's tomato production has been severely harmed by LB outbreaks, which have often resulted in crop failure of up to 100%.

Cultural practices: Cultural practices are a crucial part of a grower's disease management approach, and they can have an impact on disease development and control. The goals of LB cultural control are to reduce inoculum build-up, prevent inoculum from nearby potato cull heaps or tomato transplants from entering the system, reduce infection rates, and create unfavorable conditions for disease development and transmission. Crop rotation and fallow, eradication of volunteer tomato and potato plants, planting noninfected seedlings and tubers, and reduction of LB sources such as potato cull piles are all common cultural measures used to reduce LB. The latter is especially important since cull heaps can act as a living host for *P. infestans* mycelia over the winter, allowing it to survive and produce massive volumes of airborne spores at the start of the new field season. If this happens, the following year's crop could be ruined by LB. The pathogen's recent re-emergence, combined with its improved ability to develop more virulent isolates through sexual recombination, makes LB control by cultural practices alone extremely difficult, and the pathogen could be especially destructive in areas where both tomatoes and potatoes are grown year-round, such as the highland tropics of Africa, South America, Asia, and Europe.

Fungicide application: Chemical control techniques, especially when led by disease forecasting systems,can be useful in managing LB and have been used more frequently in recent years. Protestants (e.g. chlorothalonil, dithiocarbamates and triphenyl tin hydroxide) which are applied before or after disease onset and systemic fu ngicides (a.k.a. therapeutic fungicides; e.g. phenylam ides such as metalaxyl/mefenoxam, aliphatic nitrogen fungicides such as cymoxanil and morpho. A combination of fungicides meant to delay the disease's progression is currently used to control LB. Metalaxyl fungicides, a type of systemic fungicide, have been widely used to combat LB; they work by inhibiting the incorporation of uridine into ribosomal RNA (rRNA) polymerases in fungi. These treatments, on the other hand, can be ineffectual, especially when illness growth is aided by favorable environmental factors. Furthermore, inappropriate phenyl amide administration has put a selective pressure on the pathogen, resulting in the spread of fungicide resistance

Genetic resistance against Lb In tomato: The pathogen's pathogenicity gene product, also known as the Avr-gene product, interacts with the host resistance gene product, which is also known as the R-gene product. Typically, single gene resistance offers complete resistance to one or a small number of pathogen races. Vertical resistance to the pathogen may eventually fail due to rapid evolution of pathogen effectors and sexual reproduction of *P. infestans*, which leads to more aggressive lineages. For example, in potato, the persistence of main LB-resistance genes has been found to be variable, and isolates of *P. infestans* have been obtained that are basically resistant to LB. overcome all 11 R-genes found in *S. demissum*, a wild potato species. Although this has not been verified, a similar condition may exist for important L Bresistance genes in tomato. Race-nonspecific resistance, in contrast to vertical resistance, is generally controlled by many genes or Quantitative Trait Loci (QTLs) and may be more lasting. Horizontal resistance usually offers partial resistance to a variety of pathogen isolates/races. This sort of resistance slows, but does not stop, disease progression.

CONCLUSION

Pests are threatening tomato crop all around the world. *Tuta absoluta*, *Fusarium*, early blight, and late blight are just a few of the most common tomato pests and illnesses. The most long-term solution is to implement an integrated system that includes cultural techniques, fungicide spraying, and the adoption of broad-spectrum genetic resistance cultivars. Some insects can be managed using a combination of techniques that are ineffective when applied alone. *T. absoluta* is one of those insects that require more than one method of control to be effectively controlled. To properly control the pest, all available control techniques must be used, including cultural treatments, biological control agents, and the proper application of licensed pesticides. Massive trapping before planting, clearing the soil of crop residues, application of imidacloprid in irrigation water 8-10 days after planting, application of either spinosad or Indoxacarb if occasional individuals of *T. absoluta* are observed, and elimination of the crop remnants immediately after the last fruits have been harvested are all part of the recommended integrated control method. Chemical and biological treatments must often be used in order for an Integrated Pest Management (IPM) program for arthropod pests to be successful. In general, IPM is a smart technique of controlling illness and pests by combining chemical, biological, cultural, trapping, pheromones, and other methods when a single method is ineffective or harmful to the environment.

REFERENCES

Desneux N, Wajnberg E, Wyckhuys KAG, Burgio G, Arpaia S, Narváez-Vasquez CA., GonzálezCabrera J, Catalán Ruescas D, Tabone E, Frandon J, Pizzol J, Poncet C, Cabello T, Urbaneja A (2010). Biological invasion of

European tomato crops by Tuta absoluta:ecology, geographic expansion and prospects for biological control. J Pest Sci. 83(3):197-215.

Bawa I (2016). Management Strategies of *Fusarium* Wilt Disease of Tomato Incited By *Fusarium* oxysporum f.sp. lycopersici (Sacc.): A REVIEW. Int J Adv Acad Res. 2(5).

Burgess LW, Knight TE, Tesoriero L, Phan HT (2008). Diag manual plant dis in Viet. ACIAR 126-133.

Pritesh P, Subramanian RB (2011). PCR based method for testing *Fusarium* wilt resistance of Tomato. African J Basic Appl Sci. 3 (5):222.

Winand H, William H (1999). Crop profile of tomatoes in Pennsylvania. Pennsylvania State University Pesticide Education and Assessment Program.1-14.

Mardi D, Janet B, Paul W (2002). Organic Greenhouse Tomato Production. Fayetteville. 1-16.

Abdel-Monaim MF (2012). Induced Systemic Resistance in Tomato Plants Against *Fusarium* Wilt Disease. Int Res J Microbiol. 3(1):014-023.

Amini J, Sidovich DF (2010). The effects of fungicides on *Fusarium oxysporum f. sp. lycopersici associated with Fusarium wilt of tomato*. J Plant Protection Res. 50 (2): 175.

Sheu ZM, Wang TC (2006). First Report of Race 2 of *Fusarium oxysporum f. sp. lycopersici, the causal agent of Fusarium wilt on Tomato in Taiwan*. Plant Dis. 90:111.

Glala AA, Hoda AM, Fawzi ZF (2005) Improving tomato plant growth, health, earliness, productivity and fruit quality by chemically induced systematic resistance. J Appl Sci Res. 1:362–372.

Akila G, Einstein CR, Sathiy AM (2012). Treatment of tomato plants with yeast extract glucan induce chitinase activity, resistance to Alternaria solani, the causal agent of early blight disease. Int J Biol Pharm Allied Sci. 1:1492–1499.

Islam Z (2001). Control of rice insect pests. International Rice Reseach Institute, Phillipines. 4-20.

Vleeshouwers VG, Raffaele S, Vossen JH, Champouret N, Oliva R, Segretin ME, Kamoun S (2011). Understanding and exploiting late blight resistance in the age of effectors. Ann Rev Phytopathol. 49:507-531.

Nowicki M, Foolad M R, Nowakowska M, Kozik EU (2012) Potato and tomato late blight caused by Phytophthora infestans: an overview of pathology and resistance breeding. Plant Dis 96(1):4-17.

Retta AN, Berhe DH (2015).Tomato leaf miner–Tuta absoluta (Meyrick), a devastating pest of tomatoes in the highlands of Northern Ethiopia :A call for attention and action. Res J Agric Environ Manag. 4(6):264-269.

Desneux N, Wajnberg E, Wyckhuys KAG (2004). Biological invasion of European tomato crops by Tuta absoluta: Ecology, geographic expansion and prospects for biological control. J Pest Sci. 83(3):197-215.

Maluf W, Barbosa L, Santa-Cecília LC (1997) Tridecanone-mediated mechanisms of resistance to the South American tomato pinworm Scrobipalpuloides absoluta (Meyrick, 1917) (Lepidoptera Gelechiidae) in *Lycopersicon spp*. Euphytica. 93(2):189-194.

Agamy E (2003). The inundative release of Trichogramma evanescenes West. as biocontrol agent against the potato tuber moth, *Phthorimaea operculella* (Zeller). Egypt J Biol Pest Control.13(1-2):101-104.

Chailleux A, Desneux N, Seguret J, Do Thi Khanh H, Maignet P, Tabone E (2012). Assessing European egg parasitoids as a mean of controlling the invasive South America tomato pinworm Tuta absoluta. PLoS One.7(10):48068.

Siqueira ÂA, Guedes RNC, Picanc MC (2000).Insecticide resistance in populations of *Tuta absoluta (Lepidoptera : Gelechiidae)*. Agricultural and Forest Entomology.

Megido R, Haubruge E, Verheggen F (2013).Pheromone-based management strategies to control the tomato leafminer, *Tuta absoluta* (*Lepidoptera: Gelechiidae*). A review. Biotechnologie, Agronomie, Société et Environnement. 17(3):475-482.

Rodriguez-Saona CR, Stelinski LL (2009). Behavior-modifying strategies in IPM: theory and practice. Integrated pest management:innovation-development process. 263-315.

Salas J (2004). Capture of Tuta absoluta (*Lepidoptera:Gelechiidae*) in traps baited with its sex pheromone. Revista Colombiana de. 30(1):75-78.

Cocco A, Deliperi S, Delrio G (2012). Potential of mass trapping for *Tuta absoluta* management in greenhouse tomato crops using light and pheromone traps. IOBC-WPRS Bulletin. 80: 319-324.

Abbes K, Harbi A, Chermiti B (2012). The tomato leafminer *Tuta absoluta* (Meyrick) in Tunisia: current status and management strategies. EPPO bulletin. 42(2):226-233.

Sally AM, Randal CR, Richard MR (2006). *Fusarium Verticillium wilts* of Tomato, Potato, Pepper and Egg plant. The Ohio State University Extension.

Ajigbola CF, Babalola OO (2013). Integrated Management Strategies for Tomato *Fusarium* Wilt. Biocontrol Sci. 18(3):117-127.

Lugtenberg BJJ, Kamilova F (2009). Plant growth-promoting rhizobacteria. Annu Rev Microbiol. 63:541-556.

Freeman S, Zveibel A, Vintal H, Maymon M (2002). Isolation of non-pathogenic mutants of *Fusarium oxysporum f.* sp. lycopersici for biological control of *Fusarium* wilts in Cucurbits. Phytopathology. 92:164-168.

Momol MT, Pernezny K (2003). Florida plant disease management Guide:Tomato. University of Florida.3:53.

Akkopru A, Dermir S (2005). Biological Control of *Fusarium* Wilt of Tomato Caused by *Fusarium oxysporum* f.sp.lycopersici by AMF Glomus intraradices and some Rhizobacteria. J Phytopathol. 153:544-550.

Monda EO (2002). Biological control of *Fusarium* wilts of tomato. J Tropical Microbiol. 1:74-78.

McMilan S (2007) Promoting Growth with PGPR. The Canadian Organic Grower. 32-34.

Sarma MV, Saharan RK, Prakash K, Bisaria A, Sahai, V (2009). Application of Fluorescent Pseudomonads Inoculant Formulations on Vigna mungo through Field Trial. Int J Biol Biomed. 1:41-47.

Agbenin NO, Marley PS (2006). *In vitro* assay of some plant Extracts Against *Fusarium oxysporum f.sp. lycopersici, causal Agent of Tomato wilt*. J Plant Prot Res. 46:3.

Hanaa RMF, Abdou ZA, Salama DA, Ibrahim MAR, Sror HAM (2011) Effect of neem and willow aqueous extracts on *Fusarium* wilt disease in tomato seedlings:induction of antioxidant defensive enzymes. Ann Agric Sci. 58:1-7.

Song F, Goodman RM (2001) Molecular biology of disease resistance in rice. Physiology and Molecular Plant Pathology. 59:1-11

Nel B, Steinberg C, Labuschagne N, Viljoe A (2007). Evaluation of fungicides and and sterilants for potential application in the management of *Fusarium* wilt of banana. Crop Protection, 26:697-705.

Khan MR, Khan SM (2002). Effects of root-dip treatment with certain phosphate solublizing microorganisms on the fusarial wilt of tomato. Bioresourc Technol. 85:213-215.

Neshev G (2008). Alternatives to replace methyl bromide for soil-borne pest control in East and Central Europe. Labrada, R. 1-14.

Waiganjo MM, Wabule NM, Nyongesa D, Kibaki JM, Onyango I, Webukhulu SB, Muthoka NM (2006). Tomato production in Kiriyanga District, Kenya. A baseline survey report. KARI/IPM-CRSP Collaborative project.

Jeff G (2009). The Importance of Organic Matter in Soil Fertility and Crop Health. Organic Broadcaster. The Bi-monthly Periodical of the Midwest Organic Sustainable Education Service. 715-778.

Dishon MN (2012). Integrated Management of *Fusarium* Wilt of Tomatoes Using Fungicides, Organic Matter and Neem Extracts. MST-Plant Microb Sci. 1-18.

Foolad M R, Merk H L, Ashrafi H (2008). Genetics, genomics and breeding of late blight and early blight resistance in tomato. Critical Rev Plant Sci. 27(2):75-107

Hardham AR, Blackman LM (2010). Molecular cytology of Phytophthora-plant interactions. Australasian Plant Pathol. 39(1):29-35.

Gupta SK, Thind TS (2018). Disease problems in vegetable production. Scientific Publishers.