Review on Distribuction, Bilology and Management of Tomato Powdery Mildew (Oldium Nelycopersici)

Yirgalem Serawit Tadele Fanos
Jimma University College of Agriculture and Veterinary Medicine, P.O. Box 307, Jimma, Ethiopia

Abstract
Oidium neolycopersi is powdery white lesions found on leaves, petioles; the stem and the calyx characterize the causal agent of tomato powdery mildew. This disease severe infections lead to marked reductions in fruit size and quality, and to leaf mortality. Environmental conditions influence the different stages of the disease cycle. Severe disease outbreaks develop under moderate temperature and moderate relative humidity conditions (22-25ºC, 70-85% RH. Widespread leaf disease that affects several vegetable crops, in the field and in the greenhouse , but this pathogen affects numerous plants, especially solanaceous crops (pepper, eggplant, potato and tobacco) and weeds (nightshade). Infection begins when a conidium lands on the leaf surface and germinates forming a germ tube, a process which takes between three and nine hours to occur and is induced by contact with a hard surface. The smooth-surfaced germ tube elongates and locates a suitable penetration site, often at the intersection of three epidermal cells, and forms a lobed or 'clover-leaf' appressorium. Once completed, a haustorium is formed within the host cell, a lobed structure from which the pathogen takes up nutrients. Secondary hyphae emerge from the conidium and appressorium to produce further appressoria, resulting in rapid colonisation of the host. The cycle is complete when after a latent period of around five days conidia are produced on conidiophores positioned perpendicular to the leaf surfaceand are dispersed by wind. Oidium neolycopersici is a highly poly phagous powdery mildew fungus which infects tomatoes. It causes powdery white lesions on the adaxial tomato leaf surface. The fungus can also infect abaxial surfaces, petioles and the calyx but the fruit remains un infected. Severe infections lead to leaf chlorosis, premature senescence and a marked reduction in fruit size and quality. The disease may reduce the yields to 60-80% of the normal harvest and in general processing tomatoes are harvested much later and the harvest of processing tomatoes is more affected by powdery mildew. Fresh tomatoes are harvested earlier and it is possible to have high levels of infection in the field but no yield reduction. However, it is the fruit borer activity that has the major economic impact and the most dramatic damage is produced in the fruit itself, Fruits can be attacked as soon as they are formed and the galleries bored inside them can be invaded by secondary pathogens leading to fruit rot. Finally, an important additional problem is that the disease directly feeds on the growing tip, thereby halting plant development. Avoid high density stands, and promote air circulation through the canopy. Avoid high nitrogen rates. Scout regularly. Eliminate infected plants particularly in greenhouse production. The control was primarily through the use of chemical fungicides, although with some variability in efficacy. The need for more sustainable control methods has been recognized and a number of alternative control approaches have been investigated, including cultural and physical controls such as electrostatic spore precipitators, electrostatic discharge generators, climate management, sunflower oil and the addition of silicates to hydroponic systems.
Keywords: Tomato, powdery mildew and management

1. INTRODUCTION

A tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable in the world. According to FAOATAT (2012) tomato grows more than 175 countries around the world. World tomato production in 2012 was about 161.8 million tones of fresh fruit from an estimated 4.8 million ha. Tomato belongs to the family *Solanaceae* (also known as the nightshade family), genus *Lycopersicon*, subfamily *Solanoideae* and tribe *Solaneae* (Taylor, 1986). It was originated in the coastal highlands of Andean region that includes parts of Chile, Colombia, Ecuador, Bolivia and Peru (Sims, 1980). The Spanish introduced the tomato into Europe in the early 16th century (Harvey *et al*., 2002). European acceptance of the tomato as a cultivated crop and its inclusion in the cuisine were relatively slow. Tomatoes were initially grown only as ornamental plants: the fruits were considered to be poisonous, because of the closely related deadly nightshade (*Solanum dulcamara*). Since the mid-16th century tomatoes have been cultivated and consumed in southern Europe, though they only became widespread in north-western Europe by the end of the 18th century (Harvey *et al*., 2002).

Tomatoes contribute to a healthy, well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars and dietary fibers. Tomato contains much vitamin B and C, iron and phosphorus. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. Yellow tomatoes have higher vitamin A content than red tomatoes, but red tomatoes contain lycopene, an anti-oxidant that may contribute to protection against carcinogenic substances (Naika *et al*., 2005).Tomatoes are processed and preserves as whole peeled tomatoes, tomato juice, tomato pulp, tomato purée, tomato paste, pickled tomatoes); Canned and dried tomatoes as tomato powder, tomato flakes, dried tomato fruits); and tomato-based foods as tomato soup, tomato sauces, chilli sauce, ketchup) (Costa and Heuvelink, 2005).

Tomato is warm season vegetables, an annual or short lived perennial which can be grown under a wide range of climate and soil conditions. It can grow well on most mineral soils that have proper water holding capacity and aeration, and are free of salt (Kemble, 2000). But it prefers deep, well-drained, sandy loam, loam or clay loam soil with pH of 5.5-6.8. It is adapted to a wide range of climatic conditions from temperate to hot and humid tropical. The optimum temperature for most varieties lies between 21 and 27°C. The plants can survive a range of temperatures, but the plant tissues are damaged be-low 10 °C and above 38 °C (Naika *et al*., 2005). Even if direct seeding is possible as a means of production, Transplanting is the preferred method of production (Kemble, 2000). Seedlings are transplanted when they have three to four definitive leaves (Silva *et al*., 2008).

Powdery mildew (*Oidium neolycopersici)* is a disease of leaf tissue that occurs sporadically on Long Island, and elsewhere in the USA. It is potentially serious threat to both greenhouse and field production of tomatoes in the Northeast. It was first identified this new disease for Connecticut on greenhouse tomatoes from New Haven County in March 1995. The first occurrence on field tomatoes was identified in August 1996 in New Haven County Powdery mildew represents a new and potentially serious threat to both greenhouse and field production of tomatoes in the Northeast. *Oidium neolycopersi* is powdery white lesions found on leaves, petioles, the stem and the calyx characterize the causal agent of tomato powdery mildew .This disease. Severe infections lead to marked reductions in fruit size and quality, and to leaf mortality. Environmental conditions influence the different stages of the disease cycle. Severe disease outbreaks develop under moderate temperature and moderate relative humidity conditions (22-25ºC, 70-85% RH). Repeated applications of chemical fungicides are used to control TPM. There is great interest in alternative methods for controlling TPM, such as bio-control. Bio-control agents (BCA) can provide sufficient control, but they are sensitive to environmental conditions.

Powdery mildew is a widespread leaf disease that affects several vegetable crops, in the field and in the greenhouse (Bourbos *et al*., 1999; Matsuda *et al*., 2001).It also affects tomato, eggplant and cucumber crops. Tomato is the principal host of *O. neolycopersici*, but this pathogen affects numerous plants, especially solanaceous crops (pepper, eggplant, potato and tobacco) and weeds (nightshade).Therefore, the objective of this review is

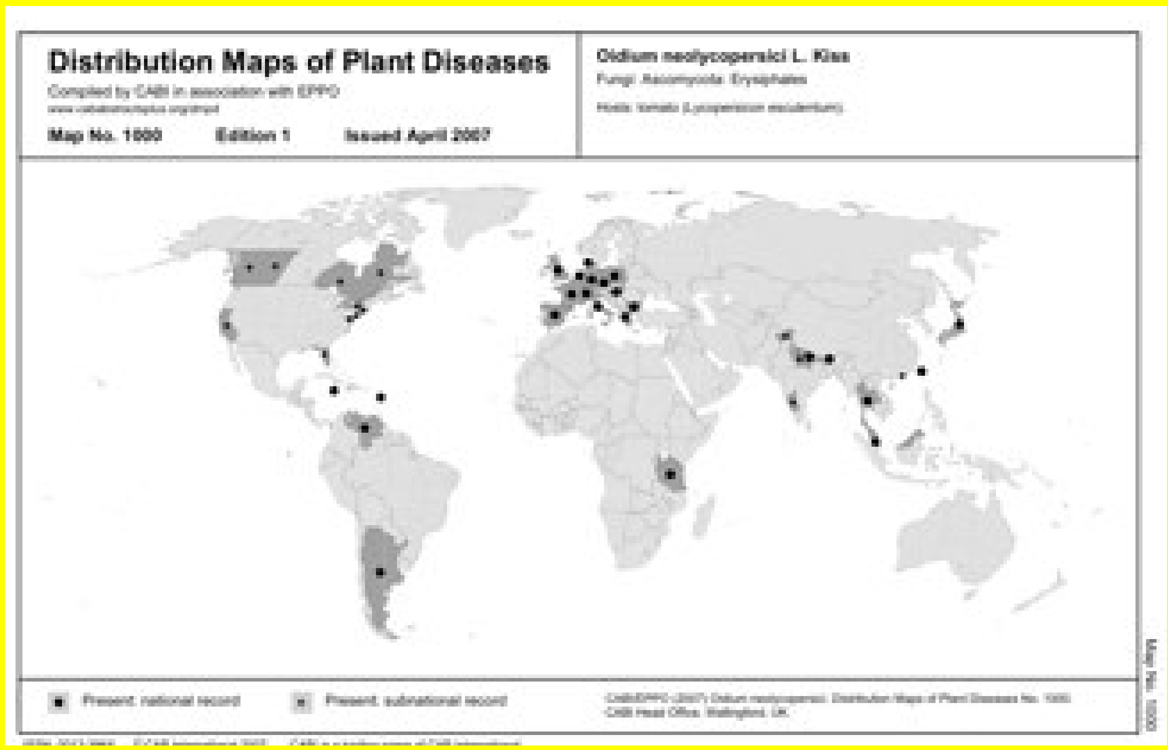
- To review the production status of tomato and the disease constraint on producing the crop and
- To review control measures regarding *O.necoloycopersici*

2. Origin and Distribution of Oidiun neoloycopersici

The origins of Oidium neolycopersici are still unclear. Huang et al (2000) proposed that O. neolycopersici may have jumped hosts by acquiring one or more pathogenicity factors but, as yet, there is no direct evidence to substantiate this suggestion. However, there are descriptions of resistance to Oidium neolycopersici identified in wild Lycopersicon species, including L. hisutum, L. pennelli and L. parviflorum (Ciccarese et al. , 1998; Kozik, 1993; Laterrot et al. , 1995; Lindhout et al. , 1994a,b; Mieslerova et al. , 2000; van der Beek et al. , 1994) which could indicate that the appearance of O. neolycopersici is not a recent phenomenon, but rather one that has just become more apparent. This is also implied from the identification of O. neolycopersici from herbarium specimens from Asia since 1947 (Kiss et al. 2001).

2.1.Taxonomy and distribution

O. neolycopersici is one of three pathogens that cause powdery mildew disease of tomato. the *O. neolycopersici* was distinguished morphologically and phylogenetically from the superficially similar *O. lycopersici* by Kiss *et al.* (2001). The latter species was shown to have smaller, cylindrical conidia that are produced in chains, be closely related to *O. longipes* (also a powdery mildew of the Solanaceae) and be confined to Australia. *O. neolycopersici* meanwhile, has doliform or ellipsoid-ovoid conidia that are produced singularly or in pseudo-chains at high humidities (Kiss *et al*., 2001) or low wind conditions (Oichi *et al*., 2006). It has a worldwide distribution (Whipps *et al*., 1998) and is considered economically more important than *O. lycopersici* (Jankovics *et al*., 2008). The differentiation of the two species means that prior to 2001 the majority of work was probably actually conducted on *O. neolycopersici* rather than *O. lycopersici*. *O. neolycopersici* infects more than 60 hosts, predominantly in the Solanaceae and Curcubitaceae (Jones *et al*., 2001; Kashimoto *et al*., 2003a; Jankovics *et al*., 2008) and it represents a particularly serious disease of tomato with almost all commercial cultivars susceptible (Jankovics *et al*., 2008). It has been widespread in Asia since at least 1947 .but only became a serious and rapidly spreading disease relatively recently (Jones *et al*., 2001). The earliest confirmed report of the pathogen outside of Asia is 1986 in the United Kingdom (Fletcher *et al*., 1988) and though earlier reports of a novel tomato powdery mildew in Europe and South America are known herbarium specimens are absent (Kiss *et al*., 2001). It has since spread to the rest of Europe, Russia, the Middle-East and North America (Arredonado *et al*., 1996;Jacob *et al*., 2008).



2.2.Biology/ life cycle

O. neolycopersici is not known to reproduce sexually (Jankovics *et al.*, 2008) and formation of the teleomorph has not been observed either naturally (Jones *et al.*,2001; Kiss *et al.*, 2001; Jankovics *et al.*, 2008) or experimentally (Kiss *et al.*, 2001). However, analysis of amplified fragment length polymorphism (AFLP) patterns from Japanese, European and North American isolates has revealed variability that suggest that either as yet unrevealed sexual reproduction or other genetic mechanisms are occurring (Jankovics *et al.*, 2008).

Infection begins when a conidium lands on the leaf surface and germinates forming a germ tube, a process which takes between three and nine hours to occur (Jones *et al.*, 2001; Kashimoto *et al.*, 2003a; Takikawa *et al.*, 2011) and is induced by contact with a hard surface (Takikawa *et al.*, 2011). The smooth-surfaced germ tube elongates and locates a suitable penetration site, often at the intersection of three epidermal cells, and forms a lobed or 'clover-leaf' appressorium (Jones *et al.*, 2001). This structure then forms a peg, which penetrates the cuticle and epidermal cell wall of the host, most probably through a combination of enzymatic and mechanical action (Jones *et al.*, 2001). Once completed, a haustorium is formed within the host cell, a lobed structure from which the pathogen takes up nutrients. Secondary hyphae emerge from the conidium and appressorium to produce further appressoria, resulting in rapid colonisation of the host (Jones *et al.*, 2001; Kashimoto *et al.*, 2003a). The cycle is complete when after a latent period of around five days (Oichi *et al.*, 2006; Jacob *et al.*, 2008) conidia are produced on conidiophores positioned perpendicular to the leaf surface (Fig. 1.1) and are dispersed by wind (Oichi *et al.*, 2006).

2.3. Hosts range

In 1988, Fletcher et al found that O. neolycopersici infected all the tomato varieties tested, in addition to aubergine, potato and tobacco. However, a more extensive host range study was carried out by Whipps et al (1998), who tested economically important plant species and also those purported to be hosts of E. orontii. Such work revealed that members of 13 families were alternative hosts for O. neolycopersici Furthermore, this work and morphological characteristics led Whipps et al (1998) to propose that O. neolycopersici was distinct from E. orontii However, not all workers agree on the exact host range of O. neolycopersici (Fletcher et al. 1988; Huanget al., 2000; Kiss, 1996; LaMondia, 1999; Mieslerova and Lebeda, 1999; Smithet al, 1997; Whippset al., 1998) perhaps suggesting that different pathotypes exist, further complicating the situation(Huanget al. , 2000; Lebeda and Mieslerová, 1999). Such disparity serves to highlight the limitations of identification of powdery mildews by host range alone. It calls for a combination of host-range work, molecular analyses and detailed morphological characterization prior to naming a given pathogen.

2.4. Disease symptoms

Oidium neolycopersici is a highly poly phagous powdery mildew fungus which infects tomatoes. It causes powdery white lesions on the adaxial tomato leaf surface. The fungus can also infect abaxial surfaces, petioles and the calyx but the fruit remains uninfected .Severe infections lead to leaf chlorosis, premature senescence and a marked reduction in fruit size and quality (Whipps et al. 1998). Infected leaves will turn first yellow, then brown and shrivel, remaining attached to the plant. The spots lack a distinctive margin, but become more noticeable as they develop a whitish-gray powder (conidia) on the opposite side of the lesions. Under severe infections, defoliation leads to lower yields and sun-scalding of exposed fruit.

Figure 4 Yellow spots, followed by brown lesions on top surface of a tomato leaf.

2.5.Economic impact/Damage

Agricultural **disease** can reduce yield, increase costs (related to their management), and lead to the use of fungicide which ultimately lead to the disruption of existing Integrated Pest Management (IPM) systems (Thomas 1999). Among species within the *Solanaceae*, tomatoes (*Lycopersicon esculentum* Miller) appear to be the minor host of *o.neolycopertsici* (Desneux *et al*.,2010). it can also feed, develop and reproduce on other cultivated Solanaceae such as egg plant (*Solanum melongena* L.), potato (*S. tuberosum* L.), sweet pepper (*S. muricatum* L.), and tobacco Nicotiana tabacum L. and weed(night shade), such as Solanaceae (*S.* nigrum L., S. eleagnifolium L., S. bonariense L., S. sisymbriifolium Lam., S. *saponaceum, Lycopersicum puberulum* Ph. etc.), Datura stramonium L., Datura ferox L., Lycium chinense Mill., and Malva sp. (EPPO 2009; Tropea Garzia 2009; Desneux *et al*. 2010).*O. neolycopersici* it is one of the tomato disease that causes reductions in fruit quality and size, and poses a significant threat to the greenhouse tomato industry (Jones *et al.*, 2001). Leaf and stem tissue of tomato are affected by the disease, resulting in reduced photosynthesis and chlorosis of underlying tissue. This leads to senescence and considerable defoliation when the plant is heavily mildewed, with the effect of reducing fruit size, quality and yield (Mieslerova *et al.*, 2004).

According to Agrios (1997) the disease may reduce the yields to 60-80% of the normal harvest. Field experiments from various sites in the United States shows a yield reduction 40%. In general processing tomatoes are harvested much later and the harvest of processing tomatoes is more affected by powdery mildew. Fresh tomatoes are harvested earlier and it is possible to have high levels of infection in the field but no yield reduction (Correll *et al.,* 1988; Jones *et al.,* 1997).

Figure 2 A heavy infestation of *O. neolycopersici* on *L. esculentum*. The white powder on the upper surface of the tomato branch is the pathogen's sporulating structures

However, it is the fruit borer activity that has the major economic impact and the most dramatic damage is produced in the fruit itself, Fruits can be attacked as soon as they are formed and the galleries bored inside them can be invaded by secondary pathogens leading to fruit rot. Finally, an important additional problem is that the disease directly feeds on the growing tip, thereby halting plant development (Flores *et al*., 2003)

2.6.Management

Plant healthy clean transplants reduce fungal inoculums by destroying crop debris between production cycles. Avoid high density stands, and promote air circulation through the canopy. Avoid high nitrogen rates. Scout regularly. Eliminate infected plants particularly in greenhouse production. The control was primarily through the use of chemical fungicides, although with some variability in efficacy (Mieslerova and Lebeda, 1999; Jones *et al.*, 2001). Following the emergence of fungicide resistant isolates (Matsuda *et al.*, 2005), considerable effort was then devoted to identifying resistance genes in tomato (Lindhout *et al.*, 1993; Mieslerova and Lebeda, 1999).which resulted in the successful release of resistant cultivars (Lindhout *et al.*, 1994;). The need for more sustainable control methods has been recognized (Jones *et al.*, 2001) and a number of alternative control approaches have been investigated, including cultural and physical controls such as electrostatic spore precipitators (Matsuda *et al.*, 2006; Shimizu *et al.*, 2007), electrostatic discharge generators (Nonomura *et al.*, 2008), climate management (Elad *et al.*, 2009), sunflower oil (Ko *et al.*, 2003) and the addition of silicates to hydroponic systems (Garibaldi *et al.*, 2011).

2.7.Biological control

Biological control approaches include the induction of host resistance through the application of noninfectious powdery mildews such as *Blumeria graminis* (Sameshima *et al.*, 2004), the application of Milsana®, an extract of the giant knotweed *Reynoutria sachalinensis* (Bardin *et al.*, 2008), the fungi *Paecilomyces farinosus* (Szentivanyi *et al.*, 2006), rhizobacteria (Silva *et al.*, 2004), a *Pseudomonas* bacteria (Agra *et al.*,2011) and a *Rhodotorula* yeast (Agra *et al.*, 2011). However, the efficacy of all these has been variable at best.

2.8.Chemical control

When O. neolycopersici appeared it spread rapidly around the world. All commercial tomato cultivars tested were found to be susceptible to O. neolycopersici (Lindhout et al. , 1994a, 1994b; van der Beek et al. , 1994), and initially, good control of the disease was only achieved by the use of fungicides. Effective active ingredients include benomyl, bitertanol, bupirimate, carbendazim, fenarimol, pyrazophos, thiabendazol, triforine and various sulphur preparations, although relative efficacy appears to vary (Mieslerova and Lebeda, 1999). Currently, in the UK, 'off-label' approval has been granted for the use of bupirimate (Nimrod, from Zeneca), fenarimol (Rubigan, from DowAgrosciences) and sulphur (Thiovit, from Novartis) (Whitehead, 2001). In addition, we found the quinoline fungicide Quinoxyfen (Fortress, from DowAgrosciences), which is known to prevent infection by other powdery mildews (Wheeler et al., 2000), showed high efficacy in the inhibition of both germination and differentiation of O. neolycopersici (Jones, 2001) but we have not undertaken extensive glasshouse tests of this compound.

Tabel -1 registered preparations against tomato powdery mildew in the Czech Republic

Preparation	Effective compound
Bioan	Lecitihin, albumin, milk cassein
Kumulus wg	Sulphur
Ortiva	Azoxystrobin
Score 250 ec	Difenoconazole
Talent	Myclobutanil
Topas 100 ec	Penconazole

2.9.Resistant cultivars

According to much research effort has focused on testing wild tomato species for their resistance to Oidium neolycopersici infection. Resistance at various levels has been found in Lycopersicon cheesmanii, L. chilense, L. chmielski L. hisutum, L. minutum, L. parviflorum, L. pennelli and L. peruvianum (Huang et al., 1998; Laterrot et al., 1995; Lindhout et al., 1994a; Mieslerova et al., 2000). These wild species are grouped into the peruvianum and esculentum complexes, according to whether they can be crossed easily with the commercial tomato, L. esculentum (Rick and Chetelat, 1995). The 'esculentum' complex comprises L. esculentum, L. cheesmanii, L. hirsutum, L. pimpinellifolium , L. parviflorum and L. pennelli, and these species form the main focus of disease resistance screening against O. neolycopersici, due to the relative ease with which they can be crossed with commercially grown tomato cultivars (Lebeda and Mieslerová, 1999; Mieslerova et al., 2000).

2.10. Integrated Pest Management

Integrated pest management is a broad-based approach that integrates practices for economic control of pests which aimed to suppress disease populations below the economic injury level (EIL). It is careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of disease populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.

3. SUMMERY

A tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable grows more than 175 countries around the world. It is warm season vegetables, an annual or short lived perennial which can be grown under a wide range of climate and soil conditions. World tomato production increases 108.25 million to 161.79 million tons during 2001- 2012. Similarly, in Ethiopia increases from 35407 to 81738 tons during 200- to 2011 but decreases to 55514 in 2012. Even though tomato production was increasing from time to time *powdery mildew* influences their productions vary greatly in the yield and quality of tomato. To control *powdery mildew* different methods are being practiced. Such as biological, chemical, using resistant variety and integrated managements. Among all these methods the using which is more convenient for the environment is using the resistant var and using biological method is the best option. Any option which does not progress friendly with environment cannot be accepted as option in every cultivation area but as scientific to overcome the effect of *powdery mildew* on tomato production we can use one of the following. One of the most effective preventative treatments is sulfur dusts and sprays, such as safer garden fungicide. But be sure to apply the sulfur product on a still day, when temperatures are well below 90º F. Apply in morning or evening, because sulfur can burn tomato plants in the direct sunlight. If you've applied oils to tomato plants, wait at least two weeks before using a sulfur product.

You can also treat tomato plants preventatively with a bio fungicide like serenade . Made up of specially-formulated microorganisms that destroy fungi, serenade can help prevent mildew from infecting tomato plants. Follow label instructions. Begin applications at the first sign of mildew. Horticultural oils or neem oil have helped reduce and sometimes eradicate powdery mildew on plants. In all cases, thoroughly cover plant with treatments. Repeat every 7-10 days or after rain.

Once mildew is present and progresses, it becomes more resistant to bio fungicide and fungicide. Tomato Dirt best advice: treat preventatively or, if powdery mildew appears, treat as consistently as possible. Powdery mildew thrives when nitrogen levels are high. Plant tomatoes more than 24 inches apart to let air to move among leaves and prevent the disease from spreading easily. In addition, stake tomato plants for better circulation. The fungus can spread easily among all kinds of plants. Wet leaves allow fungi to spread rapidly. Use drip hoses or other at-soil watering methods. Spikes in soil nitrogen encourage mildew, but systematic feeding maintains levels. Remove and destroys affected plants at the end of the season. While fungi don't overwinter in northern climates, it can proliferate in more moderate areas and in the greenhouse.

4. RESEARCH GAP

Even though the crop is consumed and cultivated almost in all our continent African, there is a little research findings to know further about the entire fungal disease to overcome the sever production effect of the disease in most of developing countries including our country, Ethiopia so a great work is expected from different researchers and stake holders including us regarding on finding the entire disease problems and overall tomato production problems.

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