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R Prasanna Lakshmi
Krishi Vigyan Kendra, Kalikiri, Chittoor DT Acharya N G Ranga Agricultural University, Guntur, Andhra Pradesh, India

P Ganesh Kumar
Krishi Vigyan Kendra, Kalikiri, Chittoor DT Acharya N G Ranga Agricultural University, Guntur, Andhra Pradesh, India

M Reddi Kumar
Krishi Vigyan Kendra, Kalikiri, Chittoor DT Acharya N G Ranga Agricultural University, Guntur, Andhra Pradesh, India

Correspondence
R Prasanna Lakshmi
Krishi Vigyan Kendra, Kalikiri, Chittoor DT Acharya N G Ranga Agricultural University, Guntur, Andhra Pradesh, India

Biotic constraints in tomato production in Chittoor district of Andhra Pradesh: A review

R Prasanna Lakshmi, P Ganesh Kumar and M Reddi Kumar

Abstract
Tomato is the major vegetable crop in Chittoor district of Andhra Pradesh. Apart from fluctuations in market price, biotic constraints like insects and diseases are major havoc to tomato production. Tomato is grown year round in the district hence pest occurrence is also high due to continuous availability of host crop. Insects like *Tuta absoluta*; diseases like early blight, late blight, Fusarium wilt and Peanut Bud Necrosis Disease are major threat to tomato production. Early blight appears year round; late blight during winter and Fusarium wilt & Peanut Bud Necrosis Disease incidence is high during summer. Pesticides are the first option to the farmers to control the pests and integrated pest management practices are gaining importance in recent times. Border cropping, usage of pheromone traps, sticky traps, azadirachtin are helpful to keep pests below economic threshold level. Growing of resistant varieties, crop rotation, irrigation management, biocontrol agents and timely usage of fungicides reduces fungal inoculum and therefore disease incidence also gets reduced.

Keywords: Tomato, biotic constraints, *Tuta absoluta*, late blight, fusarium wilt, peanut, bud necrosis disease

Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to Solanaceae family is native of Peruvian and Mexican region. It is second most important vegetable crop after potato. Tomato is regular kitchen component of Indian diet and grown for its edible fruit or cooked in the form of various processed products like juice, ketchup, sauce, pickle, pastes and powder. It is a major source of vitamin A and C (Bull, 1989) [9].

Tomato is the vegetable crop majorly grown in Chittoor district of Andhra Pradesh especially in western part of the district. Madanapalli revenue division is the horticultural hub of the district known for tomato, brinjal, mango, pomegranate, papaya, melons etc. It is grown in area of 20,000ha throughout the year. Majority of farmers grow private hybrids having oblate to round shape fruits.

As the crop is available throughout the year insects and diseases are the major constraints in tomato production causing severe yield losses to the tomato growers. Insects like *Tuta absoluta;* diseases like late blight, Fusarium wilt, viral diseases and early blight are the biotic constraints causing 25-30% yield losses to farmers despite of following adequate plant protection measures. (Prasanna lakshmi and Ganesh kumar, 2018) [39]. Most of the private hybrids adopted by farmers do not have resistance/tolerance to any of the diseases and farmers are spraying pesticides as and when pest/disease appears. Fluctuation in market price is another major problem facing by farmers where the price hovers around Rs. 1 to 60 per kilo of fresh produce. On the event of high price, farmers tend to spray heavily and in contrast, when the price falls down, crop is left in the field without following any plant protection measures and sometimes they even don't harvest the produce as they gain nothing. At this situation insects and diseases buildup rapidly because of availability of host crop and lack of protection measures and the inoculum remains in soil or on plant residues leads to severe incidence of pests during next season. Among insects *Tuta absoluta* is the major problem during *kharif* and *Rabi* whereas diseases like early blight appears year round; late blight incidence is severe during winter season and Fusarium wilt & peanut bud necrosis disease are problematic during summer.

South American Tomato leaf miner (*Tuta absoluta*)

Tuta absoluta is a Neotropical, oligophagous pest infesting solanaceous crops. The pest is of South American origin and it is one of the key pests of tomato since the 1960s in South

America. (Garcia and Espul, 1982) [18]. In India, the pest was first reported during October, 2014 infesting tomato fields in Maharashtra by Shashank *et al.*, 2015 [51]. Subsequently pest was recorded from Karnataka (Sridhar *et al.*, 2014) [56], Tamil Nadu (Shanmugam *et al.*, 2016) [49], Andhra Pradesh and Telangana (Anitha *et al.*, 2015) [4], Gujarat (Ballal *et al.*, 2016) [6], New Delhi (Shashank *et al.*, 2016) [52], Himachal Pradesh (Sharma and Gavkare, 2017) [50], Meghalaya (Sankarganesh *et al.*, 2017) [50], Punjab (Sandeep *et al.*, 2017) [49] and Madhya Pradesh (Swathi *et al.*, 2017) [59] causing severe damage to tomato in invaded areas in India. The primary host of *Tuta absoluta* is tomato, but it has been reported on other secondary hosts also belonging to solanaceous family like brinjal, potato and tobacco. In brinjal it was first reported in Kerala during 2015 by Kumar *et al.*, (2017) [30]. The pest has not been reported in China which is the largest tomato producing country worldwide (Xian *et al.* 2017 and Han *et al.* 2018) [69, 23].

Explosive spread and dissemination of the pest for a long distance could be through packaging materials from infested countries (EPPO, 2010) [16]. Adult is a moth with 5-7mm body length, having brown or silver with black spots on the narrow wings. Eggs are laid singly and the early larval instars are white or cream with a black head. As larvae grew older, they turned greenish to pink with a brown head. Larvae has got four instars and feed on leaves, stems, twigs and fruits. Feeding resulted in conspicuous mines and galleries on leaves and pinhead sized holes on fruits from the stalk end generally covered with the frass (Sridhar *et al.* 2014) [56]. It can cause substantial crop damages and yield losses reaching 100% on tomato crop growing under greenhouse and/or open-field conditions (Desneux *et al.* 2011 and Arturo *et al.*, 2012) [14, 5]. Adults and immature stages were simultaneously present during the entire cultivation period, which indicates the overlapping of generations because of long oviposition period of females (Nitin *et al.* 2017) [36].

The pest is more during *Kharif* and *Rabi* seasons and the damage was less during summer. In contradictory to this, Nitin *et al.* (2017) [36] recorded high infestation during summer and low during winter. Tomato is grown extensively during *kharif* and *Rabi* seasons in the district and continuous availability of host resulted in increased pest load but during summer tomato area reduces drastically due to lack of water and poor plant growth and subsequently pest incidence. The key mortality factor during summer–spring was predation. In addition, larvae predation is positively correlated with temperature, wind velocity, photoperiod. (Leandro Bacci *et al.* 2019) [29]. Since the initial detection, this Neotropical insect has reached economic pest status in most invaded areas around the world because of its high demographical potential, which is mainly due to a short generation time, a relatively wide host range, a good thermal adaptability and its tendency to develop insecticide resistance (Desneux *et al.* 2010, Tropea Garzia *et al.* 2012, Biondi *et al.* 2018) [13, 63, 8]. Factors including temperature, predation, parasitism, egg viability and entomopathogenic agents were proven to affect natural development and survival of this pest (Tonnag *et al.* 2015, Martins *et al.* 2016) [62, 31].

Currently farmers are adopting chemical means of management during fruiting stage because most of the farmers are unable to identify the pest feeding on leaves. After observing pin head size holes on fruits, then only going for spraying of insecticides. However, pesticides are only partially successful because of the general endophytic behaviour of the larval instars (Silva *et al.* 2011) [53]. Hence, integrated management of the pest should be initiated in the early growth period itself to avoid build-up of the pest in the later phenological cycle of the crop. (Nayana *et al.* 2018) [35]. Pheromone traps are working well in controlling the pest when installed at right time. Famers got acquaintance about usage of azadirachtin and its beneficial effects. Now it is being widely used by farmers to reduce the pest load.

Early blight Among fungal diseases, early blight caused by the pathogen *Alternaria solani*, is the most threatening one causing reduction in the quantity and quality of tomato fruit yield. (Gomaa, 2001 and Abada *et al.*, 2008) [19, 1]. Although the disease is called early blight but it can occur on the plant at all stages of development. (Sahu *et al.* 2013) [46]. the disease appears during all the seasons. High rainfall, high humidity and fairly high temperatures of 24-29^{0}C favours the disease spread (Peralta *et al.*, 2005) [38]. The disease starts as leaf spots with dark brown to black concentric rings which later coalesce and results in blighting of leaves; defoliation and shedding of leaves. Apart from the leaf symptoms *A. solani* causes other symptoms on tomato which are less economically important; including collar rot; stem lesions in the grown up plants and fruit rot (Chaerani *et al.* 2006) [10]. The production of melanin-like pigment on target host is one of distinguishing characters of *Alternaria solani* (Bell and Wheeler, 1986) [7].

The fruit is usually affected at the stem end. One or more firm, depressed rot spots appear on either the green or ripe fruit. The plants are more susceptible to infection by the disease during fruiting period (Momel and Pemezny, 2006) [32]. The disease severity was recorded up to 90% in Varanasi region by Pandey *et al.*, (2002) [37].

Application of fungicides is the most effective method of *Alternaria* blight control and fungicides like Dithane M-45, carbendazim, Dithane Z-78, CoC and Bordeaux mixture effectively manage the disease (Verma and Verma, 2010) [67]. New generation fungicides like strobilurins are broad spectrum and site specific and very effective in reducing the disease incidence (Sahu *et al.* 2013) [45]. Growing of resistant varieties reduces the cost of cultivation to the farmers. IIHR, Bangalore has developed resistant varieties like Arka Rakshak, Arka samrat and Arka Abhed and the area under these varieties is in increasing rate. Biocontrol agent *Trichoderma* sp. also controls the pathogen growth by producing extracellular enzymes, antifungal metabolites and antibiotics (Montealegre *et al.*, 2010) [33]. Resistant or tolerant tomato cultivars, biological and chemical control strategies against *A. solani* play a vital role in reducing yield losses and thus may increase the income of farmer (Sobia chohan *et al.* 2015) [55].

Late blight disease has historical significance as the cause of the Irish potato famine during 1840s. This famine resulted in the death of more than one million people. The disease is caused by the oomycete pathogen *Phytophthora infestans* (Mont.) de Bary, and it is the best known, longest studied and still among the most destructive of all plant diseases (Fry and Mizubuti 1998) [17]. The pathogen has a wider host range mainly includes solanaceous family crops. The pathogen attack leaves, petioles, stems, fruits and seeds of tomato (Irzhansky and Cohen 2006) [25].

Disease symptoms starts as brown irregular leaf lesions, which enlarge, shrivel and dry out. Under favorable conditions of moist weather, the underside of the lesions may be covered with a fine white moldy growth composed of

sporangiophores and sporangia. Then leaf completely dries up under severe incidence. On petioles and stems also brown lesions appear later turning into black and subsequently the whole plant may die. On fruits the disease appears as brown, greasy, irregular blotches and fruit become shriveled at later stages. The disease is more prevalent during winter season. During wet, cool weather, crop loss due to late blight can be rapid and nearly impossible to control if preventative measures are not used (Stone, 2014) [58]. The disease is spread by air-borne sporangia or by oospores harboring the soil and seed (Rubin and Cohen, 2004 and Govers, 2005) [44, 20].

More than 170 years have elapsed since *Phytophthora infestans* caused the Irish famine, but management strategies of late blight disease often remain unsustainable and costly. The pathogen continues to cost billions of dollars annually through yield losses in potato and tomato and increased plant protection measures (Duncan 1999 and Ristaino 2002) [15, 43]. Farmers mainly rely upon fungicide applications to control the disease. Fungicides like copper oxy chloride, *dimethomarph*, *cyamoxanil*, pyraclostrobin, propineb etc are being widely used but repeated use results in developing resistance against fungicides (Griffith *et al.*, 1992) [21]. Resistance against widely used fungicide dimethomorph, has been reported much earlier by Stein and Kirk 2004 [57]. Development of resistant cultivars following appropriate breeding methods is the only option. (Ray *et al.*, 2018) [41]. Cultural control practices like good sanitation, intercropping and providing plastic shelters also reduces disease incidence (Tumwine *et al.* 2005) [64]. Integration of biological control with fungicides, cultural practices, and other measures can contribute to manage late blight on tomato production systems (Valdir Lourenco Junior *et al.* 2006) [65].

Fusarium wilt Fusarium wilt disease in tomato is caused by a soil borne pathogen *Fusarium oxysporum* f. sp. *lycopersici*. It is known to occur at all stages of plant *i.e.* seedling to fruiting stage. The disease causes death of plants and in severe cases the damage goes up to 90% (Singh and Kamal 2012) [54]. Infection of pathogen originates from soil and the pathogen is known to persist in soil for many years. So, healthy plants, transplanted in pathogen infected soil leads to infected plants and subsequently wilting of plants occurs. (Ignjatov *et al.*, 2012) [24]. Continuous cultivation of tomato on same land also leads to increase in disease severity. Multiplication and spread of soil borne diseases especially Fusarium wilt is more when a specific crop is grown continuously (Charoenporn *et al.*, 2010) [11]. The disease is more severe during summer in the district. It requires soil temperature of around 25 to 31^{0}C for its growth and development. (Gupta and Thind, 2006) [22].The disease will be more in polyhouse where same crop is grown year round and soil temperatures are more inside than outside environment (Narender and Jitender Sharma. 2014) [34].

This pathogen invades through wounds on roots. Infected plants become stunted, chlorotic and wilt (Jones *et al.*, 1991) [26]. The first symptom of *Fusarium* wilt is golden yellowing of a single leaflet or shoot, or a slight wilting and drooping of the lower leaves on a single stem. (Madhavi *et al.*, 2006) [30]. Leaves or whole branches will turn yellow, then brown and die still attached to the plant described as a yellow-flagging appearance. (Alexander and Tucker, 1945) [3]. At advanced stage, browning of the vascular system can be seen and pathogen induces severe wilting of plants by blocking xylem vascular bundles and impending the movement of water (Decal *et al.*, 2000) [12]. Sometimes half of a leaf or branch will be affected, with the other half seemingly unaffected. The fungus can be observed as brown discoloration in the vascular tissue of affected branches (Agrios, 2005) [2].

Several management strategies are available to combat the disease e.g. cultural technique, biological control, resistant cultivars, crop rotation and chemical control (Kamal *et al.* 2009) [27]. Cultural practices like good drainage, biological control by using *Trichoderma viride* and drenching of fungicides are being adopted by the farmers. But, Crop rotation practice, which reduces the inoculum in soil, is not at all adopted by the farmers as they are growing tomato in same land year after year. Biological control plays a major role in reducing inoculums in soil. The combination of fluorescent *Pseudomonas, T. harzianum* and AMF provided significantly better control than uninoculated treatment, reducing disease incidence (Rashmi srivastava *et al.* 2010) [40]. Fungicides like copper oxy chloride 50%WP @3g or metalaxyl 8% + Mancozeb 64%WP @2g per lit of water are being used by farmers through drenching process as and when the disease appears in field.

Peanut Bud Necrosis Disease The disease is caused by Peanut bud necrosis virus and is known to cause economic losses to many commercial crops like groundnut, chilli, potato, tomato, tobacco and early maturing legumes such as blackgram and green gram. Though this virus is mechanically transmissible, it is also transmitted by the vector *Thrips palmi* in India. The losses due to this disease in tomato depend mainly on the level of infection, stage of the crop, thrips population and severity of the disease. Early stage of the crop, *i.e.* 15-20 days after transplanting and flowering stage is highly susceptible for the virus (Tamilnayagan *et al.* 2017) [60]. Until 1990, the disease in India was reported to be caused by Tomato spotted wilt virus, then it was found to be associated with a distinct tospovirus and named it as PbNvd (Reddy *et al.*, 1995) [42]. The disease incidence is more during summer crop *i.e.* crop planted from February onwards. The damage ranges from 10-60% when proper control measures are not followed. In tomato, the disease can be diagnosed by purple colour on leaves with necrotic rings or specks. Etching on petioles and stems is common. Plants are stunted. Fruits are malformed and have scars at or near the blossom end (Wongkaew. 1995) [68]. Reducing the thrips populations using appropriate insecticides helps to reduce the spread of virus. However, insecticides alone are of limited value, as virus spread from non-crop areas is an important source of infection and thrips require only limited feeding time for virus transmission. But repeated use of insecticides also leads to development of resistance in vector. Adoption of PBNV resistant variety/hybrid is one of the most practical and effective ways to combat with this deadly disease. But the work on development of PBNV resistant cultivars/hybrids is very scanty (Venkata Ramana *et al.* 2011) [66]. Management of vector with insecticides at early stage of crop reduces PBND incidence. Foliar spraying of Imidacloprid at 7th and 30th DAT; *Pseudomonas fluorescens (Pf-1)* (2%) + butter milk (0.3%) on 15, 30 and 45 DAT is also effective in controlling the disease (Thiribhuvanamala *et al.* 2013) [61]. Integrated management practices like border cropping with maize, use of sticky traps, seedling root dip with imidacloprid helps to reduce pest buildup and subsequently the disease incidence.

Conclusion

Tomato crop is infested by many number of pests and diseases from seedling to harvesting stage. Integrated management from seedling stage onwards is the only option

to reduce damage caused by the pests. Host plant resistance plays a major role in reducing disease incidence. By knowing the seasonal incidence of different pests and diseases, preventive measures can be taken up and timely management reduces usage of pesticides and there by cost of cultivation will also get reduced which in turn increases net returns to the farmers.

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