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PREVALENCE OF FUSARIUM WILT OF TOMATO IN MAJOR TOMATO GROWING AREAS OF PUNJAB, PAKISTAN

^aSalman Ahmad, ^aMaryam Yousaf, ^bRomana Anjum, ^aWaqas Raza, ^cMalik A. Rehman, ^dYasir Ali^a Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha, Pakistan.^b Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan,^c Citrus Research Institute, Sargodha, Pakistan.^d College of Agriculture, Bahauddin Zakariya University, Bahadur Sub-campus, Layyah, Pakistan.

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ABSTRACT

Tomato is an essential vegetable in the world due to its nutritional importance. It has vitamin A & C and lycopene, which reduce the prostate cancer, and heart and age-related diseases. Tomato wilt disease (TWD) is a potential threat and spreading rapidly in tomato fields in Pakistan. The survey on the disease prevalence of Fusarium wilt (*Fusarium oxysporum* f.sp. *lycopersici* (Fol)) of tomato was conducted in the major tomato growing areas of Punjab, viz., Hafizabad, Pakpattan, Khushab, Sargodha and Faisalabad districts during the cropping season 2018. Tomato wilt disease incidence was higher in district Sargodha (94%) followed by Faisalabad (92%) and Khushab (65%). Two districts, Pakpattan and Hafizabad showed 86% and 73% incidence, respectively. The survey revealed that tomato disease incidence was prevalent with varying intensities in all surveyed districts of Punjab. Moreover, the variation in disease prevalence of tomato wilt disease in different locations was due to the environmental conditions of that area and the varieties being cultivated.

Corresponding Author: Salman Ahmad

Email: salman.ahmad@uos.edu.pk

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a member of the family Solanaceae. It is originated from Peru, situated in South America. It is a precious horticultural crop for the market (Pritesh and Subramanian, 2011) and important due to its dietary components, which are contributing significantly to improve nutrition and health of both rural and urban populations (Waiganjo *et al.*, 2006). Tomatoes are grown in all conditions, but give the best production in warm conditions where optimum temperatures are 15-30 °C (Hanaa *et al.*, 2011). It is grown in both monsoon and winter Kharif and Rabi seasons (Nikhate, 2012). High humidity and temperatures reduce yields. While at the stage of ripening, temperature above 30 °C reduces the fruit yield.

Many factors can affect the yield and quality of tomato, among them; diseases play the most significant role (Pritesh and Subramanian, 2011). Commonly known diseases of tomato are early blight, anthracnose, bacterial wilt, bacterial canker, tomato spotted wilt, verticillium wilt and Fusarium wilt (Dodson *et al.*, 2002). Tomato wilt disease (TWD) mainly caused tomato plant wilting, therefore referred as wilt disease. It is very important disease, either in field or greenhouse-grown tomatoes worldwide (Abdel-Fattah and Al-Amri, 2012; Amini and Sidovich, 2010; Sheu and Wang, 2006). The disease reaches at maximum level in tomato fields when wet conditions prevail on the fruit at maturity stage. Fusarium causes 20-80% losses per year worldwide (Nikhate, 2012). Characteristic symptoms of TWD are

clearing of veins, leaves margins curling, leaves yellowing, stunting, development of adventitious roots, necrosis of blade of leaves, defoliation, and finally the whole plant died (Agrios, 1988; Srinivas *et al.*, 2019).

Disease assessment of plant diseases is not an easy method (Ajilogba and Babalola, 2013). Plant diseases are assessed on the basis of different symptoms produced by plants after infections and disease assessment is vital for estimating the yield losses caused by different plant diseases, development of disease simulating models and and organizing surveys are the best strategies for the estimation of yield losses caused by different fungal pathogens (Campbell and Neher, 1994; Ghuffar *et al.*, 2018). As per our best information, for the first time, the present study plans to record the prevalence of TWD in multiple districts of Punjab. During this study, comprehensive surveys were planned to generate large data set of incidence of tomato wilt disease (TWD). The surveys were conducted in major tomato growing areas of Punjab, viz., Hafizabad, Pakpattan, Sargodha, Khushab and Faisalabad, Pakistan, during the tomato cropping seasons of 2019-20.

MATERIALS AND METHODS

Surveys and collection of diseased samples

Surveys of most tomato wilt disease (TWD) affected districts of Province Punjab including Hafizabad, Pakpattan, Khushab, Sargodha and Faisalabad, Pakistan, was conducted in 2018 by using the GPS (GPS map76CSx, Garmin) tagging of these districts to determine the percent disease incidence (PDI) of TWD. The percent disease incidence of tomato wilt disease was determined by using following formula:

$$\text{Disease Incidence (\%)} = \frac{\text{No. of tomato wilted plants}}{\text{Total number of tomato plants}} \times 100$$

Data of percent disease incidence of TWD of each district was added in GPS and evaluated by ARCGIS and ARC View soft-wares to create the semi-variograms (Patel *et al.*, 2016). Samples were collected from diseased tomato plants with typical symptoms and were placed in polythene zipper bags separately, labeled properly and stored in an ice box prior to isolations (Table 1).

Tomato plants were grown in plastic pots having sterilized soil in greenhouse at 28 °C. Control of susceptible variety viz., Roma was also grown. Before inoculation, 2 to 3-week old plant roots were injured by repeatedly injecting a plastic peg into them. The

inoculum, 1×10^9 spores/mL at 2-mL per pot, was drenched into the soil and allowed to penetrate into the rhizosphere. After fifteen days, symptoms were appeared (Fernández-García *et al.*, 2012). Data was recorded every week according to the following disease assessment scale (Mir *et al.*, 2011) (Table 2).

Table 1. Districts of Punjab where symptomatic tomato plants were collected.

Districts of Punjab	Number of samples
Sargodha	50
Khushab	20
Pakpattan	60
Faisalabad	50
Hafizabad	30
Total	210

Table 2. Disease assessment scale used for tomato wilt disease (TWD).

Rating scale	Percent Severity
0	No symptoms
1	1-10% plant area infected
2	11-20% plant area infected
3	21-30% plant area infected
4	31-40% plant area infected
5	41-50% plant area infected
6	51-60% plant area infected
7	> 61% plant area infected

Source: Aslam *et al.* (2017)

Disease incidence (%) was calculated using following formula;

$$\text{Disease Incidence (\%)} = \frac{\text{No. of diseased plants}}{\text{Total plants}} \times 100$$

Statistical analysis

Disease incidence data was analyzed statistically using SAS (SAS Institute, NC, USA 1990). Analysis of variance (ANOVA) was used to test the main and interaction effects of the treatments. To check the effects of each treatment, means of each treatment were compared using LSD test at 5% level of significance (Steel *et al.*, 1996).

RESULTS

For the spatio-variation, the selected five districts of Punjab such as Sargodha, Faisalabad, Pakpattan, Hafizabad, and Khushab were highly affected with TWD. In surveys of five districts in Punjab, semi-variograms

were created that mapped disease incidence ratings as follows: green (0-20% severity), light green (21-40%), yellowish-green (41-60%), yellow (61-80%), orange red (81-90%) and red (91-100%). Faisalabad semi-variograms showed in Figure 1, Hifazabad semi-

variograms showed in Figure 3, Khushab semi-variograms showed in Figure 2, Sargodha semi-variograms showed in Figure 4 while Pakpattan semi-variograms showed in Figure 5.

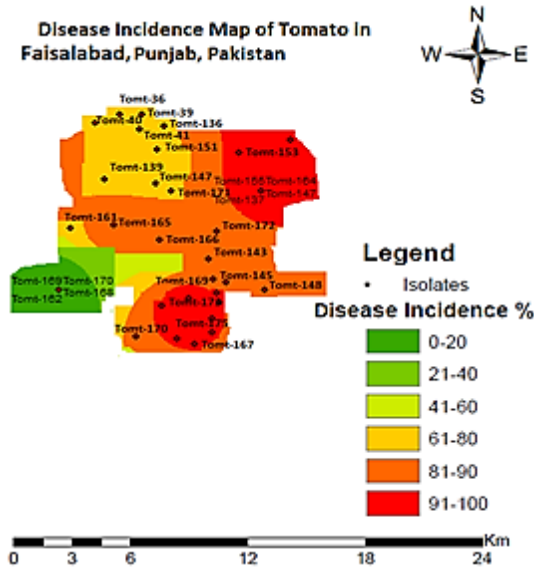


Figure 1. Map of incidence of tomato wilt caused by *Fol* in Faisalabad district.

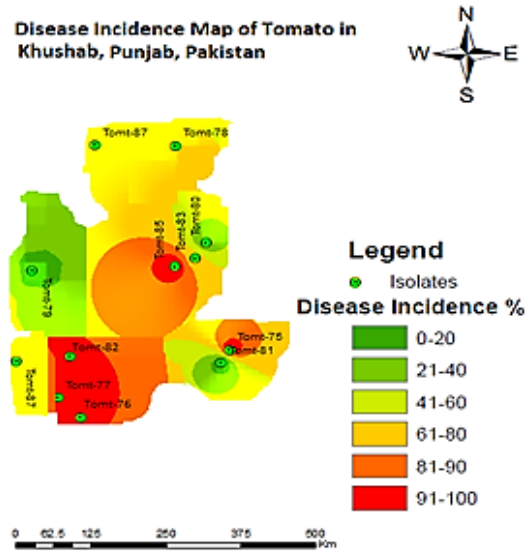


Figure 2. Map of incidence of tomato wilt caused by *Fol* in Khushab district.

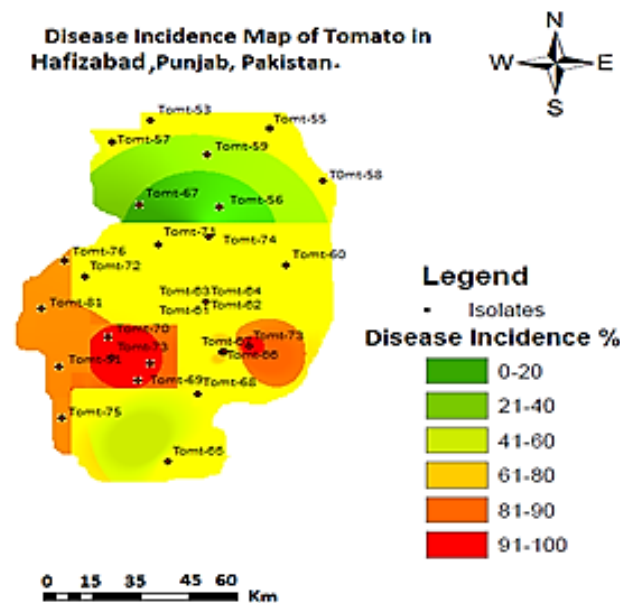


Figure 3. Map of incidence of tomato wilt caused by *Fol* in Hifazabad district

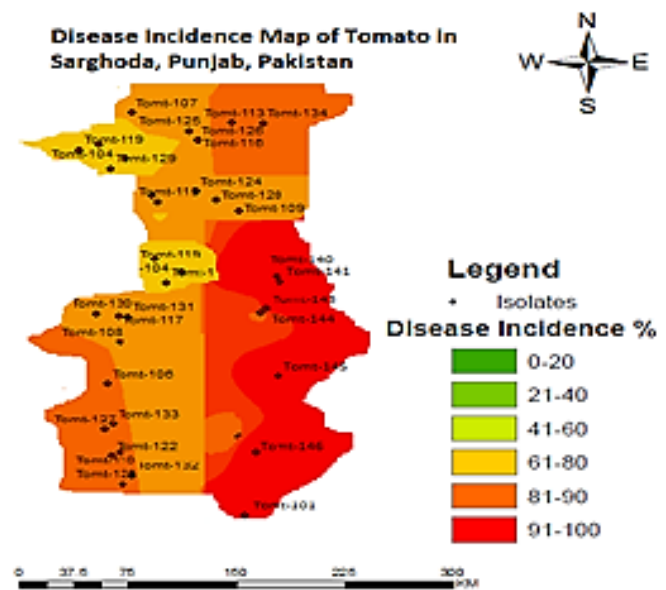


Figure 4. Map of incidence of tomato wilt caused by *Fol* in Sargodha district

Spatial variation within and among districts showed highest incidence in Sargodha 94% followed by Faisalabad 92%, Pakpattan 82%, Hafizabad 65% and Khushab 73%, respectively. On the bases of semi-

variograms, it was concluded that Sargodha and Faisalabad had the most severe outbreaks of *Fusarium* wilt (Figure 1-4).

DISCUSSION

For the effective management of crop diseases, their assessment is vital (Campbell and Neher, 1994). Meteorological variables suitable for TWD development are relative humidity, temperature, intervals of leaf wetness and precipitation. Temperature 17 to 22 °C with 90% relative humidity is considered most suitable for TWD (Modesto *et al.*, 2016).

TWD caused by soil-borne fungus *Fol* is a major cause of yield losses in warm-temperate to tropical latitudes worldwide (Dodson *et al.*, 2002). This disease causes wilting of the whole plant by entering from the roots and spreading via xylem fibers, blocking the movement of water (Cox *et al.*, 2019). In this study, a survey of tomato wilt on farms was conducted in different areas of Punjab including Sargodha, Faisalabad, Pakpattan, Hafizabad, and Khushab. This survey revealed that fields in Sargodha had 94% incidence of tomato wilt,

followed by Faisalabad (92%), Pakpattan (86%), Hafizabad (73%), and Khushab (65%). These results are in line with the findings of Heydari *et al.* (2007) and McGovern (2015). They reported 100% incidence of TWD in USA. Houterman *et al.* (2007) reported less prevalence of TWD on resistant cultivars, i.e., 0-29%, while 100% on susceptible cultivars in USA. Abdel-Fattah and Al-Amri (2012) reported 53-71% disease incidence while 47-78% disease severity of TWD in Egypt. Ishikawa *et al.* (2005) reported 50% disease severity in Japan, while Mandal *et al.* (2009) reported 40% TWD incidence in Japan in those fields where recommended foliar sprays of fungicides were applied. TWD is very notorious and has been reported in different countries even after the routine fungicidal applications, Iran 31-48%, Greece 45%, Thailand 80% and India 42% (Myresiotis *et al.*, 2012).

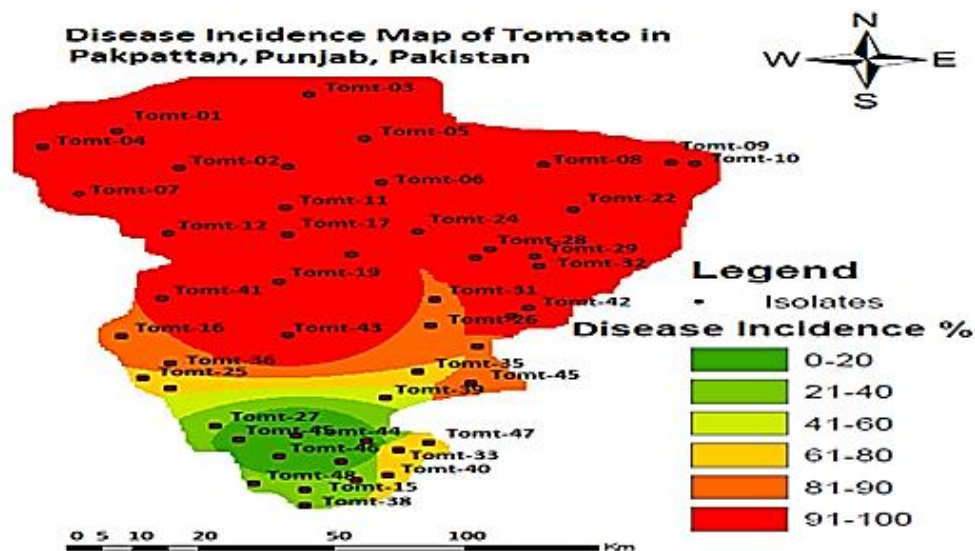


Figure 5. Map of incidence of tomato wilt caused by *Fol* in Pakpattan district.

The survey noted tomato wilt symptoms including yellowing of leaves, disappearance of veins from the leaves, stunting, curling of leaves, emergence of new adventitious roots, defoliation of leaves, drying of stem and roots, and finally plant collapses and becomes dead (Agrios, 1988). These symptoms have also been reported in previous investigation (Fassihiani, 2000). *Fol* has the ability to produce the same symptoms in other *Solanum* spp. including *S. pimpinellifolium* and *S. melogena* (Fassihiani, 2000). There are hosts which carry *Fol* but do not produce symptoms; includes

Chenopodium, *Amaranthus*, *Malva*, *Digitaria* and *Oryzopsis* spp. (Fassihiani, 2000). There are reports that legumes are very susceptible to *Fol* and show the same symptoms as observed on tomato (McGovern, 2015). Chlymadospores of *Fol* cause more severe symptoms in tomatoes than the macro- and micro conidia (McGovern, 2015). *Fusarium* spp. are versatile fungi that can survive on dead as well as living organic matter and persist in soil for years in the absence of host plants (Gordon, 2017). *Fusarium* spp. pervasive soil-borne pathogens that cause many diseases in horticulture and agronomic

crops, including rots, vascular wilts, and damping-off (Bodah, 2017). *Fol* is a soil-inhabiting fungus having phylogenetic diversity (Xiong and Zhan, 2018). Warm weather, applications of ammonium containing fertilizers and low pH of soil exacerbate the symptoms of TWD (McGovern, 2015).

Results from the current survey provided evidence of the prevalence and crop damage caused by tomato wilt in Punjab Province. This disease can undermine farm sustainability and rural livelihoods in Punjab, so it merits more intensive study in order to develop cost-effective ways to reduce economic losses.

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CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

AUTHORS CONTRIBUTIONS

Salman Ahmad and Romana Anjum supervised the research; Maryam Yousaf conducted research; Waqas Raza helped in manuscript drafting; Malik A. Rehman, Yasir Ali helped in analyzing the data.

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