Effects of Tomato Leaf Curl Virus on Growth and Yield Parameters of Tomato Crop

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Abstract

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Tomato is an important vegetable crop, belongs to the family Solanaceae and is the second most consumed vegetable following potatoes. The tomato crop is grown all over the world in both summer and winter seasons, and plant viruses are a major threat to tomato production. Among these viruses, tomato leaf curl virus (TLCV) causes considerable yield loss to tomato crop. This virus is transmitted by a whitefly (*Bemisia tabaci*) vector. In this study, the effect of TLCV infection, on the following tomato growth and yield parameters, was evaluated: plant leaf number and area, plant biomass, plant height, root length, and plant stem diameter and yield. Tomato plants were transplanted in well-prepared plots with 4 replications. The control group was covered with polyethene bag to avoid whitefly infestation. Plants were scored on the 15th and 30th day after inoculation and TLCV disease severity was recorded. Analysis of variance (ANOVA) showed the significant differences between the healthy and infected tomato plants. Moreover, growth and yield parameters were reduced with the increase in disease incidence, disease severity and whitefly infestation. Disease severity was increased with the increase in temperature during the growing season. It can be concluded from this study that TLCV significantly affects growth and yield of the tomato crop.
Keywords: Tomato, Tomato leaf curl virus, TLCV, disease incidence, disease severity.

Introduction

Tomato (*Lycopersicon esculentum*) belongs to family Solanaceae. It is a very important crop and can be grown in both summer and winter seasons. Tomatoes contribute towards a healthy diet by providing rich amount of minerals, essential amino acids, sugars and fibre (Gerhardt *et al.*, 2009). The optimum temperature range for the growth and flowering of tomato is 21-24ºC.

In Pakistan, tomato crop is grown on 48030 thousand hectares with an average yield of 9500 kg/hectare (Arooj *et al.*, 2019). Pakistan is far behind in tomato production in terms of yield/ha compared to India and China. Exports of Pakistani tomato is limited to Afghanistan due to low quality and sometimes it is imported from the neighbouring countries to meet the domestic need (Tahir *et al.*, 2012). In Pakistan the area under tomato cultivation is large but the factors behind the crop low quality and quantity are numerous including farmer economic conditions, farmer training, cultural practices and biotic factors. Among the biotic factors, viral diseases are also hindering the quality and quantity of tomato production (Hanssen *et al.*, 2010). Up to 70 different viruses were reported to affect the growth and yield of tomato crop globally (Thornberry, 1966). Tomato leaf curl disease is considered a severe hazard to tomato crop production (Hanssen *et al.*,2010). This composite of viruses in India, Pakistan and Australia region is known as Tomato leaf curl virus (TLCV) and in Europe and Middle East region it is called Tomato yellow leaf curl virus (TYLCV) (Pandey *et al.*, 2009). TLCV was initially reported in the 1980s in Sudan and is transmitted through whitefly (*Bemesia tabaci*) as a natural insect vector (Sugano *et al.*, 2011).

TLCV belongs to the genus *Begomovirus* (Fondong *et al.*, 2013) and transmitted by the whitefly *Bemisia tabaci* in a circulative (persistent) manner (Chen *et al.*, 2016). The disease is also transmitted by grafting to healthy tomato and other hosts (Arooj *et al.*,2019). Tomato leaf curl disease is reported to prevail in most tomato producing regions of the world (Li *et al.*, 2009). TLCV disease causes severe economic losses up to 100% in most tomato producing region of the world (Lefeuvre *et al.*, 2010). TLC disease symptoms of infected plants include stunting, wrinkling of leaves and yellowing between the veins, upward curling of leaf margins giving leaves a cup-shape appearance, with flower drop occurs before fruit setting (Burko *et al.*, 2013). The main objective of the present research was to investigate the effect of TLCV infection on growth and yield of tomato crop in relation to whitefly infestation in Pakistan.

Materials and Methods

The experiment was conducted in the College of Agriculture, University of Sargodha, Pakistan, during 2017/2018 growing season. Healthy tomato seeds of variety Nagina were

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obtained from the Department of Horticulture, College of Agriculture, University of Sargodha, Pakistan. Germination of seeds was tested by the wet towel method. Tomato seeds were surface disinfected by soaking them in 10% tri-sodium phosphate for 30 minutes. The 30-35 days old seedlings were transferred to the field.

Disease incidence and rating

Plants usually displayed symptoms 15 days after transplanting. Plants were randomly selected for data collection. Disease incidence data was scored every 15 days from 30 to 75 days after planting. Tomato leaf curl virus disease incidence (%) was calculated using the following formula (Allen *et al*., 1983):

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Tomato plants were rated based on a 0-5 scale to evaluate their field reaction to infection following the disease rating scale of Lapidot *et al.* (2001), which is as follows: 0= No infection (highly resistant), 1= 1-20% infection (resistant), 2= 21-40% infection (moderately resistant), 3= 41-60% infection (moderately susceptible), 4= 61-80% infection (susceptible), 5= 81-100% infection (highly susceptible).

***Bemisia tabaci* infestation**

The whitefly vector population increased with increased growth of the tomato plant. The data was recorded one week after planting and then at maximum virus infection level.

Growth and yield parameters assessment

Plant height - Five healthy as well as five diseased plants were randomly selected from each plot. Each plant was laid straight on the floor and their length was measured from the base to the tip of the plant. Average of tomato height was calculated by using the following formula:

$$\text{Average height} = \frac{\text{Height of all plants}}{\text{Number of plants}}$$

Yield per plant - Five healthy as well as five diseased plants were selected randomly from each plot. Tomato fruitswere collected from each plant and weighed. Average of tomato fruit/plant was calculated by using the following formula:

$$\text{Fruit yield/plant} = \frac{\text{Weight of all collected fruits}}{\text{Number of plants}}$$

Number of fruits - Five healthy as well as five diseased plants were randomly selected from each plot. Tomato fruits were collected from each plant and counted. The average number of tomato fruits/plant was calculated using the following formula:

$$\text{Number of fruits/plant} = \frac{\text{Total number of all collected fruits}}{\text{Number of plants}}$$

Experimental design and stastical analysis

The collected data was transferred to MS Excel. Disease incidence was calculated on MS Excel.

All the recorded data was statistically analyzed and possible interactions was determined through ANOVA and the treatment was compared by LSD test at 5% level of probability (Steel *et al*., 1997).

Results

The response of tomato germplasm to TLCV Infection

Disease incidence of three different planting dates was recorded 30, 45, 60 and 75 days after planting (Table1).The TLCV incidence at 30 days after tomato planting ranged from 8.32 to 25%. 45 days after planting, TLCV incidence ranged from 18.72 to 56.16%. 60 days after planting TLCV incidence ranged between 35.36 and 72.8%, whereas maximum disease incidence was observed 75days after planting (56.16-89.44 %). Early planting tended to slightly reduce TLCV incidence. This may be due to disease escape because of reduced vector activity.

Table 1. TLCV incidence (%) on Tomato crop during 2017/2018 growing season with three different planting dates.

	Days after planting			
Planting date	**30**	**45**	**60**	**75**
15 January	8.32 c	18.72 c	35.36 c	56.16 c
15 February	25.00 a	56.16 a	62.40 b	81.12 b
15 March	12.48 b	39.52 b	72.80 a	89.44 a

Values followed by the same letters in the same column are not significantly different at P=0.05.

The response of tomato plants to whiteflyinfestation and TLCV infection

The late tomato planting date of 15 March led to maximum TLCV incidence of 60.06%. The readings of disease incidence were obtained after the appearance of first symptoms. Earlier planting dates led to less TYLCV incidence (Table 2). This may be due to the cool temperature during the early season which is not in favor of vector activity.

Table 2. The overall response of tomato plants against TLCV infection and whitefly infestation.

Time of planting	**Number of whiteflies/ plant**	**Average Disease incidence (%) (Based upon weekly recorded data)**
15 January	36 c	29.64 c
15 February	41 b	51.92 b
15 March	50 a	60.06 a

Values followed by the same letters in the same column are not significantly different at P=0.05.

Effect of TLCV infection on tomato yield and growth parameters

Plant height (cm) - Maximum average of tomato plant height was obtained in the early January planted plots (60.32cm), and the lowest average height was obtained in the February planted plots (55.67cm) (Table 3).

Number of fruits/plant - The average number of fruits per plant ranged from 25.67 to 42 . The maximum number of fruits was recorded for the January planted plot (42 fruits/plant), followed by the February planting (32 fruits/plant). The minimum number of tomatoes fruits was obtained from the March planting (25.67 fruits/plant) (Table 3).

Fruits weight- Fruit size ranged from 29 to 43 g, with maximum size for the January planting (43g) followed by the February planting (31g), and the minimum fruit weight was recorded for the March planting date (29g) Table 3).

Tomato yield (kg/plant) -Tomato yield ranged from 3.47 to 2.01 kg/plant. The maximum yield was obtained for the January planting (3.47kg/plant) followed by the February planting (3.15kg/plant), and the minimum yield was recorded for the March planting date (2.06 kg/plant) (Table 3).

Table 3. Effect of TLCV infection on tomato yield and yield contributing parameters.

Planting date	Plant height (cm)	No. of fruits/ plant	Fruit weight (g)	Yield (kg/ plant)
15 January	60.32 a	42 a	43 a	3.47 a
15 February	55.67 c	31 b	31 b	3.15 b
15 March	57.89 b	25 c	29 c	2.01 c

Values followed by the same letters in the same column are not significantly different at P=0.05.

Relationship between TLCV incidence (%) and whitefly infestation - There was a strong positive correlation between the whitefly population and tomato leaf curl virus disease incidence (%) (R^2=0.8295).

Relationship between TLCV incidence(%) and yield - A moderately negative correlation existed between tomato yield (kg/plant) and tomato leaf curl virus disease incidence (%), with R^2 = 0.5483. Regression analysis was conducted using MS Excel 2013. R^2 value suggest that there was a poor correlation between the two variables.

Relationship between whitefly population and yield - A very strong negative correlation existed between tomato yield (kg/plant) and whitefly population, with R^2 = 0.9061(MS Excel 2013). In other words, low whitefly population contributed towards high tomato yield.

Relationship between TLCV incidence (%) and plant height - A strong negative correlation existed between tomato leaf curl virus disease incidence (%) and plant height, with R^2 = 0.8027 (MS Excel 2013).

Relationship between the whitefly population and plant height - There was a negative correlation between the whitefly population and plant height with R^2 = 0.723 (MS Excel 2013).

Discussion

In this study, tomato yield and and a number of growth parameters were affected by the different planting dates tested. Less TLCV infection was noticed in the early planting compared to the late planting. Earlier reports indicated that disease incidence was less when the crop was grown at low temperature, and disease incidence increased with a gradual increase in ambient temperature (Zeshan *et al*., 2016). TLCV symptoms were found mild in winter as compared to spring crop (Singh *et al*., 2015; Rashid *et al.*, 2008), and high temperature increases the whitefly vector population which ultimately increase the incidence of disease (Mubeen *et al.*, 2017). The current study confirmed that *Bemisia tabaci* population and TLCV incidence increased with increase in temperature. Munshi and Choudhry (1964) concluded earlier that disease severity significantly and positively correlated with temperature increase.

As Pakistan is a subtropical country, where high temperature prevails, there is a good chance for tomato to be infected with TLCV. In this study, there was a strong negative correlation between TLCV incidence and tomato yield, which is similar to what has been reported earlier (Mugit*et al.*,2007; Lapidot *et al.*, 1997). Plants infected with TLCV at the very early stage won't bear proper fruit and vegetative growth will be severly affected (Khan *et al.*,2013). The strong negative correlation exists between tomato yield and whitefly population. Kakati& Nath (2015) showed that plant raised under net did not exhibit any of TLCV symptoms as compared to uncovered plots, a strong indication that preventing the viruliferous whitefly vector from reaching young tomato plants, in any possible way, will lead to less infection and more yield.

الملخص

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تعد البندورة/الطماطم محصول خضر مهم، ينتمي للعائلة الباذنجانية ويأتي في المرتبة الثانية بعد البطاطا/البطاطس من بين أكثر الخضر استهلاكاً. تزرع البندورة في كل أنحاء العالم في موسمي الصيف والشتاء، وتشكل الفيروسات النباتية تهديداً رئيساً لإنتاج المحصول. ومن بين هذه الفيروسات، يسبب فيروس تجعد أوراق البندورة/الطماطم خسائر كبيرة للإنتاج. ينتقل هذا الفيروس بوساطة الذبابة البيضاء (*Bemisia tabaci*). تم في هذه الدراسة، تقويم تأثير الفيروس في معايير النمو والغلة التالية: عدد الأوراق ومساحتها، الكتلة الحيوية للنبات، ارتفاع النبات، طول الجذور وقطر ساق النبات والغلة. تم تشتيل البندورة في قطع أرض مهيئة جيداً وبأربعة مكررات. غطيت مجموعة الشاهد بأكياس من البوليثين لاجتناب الإصابة بالذبابة البيضاء. قومت النباتات بعد 15 و30 يوماً من الإلقاح وتم تسجيل شدة المرض. تم القيام بتحليل التباين (ANOVA) ووجدت فروقات معنوية ما بين نباتات البندورة السليمة والمصابة. وإضافة لما تقدم، انخفضت معايير النمو والغلة مع الزيادة في حدوث المرض، وشدته والإصابة بالذباب الأبيض. إزدادت شدة المرض مع ارتفاع درجة الحرارة خلال موسم النمو. يمكن الاستنتاج من هذه الدراسة أن فيروس تجعد أوراق البندورة/الطماطم يؤثر بشكل معنوي في نمو وغلة محصول البندورة.

كلمات مفتاحية: بندورة/طماطم، فيروس تجعد أوراق البندورة/الطماطم، TYLCV ، حدوث المرض، شدة المرض.

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