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ASSESSMENT OF YIELD LOSS DUE TO LEAF CURL VIRUS IN TOMATO

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ABSTRACT
An experiment was conducted to assess the yield loss in tomato due to tomato leaf curl virus disease in the Gangetic plains of West Bengal for two consecutive seasons (2012 and 2013). A linear regression equation was developed to find out the relation between the two components, diseases severity and yield loss and the prediction equation was developed. Results revealed that loss in yield was 0.65 to 0.69 t ha^{-1} for every 1% increase in disease severity in the experimental years respectively. In another experiment, evaluation of four promising tomato genotypes Patharkuchi (susceptible), BSS 575, Ajeet 11 and ARTH 2104 were evaluated both under protected and unprotected conditions. Highest disease severity recorded in unprotected condition than the protected. Highest yield observed in ARTH 2104 followed by Ajeet 11. Yield loss was highest in AJEET 11 followed by ARTH 2104 and BSS 575 and lowest yield loss was recorded in Patharkuchi though disease severity recorded maximum in it. So it may be concluded that ARTH 2104 would be the most promising genotype to be cultivated in the Indo-Gangetic region followed by Ajeet 11, provided proper prophylactic measure should be followed from the beginning to keep the crops away from the disease.

INTRODUCTION

Tomato (*Solanum lycopersicum L*) is one of the widely grown crops worldwide. It is consumed in various forms and has excellent nutritional values. In India it is one of the most important vegetable crops grown almost all the states. Total area under tomato in the world is 4.81 million ha with production of 163.02 million tons and with productivity of 33.9 tons per ha. In India it occupies an area of about 882000 ha with the production of 18735900 tones *i.e.* 21.2 tons per hectares. In West Bengal the crop is widely grown in every district during the rabi season. Every season its production is threatened by different biotic stresses including fungal, bacterial and viral agents. Tomato is susceptible to more than 200 diseases, out of which 40 are caused by viruses (Martelli and Quacquarelli 1982) and (Lukyanenko 1991). Among the different viral diseases, tomato leaf curl virus is most devastating one across the globe (Hanssen *et al.*, 2010) and known to cause even up to 100% yield loss if infection occurs at early stage. Survey conducted at different parts of India also prove its prevalence throughout the country. Sahu *et al*. (2013) reported the incidence percentage of tomato leaf curl virus ranging from 2.33-20.19. It is a whitefly transmitted Gemini virus containing ssDNA, belongs to the family Geminiviridae, genus Begomovirus and transmitted in a persistent circulative manner (Czosnek and Ghanim, 2002). This disease cause havoc damages worldwide, but no definite information regarding the actual yield loss of the disease is available. So, the hypothesis formulated before taking up the experiment was, information availability regarding the yield loss due to tomato leaf curl virus which would provide a knowledge regarding the threshold level of the disease. This will help the farmers as well as the scientists to develop proper management schedule and its time of application. Similar types of experiments were carried out for early blight of tomato by (Saha and Das, 2012) and for tikka disease of groundnut (Das *et al.*, 1995).

Tomato leaf curl disease is manifested by yellowing of leaves, upward leaf curling, bushy growth, leaf distortion, shrinking of leaf surface, stunted plant growth, excessive branching, abnormal growth of plants and flower and fruit abscission. Tomato fruits are symptomless, although they are sometimes smaller than usual; if infection occurs at an early growth stage, flower abortion can result in total yield loss (Pico *et al.*, 1996).Vasudeva and Sam Raj (1948) first described in detail the symptoms of tomato leaf curl virus (*ToLCV*) from India; subsequently, it had been reported from different parts of India by various scientists. In 2001, *ToLCV* was first reported from Gujarat by (Chakraborty *et al.*, 2003). Recently, *ToLCV* has become the prime limiting factor for tomato production but no definite information is available regarding actual loss due to this disease. Therefore, an attempt was made to assess the yield loss following two different methods direct and indirect.

MATERIALS AND METHODS

Experiment was conducted at the University Instructional Farm Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia under Gangetic plains of West Bengal during 2012-13 and 2013-14.

In indirect method of calculating yield loss of tomato, only the

local susceptible variety "Patharkuchi" was selected and planted during the rabi season in 5m X 5m plot, with 3 replication and 7 treatments. Design followed was RBD. The seven treatments comprising spray of imidacloprid (6 treatments) and one untreated control, with a view to create different level of disease severity and yield. To find out the relationship between these two, linear regression equation was developed. For calculating the yield loss standard Avoidable yield loss model was followed.

The computing yield loss was AYL = [(YP-YU)/YP] x 100 where YP = Yield under protected condition, YU = Yield under unprotected condition.

In direct method of yield loss experiment, four promising genotypes viz, Patharkuchi (susceptible), BSS 575 (susceptible), AJEET 11 (moderately susceptible) and ARTH 2104 (tolerant) were sown during rabi season in 5m x 5 m plots which were divided into two parts as protected and unprotected and laid out in a factorial design with three replications. One month old seedlings were transplanted in the replicated plots and usual agronomic practices were followed.

Treatments of protected plots were sprayed with imidacloprid @ 1ml per 5 lit of water starting from 15 days after transplanting and subsequently three more sprays at 15 days intervals were applied to keep the plot free from tomato leaf curl virus disease. The severity of the disease was measured on the basis of scale by Friedmann *et al,* 1998 and yield data were recorded from each plot and converted into (qha^{-1}). The yield was recorded by adding the quantity after each number of harvests. The disease severity was recorded as per the scale by (Mayee and Datar 1986).

PDI computing formula was

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaf observed x maximum rating}} \times 100$$

Yield loss was assessed following the same formula as stated above.

Tomato leaf curl virus is transmitted by the vector white fly (*Bemisia tabaci),* belonging to the order hemiptera. The number of white flies was counted by following the direct method, taking 5 plants from each replication at 15 days interval starting from 15 days after transplanting.

Yield data were recorded from each plot and converted into quintal per ha.

RESULTS AND DISCUSSION

The prediction equation developed to find out the correlation between the disease index and fruit yield and revealed a significant negative correlation between the variables and it was observed in both the experimental years and in pooled analysis. The equations are as follows:

Y = 68.41 – 0.652 D r = 0.908** (2012)

Y = 76.92 – 0.694 D r = 0.915** (2013)

Y = 70.09 – 0.678 D r = 0.948** (Pooled)

Thus in the year 2012-13 and 2013-14, the attainable yields were 68.41 tha^{-1} and 76.92 tha^{-1} respectively, but the yield decline by 0.65 tha^{-1} and 0.69 tha^{-1} respectively for every 1 unit increase in disease severity. The two years pooled mean also showed the similar trends. Here, the attainable yield calculated 70.09 tha^{-1} and yield loss were 0.68 tha^{-1}. Our result was in accordance to the results obtained by (Reddy *et al.* ,1988) and (Nagrajan, 1989) in blast of rice, (Saha and Das, 2012) in early blight of tomato.

Results presented in table 1 and table 2 revealed that disease severity was minimum in all the genotypes under protected condition. Maximum disease severity observed in Patharkuchi (49.41% and 45.61%) for the two consecutive experimental years under unprotected condition (Table 1 and 2). Disease

Table 1: Changes in yield of tomato on four different varieties in protected and unprotected condition for the year 2012-13

Variety	Disease severity Unprotected	Protected	Yield q ha-1 Unprotected	Protected	Yield loss %
V_1 (Patharkuchi)	49.41	15.15	476.60	699.90	27.91
V_2 (BSS 575)	37.71	9.73	432.50	691.20	36.99
V_3 (AJEET 11)	32.10	8.18	449.10	819.00	45.16
V_4 (ARTH 2104)	31.45	6.16	482.20	871.10	44.64
	SEm ±	CD(0.05)	SEm ±	CD(0.05)	
Type(unprotected/ protected)	0.879	4.796	0.412	2.760	
Variety	1.210	3.224	1.871	5.461	
Type x Variety	1.512	4.043	2.508	7.628	

Table 2: Changes in yield of tomato on four different varieties in protected and unprotected condition for the year 2013-14

Variety	Disease severity Unprotected	Protected	Yield q ha-1 Unprotected	Protected	Yield loss %
V_1 (Patharkuchi)	45.61	14.77	447.06	691.27	35.32
V_2 (BSS 575)	32.57	11.61	421.93	681.25	38.06
V_3 (AJEET 11)	31.19	22.70	419.00	748.78	78.71
V_4 (ARTH 2104)	29.19	4.73	454.71	789.19	42.38
	SEm ±	CD(0.05)	SEm ±	CD(0.05)	
Type(unprotected/ protected)	0.644	4.198	0.351	2.873	
Variety	1.980	3.281	1.667	5.831	
Type x Variety	1.645	4.728	2.074	7.011	

Table 3: Pooled analysis of disease severity and yield of tomato on four different varieties in protected and unprotected condition for the two consecutive years 2012-13 and 2013-14

Variety	Disease severity		Yield q ha-1		Yield loss %
	Unprotected	Protected	Unprotected	Protected	
V_1 (Patharkuchi)	47.51	14.96	461.83	695.58	33.61
V_2 (BSS 575)	35.14	10.67	427.21	686.22	37.74
V_3 (AJEET 11)	31.66	15.44	434.05	783.89	44.63
V_4 (ARTH 2104)	30.32	5.45	468.45	830.14	43.57
	SEm ±	CD(0.05)	SEm ±	CD(0.05)	
Type(unprotected/ protected)	0.587	2.276	0.471	1.657	
Variety	0.752	2.095	1.402	3.050	
Type x Variety	1.203	1.672	1.486	4.303	

pressure was significantly low in ARTH 2104 (6.61% and 4.73%) under protected condition in comparison to unprotected condition (31.45% and 29.19%) in the year 2012-13 and 2013-14 respectively. During 2012-13, the highest fruit yield under protected condition was obtained from ARTH 2104 871.00 q ha^{-1} followed by AJEET 11 (819.00 q ha^{-1}) and their difference was statistically significant.The minimum fruit yield q ha^{-1}) was recorded in BSS 575 (691.20 q ha^{-1}) that was statistically at par with Patharkuchi (699.90 qha^{-1}).Whereas, in unprotected condition maximum fruit was recorded in ARTH 2104 (482.20 q ha^{-1}) followed by Patharkuchi (476.60 q ha^{-1}) and their difference was not statistically significant. Result in the table 1 also indicated that highest yield loss in AJEET 11 (45.16%) followed by ARTH 2104 (44.64%) and minimum in Patharkuchi (27.91%) followed by BSS 575 (36.99%). All the tested varieties showed lowest fruit yield (q ha-1) in the unprotected plots in comparison to protected condition.

In the year 2013-14 (table 2) the highest fruit yield (q ha^{-1}) under protected condition was obtained in ARTH 2104 (789.19 q ha^{-1}) followed by AJEET 11 (748.78 q ha^{-1}) and the minimum fruit yield (q ha^{-1}) was recorded in BSS 575 (681.25 qha^{-1}) followed by Patharkuchi (691.27 q ha^{-1}) and their differences was not statistically significant. In this year the maximum yield losses was recorded in AJEET 11 (78.71%) followed by ARTH 2104 (42.38%), BSS 575 (38.06%) and Patharkuchi (35.32%).

The pooled analysis of data on disease severity and fruit yield (q ha^{-1}) of four genotypes were presented (Table 3) and the result revealed that that the average disease severity (in protected and unprotected conditions) ranged from 5.45 to 47.51.

Significantly highest disease severity was observed in Patharkuchi (PDI: 47.51) and followed by BSS 575 (PDI: 35.14) under unprotected condition and in protected condition lowest disease severity was recorded in ARTH 2104 (PDI: 5.45) followed by BSS 575 (PDI:10.67). Similar experiments were carried out on severity and yield loss were recorded by (Das *et al*. 1995) in tikka disease of groundnut and (Saha and Das 2012) in alternaria blight of tomato.

The prediction equation developed to establish the relationship between the disease severity and yield loss resulted there was a loss in 0.65 tha^{-1} and 0.69 t ha^{-1} for the two respective years due to 1% increase in disease severity, and two years pooled mean also revealed the same type i.e yield loss accounted 0.67 t ha^{-1} every 1% rise in disease severity.

The salient outcome from the experiment revealed minimum disease intensity leads maximum fruit yield and obviously under protected condition rather than the unprotected one. Among the genotypes tested, Patharkuchi showed the maximum disease prevalence but minimum yield loss. Though significantly low disease incidence was recorded in ARTH 2104 under protected plots but yield loss was highest in Ajeet11 followed by ARTH 2104. So, it can be concluded that ARTH 2104 could be the choice of the breeders for developing the new varieties best suited in the indo-gangetic plains of West Bengal. This interesting result may leads the scientists to think in different way about how the contrasting characters may merge genotypically to develop new varieties of tomato in near future.

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