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Original Research Paper

Tomato late blight yield loss assessment and risk aversion with resistant hybrid

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ABSTRACT

Late blight (*Phytophthora infestans*) is one of the devastating diseases of tomato worldwide. Field trial was carried out in *Kharif* 2019 and 2020 in Hesaraghatta, Bengaluru, Karnataka, India, to estimate yield loss due to late blight and to assess extent of protection in resistant genotype during late blight epiphytotics. Yield loss was calculated as per cent difference in yield between fungicides treated and unprotected plots in three F1 hybrids NS501, Arka Rakshak, both susceptible genotypes and Arka Abhed, a resistant genotype. Over two years, average yield loss due to late blight was 79.47 per cent in NS501, 75.53 per cent in Arka Rakshak and 12.84 per cent in Arka Abhed. With lower mean AUDPC values (147.22 in 2019 and 469.17 in 2020) and with low yield loss, Arka Abhed provided affordable protection against late blight. Our findings indicate late blight as an economically important peril to be considered for tomato yield loss coverage under insurance scheme in Bengaluru region. Arka Abhed hybrid can be cultivated to avert yield loss risk associated with late blight epiphytotics.

Keywords: Arka Abhed, resistance hybrid, tomato late blight and yield loss.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a widely cultivated vegetable crop in India. Karnataka is one of the major tomato producing states in the country. In 2017-18, Karnataka state accounted for 10.54 per cent of the total production of the country (NHB, 2021). Tomato production is limited by several biotic stresses. Among biotic stresses, late blight disease caused by *Phytophthora infestans* (Mont.) de Bary is a devastating disease on tomato in India and worldwide (Fry *et al*., 2015). Tomato late blight has emerged as a major production risk in tomato cultivation in southern hills and plains including Karnataka. Under severe epidemics, crop loss up to 100 per cent has been reported (Chowdappa *et al*., 2013).

In India, crop insurance scheme implies yield insurance. Tomato crop yield loss is covered under Pradhan Mantri Fasal Bima Yojana (PMFBY) and Restructured Weather Based Crop insurance Scheme (RWBCIS). Comprehensive risk insurance is provided to cover yield losses due to non-preventable risks, among other widespread pests and disease attack in standing crop from sowing to harvesting (Anon., 2021).

To consider tomato late blight disease as an important peril under insurance scheme, scientifically validated data on yield loss are required in a particular geography. Previously 100 per cent crop loss due to late blight in tomato due to A2-13 mating type of *Phytophthora infestans* in southern plains and hills has been reported as per rapid roving survey observation (Chowdappa *et al*., 2013; 2015). Currently there are no reports in India with data generated on yield loss assessment due to late blight based on crop cutting experiments. In this context, field trials were undertaken at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, India during *Kharif* 2019 and 2020, with two objectives *viz.*, i) to estimate the magnitude of tomato yield loss due to late blight disease ii) to assess resistant hybrid as risk management option against late blight epiphytotics.

MATERIALS AND METHODS

Estimation of yield loss

Two season field trials were undertaken in Hesaraghatta farm of ICAR-Indian Institute of Horticultural Research, Bengaluru (13.1362° N, 77.4980° E). The trials were conducted in *Kharif* (July-December) 2019 and 2020 under natural epiphytotics of late blight.

Field experiment was laid out in 2 factorial randomized complete block design. Factor 1 was tomato genotypes with three levels. The three tomato F1 hybrids were NS501, Arka Rakshak and Arka Abhed (H-397). The second factor was fungicide protection with two levels, i.e., with and without fungicide protection against late blight as treatments. Each treatment was replicated four times.

These three hybrids were selected as they have relatively different degree of resistance against major diseases of tomato, so that effect of other disease on yield loss estimation is minimal. Among three hybrids, hybrid NS 501 is tolerant to bacterial wilt and TLCV but susceptible to early and late blight. Arka Rakshak has resistance against leaf curl, bacterial wilt and moderate resistance against early blight, but it is susceptible to late blight. Arka Rakshak was chosen to minimize the effect of other diseases on yield loss, which might occur even with pesticide usage. The third hybrid chosen was Arka Abhed (H-397), which has disease resistance to tomato leaf curl disease (*Ty-2+Ty3*), bacterial wilt (Bwr.12), early blight and late blight (*Ph-2 + Ph-3*) and has field tolerance to bipartite *Tomato leaf curl New Delhi virus* (ToLCNDV) (Kaushal *et al*., 2020). Arka Abhed was included in the experiment, to test the relative efficacy of this hybrid to be adopted as a strategy against this disease risk to get assured yield in conditions of late blight epidemics.

Each plot measured 3m × 3m, with 20 plants were transplanted on raised beds and covered with reflective agriculture mulch film (30µ) at spacing 100 cm × 45 cm. Twenty-five-day old tomato seedlings at 3-4 leaf stage were transplanted on 21st July in both the years. The crop was raised with staking and drip irrigation. Fertilizer application and weed management were made as per package of practices of ICAR-Indian Institute of Horticultural Research, Bengaluru, for open field cultivation of tomato (Sadashiva *et al*., 2018).

Yield loss was calculated by subtracting yield from a plot protected with fungicides and one without fungicide protection. To protect tomato plants from late blight, a total of five sprays of dimethomorph 50% WP (1.2 g/L) + mancozeb 75%WP (2 g/L), fenamidone 10% + mancozeb 50% WG (3 g/L) and famoxadone 16.6% + cymoxanil 22.1% SC (1 ml/L), fosetyl Al 80 WP (80% w/w) (1 g/L), were sprayed at weekly interval until final harvest. All these fungicides have label claim for use on tomato in India (DPPQS, 2021). A control plot without any fungicide protection against late blight was maintained in each hybrid with four replications.

To exclude other pests additional sprays of following pesticides were given; Spinosad 45.00% SC (0.32 ml/L), indoxacarb 14.50% SC (1.34 ml/L), imidacloprid 17.80% SL(0.5 ml/L), azadirachtin 01.00% EC (10000 ppm)(3 ml/L), streptomycin sulphate 90% + tetracycline hydrochloride 10% SP (500ppm), neem Soap (10 g/L), to manage, bacterial leaf spot, South American tomato pinworm, fruit borer and sucking pests.

Fruit yield data from all the pickings from each plot was pooled and expressed as t ha^{-1}. At each harvest, observations on marketable and non-marketable fruits, incidence of late blight infection on fruits was recorded. In addition, ancillary observations on incidence of early blight, tomato GBNV, and infestation of South American tomato pin worm and tomato fruit borer on fruits were recorded. Yield loss was calculated as the difference between actual yields recorded in plots with fungicide protection and unprotected plots (Cooke *et al.,* 2006) using the formula,

$$Yield\ loss(\%) = ((Yp - Yup)/Yp) \times 100$$

Where *Yp*=yield recorded in protected plot, *Yup*=yield recorded in unprotected plot

Disease assessment

Late blight severity was assessed at weekly intervals from transplanting to final harvest on five randomly selected plants tagged in a plot. Severity on leaves was assessed by using 0-5 scale where, 0=no symptoms, 1=1 to 11% disease (midpoint 6%), 2=12 to 38% disease (midpoint 25%), 3=39 to 61% disease (midpoint 50%), 4=62 to 88% disease (midpoint 75%), 5=89 to 100% disease (midpoint 95%) (Seidl-Johnson *et al*., 2015). Per cent disease index (PDI) was calculated based using the formula,

$$\mathrm{PDI} = \frac{\text{Sum of all numerical disease rating}}{\text{Total number of observations} \times \text{Maximum disease grade}} \times 100$$

From multiple severity assessments made at periodical intervals, Area under disease progress curve for each variety was worked as per equation (Wilcoxson *et al.,* 1975).

$$A = \sum_{i-1}^{K} \frac{1}{2(Si + Si - 1)} \times d$$

Where, Si=disease severity at the end of week i, K = the number of successive evaluations of disease and d=interval between two evaluations.

Statistical Analysis: Disease severity index data was subjected to Arcsine transformation before calculating AUDPC values. The data were subjected to ANOVA at 5 per cent significance level by SPSS software. Yield loss and disease severity data were subjected to ANOVA for statistical significance among different treatments at significance level 5 per cent using SPSS software.

RESULTS AND DISCUSSION

Yield loss assessment

The results on marketable yield and yield loss in two years are presented in Table 1. Significant difference in yield was observed between varieties and level of protection. This may be attributed to inherent yielding potentials of the varieties and efficacy of plant protection schedule applied in both the years. Yield loss in *Kharif* 2019 was less compared to *Kharif* 2020. This may be attributed to higher disease incidence of late blight recorded in 2020 (Table 2).

Over two years, average yield loss due to late blight was 79.47 per cent in NS501, 75.53 per cent in Arka Rakshak and 12.84 per cent in Arka Abhed. In India, severe tomato late blight epidemics have been recorded during 2009-2010 in South Indian plains and hills by Chowdappa *et al.* (2013), during 2014 in eastern and northeastern India (NEI) by Dey *et al.* (2018) and during 2016 in eastern Uttar Pradesh by Tripathi *et al.* (2017). In all these reports there was no yield loss estimation except for reports from South India plains and Hills, where 100% crop loss is reported as per rapid roving survey observation. Our data establishes that late blight is an inevitable risk in *Kharif* cultivation of tomato causing considerable yield loss in Bengaluru region if resistant genotypes are not used. The yield loss data generated will pave way for inclusion of this peril under Pradhan Mantri Fasal Bima Yojana (PMFBY) of India for yield coverage.

Disease assessment

Data on disease severity on three varieties during 2019 and 2020 *Kharif* season are presented in Table 2. Data

Table 1 : Tomato late blight yield loss estimation in *Kharif* 2019 and 2020 at Hesaraghatta, Bengaluru

Treatment	*Kharif* 2019				*Kharif* 2020				Average yield loss (%)
	Marketable yield (t/ha)		Yield loss (%)	Mean (Variety)	Marketable yield (t/ha)		Yield loss (%)	Mean (Variety)	
	P*	UP			P	UP			
Arka Rakshak	70.94	19.98	71.92	45.46	61.47	12.82	79.14	37.15	75.53
NS-501	53.84	13.25	75.39	33.55	48.12	7.92	83.54	28.02	79.47
Arka Abedh	61.25	53.14	13.65	57.20	55.12	48.50	12.02	51.81	12.84
Mean (Protection)	62.01	28.79	-	-	54.90	23.08	-	-	-
Variety (pd≤0.05)	SeM = 1.87, CD = 5.63				SeM = 3.15, CD = 9.51				
Protection (pd≤0.05)	SeM = 1.52, CD = 4.60				SeM = 2.57, CD = 7.76				
Variety* protection (pd≤0.05)	SeM = 2.64, CD = 7.97				SeM = 4.46, CD = 13.45				
CV (%)	11.81				22.48				

*P=protected UP=Unprotected

Table 2 : Tomato late blight severity in *Kharif* 2019 and 2020 under fungicide protected and unprotected conditions

Treatment	*Kharif* 2019 Per cent disease index (PDI)			*Kharif* 2020 Per cent disease index (PDI)		
	P	UP	Mean (Variety)	P	UP	Mean (Variety)
Arka Rakshak	13.89 (21.88)	54.44 (47.55)	34.17 (34.72)	25.83 (30.55)	72.50 (58.37)	49.17 (44.46)
NS-501	18.33 (25.34)	61.11 (51.42)	39.72 (38.38)	27.50 (31.63)	74.17 (59.45)	50.84 (45.54)
Arka Abedh	8.34 (16.78)	12.22 (20.46)	10.28 (18.62)	6.67 (14.96)	17.50 (24.72)	12.09 (19.84)
Mean (Protection)	13.52 (21.33)	42.59 (39.81)	-	20.00 (25.71)	54.72 (47.51)	-
Variety (pd≤0.05)	SeM = 1.42, CD = 4.27			SeM = 1.29, CD = 3.89		
Protection (pd≤0.05)	SeM = 1.16, CD = 3.49			SeM = 1.05, CD = 3.17		
Variety*protection (pd≤0.05)	SeM = 2.01, CD = 6.04			SeM = 1.83, CD = 5.49		
CV (%)	13.12			9.95		

*Value in the parenthesis is arcsine transformed values of per cent disease index. First year peak severity data on September 12, second year peak severity on November 24. P=protected UP=Unprotected

analysis revealed significant effect of varieties and level of protection on severity of late blight. In 2019, significantly lower disease severity was recorded with variety Arka Abhed, which was statistically superior over Arka Rakshak and NS501, which were at par with respect to late blight severity. Similar trend was observed in 2020 except for higher disease severity recorded in second year. The higher incidence in second year may be attributed to build up of soil borne inoculums and prevailing favorable weather conditions. In susceptible varieties, late blight severity ranged from 54.44 to 74.17 over two years. In a trial on four years evaluation of integrated management packages for management of tomato diseases at Hesaraghatta, late blight was recorded as the predominant disease during 2015-18 *Kharif* season (Kumar *et al*., 2020). The current and previous works substantiate that Bengaluru region is a natural hot spot of tomato late blight disease.

In our experimentation, even with protective application of systemic fungicides at 7 days interval, late blight severity values in fungicide protected plots ranged from 8.34 to 18.33 in 2019 and 6.67 to 27.50 in 2020. This is due to prevailing continuous rains that might have reduced the bioefficacy of fungicides applied. This is in conformation with work of Rani *et al*. (2015) that simulated rainfall after spray reduced persistence and bioefficacy of fungicides *viz*., metalaxyl 8%+ mancozeb 64%WP, mancozeb 75%WP, which are widely used against late blight management in tomato. In *Kharif* tomato production, where weather events like continuous rains limits fungicide and protection against late blight. In such situations, Arka Abhed, a resistant F1 hybrid developed at ICAR-IIHR can be used as an effective component to get assured yield with reduction in input costs incurred on usage of protective and curative fungicides.

In two consecutive season's evaluation in Hesaraghatta under high disease pressure, the hybrid Arka Abhed had significantly recorded low AUDPC values (147.22 and 469.17 in 2019 and 2020 respectively) compared to higher AUDPC values of susceptible genotypes *viz*., Arka Rakshak (997.22, 2683.33) and NS501 (1096.68, 2655.83) which were at par with each other in Turkey's test at 5 per cent probability (Fig. 1).

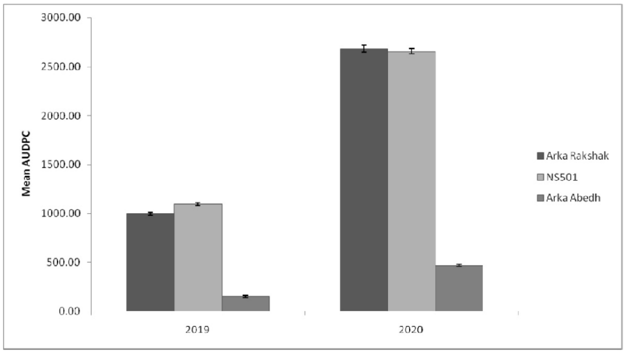

Fig. 1 : Area under disease progress curve (AUDPC) of tomato late blight in three varieties during 2019 and 2020 in unprotected plots under natural epiphytotics. AUDPC values were arrived from seven disease assessments in 2019 and six assessments in 2020.

Higher AUDPC values in 2020 can be attributed to higher late blight severity recorded in second year. Previous study by Hansen *et al*. (2014) suggests that tomato varieties possessing both *Ph-2* and *Ph-3* genes can be used to effectively manage late blight caused by *P. infestans* clonal lineage US-23. In our two years study we have found that Arka Abhed with *Ph-2* and *Ph-3* genes has provided affordable protection against the prevailing late blight population 13_A2 clonal lineage of *P. infestans* in Bengaluru location.

CONCLUSION

The current yield loss assessment validates late blight as a major production constraint causing considerable yield loss in *Kharif* cultivation of tomato in Bengaluru region. Hence, late blight disease has to be considered as an important peril and yield loss arising out of it has to be covered under national crop insurance programme. Based on disease prevalence data it is clear that Bengaluru area is hot spot for late blight disease. Tomato breeders and pathologist should evaluate their material in Bengaluru area for identification of resistant germplasm and testing field efficacy of management measures evolved against this disease. In consecutive two years, two season evaluation, we have found that Arka Abhed is a risk aversion technology with assured yield under late blight epiphytotics.

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