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Evaluation of fungicide application on late blight in popular potato cultivars of the north eastern Himalayan hills of India

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Potato late blight is one of the major constraints to potato cultivation in the north eastern hill region of India. Eight popular potato cultivars (Kufri Girdhari, Kufri Megha, Kufri Himsona, Kufri Himalini, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja) were evaluated for late blight disease progress and yield potential with or without the application of fungicide in the field. Blight appeared 103 days after planting (DAP) in Kufri Girdhari and 89 DAP in Kufri Megha in sprayed and unsprayed plots. Minimum terminal disease severity was recorded in Kufri Girdhari (6.5 and 7.5%) followed by Kufri Megha (22.5 and 35%), Kufri Himsona (62.5 and 70%) and Kufri Himalini (70 and 75%) in sprayed and unsprayed plots, respectively. Area under the disease progress curve was lowest on Kufri Girdhari (22.75 and 26.25) followed by Kufri Megha (253.75 and 402.5), Kufri Himalini (934.5 and 1333.5), Kufri Himsona (813.75 and 1162), Kufri Giriraj (1347.5 and 2082.5), Kufri Jyoti (1382.5 and 2117.5), Kufri Kanchan (1277.5 and 1951.25) and Kufri Shailja (1333.5 and 2073.75) in sprayed and unsprayed plots, respectively. There was no significant difference in areas under disease progress curves (AUDPCs) and yield of sprayed and unsprayed plots of Kufri Girdhari, whereas, significant differences (cultivar and spray) were recorded in Kufri Megha, Kufri Himalini and Kufri Himsona. The highest tuber yield was obtained in Kufri Girdhari (34.08 t/ha) and Kufri Himalini (33.48 t/ha). The study revealed that Kufri Girdhari gave highest yield with and without fungicidal applications.

Key words: Late blight, *Phytophthora infestans*, *Solanum tuberosum* disease severity, fungicidal spray, cultivars, yield.

INTRODUCTION

Potato is one of the most important vegetable crops grown in the North Eastern Hill (NEH) region of India, which is comprised of the states of Arunachal Pradesh, Mizoram, Nagaland, Manipur, Meghalaya, Tripura, Sikkim and Assam, and accounts for nearly 10% of the country's total potato area. The potato yield in all North

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Figure 1. Photograph showing symptoms of potato late blight of Kufri Jyoti cultivar in sprayed plots.

Eastern states except Tripura (17.8 t/ha) is fairly low (4.8 to 12.6 t/ha) as compared to the national average of 22.24 t/ha (NHB, 2012). One of the major constraints in attaining good yield is late blight disease in the mid- to high-hills. The entire NEH region is characterised by undulating topography, rain-fed cultivation and inadequate management practices (Sah et al., 2007). Late blight, caused by the oomycete pathogen *Phytophthora infestans* (Mont.) de Bary, is one of the most important diseases of potato. It occurs in epiphytotic proportions every year in the NEH region where, under favorable cool and moist conditions, the pathogen can cause considerable loss to the crop, making it almost impossible to achieve good yield in conventional potato production without the use of fungicides. In India, late blight appears in most of the potato growing regions in varying degrees, causing yield losses of up to 90% (Singh et al., 2003).

In general, late blight disease is managed by cultural practices, host resistance and the use of fungicides. However, the development of pathogen resistance to fungicides and the evolution of new strains of the pathogen have compounded the situation (Singh, 1996). The use of resistant cultivars is considered to be the most effective and environment-friendly strategy to manage late blight but commercially important characteristics, such as quality, yield, earliness, etc., are usually not combined with late blight resistance in the same cultivar (Cooke et al., 2011). Currently, the disease is generally managed by spraying fungicides at regular intervals, which adds to the cost of production and poses serious environmental hazards. In the NEH region of India, few resistant cultivars are available for cultivation. Also, new fungicides are rarely available in the NEH region and farmers often are reluctant to use them because of the cost involved. Late blight disease can be managed economically by planting resistant cultivars coupled with judicious, need-based application of effective fungicides. Therefore, the present study was undertaken to analyze the progress of late blight disease in popular potato cultivars recommended or being cultivated in the Meghalaya hills with and without the application of fungicides.

MATERIALS AND METHODS

The experiments were conducted at the Central Potato Research Station, Upper Shillong, Meghalaya, India (1800 m amsl, 25.54°N, 91.85°E) in the summer seasons (February-July) of 2012 and 2013 under rain fed conditions. Eight cultivars, namely Kufri Girdhari, Kufri Giriraj, Kufri Jyoti, Kufri Himalini, Kufri Himsona, Kufri Kanchan, Kufri Megha and Kufri Shailja, were planted on 25 February in both years in a randomized block design with three replications, each replication constituting of six rows of 2 m each at spacing of 60 cm between rows and 20 cm between plants (ridge and furrow method). The totally disease free seed potato (40-60 g) were taken for planting. Sixty whole seed potato tuber were planted in each plot. The potato crop was raised as per the standard recommended package of practices. Under protected conditions, a fungicide spray schedule comprising of 1st spray with mancozeb @ 0.2% at time of canopy closure or before disease appearance; 2nd spray with cymoxanil + mancozeb@ 0.3% and 3rd spray with mancozeb @ 0.2% at 7 days interval was followed whereas no fungicide was sprayed under unprotected condition. Disease severity was recorded based on percent foliage infection at seven days intervals after first appearance of late blight (Malcolmson, 1976). The area under disease progress curve (AUDPC) was calculated according to Shaner and Finney (1977) as follows:

$$AUDPC = \sum_{i=1}^{n} [(x_i + x_{i+1})/2](t_{i+1} - t_i)$$

Where, n = total number of observations; x_i = disease severity at the i^{th} observation; I = time (days) at i^{th} observations.

Data on late blight severity was used to compute area under disease progress curves (AUDPC). The average late blight severity at weekly interval, AUDPC and tuber yield (t/ha) were subjected to two factor analysis of variance (ANOVA) in order to determine effects of cutivar and fungicide applications on disease progression.

RESULTS AND DISCUSSION

Late blight disease (Figure 1) appeared 75 to 82 DAP (3rd to 4th week of May) in both years (Table 1). In hills of Meghalaya, the peak growth period of potato coincides with monsoon rains and mild temperature; resulting in the regular occurrence of late blight in epiphytotic proportions (Srivastava et al., 2012). Late blight disease appeared (1-5% blight severity) in Kufri Himalini, Kufri Himsona, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja at 75 DAP in the unsprayed crop, whereas, it was delayed by more than a week (15 DAP) in Kufri

Table 1. Average blight severity, AUDPC and tuber yield (t/ha) of potato cultivars under sprayed and un-sprayed conditions (pooled data of 2012 and 2013).

Cultivars	Crop age at first appearance of disease (days)	Average late blight severity (%) at 7 days interval starting at 75 DAP					AUDPC**	Tuber yield (t/ha)
		75	82	89	96	103 (TDS)*		
Unsprayed crop								
Kufri Girdhari	103	0	0	0	0	7.5	26.25	33.43
Kufri Megha	89	0	0	10	30	35	402.50	20.20
Kufri Himalini	75	1	25	57.5	70	75	1333.50	27.62
Kufri Himsona	75	1	15	50.5	65	70	1162.00	23.31
Kufri Giriraj	75	5	50	95	100	100	2082.50	22.75
Kufri Jyoti	75	5	55	95	100	100	2117.50	20.22
Kufri Kanchan	75	2.5	42.5	85	100	100	1951.25	18.91
Kufri Shailja	75	2.5	50	95	100	100	2073.75	17.15
Sprayed crop								
Kufri Girdhari	103	0	0	0	0	6.5	22.75	34.08
Kufri Megha	89	0	0	7.5	17.5	22.5	253.75	22.80
Kufri Himalini	82	0	1	42.5	55	70	934.50	33.48
Kufri Himsona	89	0	0	35	50	62.5	813.75	28.49
Kufri Giriraj	82	0	5	57.5	80	100	1347.50	27.97
Kufri Jyoti	82	0	5	60	82.5	100	1382.50	28.64
Kufri Kanchan	82	0	5	50	77.5	100	1277.50	22.98
Kufri Shailja	82	0	5	55	80.5	100	1333.50	20.79
CD (0.05)								
Cultivars		0.43	4.57	3.29	3.67	1.29	47.58	0.91
Spray		0.21	2.29	1.64	1.83	0.64	23.79	0.45
Cultivar x spray		0.61	6.47	4.65	5.19	1.82	67.29	1.29

*TDS = Terminal disease severity; **AUDPC = area under the disease progress curve.

Himsona and by less than a week in the other cultivars under fungicide protection. Based on AUDPC, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja would be considered highly susceptible to late blight and Kufri Himsona and Kufri Himalini would be considered moderately susceptible. As compared to the susceptible cultivars, the appearance of late blight in Kufri Megha was delayed by about one week in the sprayed plots and about two weeks in the unsprayed plots, and the appearance of late blight in Kufri Girdhari was delayed by about three weeks in the sprayed plots and about four weeks in the unsprayed plots. These results obtained indicate that the weekly application of fungicide resulted in a reduction of late blight progression (Table 1). Earlier workers studied that Singh et al. (2001) have reported that late blight can be managed effectively even on susceptible cultivars by a timely fungicidal spray schedule.

The percent rate of disease progression was highest in Kufri Jyoti, Kufri Giriraj, Kufri Kanchan, and Kufri Shailja in unsprayed as well as in sprayed conditions but lowest in Kufri Girdhari, Kufri Megha, Kufri Himsona and Kufri Himalini. Minimum terminal late blight severity (at five weeks after appearance of disease and 103 DAP) was recorded in Kufri Girdhari (6.5%) followed by Kufri Megha (22.5 %), Kufri Himsona (62.5 %) and Kufri Himalini (70 %) in sprayed crop while it was hundred percent on Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja under both conditions. Prevailing weather conditions are well known factors that influence the disease spread and development of disease on the foliage.

Area under the disease progress curve (AUDPC) was highest on Kufri Jyoti (2117.5) in unsprayed crop and lowest on Kufri Girdhari (22.75). AUDPC of sprayed crop was 253.75, 934.5, 813.75, 1347.5, 1382.5, 1277.5, 1333.5 in Kufri Megha, Kufri Himalini, Kufri Himsona, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja, respectively (Table 1) whereas overall AUDPC was highest in unsprayed as compared to sprayed crop. There were no significant differences in AUDPC and yield of Kufri Girdhari in sprayed and unsprayed but significant differences (cultivar and spray) were observed in terms of yield and AUDPC of Kufri Megha, Kufri Himalini, Kufri Himsona, Kufri Giriraj, Kufri Jyoti,

Table 2. Analysis of variance of the effect of fungicide sprayed and unsprayed on blight disease severity at weekly interval, AUDPC and yield (t/ha).

Source	d.f.	Mean sum of square due to						
		Disease Severity					AUDPC	Yield (t/ha)
		75 DAP	82 DAP	89 DAP	96 DAP	TDS# (103 DAP)		
Rep.	2	0.28	35.25	20.54	25.25	2.51	3005.25	1.26
Cultivars.	7	7.20**	1285.96**	6061.65**	7395.63**	7812.99**	2716907.81**	148.73**
Spray	1	70.33**	10785.01**	6063.76**	2133.33**	126.75**	2684038.55**	238.16**
Cultivar x spray	7	7.20**	758.89**	381.31**	49.79**	33.00**	127632.42**	8.04**
Error	32	0.13	15.04	7.78	9.68	1.20	1628.85	0.60

#Terminal disease severity; **significant at P = 0.01.

Kufri Kanchan and Kufri Shailja (Table 1).

Crop receiving alternative spray of mancozeb @ 0.2% followed by cymoxanil + mancozeb @ 0.3% and spray of mancozeb @ 0.2% responded significantly showing reduction in disease progress and increased yield under fungicidal protection. The highest total tuber yield was recorded in Kufri Girdhari (34.08 t/ha) followed by Kufri Himalini (33.48 t/ha) and Kufri Himsona (28.49 t/ha), in sprayed crop whereas Kufri Girdhari also gave highest yield (33.43 t/ha) significantly in unsprayed crop which indicated that fungicidal sprays have no impact on yield of Kufri Girdhari (Table 1). The tuber yield of 22.80 t/ha significantly obtained in Kufri Megha under protection. In the context of cultivar and spray interaction, tuber yield was significantly higher in Kufri Himalini followed by Kufri Himsona, Kufri Megha, Kufri Giriraj, Kufri Jyoti, Kufri Kanchan and Kufri Shailja. Although, terminal disease severity was hundred percent in Kufri Jyoti and Kufri Giriraj, both cultivars gave significantly higher yield (28.64 and 27.97 t/ha) under fungicidal protection. It may be due to short duration, varietal character and early bulking in addition to fungicide effect. Kufri Himalini, Kufri Himsona, Kufri Jyoti and Kufri Giriraj can also be grown with an effective spray schedule of three fungicidal applications. Overall, the results of the combined analysis of variance showed that the interaction of cultivars and spray was significant at P=0.01 (Table 2). Integrated approaches of late blight monitoring and effective fungicide application, resulted in significant increase in yield as compared to unsprayed crop. Still, farmers are growing local unhealthy seed and susceptible potato cultivars in the north eastern Himalayan hill region of India. Therefore, there are definite need of fungicide spray and stable high yielding resistant cultivars.

Conclusions

Late blight causes heavy yield losses in summer and autumn crops under rain fed conditions in the mid to high hills of Meghalaya. The study revealed that Kufri Girdhari gave highest yield without any fungicidal applications. Farmers can grow Kufri Girdhari without spray till the high degree of resistance persists. They can also grow cultivars *viz*. Kufri Himalini, Kufri Himsona, Kufri Jyoti and Kufri Giriraj successfully when accompanied by effective first spray of mancozeb @ 0.2% at the time of canopy closure or before the appearance of late blight, second spray of systemic fungicide (cymoxanil + mancozeb) @ 0.3% and third spray of mancozeb @ 0.2% fungicides.

Conflict of Interests

The authors have not declared any conflict of interests.

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