

## RESPONSE OF LOCAL POTATO CULTIVARS TO LATE BLIGHT DISEASE (*Phytophthora infestans* (Mont.) de Bary) UNDER FIELD CONDITIONS

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**Abstract.** Developing host resistance is an economic and long-term approach to disease management; however, resistance reactions that differ depending on the genotypes. Potato late blight is the devastating disease caused due to *Phytophthora infestans* (Mont.) de Bary. In order to identify late blight resistance in potato genotypes, seven local potato cultivars (Bardiya Rato Local, Bardiya Seto Local, Cardinal, Deukhuri Rato Local, Deukhuri Seto Local, Kailali Local and Khumal Ujjowal) were evaluated in randomized complete block design (RCBD) with three replications during October 2018 to January 2019 on naturally infested soils in Deukhuri, Dang, Nepal. Results showed that significantly the highest disease incidence (99.17%), and the highest disease severity (88%) were found on Cardinal followed by Deukhuri Rato Local (64%), and Deukhuri Seto Local (60%). Potato cultivar namely Khumal Ujjowal was moderately resistant, whereas Deukhuri Rato local and Deukhuri Seto Local were susceptible to late blight disease. Significantly the highest yield (12.67 t ha<sup>-1</sup>) was produced by Khumal Ujjowal followed by Bardiya Rato Local (10.78 t ha<sup>-1</sup>) and Bardiya Seto Local (9.40 t ha<sup>-1</sup>). The disease incidence and Area under disease progressive curve (AUDPC) value was negatively co-related with the tuber yield. The potato cultivar Khumal Ujjowal followed by Bardiya Rato Local were found moderately resistant to late blight disease in Deukhuri conditions. This study suggests that potato cultivar Bardiya Rato Local can be grown for higher tuber production in Dang and similar topographic regions.

**Keywords:** *Phytophthora infestans*, disease severity, disease incidence, local cultivars

### INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important vegetables and agronomic crops grown in Nepal. It ranks fourth important staple crop after rice, maize and wheat in Nepal (Gairhe et al., 2017). The crop is grown across the broad agro-ecological conditions from 100 m to 4000 m altitude (Dahal & Rijal, 2019). The productivity is quite low (14.7 t/ha) (MoALD, 2019) compared with other developed agricultural countries. Potato is also an important crop from a viewpoint of food security and even in increasing poverty

reduction measures. Among the various constraints including biotic and abiotic causes, Late blight caused by *Phytophthora infestans* (Mont.) de Bary. is one of the major (Hardy et al., 1995) cause of reducing yield in almost all potato growing area among the world. In Nepal, the disease was first reported between 1883 and 1897 and has become epidemic since the mid-1990s (Shrestha, 1976). It appears occasionally in the plains (Terai) rather it occurs in epidemic conditions in high hill every year (Shrestha et al., 1998). Sometime about 50-90% loss has been reported in the terai similarly more than

75% in the high hill (Shrestha, 2000). Potato varieties grown in Nepal have low levels of general resistance to late blight disease (André et al., 2014).

The genus *Phytophthora* derived from Greek words: Phyton = plant and Phthora = destroyer; and in case of *Phytophthora infestans* this name makes sense (Mizubuti et al., 2007). The pathogen seriously infects potatoes as well as tomatoes and some other members of the family Solanaceae (Agrios, 2005). Internal inoculum sources include infected seed tubers, infected volunteer plants and cull piles around the field which play major roles in late blight epidemics in temperate regions (Powelson et al., 2002). External inoculum sources include infected potato debris from previous seasons which contribute a major role in the disease epidemics in tropical and subtropical regions (Lima et al., 2009).

Mostly the commercial potato farmers rely on fungicide applications for control of late blight (Neupane et al., 2018). Fungicide treatments for the management are not economic and the frequent and haphazard use of fungicide creates for the emergence of new virulent races which may cause havoc in potato cultivation by the breakdown of resistance even in resistant cultivars (Shrestha et al., 2019). Moreover, the use of host resistance genotype can allow a significant reduction in fungicides application along with maintaining the yield and quality of the produce (Inglis et al., 1996). Low cost and effective management of late blight requires resistant varieties. Thus, host plant resistance is the most economical, effective, efficient, and safe

measure. The resistance level for each potato variety is to be screened and updated each year. Screening of the existing genotype is necessary to find out the resistant source of variety or genotype against late blight disease. So, the present study was undertaken to find out the late blight resistant potato cultivars for the efficient management of late blight disease of potato.

## **MATERIALS AND METHODS**

### **Experimental location**

The experiment was conducted in research plot of Prithu Technical College, IAAS, Dang which is located in Province 5, Lamahi Municipality, Ward No. 1, Dang, Nepal. The experimental site was situated at 410 km west from Kathmandu, the capital of Nepal and 7 km west from Lamahi. Geographically, it is located at 27.9904' N Latitude and 82.3018' E Longitudes at the elevation of 275m masl.

### **Climatic observation**

Experiment was conducted in winter season from October 29, 2018 to January 30, 2019. The site has winter type of climate and data of temperature ( $^{\circ}\text{C}$ ), relative humidity, solar intensity, wind velocity ( $\text{m s}^{-1}$ ) and total rainfall ( $\text{mm day}^{-1}$ ) were described below Table 1. The maximum temperature was recorded on 29<sup>th</sup> October and the minimum on 28<sup>th</sup> January. Similarly, relative humidity was highest on 28<sup>th</sup> January. The maximum rainfall was recorded during 28<sup>th</sup> January, as shown in Table 1.

**Table 1.** Weekly climatic data during experiments at Lamahi, Dang, Nepal, 2018/19

Week	maximum temperature (°C)	minimum temperature (°C)	relative humidity (%)	solar intensity (mJ m <sup>-2</sup> )	wind velocity (m s <sup>-1</sup> )	total rainfall (mm day <sup>-1</sup> )
1	28.42	17.32	51.27	29.33	1.29	0.06
2	26.07	15.34	55.81	27.8	1.29	0
3	25.62	14.41	55.03	28.11	1.67	0.19
4	24.84	13.98	53.18	27.02	1.26	0
5	25	14.87	54.94	27.8	1.14	0
6	23	12.71	53.76	25.96	1.22	0
7	22.55	11.48	47.66	25.99	1.32	0.03
8	21.94	10.21	44.72	24.75	1.18	0
9	20.49	8.65	40.12	23.05	1.4	0
10	21.25	9.26	42.1	24.97	1.39	1.09
11	21.04	9.76	49.44	25.68	1.38	1.83
12	22.48	10.08	40.4	25.39	1.4	0
13	21.25	11.11	58.67	28.58	1.5	28.86
14	20.48	7.62	47.04	24.23	1.67	0.02

*Week 1: 10/29/2018; Week 14: 1/30/2019*

**Table 2.** List of potato cultivars used in the experiment at Lamahi, Dang, Nepal, 2018/19

SN	Potato cultivars
1	Bardiya Seto Local
2	Bardiya Rato Local
3	Kailali Local
4	Deukhuri Seto Local
5	Deukhuri Rato Local
6	Khumal Ujjawal
7	Cardinal

### Experimental design, treatment and cultural practices

Seven potato varieties collected locally were tested in the experiment. The name of potato cultivars was given in Table 2. The experiment was conducted on randomized complete block design with 3 replications. Individual plot size was 7.2 m<sup>2</sup> (3 m × 2.4 m) and the total area of research field was 208.08 m<sup>2</sup> (20.4 m × 10.2 m). There were 4 rows in individual plot at 60 cm apart and each row consists of 12 plants. The spacing between treatment and replication was 60 cm.

Two manual weeding were done throughout the potato growing period. First weeding was done 20 days after sowing (DAS) and second on 45 DAS. Irrigations were done prior to sowing, 30 DAS and 45 DAS. Irrigation was applied on furrows. Water application was stopped 2 weeks prior to harvesting to enhance storage life. Earthing up was done to cover the tuber properly on 60 DAS. Plant nutrient in the form of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O @ 100:100:60 kg NPK ha<sup>-1</sup>, through urea, di-ammonium phosphate and murate of potash were applied

on the furrows and covered with soil just prior to planting. Sprouted potato seed tubers of approximately similar physiological age were planted at 5-6 cm depth in ridges.

### Scoring and data collection

Ten plants were randomly selected from the middle of the plot and were tagged for disease scoring. Data on disease scoring was recorded from all tagged plants in 0-5 scoring scale. AUDPC value, disease incidence and disease severity were recorded for determining disease infestation and total yield was also recorded for observing diseases impact in plant. From each experiment plot, total yield were taken from the net harvested area (7.2 m<sup>2</sup>) at the time of harvesting. Tubers were cleaned properly and each grading was weighed separately from each plot. The weight of tuber from each net plot was recorded. The data were then converted in tones per hectare (t ha<sup>-1</sup>). Percentage disease severity was then calculated using the following formula;

$$\text{Disease severity (\%)} = \frac{\text{Sum of all numerical rating} \times 100}{\text{Number of plants observed} \times \text{maximum rating scale}}$$

The area under the disease progress curve (AUDPC) was estimated using the following formula.

AUDPC value was estimated by Das *et al.* (1992)'s given formula

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left[ \left( \frac{Y_i + Y_{i+1}}{2} \right) \times (t_{i+1} - t_i) \right]$$

where,

Y<sub>i</sub>= late blight disease severity % on the i<sup>th</sup> date

t<sub>i</sub>= date from sowing up to date of disease scored

n= numbers of dates on which disease was scored

Harvesting was done manually after taking all the data on 20<sup>th</sup> January 2019. From each experiment plot, total yield was recorded from the net harvested area (7.2 m<sup>2</sup>). Tubers were cleaned properly and each grading was weighed separately from each plot.

### Statistical analysis

Data were collected and analyzed by analysis of variance (ANOVA). Means were compared by the least significance difference (LSD) at 5% levels of significance (Gomez & Gomez, 1984; J. Shrestha, 2019). Statistical software used for data analysis was Microsoft Excel 2010 and R version.

## RESULTS AND DISCUSSION

### Disease incidence and severity

There was highly significant difference in disease incidence on different cultivars. Significantly highest disease incidence was found on Cardinal (99.17%) followed by Deukhuri Rato Local (63.83%) and Bardiya Seto Local (55.67%). Significantly the lowest disease incidence was recorded in Khumal Ujjowal (39.67%) followed by Kailali Local (51.50%) and Bardiya Rato Local (53.33%). Similarly, significantly the highest disease severity was found on Cardinal (88%) followed by Deukhuri Rato Local (64%) and Deukhuri Seto Local (60%) Khumal Ujjowal had significantly the lowest severity (21.33 %) followed by Bardiya Rato Local (44%).

### Area under disease progressive curve (AUDPC)

Potato cultivars on 63, 68, 73 and 78 day after planting (DAP) differed highly significantly in AUDPC value and increased with time. On 63 DAP Cardinal showed the highest AUDPC value (247) and followed by Deukhuri Rato Local (160) and Bardiya Seto Local (153). The least was in Khumal Ujjowal (57)(Table 5). On 68 DAP, Cardinal showed the highest AUDPC value (287) and followed

by Bardiya Seto Local (173) and Deukhuri Rato Local (170). The least was in Khumal Ujowal (67) (Table 5). On 73 DAP, Cardinal showed the highest AUDPC value (333) followed by Kailali Local (199) and Deukhuri Rato Local (197). The least was in Khumal Ujowal (87) (Table 5). On 78 DAP, Cardinal showed the highest AUDPC value

(400) followed by Deukhuri Rato Local (270) and Deukhuri Seto Local (250). The least was in Khumal Ujjowal (103) (Table 5). The mean AUDPC value was recorded the highest in Cardinal (317) followed by Deukhuri Rato Local (199), Deukhuri Seto Local (183) and Bardiya Seto local (183). The least was in Khumal Ujjowal (78 ) (Table 5).

**Table 3.** Disease incidence of different potato cultivars at Lamahi, Dang, Nepal, 2018/19.

Cultivars	Days of first diseases appearance	Disease Incidence (%)
Bardiya Rato Local	41	53.33
Bardiya Seto Local	41.67	55.67
Cardinal	41.67	99.17
Deukhuri Rato Local	41.33	63.83
Deukhuri Seto Local	41	55.83
Kailali Local	42	51.50
Khumal Ujjowal	42	39.67
Mean	41.52	59.86
LSD (0.05)	1.278	3.721
CV (%)	1.7	3.5
P value	0.444	<.001

*LSD=Least significant difference at 0.05 level, CV= Coefficient of variation (%).*

**Table 4.** Maximum disease severity and severity response of potato cultivars at Lamahi, Dang, Nepal, 2018/19

Potato cultivars	Disease severity (%) (78 DAP)	Reaction
Bardiya Rato Local	44	MS
Bardiya Seto Local	48	MS
Cardinal	88	HS
Deukhuri Rato Local	64	S
Deukhuri Seto Local	60	S
Kailali Local	54.7	MS
Khumal Ujowal	21.3	MR
Mean	54.3	
LSD(0.05)	22.03	
CV (%)	22.8	
P value	<.001	

*LSD=Least significant difference at 0.05 level, CV= Coefficient of variation (%).*

**Table 5.** AUDPC values at different days after planting at Lamahi, Dang, Nepal, 2018/19

Potato cultivars	63DAP	68DAP	73DAP	78DAP	Mean AUDPC
Bardiya Seto Local	153	173	193	213	183
Bardiya Rato Local	110	143	177	217	162
Cardinal	247	287	333	400	317
Deukhuri Rato Local	160	170	197	270	199
Deukhuri Seto Local	130	163	190	250	183
Kailali Local	130	153	199	247	182
Khumal Ujowal	57	67	87	103	78
Mean	141	165	196	243	186
CV (%)	35.5	29.1	25.2	24	26.6
LSD(0.05)	89.1	85.6	90.2	103.6	88
P value	0.02	0.006	0.004	0.002	0.004

LSD=Least significant difference at 0.05 level, CV= Coefficient of variation (%).

### Tuber yield

The potato cultivars varied highly significantly ( $p \leq 0.01$ ) on tuber yield and it ranged from 3.40 t ha<sup>-1</sup> to 12.67 t ha<sup>-1</sup> (Table 6). Significantly the highest tuber yield was found on Khumal Ujjowal (12.67 t ha<sup>-1</sup>)

followed Bardiya Rato Local (10.78 t ha<sup>-1</sup>) and Bardiya Seto Local (9.40 t ha<sup>-1</sup>), while, the lowest tuber yield was recorded in Deukhuri Rato Local (3.40 t ha<sup>-1</sup>) followed by Deukhuri Seto Local (4.75 t ha<sup>-1</sup>) and Kailali Local (7.45 t ha<sup>-1</sup>).

**Table 6.** Tuber yield and biomass (vine mass) yield of potato cultivars at Lamahi, Dang, Nepal, 2018/19

Cultivars	Biomass (t ha <sup>-1</sup> )	Tuber yield (t ha <sup>-1</sup> )
Bardiya Rato Local	3.32c	10.78e
Bardiya Seto Local	3.16c	9.40d
Cardinal	0.61a	7.69c
Deukhuri Rato Local	1.95b	3.40a
Deukhuri Seto Local	1.87b	4.75b
Kailali Local	3.41c	7.45c
Khumal Ujowal	3.82c	12.67f
Mean	2.59	8.035
LSD (0.05)	1.135	0.463
CV (%)	24.6	3.23.2
P value	<.001	<.001

LSD=Least significant difference at 0.05 level, CV= Coefficient of variation (%).

### Biomass (Vine mass)

The potato cultivars varied highly significantly ( $p \leq 0.01$ ) on vine mass and it ranged from 0.61 t ha<sup>-1</sup> to 3.82 t ha<sup>-1</sup> (Table 6). Significantly the highest vine mass was

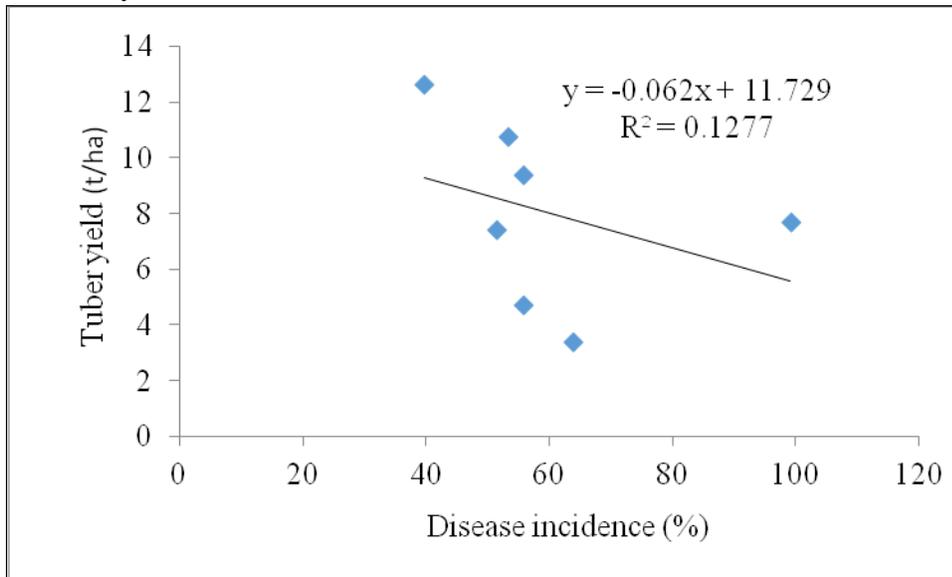
found on Khumal Ujjowal (3.82 t ha<sup>-1</sup>) followed by Kailali Local (3.41 t ha<sup>-1</sup>) and Bardiya Rato Local (3.32 t ha<sup>-1</sup>) and where as statistically the lowest vine mass was found on Cardinal (0.61 t ha<sup>-1</sup>) followed by

Deukhuri seto local (1.87 t ha<sup>-1</sup>) and Deukhuri rato local (1.95 t ha<sup>-1</sup>) (Table 6).

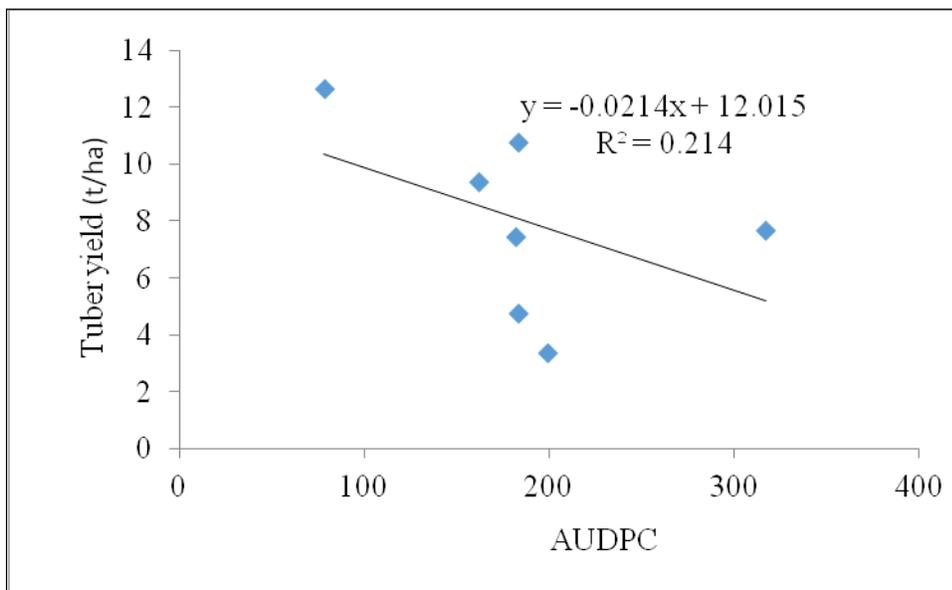
13% variation in grain yield was due to disease incidence and remaining portion due to other factors. Similarly, Tuber yield was also negatively correlated with mean AUDPC. About 21% variation in grain yield was due to AUDPC and remaining portion due to other factors.

### Relationship between tuber yield and disease incidence and severity

There was negative linear relationship between yield and disease incidence. About



**Figure 1.** Estimated linear relationship between disease incidence and tuber yield (t ha<sup>-1</sup>) of seven potato cultivars at Lamahi, Dang, Nepal, 2018/19



**Figure 2.** Estimated linear relationship between AUDPC and tuber yield (t ha<sup>-1</sup>) of seven potato cultivars at Lamahi, Dang, Nepal, 2018/19

## Discussion

Different potato cultivars tested under natural infection showed different response to late blight. Due to different genetic background, prevailing environmental conditions etc., differential rate of disease development may have been recorded in different cultivars. The most effective approach to combat plant disease is the use of host resistance (Subedi, 2015). In the present study Khumal Ujjowal was taken as resistant check and Cardinal as susceptible check. The results clearly indicated that the resistance and susceptibility of these genotypes are still maintained as reported by earlier workers. Rate of disease progress was less in Bardiya Rato Local and Bardiya Seto Local compared to other cultivars indicating their higher level of partial resistance in these cultivars. Late blight symptoms first appeared on Bardiya Rato Local (40 DAP) followed by Cardinal (Susceptible Check, 41 DAP) and Deukhuri Seto Local (41 DAP). Jaime et al. (2014) also reported that potato genotypes which developed late blight symptom early are susceptible and genotypes that developed late blight in the crop cycle are resistant. Sharma et al. (2013) reported that late blight severity observations in the field started at 30 days after planting and continued up to 76 days until the susceptible check had 100% infection.

It was observed that late blight directly affect the yield attributing characters like vine mass and tuber yield. The highest disease severity (up to 88%) was recorded in susceptible check plot indicates suitable climate for late blight development in the tested site. The present study shows the significant effect of late blight in reducing the tuber yield. Similar findings were also reported by Shrestha et al. (2019). It clearly indicates that the higher yield under low disease condition and lower yield in higher disease severity. The results showed that

selection of resistant cultivar has significant effect on late blight control and increase in tuber yield under field conditions when compared with susceptible cultivar, though it varies on yield potentiality of the cultivar. The result clearly indicated that the cultivation of the Bardiya Rato Local cultivar is effective for the management of late blight of potato as obtained by the lowest mean AUDPC (183), lowest disease severity (21.3%) and the highest yield (12.67 t ha<sup>-1</sup>). Addisu *et al.* (2013) and Baye (2002) also reported potato genotypes had higher tuber yield than the existing commercial potato varieties.

## CONCLUSION

From this experiment we found that potato cultivars Bardiya Rato Local and Khumal Ujjowal appear more resistant and produced higher tuber yield than other cultivars. The identified late blight resistant potato cultivars could be used for the source parents to breeding programs to develop late blight resistant potato varieties in Dang, Deukhuri valley of Nepal.

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## Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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