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Research Article

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Effect of Date of Planting and Seed Treatment to Control Late Blight (*Phytophthora infestans*) Disease of Potato in Nigale, Sindhupalchowk

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Abstract

An experiment was conducted from February to June 2020 with the objective to analyse the effect of the date of planting and fungicidal seed treatment to control the late blight disease of potato in Sindhupalchowk district. The experiment was done in a split plot design and each treatment was replicated three times. The main-plot factor was the planting dates; February 15 and March 15 and the sub-plot factor was the seed treatments with fungicides application of (i) Bavistin @0.2% concentration, (ii) Mancozeb @0.25% concentration, (iii) Krilaxyl @0.2% concentration, and (iv) untreated control. Potato variety used was Kufri Jyoti, a released variety for the hills of Nepal. Records were maintained for major pathological parameters at different dates. The fungicidal seed treatment had a significant ($p<0.05$) effect on disease severity after the appearance of the disease, but was non-significant to disease incidence. Disease severity was the least on Mancozeb treatment (4), but was statistically similar to the other two treatments Bavistin (4) and Krilaxyl (5). The planting dates had a non-significant effect on disease severity but least disease severity was found with the application of Mancozeb planted on March 15 (3). Further validation of the results with in-depth study is required before coming to concrete findings.

Keywords : Disease incidence, Disease severity, Fungicides, Planting dates, Seed treatment

Introduction:

Potato (*Solanum tuberosum* L.) is an important crop in Nepal, occupying one of the major places in the agrarian pattern as well as in the dietary habits of the population. It is the second most important cash crop after oilseeds and the fourth most important staple crop after rice, maize and wheat (Subedi *et al.*, 2019). But the average productivity is only 16.73 t/ha (MoALD, 2022) which is far lower than the world average(21 t/ha) (FAOSTAT, 2022). One of the major reasons of low productivity is late blight disease, caused by *Phytophthora infestans* (Mont.) de Bary which can destroy all parts of potato plants within two weeks in wet conditions (Hooker, 2005).

Late blight disease was first reported in Nepal between 1883 and 1897 (Gaire and Adhikari, 2014). But from mid-1990s only, it started to be seen in epidemic proportions (Ghimire *et al.*, 2003) constituting 94% of the total population, whereas frequencies of other genotypes ranged from 0.004 to 0.014. The overall genotypic diversity as estimated by the Gleason index was 1.78. Most of the overall diversity was present at the highest level (i.e., interregional, 46%). This disease now a days occurs every year in the high hills above 2000 masl (Sharma *et al.*, 2008) and causes significant losses in the total production (Adhikari *et al.*., 2023).

Late blight is caused by the fungus-like oomycete pathogen *P. infestans* (Robinson *et al.*, 2017, p. 1). It infects many of the solanaceous crops like chilly, tomato, brinjal and many others however, its main host is potato (Poczai *et al*., 2022).

Pathogens of late blight disease can survive between the seasons in infected seed tubers, cull piles and secondary hosts, as well (Kumar *et al.*, 2017). The spores of this fungus transmit through wind and water and on finding the host surface, it can germinate and enter the leaf if the leaf is wet for half a day (Haverkort *et al.*, 2009) grown worldwide. It suffers from many pests and diseases among which late blight, caused by the oomycete *Phytophthora infestans*, is the worst. The disease is still causing major damage in many potato production areas and control is only possible by applying fungicides frequently. The knowledge on the molecular biology and genetics of the interaction between the plant and the oomycete is developing rapidly. These are relevant fields of study, currently dominated by the discovery of many resistance genes and numerous effector proteins and the analysis of their specific mode of action. These studies may yield essential information needed for the development of durable resistance. The long-term and worldwide effort to breed for resistance so far has had little effect. A novel breeding approach may change this. It is based on cisgenic modification (CM). Late blight is also readily transmitted by seed-borne inoculum and consequently, immature stems and leaves may be exposed to late blight from infected seed pieces as well (Kirk *et al.*, 2009). *P. infestans* can survive under adverse conditions and over winter in the form of oospores. The pathogen, however, infects the plant sporangia which transfers through rain splash or wind (Fry, 1977). Due to the appearance of new virulence strains of the pathogen, the commercial variety, Kufri Jyoti, which was resistant in the past has become susceptible to the disease from the 1990s (Shrestha, 2005). The inoculation of the pathogen is observed during storage of the tubers. The pathogen requires moderate temperature and wet conditions for its growth and development. Extremely wet warm daytime temperature followed by moderate night time temperature may lead to epidemic results of late blight. Delay in planting leads to higher disease incidence due to favourable environment for pathogen build up (Thongam *et al.*, 2017). Therefore, the date of planting of tubers can be altered to escape the disease build up (Pundhir and Singh, 2012).

It is difficult to cure the disease once it is established on the plant and further, the transfer from infected tuber to healthy ones is also a major cause of the disease. The use of synthetic chemical fungicides like Mancozeb, Metalaxyl for the treatment of potato tubers before planting has been the major method to prevent late blight in potatoes (Tsedaley, 2014). Chemical seed treatment, not only, kills the pathogen present in the tuber to some extent but also protects the plant during its growth period. Seed treatment keeps the seed pieces free from pathogens thus, the plants are more vigorous and have greater yield. Systemic fungicides are found to be effective against late blight when used for seed treatment along with timely foliar spray (Lal *et al.*, 2018). Fungicides Bavistin, Mancozeb and Krilaxyl are used mainly for foliar spray. As they have both protectant and systemic activity, whether they can be used as seed pieces treatment to prevent from outside infection is of major interest of this research.

Many varietal and chemical fungicides trials have been conducted to control the disease by various researchers in this place but still, no research has been done to compare the efficacy of different fungicides for seed treatment alone in accordance with their date of planting. Thus, this trail was conducted with the major objective of reducing the loss in potato yield due to late blight, by the possible alteration in sowing dates and use of common fungicides to treat the seeds.

Materials and methods:

Experimental site and experimental design

The experiment was carried out in 2020 in the field of Potato Crop Development Centre, Nigale, Sindhupalchowk. It is situated at an altitude of approximately 1500 masl with the relative humidity ranging from 60% to 80% depending on the season and weather conditions (Poudel, 2017). The experiment was laid out in split-plot design with date of planting as main plot factor and seed treatment as sub-plot factor. Planting was conducted on February 15th and March 15th. There were 3 replications and 8 treatments in combination. Bavistin 75% wp @ 2g/ltr of water, Mancozeb 75% wp @ 2.5g/ltr of water and Krilaxyl @ 2g/ltr of water were the chemical fungicides used for the treatment along with the control. Whole tubers were treated for 15 minutes, 24 hours prior to planting, and then allowed to dry.

Planting materials

Kufri Jyoti, a highly suceptible variety to late blight disease was used for the experiment. The original designation of this variety is CIP-800258. It was introduced from the Central Potato Research Institute (CPRI), Shimla, India and released to be cultivated in mid and high hills of Nepal since the year 1992. This variety was selected in the trial because of its susceptibility to late blight disease and it's early to medium maturity type.

Data collection

Quantitative observation

Tuber yield: The total tuber yield from each plot was weighed using digital balance and the mean for each treatment was calculated.

Pathological observations

Disease incidence: Total number of plants affected by disease in a plot was recorded. The percent disease incidence was calculated by following formula (Arefin *et al.*, 2019; Mishra *et al.*, 2019).

$$\%\ disease\ incidence = \frac{Number\ of\ plants\ affected}{Total\ number\ of\ plants\ observed} \times 100$$

Disease severity: The disease severity was recorded by following Henfling as cited by (I. Hossain *et al.*, 2014; Mishra *et al.*, 2019) for its finer resolution in assessing disease severity.

Table 1: Disease severity table

Score	% foliage affected	Description
1	0	No lesions on the leaflet
2	3	Less than 10% lesions
3	10	More than 10% but less than 25% lesions
4	25	More than 25% but less than 50% lesions
5	50	Half of the foliage destroyed
6	75	More than 50% but less than 75% lesions
7	90	More than 75% but less than 90% lesions
8	97	Only few green areas left (less than 10%)
9	100	Foliage completely destroyed

Data analysis

The data collected was refined and entered in MS-Excel 2013. The data was analysed by using statistical software R-STAT (RStudio Team, 2021) and MS Excel. Analysis of variance (ANOVA) for all the parameters was analysed. DMRT analysis was done at 5% level of significance.

Results and discussion:

Disease incidence

Table 2 presents the data pertaining to disease incidence as influenced by planting dates and fungicidal seed treatments on two dates.

The data pertaining to influence of interaction of planting dates and fungicidal seed treatment on disease incidence on two different dates is presented in Table 2. There was no significant effect of the interaction on the disease incidence. However, higher incidence was seen on the later date of planting as compared to the earlier planting at the time of first appearance of the disease. This result coincides with the experiment conducted on late blight in Chitwan (Gaire and Adhikari, 2014). Lower level of incidence was found in the fungicide treated seeds than on control during the first appearance of the pathogen. This result is also supported by the same experiment conducted on late blight in Chitwan (Gaire and Adhikari, 2014).

The data presented in the Table below shows that neither planting dates nor fungicidal seed treatment had much influence on disease incidence. More importantly, it can be seen through the given data that once the plants are infected by the pathogen, seed treatment only is useless to control the spread. The result is in accordance with previous findings of Lal *et al.*, 2018; Powelson and Inglis, 1999. A more or less similar result was found in the experiment conducted by Hossain *et al.*, 2014; Hossain and Hossain, 2014.

After 10 days of first appearance of the late blight symptoms in the field, the whole field was completely infected by the disease and disease incidence was observed 100% during 2nd data collection time.

Disease severity

Table 2 presents the data on disease severity as influenced by planting dates and fungicidal seed treatments. The Table 2 presents the data pertaining to influence of interaction of planting dates and fungicidal seed treatment in disease severity. Although, no significant difference was observed due to interaction in severity during the first occurrence, significant difference was found at 2nd data collection. Highest disease severity score was found in Control plot of second planting (7) followed by Control plot of first planting (6) while least score was found for Mancozeb treated at March 15 planting (3).

As seen from the data in Table 2 below, there is no significant difference in disease severity due to planting dates. The application of fungicides for seed tuber treatment, however, shows a significant difference in the severity during the 2nd data collection. The highest score of disease severity is found on control (7) while the least score was found for Mancozeb treatment (4) which is at par with both Bavistin(4) and Krilaxyl(5). This result is in accordance to the experiment carried out in Chitwan for late blight of Potato (Gaire and Adhikari, 2014). Similar kind of result for fungicidal treatments was also found in in-vitro experiment (Islam *et al.*, 2018)

Table 2: Effect of date of planting and fungicidal seed treatment on disease incidence and severity

Treatments	Disease incidence (%)		Disease severity (1 to 9 scale)	
	1st data recording	2nd data recording	1st data recording	2nd data recording
	Date of planting (D)			
February 15 (D_1)	0.27	1	2	6
March 15 (D_2)	0.35	1	2	5
Grand mean	0.30	1	2	5
LSD	0.40	-	1.3	2
CV %	58.6	-	30.1	35.1
	Seed treatment (T)			
Bavistin (T_1)	0.32	1	2	4^b
Mancozeb (T_2)	0.27	1	1	4^b
Krilaxyl (T_3)	0.32	1	1	5^b
Control (T_4)	0.33	1	2	7^a
Grand mean	0.31	1	2	5
LSD	0.30	-	1.5	0.8
CV %	55.4	-	59.5	11.9
	Interaction (DxT)			
D_1 x T_1	0.30	1	1	5^b
D_1 x T_2	0.14	1	1	5^b
D_1 x T_3	0.28	1	1	5^b
D_1 x T_4	0.30	1	1	6^a
D_2 x T_1	0.35	1	2	4^c
D_2 x T_2	0.35	1	2	3^d
D_2 x T_3	0.35	1	2	4^c
D_2 x T_4	0.36	1	2	7^a
Grand mean	0.30	1	2	5
LSD	0.35	-	2	1
CV %	55.2	-	59.5	11.9

Means within the column followed by the same letter are not significantly different at 5% level of significance. LSD= Least Significant Difference, CV= Coefficient of variance. To reduce variability and meet assumptions of normality, a square root transformation was applied to the disease incidence and severity data prior to statistical analysis. This transformation reduced the coefficient of variation and improved the homogeneity of variances, allowing for more reliable comparisons across treatments.

Tuber yield

The data on the total tuber yield as influenced by the dates of planting and fungicidal seed treatments are presented in the Table 3. The data clearly indicated that there is not much influence of dates of planting on the tuber yield at 5% level of significance. Several previous experiments investigating the effect of planting dates on tuber yield showed that appropriate planting dates helped avoid yield loss due to early or late planting (Arab *et al.*, 2011; Maji *et al.*, 2014; Tang *et al.*, 2018). Among different seed treatments, yields was significantly higher in treated plots than untreated controls which is in line to the findings with (Mantecón, 2009). Similar results for foliar spray of fungicides were observed for fruit yield of Chilli (Mishra *et al.*, 2019) and pod yield of ground nut (Hossain and Hossain, 2014).

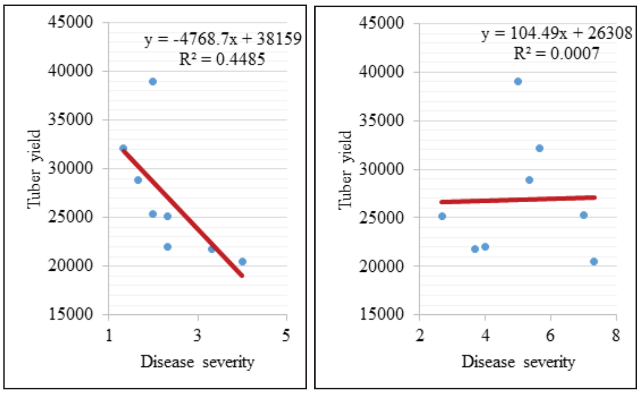
Table 3: Effect of date of planting, fungicidal seed treatment and their interaction on total tuber yield

Treatments	Total tuber yield (t/ha)
Date of planting (D)	
February 15 (D_1)	31.34
March 15 (D_2)	22.34
Grand mean	26.84
LSD	10.26
CV %	21.78
Seed treatment (T)	
Bavistin (T_1)	30.38^{a}
Mancozeb (T_2)	28.63^{ab}
Krilaxyl (T_3)	25.45^{bc}
Control (T_4)	22.89^{c}
Grand mean	26.84
LSD	3.54
CV %	10.50
Interaction (DxT)	
D_1 x T_1	39.00^{a}
D_1 x T_2	32.13^{b}
D_1 x T_3	28.90^{bc}
D_1 x T_4	25.32^{cd}
D_2 x T_1	21.77^{d}
D_2 x T_2	25.13^{cd}
D_2 x T_3	22.00^{d}
D_2 x T_4	20.47^{d}
Grand mean	26.84
LSD	5.02
CV %	10.50

Means within the column followed by the same letter are not significantly different at 5% level of significance. LSD= Least Significant Difference, CV= Coefficient of variance.

Data on the interaction of planting dates and fungicidal treatments on total tuber yield (t/ha) are presented in Table 3. The Bavistin treatment, when applied on February 15, resulted in significantly higher production (39.00 t/ha) compared to other treatments (Adhikari *et al.*., 2023; Mamta *et al.*., 2005). The Mancozeb treatment, also applied on February 15, followed with the next highest yield (Adhikari *et al.*., 2023; Mamta *et al.*., 2005). The lowest production was observed in the Control treatment planted on March 15, which was comparable to the yields of Krilaxyl and Bavistin treatments applied on the same date (Adhikari *et al.*., 2023).

This study unveils a dynamic temporal relationship between disease severity and potato yield (Figure 1). The negative correlation observed at the initial recording Figure 1(a) aligns with existing literature, emphasizing the critical impact on the bulking stage. In contrast, the positive correlation at later stages Figure 1(b) suggests reduced susceptibility to disease influence post-bulking. This nuanced understanding underscores the necessity of considering crop developmental stages for effective disease management strategies, contributing to the broader knowledge base on sustainable potato cultivation (Dey *et al.*., 2022; Hou *et al.*., 2022).



(a) (b)

Figure 1. Linear regression graph showing the relationship between disease severity and the total tuber yield (a) At 1st data recording, (b) At 2nd data recording.

Conclusion:

From the experiment, it was concluded that earlier planting (February 15) with seed treatment of fungicides (Bavistin 75% wp @ 2g/ltr of water, Mancozeb 75% wp @ 2.5g/ltr of water and Krilaxyl @ 2g/ltr of water) would be more beneficial. Further validation of this results with in-depth study is required before coming into concrete findings.

The findings of this experiment are particularly relevant for the Sindhupalchowk district and similar regions, given that the experiment was conducted at the Potato Crop Development Center in Nigale, Sindhupalchowk. This area is characterized by an altitude of approximately 2,734 meters, a monsoon-influenced rainfall pattern with significant precipitation during the summer months, and relative humidity levels that vary seasonally.

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Declaration of conflict of interest and ethical approval:

A. Shrestha and D. Devkota designed the research plan. A. Shrestha collected the data and designed the data entry template in Ms-Excel while data analysis and preparation of manuscript was carried out by A. Shrestha, A. Senchuri and G. Adhikari together. D. Devkota provided comments and feedbacks to finalize the manuscript. Final form of manuscript was approved by all the authors. The authors declare that there is no conflict of interest with present publication.

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