EFFICACY OF FUNGICIDES AGAINST LATE BLIGHT OF POTATO

[1]Pasmita Neupane*, [1]Ram Kumar Shrestha, [2]Jiban Shrestha
[1]Institute of Agriculture and Animal Science,
Department of Horticulture and Plant Protection, Lamjung Campus, Lamjung, Nepal
[2]Nepal Agricultural Research Council,
National Commercial Agriculture Research Program, Pakhribas, Dhankuta, Nepal
**Corresponding Author's email: npasmitas@gmail.com*

Abstract.
Potato varieties grown in Nepal have low levels of general resistance to late blight. Mostly the commercial potato farmers rely on fungicide applications for control of Phytophthora infestans, the causal agent of late blight. Field study was conducted in winter 2017 at research field of Institute of Agriculture and Animal Science, Lamjung Campus, Sundarbazar, Lamjung, Nepal to evaluate the efficacy of commercially available fungicides against late blight of potato. Experiment was laid in randomized complete block design with five replications. Treatments consisted of Dimethomorph 50% WDG@1.5g/L, Cholothalonil 75% WP @ 2g/L, Mancozeb 75% WP@ 2.5g/L and Trichoderma @ 2ml/L as recommended for field use and a variant with no application of fungicide (only tap water) was used as a control. Spore suspension of respective plant pathogen was inoculated twice @ 500 ml per plot ($4m^2$). Treatments were applied after the appearance of first blight symptom and level of disease development was followed. The best control was obtained with application of Dimethomorph with significant reduction in AUDPC (139 dsu) while the control treatment gave the highest AUDPC of 223.2 dsu. Same pattern was seen for tuber production where application of Dimethomorph gave 170.8 g tuber/plant, which was significantly higher than that of control treatment (73.7 g). Chlorothalonil and Mancozeb gave the intermediate level of disease control still significantly superior than control treatment. However; the application of Trichoderma showed the AUDPC of 228 dsu with 89.7 g of tuber yield per plant which was statistically indifferent with the control treatment. Thus, this study recommends Dimethomorph 50% WDG@1.5g/L in controlling the prevailing strain of P. infestans and multi-location trial is necessary in future for general validation.

Keywords: AUDPC, Chemical control, Late blight, *Trichoderma*

Abbreviations
AUDPC- The area under the disease progress curve
RAUDPC-Relative Area Under Disease Progress Curve
WDG- Water Dispersible Granule
DMM- Dimethomorph
WP- Wettable powders

INTRODUCTION

Late blight of potato which is caused by oomycete Phytophthora infestans (Mont.) de Bary is the major worldwide agricultural problem. Historically it has been an important disease as it was responsible for widespread crop failures in Northern Europe causing the famous Irish Famine in 1840s (Arora et al., 2014). Late blight of potato was first appeared in Nepal between 1883 and 1897 and still challenging in epidemic proportions since mid 1990s (Shrestha, 1998). The genus Phytophthora belongs to kingdom Stramenophila, the order Perenosporales and the family Pythiaceae. The major features includes: cell walls

devoid of chitin, zoospores with heterokont flagella sporangium of ellipsoid to lemon shaped and sexual reproduction through antheridia and oogonia. The host range of this pathogen is limited to Solanaceous crops (Nelson, 2008). Phytophthora infestans (Mont.) de Bary has two compatible mating types: A1 and A2. Sexual reproduction produces oospores which act as a resistant structure in adverse environmental condition. The symptoms of late blight of potato may vary; the initial symptom of the disease appear as the water- soaked irregular pale green lesion starting form tip and margin of the leaves which rapidly grows inwards forming brown to black necrotic spots in case of young lesions. Older lesions are large with circular appearance unless delimited by the leaflet margin. Cool and humid environments with the temperature of 10 ºC and relative humidity of 90% for at least 11 hours during the first 24 hours and at least 11 hours during the last 24 hours are the ideal condition for the late blight severity (Majeed et al., 2014) and this is called Smith periods.

Different types of fungicides are available in market with different trade names and formulations. Some of them are: Mancozeb, Metalaxyl, Dimethomorph, Cholothalonil, Ridomil, Cymoxanil, Copper hydroxide . Dimethomorph is a novel fungicide with curative protectant and antisporulant properties (Cohen et al., 1995). Mancozeb perform multi site contact activity. This reduces the probability of resistance development (Surge, 2015). Tricoderma viride is the biological agent which acts as the inhibitor for reduction in the radical growth of the pathogen (Fatima et al., 2015).

Number of fungicides has been developed to resist the negative impact of this pathogen. However these fungicides lose their resistivity due to development of new races of pathogen. Meanwhile, chemical control is indispensable for alternative approach to manage the disease. Thus the objective of this study was to evaluate the effectiveness of some of the recommended fungicides for potato late blight control in field conditions.

MATERIALS AND METHODS

Experimental location

The experiment was carried out in the field of Institute of Agriculture and Animal Science, Lamjung Campus, Sundarbazar, Lamjung, Nepal during the winter season (From 13 January 2017 to 19 May 2017). This place has a humid tropical climate with an annual rainfall of 280 cm. The geographical position of the farm is at the latitude of 28° 8' 41"N and longitude of 84° 24' 43" E and elevation of 610 masl (Mahato et al., 2018).

The plant materials

Kufri Jyoti, an early maturing variety of potato was used in this experiment. This variety was recommended for mid and high hills of Nepal. This variety was received from National Potato Research Program, Khumaltar, Lalitpur, Nepal.

Experimental design, treatment and cultural practices

The experiment was conducted in Randomized Complete Block Design with five replications. Treatments include Dimethomorph 50% WDG@1.5g/L, Chlorothalonil 75% WP @ 2g/L, Mancozeb 75% WP@ 2.5g/L and Trichoderma @ 2ml/L as recommended for

field use and the control. The crop was raised as per standard agronomic practices during main season. Suspension @500ml per plot (4m^2) was inoculated twice in the field.

Scoring and data collection

Scoring was done on daily basis after the incidence of first disease symptoms based on 0-9 scale given by Malcolmson (1976). Number of leaves affected, affected stalk, Area affected/leaves and leaves affected/plant were taken into considerations. After a week of inoculation, treatments were applied at the recommended doses. The area under disease progress curve is a useful quantitative summary of disease development over, for comparison to be made between years, locations and management options which was calculated by using the formula (Simko and Piepho 2012),

$$A_k = \sum_{i=1}^{N_i-1} \frac{(y_i + y_{i+1})}{2}(t_{i+1} - t_i)$$

Where,

N= Total number of observations

y_i= Disease Intensity observed at $_i$th observation

t= Time at $_i$th observation

Statistical analysis.

MS-Excel worksheet version 13 was used to record the data and perform simple statistical analysis as well as table, charts, and graph. Further statistical analysis to determine the significance (at 5%) among various treatments was performed using Genstat version 15.

RESULTS AND DISCUSSIONS

Infectious plant disease occurs due to the interactions of three factors; Host, Environment and Pathogen. Therefore, climatic parameters play an important role in occurrence and development of late blight symptoms in crop field. Microclimatic factors like relative humidity (RH) above 80 percent, temperature 10-24 ºC, night temperature falling below the dew point for 4days along with continuous cloudy days and light showers for 3-4 days is most optimum conditions for disease incidence in epiphytotic form.

Disease Severity:

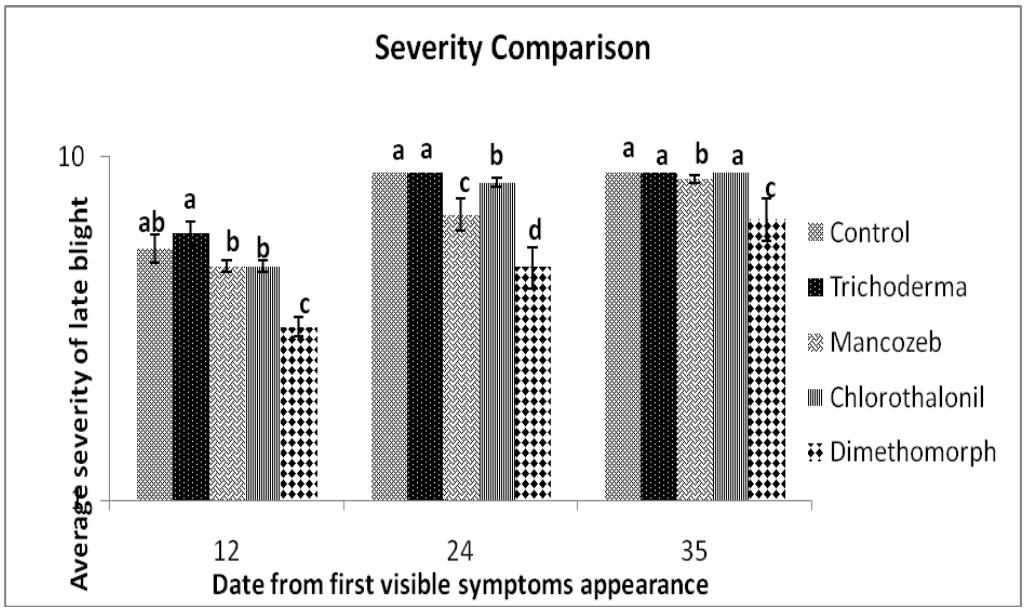

Fig.1. Showing Severity Comparison Between Different Treatments Applied

Maximum defoliation occurred in control with maximum disease severity. Late blight infection of the treated variants was low in plots treated with the Dimethomorph followed by Chlorothalonil and Mancozeb. In first 12 days (leaf development stage) of disease incidence, plots applied with *Trichoderma* were more severely affected. Observation made in 24^{th} (tuber initiation stage)and 35^{th} (first flower opening stage) days of symptoms appearance (scoring) shows that, plots applied with tap water (Control) and *Trichoderma* were infested to the highest degree in comparison to other treatments. Fungicidal action sequence: Dimethomorph > Chlorothalonil > Mancozeb > *Trichoderma* ≥ Control; this pattern was followed throughout the crop duration.

Climatic Impacts in Disease Development:

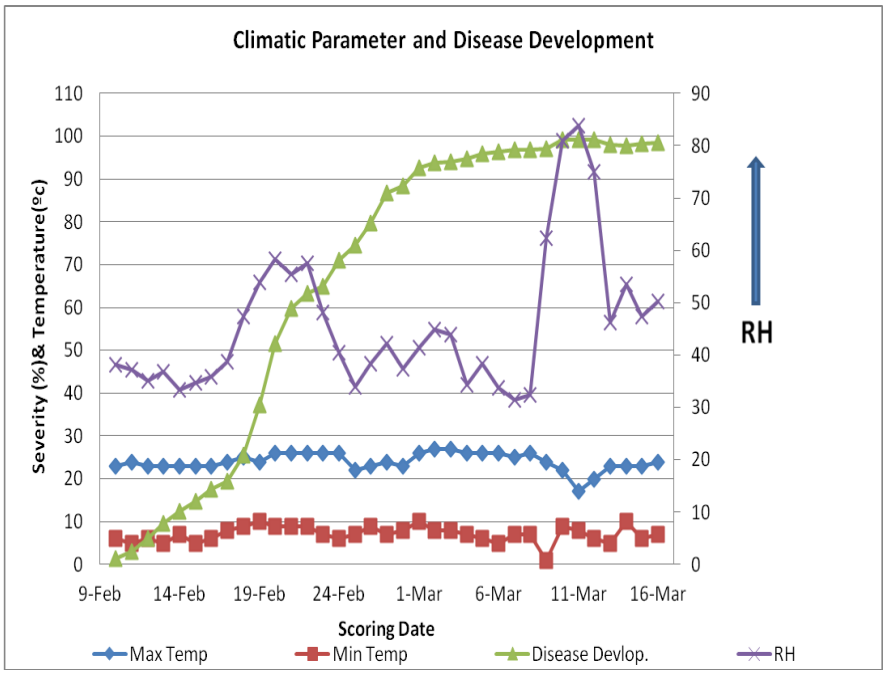

Fig. 2. Climatic parameter and disease development in control as treatment
(Source: Retrieved from Accu Weather, 2018)

During the entire crop duration, the average minimum and maximum temperature was 5.9 ºC and 21.8 ºC respectively and the recorded average relative humidity was 50%. Relative humidity was not favoring the disease development. Furthermore, there was no effective drizzle shower eventuates to maintain the leaf wetness in field which necessitates the application of spore suspension of respective pathogen.

AUDPC (Area Under Disease Progress Curve)

Table1: Area Under Disease Progress Curve, Average Diameter and Average Weight of tubers.

S.N.	Treatment	Average weight (g)/plant	AUDPC (DSU)	Average Diameter (cm)
1.	Control	73.71^{c}	223.2^{a}	4.224^{c}
2.	*Trichoderma*	89.7^{bc}	228^{a}	4.42^{c}
3.	Chlorothalonil	139.5^{abc}	181.8^{b}	5.198^{ab}
4.	Mancozeb	150.68^{ab}	210.4^{ab}	4.87^{bc}
5.	Dimethomorph	170.8^{a}	139^{c}	5.73^{a}
	F-Test	**	**	**

*Means in columns followed by same letter (s) are not significantly different according to the least significant difference test. In the above table, Level of significance = 0.05 ** shows highly significant.*

Analysis of AUDPC shows that, mean area under disease progress curve is less in plots applied with Dimethomorph (139 dsu) and highest in Control (223.2 dsu). This is accordance with the finding of Alexandrov (2011) who found out that potato late blight infection is low (1.3%) in plants treated with Acrobat (Dimethomorph) in comparison to control (47.1%). The smallest percentage of leaf spots (4.5%) was also found in the same treatment. Futhermore, symptoms of disease were detected in small degree in Acrobat application 5.8% compared to 89% of control.

Chlorothalonil (181.8 dsu) and Mancozeb (210.4 dsu) gave the intermediate level of disease control still significantly superior than control treatment and inferior than Dimethomorph. Similar result was obtained in the in vivo experiment carried out by Bruck *et al*. (1981) in which zoospores and sporangia were equally affected by these two fungicides. In vitro; at equivalent dosages, consistent suppression of spore germination was shown more effectively by Chlorothalonil then by Mancozeb.

In the experiment performed by Gaire et al. (2014); minimum RAUDPC (Relative Area Under Disease Progress Curve) of 0.21 was recorded in the plot with the application of Dimethomorph followed by Mancozeb (0.26). RAUDPC was significantly highest (0.57) in untreated plots. Sharma et al. (2011) also obtained that, RAUDPC was less with spray of DMM (0.083) as compared to control sprayed plots (0.459).

Anwar et al. (2015) reported that among 13 different fungicides Diamond 80WP (Mancozeb), Netcozeb 80WP (Mancozeb), Advance 72 WP (Mancozeb + Metalaxyl) showed better performance than other treatment with reduction of disease control of more than 80% over control. Kankwasta et al. (2002) suggested that application of Mancozeb reduced the late blight severity more than 50% with increment of yield by more than 30%. However in our experiment, Mancozeb was not much effective in disease control.

Less efficient was *Trichoderma* (AUDPC: 228 dsu). Similar result was obtained by Khalil, (2008). In his experiment disease severity was reduced by 96% by application of Chlorothalonil (Bravo 500 F) than that of *T. atroviride*. Only 27% of disease was control by *T. atroviride*. Likewise, Sharma et al. (2011) reported that there was not any significant difference between Trichoderma (Jeebatu) sprayed and unsprayed (Control) plots. In contrast, the result of the lab experiment performed Fatima et al. (2015) shows that the radial growth of pathogen was inhibited by 85% in treatment with *Trichoderma harzianum* which sight its antagonistic properties.

Tuber Yield

From the results obtained during the measurement of average diameter (cm), it has been found that out of five variants used to control late blight the average diameter of the tuber was higher in the case of using Dimethomorph followed by Chlorothalonil.
According to findings of Gaire et al. (2014) maximum tuber yield was recorded from Acrobat i.e. 11.86 t/ha (DMM) sprayed plots followed by Dithane M 45 i.e. 11.15 t/ha (Mancozeb). In control, tuber yield was lowest of all i.e. 7.08 t/ha. Sharma et al. (2011) reported that over the yield of untreated plots, highest yield was obtained from Sectin (131.9%) sprayed plots followed by DMM (127.8%). Whereas, microbial product

(Trichoderma) Jeebatu was ineffective in both increasing the tuber yield as well as in disease controlling.

CONCLUSIONS

Late blight is the most dreaded disease of potato. Commercially available fungicides like Mancozeb, Chlorothalonil, Trichoderma and Dimethomorph suppressed the appearance of late blight in potato fields. Dimethomorph WDP @1.5g/L can be recommended to control the prevailing strain of *P. infestans* in Sundarbazar municipality of Lamjung district, Lamjung, Nepal.

Acknowledgments. This work was supported by a grant of Institute of Agriculture and Animal Science, Lamjung Campus, Sundarbazar, Lamjung, Nepal

REFERENCES

1. Alexandrov,V. (2011). Efficacy of Some Fungicides against Late Blight of Tomato. Bulgarian Journal of Agricultural Science, 17(4): 465-469.
2. Anwar, M.M., A. Parveen, M. M. Hossain, N. U. Mahamud and R. K. Roy. (2015). Efficacy of fungicides in controlling late blight of potato. Progressive Agriculture, 26: 103-108. DOI: http://dx.doi.org/10.3329/pa.v26i2.25963
3. Arora, A. K., S. Sharma and B. P. Singh. (2014). Late blight disease of potato and its management. Potato Journal, 41 (1): 16-40.
4. Bruck, R. I., W. E. Fry, A. E. Apple and C. C. Mundt. (1981). Effect of protectant fungicides on the developmental stages of Phytophthora infestans in potato foliage. Phytopathology, 71: 164-166.
5. Cohen, Y., A. Baider and B. H. Cohen. (1995). Dimethomorph Activity Against Oomycetes Fungal Plant Pathogens Phytopathology, 85(2): 1500-1506.
6. Fatima, K., K. Noureddine, J. E. Henni and K. Mabrouk. (2015). Antagonistic effect of *Trichoderma harzianum* against *Phytophthora infestans* in the North-west of Algeria. International Journal of Agronomy and Agricultural Research (IJAAR), 6 (4): 44-53.
7. Gaire, S.P., S. M. Shrestha and B. P. Sharma .(2014). Effect Of Planting Dates and Fungicides on Potato Late Blight (*Phytophthora Infestans* (Mont.) De Bary Development and Tuber Yield In Chitwan, Nepal. International Journal of Research, 1(5): 148-160.
8. Kalil, I. (2008). Biological Control of *Phytopthora infestans* of Potatoes using *Trichoderma atroviride*. Pest Technology, 2(2): 104-108.
9. Kankwasta, P., J. J. Hakiza, M. Olany, H. M. Kidanemari and E. Adipala. (2003). Efficacy of different fungicide spray schedules for control of late blighting southwestern Uganda. Crop Prot., 22: 545 -552.
10. Mahato, S., Bhuju, S. and Shrestha, J. (2018). Effect of *Trichoderma viride* as biofertilizer on growth and yield of wheat. Malaysian Journal of Sustainable Agriculture, 2(2) : 01-05.
11. Majeed, A., H. Ahmad, M. A. Ali and H. Khan. (2014). Effect of systemic and contact fungicides on late blight disease and tuber yield of potato. Journal of Agricultural Science and Technology, 10(1): 209-217. http://www.ijat-aatsea.com/.
12. Malcolmson, J. F. (1976). Assessment of field resistance to blight (*Phytophthora infestans*) in potatoes. Transactions of the British Mycological Society, 67: 321–326.

13. Nelson, S. C. (2008). Late Blight of Tomato (*Phytophthora infestans*). College of Tropical Agriculture and Human Resources. http://hdl.handle.net/10125/12406.
14. Sharma, B. P., H. K. Manandhar, G. A. Forbes, S. M. Shrestha and R. B. Thapa. (2011). Efficacy of fungicides against Phytophthora infestans in potato under laboratory and field conditions. Nepal Agriculture Research Journal,11: 28-39.
15. Shrestha, S. K., K. Shrestha, K. Kobayashi, N. Kondo, R. Nishimura, K. Sato and A. Ogoshi, (1998). First report of A1 and A2 mating types of *Phytophthora infestans* on potato and tomato in Nepal. Plant Disease, 82(9): 1064.
16. Simko, I., and H.-P Piepho. (2012). The area under the disease progress stairs: Calculation, advantage, and application. Phytopathology 102(4) :381- 389.
17. Surge, D. and R. Daniele. (2015). Mancozeb: essential tool for sustainable protection of potato against late blight. Fifteenth Euroblight Workshop. PPO – SPECIAL REPORT NO 17 – 2015, 109-118.