# RATIONAL APPLICATION OF FUNGICIDE TO CONTROL LATE BLIGHT OF POTATO UNDER KATHMANDU VALLEY CONDITIONS

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## ABSTRACT

An experiment was conducted to optimize the application of fungicides for late blight control under natural epiphytotic conditions at Khumaltar during autumn season of 2004 and 2005. Most commonly used metalaxyl containing fungicide Krilaxyl (Metalaxyl 8% + Mancozeb 64%) was tested for its rational use with varying number of sprays at 10 days intervals starting from 25 days after planting (DAP) up to the 75 DAP. Disease severity on foliage was recorded at 30, 40,50,60,70, and 80 DAP and tuber infection was recorded based on visual observation just after harvest. At 80 DAP, highest remained green leaf (RGL) area was found (69.4 %) in six times sprayed plot followed by 5, 4, 3, 2 and single spray plots 62.8%, 55.3%, 50.9%, 33.8% and 23.1% respectively. Tuber blight was highest in untreated check plot (6.6%) and incidence was found decreasing as the number of sprays increased. Tuber yield was also increased ranging 1.5 to 9.6 t/ha as per the number of sprays increased. Total cost of fungicide and application as per treatment were Rs. 3, 800 to 31,170 per hectare. When cost per treatment was compared with the additional return due to treatment, highest cost benefit (C:B) ratio (1:2.6) was obtained from three sprays. C:B ratio was found minimum in six sprays (1:1.5). Cost benefit ratio was better (1:2.1) in single spray of Krinoxyl at 25 DAP as compared to six times sprays.

**Key words:** Cost benefit ratio, krilaxyl, late blight, remained green leaf area, tuber blight

## INTRODUCTION

Late blight caused by *Phytophthora infestans* (Mont.) de Bary is the most economically important disease of potato. In Nepal more than 21 potato diseases have been reported but a few of them such as late blight ( *P.infestans*), bacterial wilt (*Rolstonia solanacearum*) and wart (*Synchytrium endobioticum*) are economically important (Shrestha1997, Shrestha and Kharel 1996). In high hills (above 2000 m a s l), yield loss in potato due to late blight has been recorded up to 90 percent (Shrestha and Kharel, 1996; Shrestha, 1997). The International Potato Center (CIP) has estimated a production loss of 15 % in potato in developing countries due to late blight with an annual fungicide use in developing countries amounting 750 million USD (IPC, 1997).

Yield loss in potato due to late blight is estimated to a minimum level of 20 %, the monitory loss value may rise up to NRs.1.8 billion annually in the country (Sharma and KC, 2004). With regard to disease management, most of the farmers of Kathmandu valley apply fungicides 10 to 15 times to control late blight depending on the crop season and disease severity (Sharma and KC, 2004).

In an experiment extracts of Artemisia indica and Justicia adhatoda and application of fungal antagonist Trichoderma harzianum did not show their effectiveness on late blight

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control and results were found comparable with the disease severity of untreated plot (Sharma, 2007)Spring season potato suffers minimum with late blight as compared to the crop of autumn season in the Kathmandu and Panchakhal valley whereas in high hills disease becomes epidemic each year. However, losses are minimized with the application of high amount of fungicides particularly Mancozeb and Metalaxyl containing fungicides. Most of the potato-growing farmers of Kathmandu Valley use 10–15 times fungicides spray on Sept-Oct planting potato to control late blight (Sharma et al., 2007; Dhital et al., 2007). Efficacy of fungicides depends on the types of pathogen strains and the metalaxyl sensitivity of the pathogen and quality of fungicides. Ghimire (2002) and Shrestha (2005) have reported the prevalence of A1 and A2 mating types in the country.

Most of the commercial potato growing farmers periphery of urban areas use quite large amount of krilaxyl with high dose. Since metalaxyl is highly toxic an expensive, application of such chemical must be rationalize to make cost effective. With this context, efficacy of Krilaxyl was retested along with it's cost of application and benefit analysis under field condition was performed.

## MATERIALS AND METHODS

An experiment was conducted to optimize the application of fungicides to minimize the cost of late blight control under natural epiphytotic conditions at Khumaltar during autumn season (Sept-Dec) of 2004 and 2005. In this experiment late blight susceptible potato variety (Kufri Jyoti) was used. Potato crop was kept late blight disease free for fixed periods of time ranging from 30 days after planting (DAP) to 80 DAP by applying different frequencies of Krilaxyl MZ 72% WP (Metalaxyl 8% + Mancozeb 64%) manufactured by Krishi Rasayan Exports Pvt. Ltd, Samba, Jammu (J&K). Spraying of fungicide was done at 10 days intervals starting from 25 DAP to 75 DAP to keep the crop late blight free periods 30, 40, 50, 60, 70 and 80 days of crop age. It was estimated that single spray at 25 DAP would protect the crop from late blight up to 30 days. Likewise two sprays at 25 and 35 DAP for 40 days, three sprays for 50 Days, and four sprays for 60 days, five sprays for 70 days and six sprays for 80 days. The total treatment were 7 including check (water spray). Spray volume was made variable ranging 800 to 1200 l/ha depending on the crop canopy. Dose of Krinoxyl was 1.5 g/l of water along with the adjuvant APSA-80 at 0.33 ml/l spray solution in all the sprays.

Treatments were replicated thrice with randomized complete block design. Plot size was 2.4 m x 3 m. Potato was planted on ridge after the application of compost and recommended dose of fertilizers. Late blight susceptible variety Kufri Jyoti was planted at the spacing of 25 x 60 cm. Farm yard manure 10 t/ha and fertilizer 150:100:60 Kg NPK was applied. Half of Nitrogen and all other nutrients were applied as basal. Remaining half of N was applied as top dressing during first intercultural operation.

### Remained green leaf (RGL) on foliage

Out of 24 plants in the central two rows 5 plants were randomly selected and numbered as 1 to 5 and tagged on main stem. Observation was taken at 10 days intervals at 30, 40, 50, 60, 70 and 80 days of crop age. Parameters for computing RGL, defoliated leaves, necrotic leaves, remained green leaves and the estimated area damage percent on remained leaves were recorded. Based on these data remained green leaves percent (RGL %) was calculated.

$$\text{RGL \%} = \frac{100 - \{(\text{Defoliated leaves} + \text{necrotic leaves} + (\text{remained green leaves No.} \times \text{Area damage \%}) \times 100\}}{\text{Total number of leaves}}$$

### Late blight incidence on tuber

Late blight incidence on tubers was recorded based on the symptoms appeared on the surface of tubers at harvest. Disease incidence was calculated as follows:

$$\text{Late blight incidence on tuber \%} = \frac{\text{Number of tubers infected} \times 100}{\text{Total tubers produced/plot}}$$

## RESULTS AND DISCUSSION

### Effects on foliage

Plots having six sprays of Krilaxyl after 80 DAP was found significantly highest remained green leaf (RGL) area (69.4 %) followed by Krilaxyl five sprays (62.8%), four sprays (55.3 %) and three sprays (50.9 %), whereas in check plot RGL was 9.19 percent. There was significant differences in fungicide sprayed and unsprayed plots in both the years. Disease severity in 2005 was higher than the 2004. RGL value of three sprays was found comparable with four and five sprays (Table 1). Single spray given at 25 DAP showed highly significant effect on maintaining green leaf area 23 percent as compared to water spray (Table 1). Almost similar results were obtained in both years 2004 and 2005. Results of this field experiment conducted on autumn planting (Sept-Dec) potato clearly showed that three sprays of Krilaxyl starting from 25 DAP at 10 days interval protected the crop with 50.9% green leaf foliage (Table1).

In general late blight infection starts from lower leaves and in the presence of relatively high humid (>90 %) and low temperatures (10-15$^{o}$ C ) conditions white colony fungal growth could be observed on lower side of leaves. However, symptoms may appear simultaneously on upper leaves or petioles or growing buds or on stems under prolong conducive weather condition or due to the presence of virulent strain of *Phytophthora infestans*.

*Disease development*

Late blight symptoms were not observed until the crop age of 30 days. There were no significant differences in disease severity between the treatments even at 40 DAP. Treatment effects were found significantly difference in late blight severity particularly between water spray, single spray and rest of the treatments at 50 DAP (fig.1). At the crop age of 60 days, three to six spray treatments were found comparable on maintaining green foliage and that trend remained almost constant up to six sprays or 80 DAP (fig. 1). Area under disease progress curve (AUDPC) based on six observations at 10 days intervals in both years 2004 and 2005 were found in similar trend (fig. 2). AUDPC of six sprays was minimum (865) followed by five sprays (964), four sprays (1076) and three sprays (1187) which were significantly lower than the water spray (Table 2).

**Effects on tuber health**

Late blight incidence on tubers of whole experiment was low (0.0 to 4.5 %) in 2004 and 0.6 to 8.8 percent in 2005. Tuber blight incidence was higher in 2005 than 2004. It was observed that tuber blight incidence was found decreasing as the frequency and amount of Krilaxyl increased. Tuber blight incidence was observed low on four, five and six times sprayed plots (Table 1). Since late blight disease is also of seed borne nature, small amount of infected tubers may be sufficient to spoil the huge amount of seed and ware potatoes during storage. *Phytophthora infestans* harboring onto the tuber may serve as primary source of inoculums of the disease development for the succeeding crop.

Under conducive environment and sever infection on foliage, pathogen tends to infect uncovered tubers in the soil. Infected tubers develop brownish/ gray patchy symptoms appear on tuber surface and inside the tuber that lead to rotting of tubers during the storage.

**Effects on tuber yield**

Highest tuber yield was produced in six times sprayed plots (27.29 t/ha) followed by five (26.74 t/ha) and four sprays (24.99 kg/ha) and three sprays (24.42 t/ha). Tuber yield produced in three, four, five and six times krilaxyl sprayed plots were at par (table 1). The result was found interesting that late blight disease control due to treatment was highest (66 %) whereas tubers yield increased by 54 percent. Tuber yield difference between three sprays and unsprayed plot was high whereas yield difference between six sprays and three was insignificant.

**Cost of late blight control**

Metalaxyl containing fungicides in general are costlier than the Mancozeb and other contact fungicides. Cost of Krilaxyl sprays were found ranging Rs.3800 to Rs. 31170, depending on spray volumes (800 to 1200 L /ha), fungicide amount (1.2 to 10.2 kg/ha) and the frequency of sprays ranging 1 to 6 sprays (Table3).

**Cost benefit analysis**

Six times spray Krilaxyl treatment yielded 9.6 t/ha tubers followed by five sprays (9.0 t/ha), four sprays (7.3 t/ha) and three sprays (6.7 t/ha). When additional return due to treatment and additional cost of treatments (cost of fungicide spray) were compared, cost benefit ratio was found highest from three sprays (2.6) followed by two sprays (2.4) and single spray (2.1). Cost benefit ratio was found minimum (1.5) in six sprays (Table4).

**Economic threshold level of foliage damage**

Starting from 25 DAP to 45 DAP at 10 days intervals three sprays were given. Tuber yield was found to be increasing up to three sprays. The yield difference between unsprayed and three sprays was 6.69 t/ha, whereas yield difference between three and six sprays was 2.3 t/ha (fig.3). Three sprays at the early crop growth stage might have kept the crop comparatively safe from late blight up to the age of 60 days because of systemic nature of fungicide. After four sprays, yield increment rate was found lower with increasing frequency of spray. Tuber yields of three sprays and the six sprays treatment were found statistically insignificant in both experimental years 2004 and 2005 (Table1). Fifty percent foliage up to the crop age of 60 days was found to be the economic threshold damage of foliage for obtaining considerable tuber yield during autumn (Sept-Dec) season. In an experiment Keil et al (2008) also found the best result in reducing the frequency of late blight by the early application of systemic fungicides.

## CONCLUSION

Maintenance of potato crop foliage (green leaves) at least 50% up to the age of 60 days by spraying Metalaxyl containing fungicide (Krilaxyl) at an interval of 10 days starting from 25 DAP to 45 DAP with the dose of 1.5 g/L of water and spray volume of 800 to 1000 L/ha was found cost effective provided fungicide must be of appropriate quality. Cost benefit ratio was found highest (2.6) in three sprays whereas onward increasing number of sprays showed cost benefit ratio in decreasing trend.

**Table 1**. Effects of Krilaxyl spray frequencies on remaining green leaf area (RGL %) and late blight incidence

| Treatments | RGL % | | | Tuber infection (%) | | | Yield t/ha | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | Mean | 2004 | 2005 | Mean | 2004 | 2005 | Mean |
| Singe spray of Krilaxyl | 32.87 | 13.33 | 23.1 | 3.4 | 7.1 | 5.2 | 19.12 | 19.26 | 19.19 |
| Two spray of Krilaxyl | 41.86 | 25.8 | 33.8 | 2.7 | 5.8 | 4.2 | 20.8 | 21.2 | 21.00 |
| Three spray of Krilaxyl | 54.88 | 47 | 50.9 | 0.8 | 3.1 | 2.0 | 23.98 | 24.86 | 24.42 |
| Four spray of Krilaxyl | 56.86 | 53.7 | 55.3 | 0.0 | 2.3 | 1.1 | 25.09 | 24.89 | 24.99 |
| Five spray of Krilaxyl | 64.84 | 60.8 | 62.8 | 0.0 | 1.3 | 0.7 | 26.76 | 26.71 | 26.74 |
| Six spray of Krilaxyl | 73.25 | 65.46 | 69.4 | 0.0 | 0.6 | 0.3 | 27.22 | 27.36 | 27.29 |
| Without chemical | 9.98 | 8.4 | 9.19 | 4.5 | 8.8 | 6.6 | 19.07 | 16.39 | 17.73 |
| F test | ** | ** | | ** | * | | ** | ** | |
| Cv% | 13.75 | 19.8 | | 33 | 18.46 | | 16.89 | 9.04 | |
| $LSD_{0.05}$ | 11.43 | 14.76 | | 0.95 | 2.8 | | 3.37 | 3.73 | |

**Table 2.** Late blight severity (%) at 10 days intervals and area under disease progress curve (AUDPC) mean of two years (2004 and 2005)

| Treatments | late blight severity ( %) days after planting | | | | | | AUDPC |
|---|---|---|---|---|---|---|---|
| | 30 | 40 | 50 | 60 | 70 | 80 | |
| Singe spray of Krilaxyl | 0.0 | 5.0 | 34.2 | 43.1 | 64.6 | 75.8 | 1848 |
| Two spray of Krilaxyl | 0.0 | 3.3 | 23.4 | 35.5 | 51.0 | 66.1 | 1463 |
| Three spray of Krilaxyl | 0.0 | 2.5 | 20.2 | 28.0 | 43.5 | 49.0 | 1187 |
| Four spray of Krilaxyl | 0.0 | 2.9 | 19.6 | 25.0 | 37.8 | 44.7 | 1076 |
| Five spray of Krilaxyl | 0.0 | 2.5 | 21.1 | 22.4 | 31.7 | 37.2 | 964 |
| Six spray of Krilaxyl | 0.0 | 2.6 | 20.2 | 21.2 | 27.3 | 30.6 | 865 |
| Without chemical | 0.0 | 8.0 | 43.4 | 57.3 | 74.9 | 92.5 | 2298 |

**Table 3.** Cost of fungicide spray to protect the potato crop for different time periods during 2004 and 2005 under Kathmandu valley conditions.

| Treatments | Amount of Krinoxyl (kg/ha) | Cost of Krinoxyl (R 000) | Amount of adjuvant | Cost of adjuvant (Rs 000) | No. of Labour/ha | Labour cost (Rs 000) | Total cost per trt. (Rs 000/ha) |
|---|---|---|---|---|---|---|---|
| Singe spray | 1.2 | 2.64 | 0.26 | 0.26 | 6 | 0.90 | 3.80 |
| Two spray | 2.4 | 5.28 | 0.53 | 0.53 | 12 | 1.80 | 7.61 |
| Three spray | 5.1 | 11.22 | 0.86 | 0.86 | 20 | 2.93 | 15.00 |
| Four spray | 6.6 | 14.52 | 1.19 | 1.19 | 27 | 4.05 | 19.76 |
| Five spray | 8.4 | 18.48 | 1.58 | 1.58 | 36 | 5.40 | 25.46 |
| Six spray | 10.2 | 22.44 | 1.98 | 1.98 | 45 | 6.75 | 31.17 |
| Without chemical | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Costing norms: Spray volumes 800 l for 1st and 2nd sprays; 1000 l for 3rd and 4th sprays; 1200 l for 5th and 6th sprays; Krinoxyl @1.5g/l water; Price of Krinoxyl Rs.2200.0 /Kg; Adjuvant (APSA 80) Rs.1000/l; APSA-80 @ 0.33ml/l water; Labour Rs.150/man day

**Table 4.** Cost of fungicide application and its effects on the ratio of economic return (mean of 2004 and 2005 )

| Treatments | Yield t/ha | Yield increase over check (t/ha) | Gross return (Rs 000/ha) | Additional cos of sprays (Rs 000/ha) | Net return (Rs 000/ha) | Additional return due to treatment (Rs 000/ha) | Cost benefit ratio |
|---|---|---|---|---|---|---|---|
| Singe spray | 19.19 | 1.46 | 153.52 | 3.80 | 149.72 | 7.88 | 2.1 |
| Two spray | 21.00 | 3.27 | 168.00 | 7.61 | 160.39 | 18.55 | 2.4 |
| Three spray | 24.42 | 6.69 | 195.36 | 15.00 | 180.36 | 38.52 | 2.6 |
| Four spray | 24.99 | 7.26 | 199.92 | 19.76 | 180.16 | 38.32 | 1.9 |
| Five spray | 26.74 | 9.01 | 213.88 | 25.46 | 188.42 | 46.58 | 1.8 |
| Six spray | 27.29 | 9.56 | 218.32 | 31.17 | 187.15 | 45.31 | 1.5 |
| W/o chemical | 17.73 | 0.00 | 141.84 | 0 | 141.84 | 0.00 | 0.0 |

Farm gate price of potato at harvest = Rs. 8/kg

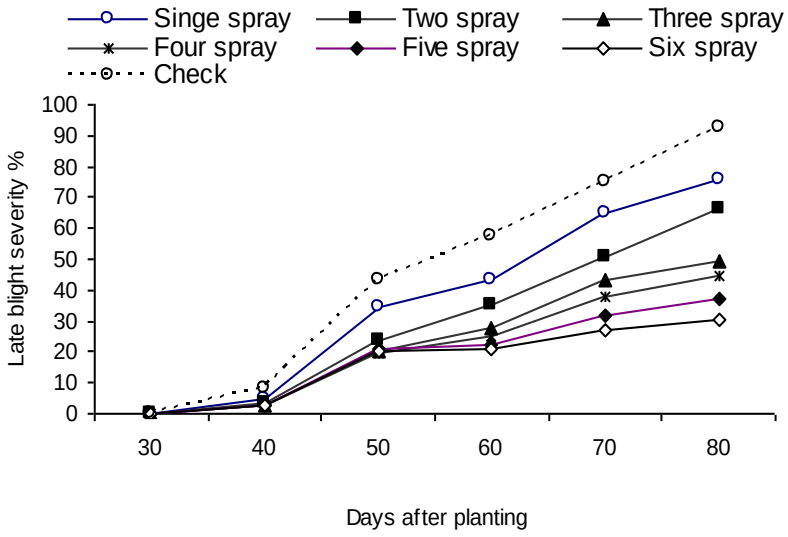


**Figure 1.** Frequency of krilaxyl spray and late blight severity (Mean of 2004 and 2005)

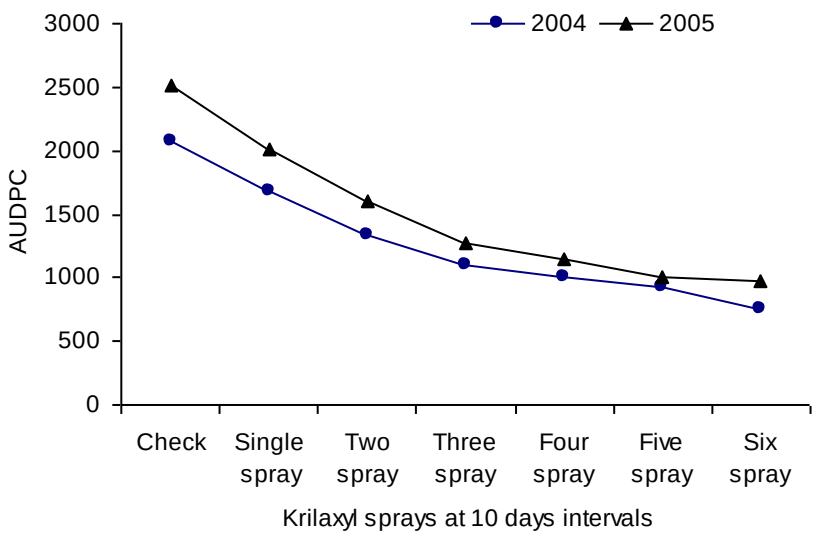


**Figure2.** Trend of area under disease progress curve (AUDPC) due to late blight damage in 2004 and 2005.

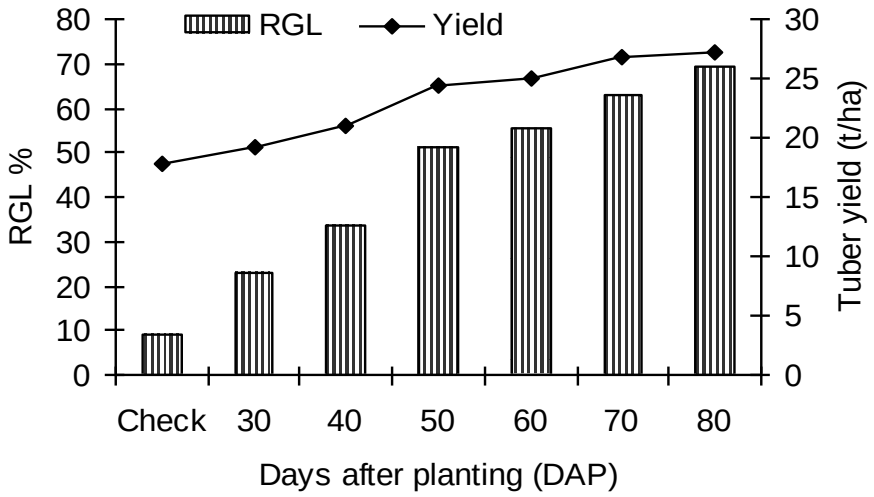


**Figure 3.** Economic threshold level of foliage damaged due to late blight disease on Autumn planting.

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