

Full Length Research

Efficacy of fungicides against Late blight of potato incited by *Phytophthora infestans* (Mont.) de Bary

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Chemical control remains the most important control measure against late blight. Growing potatoes without using fungicides has become unthinkable in most parts of the world. The control strategy is primarily preventive but in case the pathogen infects the crop, the epidemic must be stopped by using more powerful formulations. Late blight disease severity was successfully reduced by Metalaxyl + Mancozeb (Ridomil Gold) and IproWelcarb + Mancozeb (Melody Dew) all the treated varieties/lines after the second and third consecutive spray. In protective management program Melody dew was most effective followed by Dithane M-45 while Score was least effective on all the five varieties (Cardinal, Karoda, Rodio, Shanan and Sibly Red). Most effective spray interval was 7 days followed by 14 days and 21, 28 days being least effective in spray interval. Metalaxyl was proved to be an excellent weapon against established infection. "Metalaxyl" in the trade name of Ridomil Gold was most effective followed by Melody dew while Score being least effective on all the five varieties (Cardinal, Karoda, Rodio, Shanan and Sibly Red). Three consecutive sprays at 7 days interval after disease appearance were most effective among all the tested fungicides as compared to 2 or 1 spray being least effective. Our study concluded that host resistance when integrated with fungicide application enhanced the control of late blight and reduced losses.

Key Words: Potato, Late Blight, Management, Fungicides, Chemical Control, disease index, disease severity

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most important and leading vegetable crop of the world with immense yield potential giving remunerative income to the farmers and having excellent nutritional value. It is one of the most productive and widely grown food crops in the world and produces approximately twice as many calories per hectare as rice and wheat (Poehlman and Sleppey, 1995).

It is the fourth major crop of Pakistan after Wheat, Rice and Maize. At the time of Independence potato was grown on an area of 3,000 ha which increased to 185,100 ha during 2009-2010 with a total production of 410.44 thousand tons (Anon. 2012). During this period rise in average yield up to 2009-10 was 22.17 metric tons per hectare. Average yield of potato tuber is only 22.17 MT per ha in the country which is very low as compared to

other potato growing countries of the world, Netherlands produces 46.7, USA 46.27, UK 41.43 and Australia 36.18 t/ha respectively, (Swaminathan, 2000).

Late blight caused by *Phytophthora infestans* (Mont.) de Bary is a major threat to potato production in Pakistan because of its increasing distribution and brutality (Ahmad and Mirza, 1995). Chemical control of this disease is playing a vital role in potato production as resistant varieties are being not available. The mancozeb gave good control of late blight of potato in field tests in the Kaghan valley of Pakistan. However, fungicides are not easily available in the area and the farmers are not aware of its use for late blight control. (Jan, 1999). Evaluations of Protectant and systemic fungicides have been the most important aspect of late blight's management in countries of temperate regions of the world (Olanya *et al.*, 2001). Outbreaks of this disease are controlled by extensive use of fungicides. Cultivation of resistant cultivar and regular applications of fungicides has reduced the foliar infection of late blight of potato (Kirk *et al.*, 2005).

Late blight of potato can be successfully controlled by a combination of sanitary practices, resistant varieties and fungicide sprays. As fungicides encourage the development of resistance in *P. infestans* and the pathogen requires higher doses for control which disturbs the cost benefit ratio and environment. To eliminate an extensive and un-judicial use of fungicide studies were carried out to get best effective spray interval, combination and number of spray under field conditions before and after the disease appearance.

Evaluation of foliar applied Fungicides as Protective

Experiment was conducted on large scale involving five varieties/lines named Cardinal, Karoda, Rodio, Shanan and Sibly Red obtained from Potato Research Institute, Sahiwal and Haji sons, Chiniot. These advanced lines/varieties were planted in a randomized complete block design with four replications. Each set consisted of five varieties/lines, eight fungicides and four spray intervals which served as one block and the treatments were randomized within these blocks. Each treatment plot consisted of six rows of 10 meters. Seed tubers were planted 20 cm plant to plant and 60 cm row to row distance. These plots were watered by surface irrigation at regular intervals (6 to 8 days) throughout the season and stopped 15 days before harvesting. Recommended doses of eight fungicides *viz.*

Ridomil Gold MZ 68 WP → Metalaxyl 8 + Mancozeb 64
 Curzate 500 SC → Simoxanil 8 + Mancozeb 64
 Revus → Mandipropamide
 Melody Dew → Ipro walcarb 5.5 + Propeneb 61.3
 Score 250 EC → Iphanoconazole 250,

Cabrio Top → Pyraclostrobin 5 + Metiram 5
 Protest 70 WP → Propeneb 70WP and
 Dithane M-45 70WP → Mancozeb 70 WP

were applied. Untreated rows of each varieties/lines served as check. First spray of the fungicides was carried out one month after the sowing of crop and was continued at intervals of (07, 14, 21 and 28 days) till the destruction of most of the check plot. The data on disease severity were recorded one day before spray and at weekly intervals after spraying using 0-9 scale (Shutong *et al.*, 2007).

Evaluation of foliar applied Fungicides as curative

Experiment was conducted involving five varieties/lines named Cardinal, Karoda, Rodio, Shanan and Sibly Red obtained from Potato Research Institute, Sahiwal and Haji sons, Chiniot. These advanced lines/varieties were planted in a randomized complete block design with four replications. Each set consisted of five varieties/lines, eight fungicides and number of spray *viz.*, set one having only one spray, second set was sprayed twice and the third one being sprayed thrice, which served as one block and the treatments were randomized within these blocks. Each treatment plot consisted of six rows of 10 meters. Seed tubers were planted 20 cm plant to plant and 60 cm row to row distance. Recommended doses of eight fungicides *viz.*

Ridomil Gold MZ 68 WP → Metalaxyl + Mancozeb @
 Curzate 500 SC → Simoxanil 8 + Mancozeb 64
 Revus → Mandipropamide
 Melody Dew → Ipro walcarb 5.5 + Propeneb 61.3
 Score 250 EC → Iphanoconazole (),
 Cabrio Top → Pyraclostrobin 5 + Metiram 5 (),
 Protest 70 WP → Propeneb 70WP (Propineb) and
 Dithane M-45 70WP → Mancozeb 70 WP (Dithane M-45 70WP)

were applied. Untreated rows of each varieties/lines served as check. First curative spray was sprayed immediately after the initial appearance of disease symptoms and repeated after seven days according to the treatment plan. The data on disease severity were recorded one day before spray and at weekly intervals after spraying using 0-9 scale (Shutong *et al.*, 2007).

Data were subjected to Analysis of Variance (ANOVA) by using MStatC. The significant difference between mean values was evaluated by Least Significant Difference Test (LSD) (Steel *et al.*, 1997).

RESULT AND DISCUSSIONS

Evaluation Fungicides against late blight of potato in natural field condition as protective Spray during 2009-10 and 2010-11

Analysis of variance indicates that Varieties, treatments, spray interval, interactions between varieties, treatments and spray interval were highly significant. Effective protective spray intervals were 7 days and 14 days while 21 and 28 days spray interval gave minimum protection against Late Blight of Potato. This trend was found similar during both the trial years (2009-10 and 2010-11).

Among fungicides, Melody Dew gave 98.45 and 94.04% protection over the unsprayed control at seven days spray interval during 2009-10 and 2010-11 respectively. Score was least effective with the value of 71.8 and 72.94% during 2009-10 and 2010-11 respectively. The disease severity under field conditions was decreased as the spray interval was reduced from 28 to 21 to 14 days and it was maximised at 7 days spray interval. This trend was observed on all the varieties that by decreasing the spray interval control efficacy were increased significantly as maximum protection from late blight of potato was observed at 7 and 14 days spray interval while least protection was observed 21 and 28 days spray interval. Best control was observed on moderately resistant cultivar/line (Karoda) while least protection was observed on highly susceptible cultivar/line (Shanan) at all spray intervals.

Evaluation Fungicides against late blight of potato in natural field condition as curative Spray during 2009-10 and 2010-11

Analysis of variance indicates that Varieties, treatments, number of sprays, two way and three way interactions between varieties, treatments and number of sprays were highly significant. In present studies Ridomil Gold has given maximum control (98.03 and 98.96%) over the unsprayed control with three sprays seven days during 2009-10 and 2010-11, respectively. On the other hand least effective fungicide was Score with (50.5 and 51.85%) with single spray during 2009-10 and 2010-11. The disease severity under field conditions was decreased as the number of sprays were increased on all varieties and fungicides used. This trend was observed on all the varieties that with increasing the number of sprays, fungicide efficacy was also increased significantly. Among varieties best control was observed on Sibly Red (98.03%) and Karoda (97.31%) while least protection was observed on Shanan with all fungicides and number of sprays. This trend was found similar during both the trial years (2009-10 and 2010-11).

Eight fungicides present in the local market were tested

for their antifungal potential against *Phytophthora infestans* under natural field conditions in protective as well as curative manner. Most of the fungicides are more efficient when applied prior to infection than after the infection has occurred, or after the symptoms have appeared. The recommended rates of currently used fungicides are too much higher to be afforded by farmers having small holdings. Fungicide inputs for potato crop management can be reduced by using formulations of protectant fungicides with less active ingredients or reducing the rate of application or by increasing the interval between two applications or a combining of any of the above mentioned strategies. Regular application of protective fungicides in combination with resistant cultivars has reduced the foliar late blight in potato crop (Kirk *et al.*, 2001). Ojiambo *et al.*, (2001) reported that it is possible to reduce the infection rate and ultimately the epidemic development by using lesser quantity of fungicides on a cultivars having polygenic resistance as compared to cultivar having lesser resistance. Samoucha and Cohen (1989) reported that a mixture of contact and systemic fungicides gives better control of late blight than the fungicides applied singly. Systemic fungicides provide better control as compared to contact fungicides (Fontem, 2001). However, the failure of Ridomil in some countries of the region in giving perfect control of the disease and in some cases the intensive frequency of usage (Schiessendoppler *et al.*, 2003) necessitated an urgent action to be taken in a coordinated manner throughout the region (Tesserra and Giorgis, 2007).

These findings were also confirmed by Speiser *et al.* (2006) who studied the effect of copper fungicides against *Phytophthora infestans* for all the cultivars in England for two years. Dowley and Sullivan (1994) conducted field experiments in the Irish Republic to determine the effectiveness of spray programmes using mixtures of phenylamide and mancozeb in controlling late blight of potatoes (*Phytophthora infestans*) and the results revealed that mixtures significantly delayed disease onset in 6 of the 7 years of the experiments, while the level of leaf blight at the end of the season was significantly lower in 5 years. Our results are also congruent to the findings of Olosson and Carlsson (1994) who evaluated the fungicides (mainly mancozeb + metalaxyl) applied at 7, 14, 21 and 28 day intervals and reported that it significantly reduced the disease. The experiment conducted by Dhanbir *et al.* (1994) also similar to the present findings who concluded that all of the treatments reduced the disease but 8% metalaxyl + 64% mancozeb (as Ridomil MZ 72 WP) was the most effective. Present results are validating the previous studies in which late blight was successfully managed with the use fungicides on resistant cultivars by Kirk *et al.*, (2001).

The results of (Rehman *et al.*, 2008) are also in line with the present studies, as they reported that application

Table: 1. Percent Disease Reduction over the Control as protective Spray at different intervals during 2009-10

	Cardinal				Shanan				Rodio				Karoda				Siply Red			
	7 Day	14 Day	21 Day	28 Day	7 Day	14 Day	21 Day	28 Day	7 Day	14 Day	21 Day	28 Day	7 Day	14 Day	21 Day	28 Day	7 Day	14 Day	21 Day	28 Day
Cabrio Top	87.57	84.28	80.32	61.42	94.77	95.75	86.49	57.84	90.61	88.13	84.76	67.01	94.20	81.51	74.22	68.29	87.82	87.30	82.53	69.11
Curzate	72.95	77.61	76.95	69.07	81.90	81.56	70.23	50.50	78.07	76.85	80.94	69.64	82.31	81.17	72.76	60.51	82.97	74.01	73.06	62.72
Dithane M-45	88.23	85.38	77.17	61.05	96.13	96.33	80.42	64.26	92.00	91.20	85.99	72.35	94.23	82.81	79.73	63.57	87.62	85.67	82.62	69.38
Melody Dew	98.09	95.49	74.08	56.95	98.45	97.62	86.31	78.11	98.32	97.31	88.99	73.02	95.40	93.62	82.23	70.70	98.03	96.81	89.78	76.81
Protest	86.20	77.61	76.95	69.07	83.10	81.56	71.74	50.50	81.57	78.07	76.57	69.64	85.17	81.50	72.76	60.37	82.97	75.35	73.51	62.42
Radomil Gold	83.09	81.95	81.46	68.61	82.36	82.66	61.19	55.42	86.43	84.40	81.67	73.72	90.35	77.89	76.00	64.50	83.20	85.09	77.70	65.91
Revus	76.94	80.31	66.31	52.01	81.14	81.75	67.05	54.48	81.06	78.46	70.53	58.97	84.74	75.98	70.89	57.31	75.12	75.73	71.77	61.41
Score	71.80	75.19	71.25	58.53	83.33	82.84	55.00	59.10	75.31	74.22	70.34	64.23	80.45	75.53	71.47	63.59	71.91	70.84	74.90	63.71

Table: 2. Percent Disease Reduction over the Control as protective Spray at different intervals during 2010-11

	Cardinal				Shanan				Rodio				Karoda				Siply Red			
	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days	7 Days	14 Days	21 Days	28 Days
Cabrio Top	71.19	67.80	67.25	54.53	78.84	79.33	51.00	55.10	70.90	67.91	66.84	59.71	71.31	70.22	66.34	60.23	76.45	71.53	67.47	59.59
Curzate	83.57	80.28	76.32	57.42	91.75	90.77	82.49	53.84	83.82	83.30	78.53	65.11	86.61	84.13	80.76	63.01	90.20	77.51	70.22	64.29
Dithane M-45	82.20	73.61	72.95	65.07	77.56	79.10	67.74	46.5	78.97	71.35	69.51	58.42	77.57	74.07	72.85	65.64	81.17	77.50	68.76	56.37
Melody Dew	94.09	91.49	70.08	52.95	94.45	93.62	82.31	74.11	94.03	92.81	85.78	72.81	94.32	93.31	84.99	69.02	91.40	89.62	78.23	66.7
Protest	84.23	81.38	73.17	57.05	92.33	92.13	76.42	60.26	83.62	81.67	78.62	65.38	88.00	87.20	81.99	68.35	90.23	78.81	75.73	59.57
Ridomil Gold	77.96	77.95	77.46	64.61	78.66	78.36	57.19	51.42	81.09	79.20	73.70	61.91	82.43	80.40	77.65	69.72	86.35	73.89	72.00	60.50
Revus	73.61	72.95	68.95	65.07	77.56	77.90	66.23	46.50	78.97	70.01	69.06	58.72	76.94	74.07	72.85	65.64	78.31	77.17	68.76	56.51
Score	72.94	76.31	62.31	48.01	77.75	77.14	63.05	50.48	71.12	71.73	67.77	57.41	77.06	74.46	66.53	54.97	80.74	71.98	66.89	53.31

Table 3. Percent Disease Reduction over the Control as Curative Spray different fungicides during 2009-10

Fungicides	Cardinal			Shanan			Rodio			Karoda			Siply Red		
	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3
Radomil Gold	56.95	74.08	95.49	78.11	86.31	97.62	73.02	88.99	97.31	70.70	82.23	95.40	76.81	89.78	98.03
Curzate	69.07	76.95	77.61	50.50	70.23	81.56	69.64	76.85	80.94	60.51	72.76	82.31	62.72	73.06	82.97
Revus	52.01	66.31	80.31	64.26	80.42	96.33	72.35	85.99	92.00	63.57	79.73	82.81	69.38	82.62	85.67
Melody Dew	61.42	80.32	84.28	57.84	86.49	95.75	67.01	84.76	88.13	68.29	74.22	81.51	69.11	82.53	87.82
Score	69.07	76.95	77.61	50.50	71.74	81.56	69.64	76.85	81.57	60.37	72.76	81.50	62.42	73.51	80.97
Cabrio Top	68.61	81.46	81.95	55.42	61.19	82.66	73.72	81.65	86.43	64.50	76.00	77.89	65.91	77.70	85.09
Protest	69.07	76.95	77.61	54.48	67.05	81.75	58.97	70.53	78.46	57.31	70.89	75.98	61.41	71.77	75.73
Dithane M-45	58.53	71.25	75.19	59.10	55.00	82.84	64.23	70.34	74.22	63.59	71.47	75.53	63.71	70.84	74.90

Table 4. Percent Disease Reduction over the Control as Curative Spray different fungicides during 2010-11

	Cardinal			Shanan			Rodio			Karoda			Siply Red		
	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3	Spray 1	Spray 2	Spray 3
Ridomil Gold	58.08	75.50	97.10	79.54	88.75	99.96	74.18	91.36	99.50	72.14	83.78	96.50	79.24	91.40	98.96
Curzate	70.49	78.39	82.78	51.85	72.66	86.00	72.01	77.66	89.38	61.43	74.67	87.41	63.85	75.67	86.13
Revus	62.49	78.51	87.76	66.70	82.03	97.26	73.78	87.54	93.55	65.18	81.92	85.00	70.82	85.00	88.05
Melody Dew	62.86	81.42	86.66	60.28	87.62	96.68	69.45	86.32	89.05	69.90	76.13	83.70	70.53	83.70	90.20
Score	70.49	78.39	78.78	51.85	72.66	83.00	72.01	77.66	82.38	61.43	74.67	83.41	63.85	74.67	84.13
Cabrio Top	69.96	82.56	83.38	56.54	62.61	84.27	74.84	82.75	88.04	66.68	77.16	80.07	67.35	80.07	86.53
Protest	54.45	67.44	81.23	55.91	68.40	82.92	60.58	72.44	80.37	59.68	72.44	77.52	62.76	72.69	77.52
Dithane M-45	59.88	73.69	76.63	60.22	56.44	84.45	65.15	71.44	75.32	64.76	72.28	76.34	65.15	72.28	76.34

of fungicides Secure, Filthane M-45, Ridomil gold, Metaril and Melody Duo are highly effective to minimize late blight. Platt and colleagues in 1998 treated the plots of potatoes cv. Green Mountain with copper oxychloride and concluded that all treatments, except dimethomorph, reduced foliar and tuber late blight and increased tuber yields relative to control plots. When late blight susceptible varieties are sown applications of

fluazinam at either 10 or 14 day intervals were partially effective in managing the disease (Kirk *et al.*, 2005). The mixture of fungicides is very effective in managing late blight proved by (Kankwastæ *et al.*, 2003) as the application of Ridomil consistently retarded late blight development and increased the yield when used in combination with Dithane M-45 due to the reason of that being contact fungicide Dithane M-

45 dose not persist long on the leave (Ghazanfaret *al.*, 2010) and plots that sprayed with longer intervals were unprotected. The above statement is also in confirmation with our finding. Our study concluded that integration of host resistance and fungicide applications enhances disease control and reduces losses. Susceptible cultivars can be grown

successfully accompanied by adequate fungicide protection.

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