



Fungicidal management of major foliar fungal diseases of potato (*Solanum tuberosum* L.) through different spray schedules

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Abstract: Early and late blight are the important diseases of potato. Application of fungicidal schedule like first spray of Mancozeb @ 0.2% at 30 DAS followed by spray of Sectin @ 0.3% at after disease initiation and one more spray of Mancozeb found most effective in terms of percent reduction of early blight disease (77.94 & 76.39% in first year and 77.92% & 78.45% in second year) over control on cultivar K. Ashoka and K. Pukhraj, respectively. Similarly, reduction percentage of late blight disease (75.69% & 77.53% and 74.45% & 76.12%) recorded on both cultivars in two consecutive years. Appearance of both diseases delayed about one week as comparison to control plots, terminal disease severity and AUDPC found minimum on those plots were treated with alternation schedule of Mancozeb and Sectin in both years.

Key words: Early blight, Late blight, Management, Potato and Fungicides

Introduction

Potato (*Solanum tuberosum* L.) is the most important food crop grown throughout the world. It is emerged as one of the most important food crops. At global level annual production of potato during 2013 was 453.44 million tonnes covering an area of 19.92 million hectare with the productivity of 22.8 tonnes/hectare. Indian contribution to the world's production was 45.34 million tonnes from 1.99 million hectare area with average productivity of 22.8 tonnes per hectare (Anonymous, 2013). Early blight caused by *Alternaria solani* (Ell. and Mart.) Jones and Groot and late blight caused by *Phytophthora infestans* (Mont.) de Bary, are most important diseases attacking potato plants in different countries of the world.

Several components are available on their management. Basically, these diseases are controlled with chemicals. Shashilbala and Pundhir (2008), Chowdhury and Hitra (2006) and Naskar *et al.* (2006) have reported the inhibiting effect of mephenoxam and mancozeb combination, a weaker effect of carbendazim and mancozeb and an insignificant effect of cupric hydroxide. Several chemicals, derivatives of chlorothalonil, are more effectiveness for potato late blight control and early blight also, compared to copper based products (Hariki, 2006). Since the pathogens are highly variable and changes itself with a slight change in environment, the host genotype resistance in most of the varieties is broken within few years of their cultivation Singh *et al.* (2001). Hence, the only option left is the judicious use of fungicides for the management of these diseases. In the present study, investigation was carried out to evaluate the fungicides in different spray schedules for management of major foliar fungal diseases of potato.

Materials and Methods

The experiment was carried out on spray schedules of different fungicides for the management of early and late blight diseases of potato, two cultivars viz. Kufri Ashoka (V_1) and K. Pukhraj (V_2) were sown on dated 17th November, with four replications and six treatments in RBD design along with recommended package and practices during 2011-13 at Vegetable Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad. The six treatments were used viz: Prophylactic spray with Mancozeb @ 0.2 per cent at 30 DAS followed by two more spray at weekly intervals (T_1), Prophylactic spray with Mancozeb @ 0.2 per cent at 30 DAS followed by three more spray at weekly intervals (T_2), Prophylactic spray with Mancozeb @ 0.2 per cent at 30 DAS followed by Cymoxanil + Mancozeb (Curzate) @ 0.3 per cent after disease initiation and one more spray with Mancozeb after 15 days of 2nd Spray (T_3), Prophylactic spray with Mancozeb @ 0.2 per cent at 30 DAS followed by Fenamidone + Mancozeb (Sectin) @ 0.3 per cent after disease initiation and one more spray with Mancozeb after 15 days of 2nd Spray (T_4), Prophylactic spray with Mancozeb @ 0.2 per cent at 30 DAS followed by Dimethomorph + Mancozeb (Acrobat) @ 0.3 per cent after disease initiation and one more spray with Mancozeb after 15 days of 2nd Spray (T_5) and T_6 serve as untreated.

The observations on appearance and progression of severity of individual disease at weekly intervals were recorded. Data of severity were used for calculating area under disease progress curve (AUDPC). Observations on disease severity were recorded on the basis of percentage leaf area affected in newer

and older leaves of 10 plants selected randomly for each disease in each plot using 0-5 rating scale (Singh, 1998) to early blight and 0-9 rating scale for late blight (Shutong *et al.*, 2007).

Results and Discussion

In crop season 2011-12 earliest disease early blight appeared during last week of December 2011 and first week of January 2012 in untreated and treated plots, respectively on both varieties. The percent disease severity of early blight increased gradually till maturity and reached its maximum i.e. 8.39, 9.13, 9.51, 16.58, 17.51 and 38.04 per cent on cultivar K. Ashoka (V_1) in treatment fourth, third, fifth, second, first and six, respectively. Similarly the disease was also progressed on cultivar K. Pukhraj (V_2) and terminal severity noted from minimum to maximum (5.96, 6.54, 6.81, 11.94, 12.63 and 27.70 per cent) in the respective order of same treatments. Among the treated plots minimum AUDPCs were 18.42 and 23.03 noted in treatment fourth followed by treatment third and fifth while, maximum AUDPCs 39.07 and 48.15 were recorded in treatment first followed by treatment second on cultivars K. Pukhraj and K. Ashoka, respectively. In the control plots maximum AUDPCs 104.68 and 85.68 were noted on K. Ashoka and K. Pukhraj,

respectively (Table 1). In the crop season 2012-13 progression of the disease severity of early blight was noted at weekly intervals. The per cent disease severity of early blight increased gradually till maturity of the crop in February and reached upto 8.83, 9.64, 10.04, 17.60 18.47 and 39.99 per cent on cultivar K. Ashoka (V_1) in treatment fourth, third, fifth, second, first and six, respectively. Progression of the disease in similar manner was also recorded on cultivar K. Pukhraj (V_2) and terminal severity to be noted from minimum to maximum (6.30, 6.91, 7.21, 12.61, 13.38 and 29.24 per cent) in the respective order of same treatments. Among the treated plots minimum AUDPCs were 16.94 and 25.38 noted in treatment fourth, while maximum AUDPCs 30.38 and 43.23 were recorded in treatment first on cultivars K. Pukhraj and K. Ashoka, respectively. In the control plots maximum and minimum AUDPCs 106.77 and 87.39 were noted on K. Ashoka and K. Pukhraj, respectively. Maximum reduction percentage of disease over control was found in treatment fourth followed by treatment third and fifth on both the varieties in both crop seasons (Table 2).

Late blight appeared between 15-19 January and 17-21 January 2012 in different treatments on K. Ashoka and K. Pukhraj,

Table-1: Effect of different fungicidal schedules on appearance and progress of early blight in potato (2011-12)

Treatments	Appearance		Per cent disease severity at weekly intervals								Disease reduction over control (%)	AUDPC
	Date	DAS	1. 01.12	8.01.12	15.01.12	22.01.12	29.01.12	5.02.12	12.02.12	19.02.12		
$V_1 T_1$	02.01.2012	46	0	2.45	3.57	4.81	5.82	9.05	13.4	17.51	53.97	48.15
$V_1 T_2$	02.01.2012	46	0	2.34	3.41	4.58	5.55	8.63	12.77	16.68	56.15	45.89
$V_1 T_3$	01.01.2012	45	0	1.28	1.86	2.51	3.04	4.72	6.99	9.13	76.00	25.12
$V_1 T_4$	01.01.2012	45	0	1.17	1.71	2.3	2.79	4.33	6.41	8.39	77.94	23.03
$V_1 T_5$	01.01.2012	45	0	1.33	1.94	2.61	3.17	4.92	7.28	9.51	75.00	26.17
$V_1 T_6$	25.12.2011	38	1.27	5.33	7.77	10.45	12.66	19.68	29.13	38.04	-	104.68
$V_2 T_1$	04.01.2012	48	0	1.76	2.55	4.87	5.94	7.58	9.78	12.63	54.40	39.07
$V_2 T_2$	04.01.2012	48	0	1.66	2.41	4.61	5.62	7.17	9.25	11.94	56.90	36.94
$V_2 T_3$	03.01.2012	47	0	0.91	1.32	2.52	3.08	3.92	5.06	6.54	76.39	20.22
$V_2 T_4$	03.01.2012	47	0	0.83	1.20	2.3	2.8	3.57	4.61	5.96	78.48	18.42
$V_2 T_5$	03.01.2012	47	0	0.95	1.38	2.63	3.21	4.09	5.28	6.81	75.42	21.08
$V_2 T_6$	27.12.2011	40	1.15	3.86	5.6	10.69	13.03	16.62	21.45	27.70	-	85.68

DAS = Days After Sowing, AUDPC = Area Under Disease Progress Curve

Table-2: Effect of different fungicidal schedules on appearance and progress of early blight in potato (2012-13)

Treatments	Appearance		Per cent disease severity at weekly intervals								Disease reduction over control (%)	AUDPC
	Date	DAS	30.12.12	6.01.13	13.01.13	20.01.13	27.01.13	3.02.13	10.02.13	17.02.13		
$V_1 T_1$	31.12.2012	44	0.00	2.59	3.77	5.07	6.15	9.55	14.14	18.47	53.81	43.23
$V_1 T_2$	31.12.2012	44	0.00	2.47	3.60	4.84	5.86	9.11	13.48	17.60	55.99	40.53
$V_1 T_3$	30.12.2012	43	0.00	1.35	1.97	2.65	3.21	4.99	7.38	9.64	75.89	26.43
$V_1 T_4$	30.12.2012	43	0.00	1.24	1.80	2.43	2.94	4.57	6.76	8.83	77.92	25.38
$V_1 T_5$	30.12.2012	43	0.00	1.41	2.05	2.76	3.34	5.19	7.69	10.04	74.89	27.25
$V_1 T_6$	23.12.2012	36	1.34	5.60	8.17	10.99	13.31	20.69	30.63	39.99	-	106.77
$V_2 T_1$	02.01.13	46	0.00	1.86	2.70	5.14	6.27	8.00	10.32	13.38	54.24	30.38
$V_2 T_2$	02.01.13	46	0.00	1.76	2.55	4.87	5.93	7.56	9.76	12.61	56.87	27.75
$V_2 T_3$	01.01.13	45	0.00	0.96	1.39	2.66	3.25	4.14	5.34	6.91	76.37	17.31
$V_2 T_4$	01.01.13	45	0.00	0.88	1.27	2.43	2.96	3.77	4.87	6.30	78.45	16.94
$V_2 T_5$	01.01.13	45	0.00	1.00	1.45	2.78	3.38	4.32	5.57	7.21	75.34	17.76
$V_2 T_6$	25.12.12	38	1.21	4.07	5.91	11.28	13.75	17.54	22.64	29.24	-	87.39

DAS = Days After Sowing, AUDPC = Area Under Disease Progress Curve

Table-3: Effect of different fungicidal schedules on appearance and progress of late blight of potato (2011-12)

Treatment	Appearance		Percent disease severity at weekly intervals					Disease reduction over control (%)	AUDPC
	Date	DAS	Reduction	29.01.2012	05.02.2012	12.02.2012	19.02.2012		
V ₁ T ₁	19.01.2012	63	5.4	14.12	16.5	18.45	21.42	52.54	109.34
V ₁ T ₂	20.01.2012	64	5.2	12.45	15.6	17.56	20.62	54.31	102.41
V ₁ T ₃	23.01.2012	67	0	7.61	9.57	10.85	11.41	74.72	59.04
V ₁ T ₄	23.01.2012	67	0	7.58	9.5	10.04	10.97	75.69	57.06
V ₁ T ₅	23.01.2012	67	0	7.64	9.59	11.15	11.97	73.48	60.14
V ₁ T ₆	15.01.2012	59	5.8	25.5	36.55	42.6	45.13	-	227.70
V ₂ T ₁	21.01.2012	65	3.22	8.8	10.05	12.35	13.18	53.66	68.95
V ₂ T ₂	22.01.2012	66	0	7.95	9.93	11.71	12.67	55.45	62.87
V ₂ T ₃	25.01.2012	69	0	4.65	5.81	6.03	6.56	76.93	34.60
V ₂ T ₄	25.01.2012	69	0	4.63	5.78	5.96	6.39	77.53	34.24
V ₂ T ₅	25.01.2012	69	0	4.66	5.82	6.23	6.88	75.81	35.26
V ₂ T ₆	17.01.2012	61	4.8	17.1	20.9	25.8	28.44	-	140.74

DAS = Days After Sowing, AUDPC = Area Under Disease Progress Curve

Table-4: Effect of different fungicidal schedules on appearance and progress of late blight of potato (2012-13)

Treatment	Appearance		Percent disease severity at weekly intervals		Percent reduction over control	AUDPC
	Date	DAS	10.02.13	17.02.13		
V ₁ T ₁	08.02.2013	83	3.4	16.48	51.60	69.58
V ₁ T ₂	09.02.2013	84	3.3	15.84	53.48	66.99
V ₁ T ₃	10.02.2013	85	0	8.9	73.86	31.15
V ₁ T ₄	10.02.2013	85	0	8.7	74.45	30.45
V ₁ T ₅	10.02.2013	85	0	9.31	72.66	32.58
V ₁ T ₆	06.02.2013	81	6.2	34.05	-	140.88
V ₂ T ₁	10.02.2013	85	0	12.02	52.86	42.07
V ₂ T ₂	11.02.2013	86	0	11.56	54.67	40.46
V ₂ T ₃	12.02.2013	87	0	6.23	75.57	21.81
V ₂ T ₄	12.02.2013	87	0	6.09	76.12	21.31
V ₂ T ₅	12.02.2013	87	0	6.54	74.35	22.89
V ₂ T ₆	08.02.2013	83	4.55	25.5	-	105.18

DAS = Days After Sowing, AUDPC = Area Under Disease Progress Curve

respectively in crop season 2011-12. The experimental results are presented in Table (3). It was observed that the late blight first time appeared in control plots 4 days earlier than those plots sprayed with mancozeb (three spray) only (T₁) and three days earlier in the plots sprayed with mancozeb (four spray) only (T₂) but it appeared after seven days from control plots in those plots treated with alternation of Mancozeb and Curzate (T₃), Mancozeb with Sektin (T₄) and Mancozeb with Acrobat (T₅). The result also revealed in the respect of variety K. Ashoka, the best result was observed in T₄ where severity of the disease was 10.97 per cent and AUDPC was 57.06. The second and third best result were observed in T₃ and T₅ where disease severity were 11.41 and 11.97 per cent and AUDPC were 59.04 and 60.14 found, respectively, after 35 days of its appearance. These treatments were statistically at par and significantly differed from other treatments. T₁ and T₂ also best as compared to control, it was found 21.42 and 20.62 per cent severity and 109.34 and 102.41 AUDPC in the respective order of T₁ and T₂. However, highest disease severity 45.13 per cent and 227.70 AUDPC recorded in control plots. In case of K. Pukhraj result was

found in similar trend in different treatments. The best result was noted in T₄ with minimum severity of the disease i.e., 6.39 per cent along with minimum AUDPC (34.24). The second and third best result was observed in T₃ and T₅ where disease severity was 6.56 and 6.88 per cent, and AUDPC 34.60 and 35.26, respectively, after 33 days of its appearance. Treatments T₃, T₄ and T₅ were statistically at par and significantly differed from other treatments. T₁ and T₂ also best as compared to control, it was found 13.18 and 12.67 per cent severity and 68.95 and 62.87 AUDPC in T₁ and T₂ respectively. While maximum disease severity 28.44 per cent and maximum AUDPC 140.74 was recorded in control plots (Table 3).

During 2012-13, late blight was occurred at 81 and 83 days after sowing on control plots in K. Ashoka and K. Pukhraj, respectively. Late blight was also noted 4-8 days delayed on treated plots with different fungicidal schedules than control in both the varieties. Table (4) revealed that the variety K. Ashoka showed minimum disease severity (8.7 per cent) along with minimum AUDPC (30.45) in T₄ which was proved most effective by maximum reduction of disease (74.45 per cent). The disease severity 8.9 and 9.31

per cent along with AUDPC 31.15 and 32.58 were recorded in the respective order of T₃ and T₅ which were significantly at par with T₄ and these were differed from others. In case of T₁ and T₂ both were significantly at par and found superior than control. Disease severity 16.48 and 15.84 per cent and AUDPC 69.58 and 66.99 were found in respective order of T₁ and T₂. While, the highest disease severity (34.05 per cent) and highest AUDPC (140.88) recorded in control plots, respectively. Similarly, K. Pukhraj showed that the best result in T₄ with minimum severity of the disease i.e., 6.09 per cent along with minimum AUDPC (21.31). The second and third best result was observed in T₃ and T₅ where disease severity (6.23 and 6.54 per cent), and AUDPC (34.60 and 35.26) were found, respectively. Statistically all treatments have similar trend as 2011-12. The disease severity 12.02 and 11.56 per cent and AUDPC 42.07 and 40.46 were found with T₁ and T₂ respectively. However, maximum disease severity 25.5 per cent and maximum AUDPC 105.18 were recorded in control plots. These observations are in accordance with Kapsa (2010) reported that the effectiveness of new chemicals *viz.*, Curzate, Fenamidone Acrobat to management of early and late blight. Muchiri *et al.* (2009), reported that the efficacy of fungicide mixers for the management of *Phytophthora infestans* on potato. Similar results were also revealed by Singh (2008), Shashibala and Pundhir (2008), Chaudhari *et al.* (2005), Singh *et al.* (1997) and Chakraborty and Majumdar (2012).

All treatments were found effective to manage the disease however, Sectin fungicide with alternation of Mancozeb is the best among all treatments. It is suggested that the one prophylactic spray of Mancozeb, second spray after disease initiation with mixture of Mancozeb + Sectin or Curzate or Acrobat and one more spray of Mancozeb should be done at 15 days interval for management of foliar fungal diseases of potato. Further research is needed to minimize disease severity of potato to foliar fungal pathogens (*Alternaria solani* and *Phytophthora infestans*). The next step would be to examine

severity of foliar fungal diseases on foliage of several cultivars and its eco-friendly management.

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