



Developed the fungicide schedule for the management of early blight in potato in Rajasthan

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Summary

Field experiments were conducted at Agricultural Research Station, Kota to develop a fungicide spray schedule for the management of early blight (*Alternaria alternata*), the most significant foliar disease of potato during the year 2018-19 and 2019-20. The protective and curative activity of fungicides were assessed in field studies. All spray schedules inhibited disease progress and enhanced total tuber yields compared with unsprayed plots. Most minor disease severity (11.40%) with the highest disease control (74.32%) was recorded in the treatment (T3), where the first spray of mancozeb 75WP (0.25%) was followed by a second spray of difenoconazole 25% EC (0.05%) and a third spray of mancozeb 75WP (0.25%) at 10 days interval was applied. The second-best treatment was T2, where the first spray of mancozeb 75WP (0.25%) was followed by a second spray of hexaconazole 5EC (0.05%) and a third spray of mancozeb 75WP (0.25%) at 10 days interval (17.10% & 61.48) was applied. The higher tuber yield was achieved in the treatment T3 with the highest benefit-cost ratio (2.18). Thus, a spray schedule consisting of preventive and curative fungicides may be recommended to effectively manage early blight and higher tuber yield in south eastern Rajasthan.

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Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food and cash crop belonging to the family Solanaceae. Early blight of potato is one of the most important foliar diseases which are distributed worldwide (Christ, 1991). The genus *Alternaria* is a broad-spectrum and important group of phytopathogenic fungi, which incites a significant number of important diseases in various crops. It includes two species of genus *A. solani* and *A. alternata* worldwide on potato crops (Gudmestad & Pasche 2007; Meena & Yadav 2022). *A. solani* and *A. alternata* both have significant impact on the tuber yield of potato (Hausladen and Leiminger, 2007). Early blight has become widespread in recent years and become one of most important diseases after late blight. Recent studies have shown that the *Alternaria* population on potato is much more elaborate than a two-species disease complex. Ten species of *Alternaria* have been implicated to cause foliar diseases of potato worldwide. Knowledge of which *Alternaria* species are associated with potato foliar diseases nationwide is essential in designing management schedules. Severely affected potato foliage hamper photosynthetic activity, thereby affecting yield (Horsfield et al. 2010). Yield losses to the tune of 5 to 40 per cent have been reported in Israel (Rotem and Feldman, 1965) and 20 to 30 per cent in the USA (Shtienberg et al. 1989). In Gujarat, the disease

occurs every year and yield loss up to 30 per cent in unsprayed crop has been reported (Patel 2007). The average annual yield harms due to early blight vary enormously from 5-78 per cent but it depends on weather conditions and the type of variety grown (Waals et al. 2004). Preventative fungicides check the spore incubation and penetration but pathogen can develop resistance against fungicide application so regular application of fungicides at recommended doses and intervals of time is mandatory (Hossain & Hossain 2009; Maheshwari et al. 2022). Early blight in potato, and other diseases caused by *Alternaria* spp., have typically been managed by repeated fungicide applications (Horsfield et al. 2010; Haldhar & Maheshwari 2021). Under South Eastern Rajasthan, early blight of potato caused by *A. solani* poses a great threat to its cultivation. Therefore, considering the devastating nature of the disease, a detailed investigation was undertaken with some alternate curative and preventive fungicides to the management programme of the disease.

Materials and Methods

Field experiments were conducted to see the effect of fungicide spray schedule on the management of early blight at AICRP on Potato Agricultural Research Station, Kota, during 2018-19 and 2019-20 crop seasons. The soil of the experimental site has 7.4 pH, 0.42 % OC, 210 kg/ha available Nitrogen, 23.2 kg/ha available Phosphorus and 591 kg/ha available potassium. The experiment was laid out in Randomized Block Design (RBD) with five replications during the month of October at a spacing of 60 cm (row to row) x 20 cm (plant to plant). The recommended package of practices was followed to raise the crop. The potato plants were dehaulmned 20

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days before the harvesting of the crop. Two sprays of the fungicides viz., mancozeb 75WP (0.25%), hexaconazole 5EC (0.05%), difenoconazole 25 % EC (0.05%) and chlorothalonil 75%WP (0.2%) were given at 10 days interval. The first spray was given immediately after the first appearance of early blight symptoms i.e. 45 days after planting, and 2nd spray was given at 60 days after planting. Five plants in each subplot were considered for

The disease intensity was calculated by using the following formula:

$$\text{Per cent Disease Intensity} = \frac{\text{Sum of individual ratings}}{\text{No. of plants observed} \times \text{Maximum disease rating}} \times 100$$

The per cent disease control was calculated by using the following formula:

$$\text{Per cent disease control} = \frac{\text{Disease in control} - \text{Disease in treatment}}{\text{Disease in control}} \times 100$$

Disease Score	Disease Intensity
0	Leaves free from infection.
1	Small irregular spots covering < 5% leaf area.
2	Small irregular brown spots with concentric rings covering 5.1-10% leaf area.
3	Lesions enlarging, irregular brown with concentric rings covering 10.1- 25% leaf area.
4	Lesions coalesce to form irregular and appears as a typical blight symptom covering 25.1-50% leaf area.
5	Lesions coalesce to form irregular and appears as a typical blight symptom covering >50% leaf area.

Per cent Disease Intensity (PDI) was calculated by using the following formula given by Chester (1959) and Wheeler (1969). The means were compared using the Duncan Multiple Range Test (DMRT) test of significance. The following procedure of RBD statistically analysed all the data of disease intensity and yields. Calculations were made after applying the test of significance of the means. The per cent data of disease intensity is transformed to Arc sine value.

Results and Discussion

The assembled scrutinized data stated that least disease severity (11.40%) and highest disease control was recorded (74.32) within treatment (T3) where the first spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25% EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval was applied followed by T2 i.e. first spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval (17.10% & 61.48) and spray of chlorothalonil 75%WP (0.2%) at 10 days interval (20.60% & 53.60) as against of control (44.40%) (Table 2). The findings are also in settlement with Chethana *et al.* (2011), who reported that among systemic fungicides, difenconazole at 0.1% showed 98.85% while among non-systemic fungicides, mancozeb at 0.3% was best in inhibiting the growth of *Alternaria porri* with 100% inhibition. The existing findings also confirm the ability of mancozeb to inhibit the growth of *A. solani* isolated from tomato (Gondal *et al.* 2012). Several workers obtained similar results (Kapsa & Osowski 2003; Chourasiya *et al.* 2013)

disease, and data were converted into per cent disease intensity (PDI). The data on a number of shoots and plant heights was recorded before the dehauling of the potato foliage. The number of tubers under three categories on the basis of tuber weight (≤ 25 g, 25-75 g and >75 g) were counted and weighted. Finally yield data was taken after harvest.

Experiment details

who found mancozeb an effective fungicide for managing early blight and maximum fruit yield. Current results specified that minimum disease severity was recorded when difenoconazole 25% EC (0.05%) was applied as a foliar spray. These results are in line with Dahman and Staub, (1992) who also reported the efficacy of difenoconazole against early blight due to its protectant, curative and eradicated mode of action and durable protective activity up to 3 weeks. Mancozeb has been proven a very effective fungicide against early blight, having prophylactic and curative properties. The protective mancozeb and the systemic azoxystrobin and difenoconazole materials are widely used fungicides against *A. solani* in Solanaceous crops (Horsfield *et al.* 2010).

Significantly maximum total tuber yield (25.27 t/ha) was attained by first spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25% EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval followed by spray chlorothalonil 75%WP (0.2%) at 10 days interval (24.18 t/ha). While, a spray of mancozeb 75WP (0.25%), a second spray of hexaconazole 5EC (0.05%) and a third spray of mancozeb 75WP (0.25%) at 10 days interval gave 22.08 t/ha. These conclusions are also in accordance with Leitao *et al.* 2014 they testified that chlorothalonil is very effective in protecting plants against fungal diseases caused mainly by *Phytophthora infestans* and *Alternaria solani*, and prevents germination of fungal spores. Tofoli *et al.* (2003) also evaluated the effectiveness of various groups of fungicides for managing early blight and on the yield of tomato and reported that the highest level of disease control, quality

and increase in fruit yields were obtained with Azoxystrobin followed by Mancozeb and Chlorothalonil.

Further, it was also concluded that the highest cost-benefit ratio of 1:2.18 was accomplished in the use of first spray Mancozeb 75WP (0.25%), a second spray of difenoconazole 25% EC (0.05%) and third spray of Mancozeb 75WP (0.25%) which was at par with spray chlorothalonil 75%WP (0.2%) at 10 days interval 1:2.08 (Table 1).

In the present exploration, first spray Mancozeb 75WP (0.25%), second spray of difenoconazole 25% EC (0.05%) and third spray of Mancozeb 75WP (0.25%) recorded enhanced show to plant height, grade tuber, total tuber yield and lessen disease severity as compared to rest of treatment. The higher yield attribute may be due to the two-time spray of mancozeb and mancozeb, which has a broad-spectrum fungicide of zinc and manganese salts also known. These results verify with the earlier findings mancozeb is a well-known agricultural non-systemic

dithiocarbamate fungicide and a broad-spectrum fungicide with a multisite protective action, which is a fusion of maneb and zineb (Gullino et al. 2010). It inhibits or interferes at least six different biochemical methods within the cell cytoplasm and mitochondria, resulting in inhibition of spore germination in fungi due to its interruption of lipid metabolism, respiration, and production of adenosine triphosphate (Iorio et al. 2015). Mancozeb has managed potato early blight (Gent & Schwartz 2003) routinely. In a study conducted by Singh et al. 2018, it is concluded that micronutrients (Zn and Mn) are very necessary to improve the yield and quality of potato tuber crops as depicted by positive results were obtained from foliar application of zinc and manganese sulphate on all plant characteristics relating to yield and quality of potato crop. The information obtained in the present study should be helpful to potato growers as they develop and implement strategies to successfully manage early blight in potato.

Table 1. Fungicide schedules effect on growth parameters and yield attributes (Pooled)

Treatments	Yield of tubers 0-25g (t/ha)	Yield of tubers 25-75g (t/ha)	Yield of tubers >75g (t/ha)	Total tuber yield (t/ha)	IC:BR
T1: Control	2.7b	7.1b	6.8b	16.52c	1:1.53
T2: First spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval	4.1ab	8.9ab	9.1ab	22.08b	1:1.91
T3: First spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25 % EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval	4.9a	9.6a	10.8a	25.27a	1:2.18
T4: Spray chlorothalonil 75%WP(0.2%) at 10 days interval	4.4ab	9.1ab	10.7a	24.18ab	1:2.08
S. Em. $\pm$	0.25	0.50	0.49	0.84	
CD (0.05)	0.54	1.09	1.07	1.83	

Table 2. Fungicide schedules on number of tubers and per cent disease severity

Treatments	No of tubers 0-25g (000'/ha)	No of tubers 25-75g (000'/ha)	No of tubers >75g (000'/ha)	Total number of tuber (000'/ha)	% Disease severity	Per cent disease control
T1: Control	185.2b	186.6c	112.0c	483.8d	44.40 (41.78)d	—
T2: First spray of mancozeb 75WP (0.25%), second spray of hexaconazole 5EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval	204.0ab	205.4b	117.4b	526.8c	17.10 (24.43)b	61.48
T3: First spray of mancozeb 75WP (0.25%), second spray of difenoconazole 25 % EC (0.05%) and third spray of mancozeb 75WP (0.25%) at 10 days interval	221.0a	224.8a	138.4a	584.2a	11.40 (19.73)a	74.32
T4: Spray chlorothalonil 75%WP (0.2%) at 10 days interval	206.0ab	213.8ab	126.8ab	546.6b	20.60 (26.99)c	53.60
S. Em. $\pm$	7.85	7.17	5.77	12.27	1.00	—
CD (0.05)	17.09	15.62	12.56	26.72	2.25	—

Conclusion

Minimum disease severity with maximum disease control was recorded in the treatment with first spray of mancozeb 75WP (0.25%) followed by a second spray of difenoconazole 25% EC (0.05%) and a third spray of mancozeb 75WP (0.25%). The second-best treatment was where the first spray of mancozeb 75WP (0.25%) was followed by the second spray of hexaconazole 5EC (0.05%) and a third spray of mancozeb 75WP (0.25%).

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Declarations of interests

All authors of this manuscript declare that they have no conflict of interest.

Data sharing

All relevant data are within the manuscript.

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