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Invitro Efficacy of Different Chemical Fungicides against *Fusarium* Spp. in Potato

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ABSTRACT

This study was carried out at the National Plant Pathology Research Center (NPPRC), Khumaltar, Lalitpur to evaluate the efficacy of different chemical fungicides against *Fusarium* spp. causing dry rot in potato (*Solanum tuberosum* L.) leading to considerable post-harvest losses. The experiment was conducted using the poisoned food technique in PDA media under laboratory condition. Five fungicides including Samradhi (Mancozeb 75% WP), Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG), M-Control (Chlorothalonil 75% WP), G-Tuphan (Dimethomorph 50% WDG) and Sectin (Fenamidone 10% + Mancozeb 50% WDG) were tested at concentrations of 50 ppm, 100 ppm and 200 ppm in a Completely Randomized Design with four replications. Findings revealed that all fungicides inhibited the mycelial growth of *Fusarium* spp., with variations among concentrations and observation days. Samradhi (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) were the most effective fungicides, providing 100% mycelial inhibition from day 1 to day 5 at all concentrations tested. Moderate inhibition was recorded with M-Control (Chlorothalonil 75% WP), ranging from 51.31% at 50 ppm on day 1 to 61.70% at 200 ppm on day 5. G-Tuphan (Dimethomorph 50% WDG) also showed moderate suppression, increasing from 35.20% at 50 ppm on day 1 to 59.62% at 200 ppm on day 5. Sectin (Fenamidone 10% + Mancozeb 50% WDG) showed the lowest efficacy, with inhibition values ranging from 34.21% at 50 ppm on day 1 to 47.32% at 200 ppm on day 5. The results indicate that Samradhi (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) are highly effective in suppressing *Fusarium* spp. under laboratory conditions. Field-level validation is essential before recommending these fungicides for integration into potato dry rot management practices.

Keywords: Disease management, dry rot, mycelial growth inhibition, poisoned food technique, post-harvest losses

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INTRODUCTION

In Nepal, potato (*Solanum tuberosum* L.) is considered an important food crop with high economic and nutritional value (MoALD, 2022). Potato ranks fifth in global production after paddy, maize, wheat, and sugarcane, with China and India being the major producers (FAOSTAT, 2022). Originating from the Peruvian-Bolivian Andes, potatoes are now cultivated worldwide under diverse climatic conditions (Singh et al., 2020). China is the largest producer globally, contributing over 93 million metric tons, followed by Germany, Russia, Ukraine, India, and the United States, highlighting the widespread geographic distribution of potato cultivation.

In Nepal, agriculture is a key sector that contributes to food security, employment, and income generation. Out of the total land area of 147,181 square kilometer, agricultural land comprises 41,275.54 square kilometer of which 21% (3,091 ha) is cultivated and 7% (1,030 ha) remains uncultivated (MoALD, 2022). Potato is cultivated on 203,812 ha with an annual production of 3,487,816 tons, ranking second in production and sixth in cultivated area after paddy, maize, wheat, oilseeds, and lentils (Nandwani et al., 2021). Nepal is also among the top 20 countries in per capita potato consumption (Subedi et al., 2019).

Potato production in Nepal is affected by several fungal diseases, among which dry rot caused by *Fusarium* spp. is a major post-harvest problem, resulting in significant economic losses worldwide (Mortensen & Bullard, 2025). Fusarium dry rot affects tubers during storage and seed pieces after planting. Annual crop losses due to dry rot are estimated between 6 to 25 percent (Chełkowski, 1989), with over 60% of stored tubers potentially affected (Carnegie et al., 1990). The disease is characterized by necrotic dry lesions that often develop through wounds such as cuts or bruises. Infected tubers frequently rot from the center (Sandipan et al., 2016). Fusarium dry rot develops optimally under high relative humidity and temperatures of 15-20°C. Multiple species of *Fusarium* are responsible for the disease, with *Fusarium sambucinum* (teleomorph *Gibberella pulicaris*) being the most common, while *F. solani* var. *coeruleum* and *F. avenaceum* also contribute. Globally, thirteen *Fusarium* species are reported to cause potato dry rot (Cullen et al., 2005).

Management of Fusarium dry rot is challenging due to its soil-borne nature, infection through wounds, and limited curative measures. Cultural practices such as crop rotation are often ineffective against this disease (Bojanowski et al., 2013). Chemical control using fungicides remains a widely adopted strategy; however, over-reliance on

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chemicals can lead to fungicide resistance, environmental hazards, and potential health risks. In-vitro evaluation of fungicides provides a controlled approach to screen for effective treatments against *Fusarium* spp., thereby guiding efficient disease management strategies and reducing unnecessary chemical application in the field.

MATERIALS AND METHODS

Study area

The research was conducted at National Plant Pathology Research Centre (NPPRC) which is one of the seven plant science disciplinary of National Agricultural Research Institute (NARI) under Nepal Agricultural Research Council (NARC) located in Khumaltar, Lalitpur district of Nepal.

Materials used

All laboratory equipment, chemicals, media, and pure culture were obtained from the National Plant Pathology Research Centre, NARC. Hot pan, autoclave, incubator, hot air oven, laminar air flow, weighing balance, compound microscope, micropipette, forceps, needles, corn borer, Bunsen burner, conical flasks, Petri plates, and parafilm were among the main equipment. Potato Dextrose Agar, 70% alcohol, streptomycin, and five commercial fungicides were utilized.

Preparation of test pathogen

A pure culture of *Fusarium* sp. was provided by the Plant Pathology Laboratory. To obtain the test pathogen, a pure culture of *Fusarium* spp. isolated from potato tubers affected with dry rot obtained from Dhanusha district was sub-cultured on PDA and incubated at 25°C for seven days.

Pathogen identification

The isolate produced soft, fluffy, white mycelium with pinkish-purple centers on PDA. Macroconidia were large, sickle-shaped and multi-celled; microconidia were single-celled, oval to elliptical, clustered under the microscope.

In Vitro evaluation of fungicides

PDA preparation

One liter of distilled water was used to prepare 40 grams of PDA. After preparing 1.5 L of medium, it was heated to 200℃ using a magnetic stirrer, split into 100 ml conical flasks, covered, plugged, and autoclaved for 20 minutes at 121°C.

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Fungicides tested

Five fungicides viz Samradhi (Mancozeb 75% WP), M-Control (Chlorothalonil 75% WP), G-Tuphan (Dimethomorph 50% WDG), Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG), and Sectin (Fenamidone 10% + Mancozeb 50% WDG) were evaluated at three different concentrations of 50, 100, and 200 ppm using the poisoned food technique.

Preparation of fungicide-amended PDA

Cooled autoclaved media were amended with fungicides. As quantities were less than 1 g, stock solutions were prepared in 1 ml distilled water before mixing with PDA. Streptomycin (0.05 g) was added to prevent bacterial contamination. Each 90 mm Petri plate received 20 ml of poisoned medium and was left to solidify overnight in a laminar flow cabinet.

Pathogen inoculation

Poisoned PDA plates were left overnight in a laminar air flow cabinet. A 5mm cork borer was used to cut and transfer 7 days old *Fusarium* spp. mycelium to the center of each plate. Plates were sealed with parafilm to prevent contamination. Four replicates were maintained for each treatment and a control plate was also maintained on fungicide free PDA media. All plates were incubated at 25°C in an incubator.

Research design

A total of sixteen treatments were assessed, including five chemical fungicides and a control treatment. Four replications of each treatment were used in Randomized Complete Block Design (RCBD experiment. The fungicidal efficacy was evaluated using the poisoned food method.

Data recording

After the inoculation, data collection started 24 hours later. For five days in a sequence, measurements of the pathogen's growth were taken every day. Two lines were drawn through the center of each plate, vertical (V) and horizontal (H), and the average was calculated to determine the colony diameter.

Data analysis

All the recorded data were compiled in MS Excel (2016). Percent inhibition of mycelial growth over the control was calculated using the formula by Vincent (1947):

Growth inhibition (%) = C-T/C*100

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where:
C = colony diameter of *Fusarium* spp. in control (mean of both diagonals)
T = colony diameter of *Fusarium* spp. in treatment (mean of both diagonals)
Statistical analysis was performed using R-Studio through one-way ANOVA, and treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Efficacy of fungicides against mycelial growth of *Fusarium* spp. by poisoned food method

Using the poisoned food method, five fungicides were evaluated in vitro for their ability to inhibit the mycelial growth of *Fusarium* spp. at three different concentrations. From Day 1 to Day 5, the coefficients of variation for each fungicide were 10.88%, 14.74%, 11.53%, 10.63%, and 9.17%, all of which inhibited growth relative to the control. The control exhibited the greatest growth, rising from 3.04 cm on Day 1 to 7.86 cm on Day 5, and it was statistically different from all other treatments. At all concentrations of 50, 100, and 200 ppm, Samradhi M-45 (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) totally inhibited growth, maintaining it at zero centimeters. G-Tuphan (Dimethomorph 50% WDG) showed moderate inhibition, with 2.3 cm growth at 100 ppm on Day 5, though 200 ppm showed slightly reduced efficacy. M-Control (Chlorothalonil 75% WP) produced consistent moderate inhibition with Day 5 growth between 3.01 cm (200 ppm) and 3.16 cm (50 ppm). Sectin (Fenamidone 10% + Mancozeb 50% WDG) was less effective, allowing 5.03 cm (50 ppm) to 4.14 cm (200 ppm) growth on Day 5. Overall, Samradhi (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) were most effective, followed by moderate efficacy of G-Tuphan (Dimethomorph 50% WDG) and M-Control (Chlorothalonil 75% WP) while Sectin (Fenamidone 10% + Mancozeb 50% WDG) showed comparatively lower suppression.

The effectiveness of different fungicides against *Fusarium* spp. was observed over a 5-day period, and the results showed clear differences among the fungicides and their concentrations. Samradhi (Mancozeb 75% WP) proved to be the most reliable treatment, achieving complete 100% inhibition at 50, 100, and 200 ppm throughout all five days. Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) performed equally well, maintaining 100% inhibition from the beginning to the end of the experiment at

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every concentration tested. M-Control (Chlorothalonil 75% WP) provided a moderate level of suppression, with inhibition increasing slightly from 59.79% at 50 ppm to 61.70% at 200 ppm by Day 5

Table 5. Results of poisoned food technique showing mycelium growth of pathogen

Fungicides	Mean mycelial growth (cm)				
	Day1	Day2	Day3	Day4	Day5
Control	3.04^{a}	4.01^{a}	6.14^{a}	7.25 ^{a}	7.86^{a}
Dimethomorph 50% WDG 50 ppm	1.96^{c}	2.43^{bc}	2.61^{de}	2.75^{d}	2.83^{e}
Dimethomorph 50% WDG 100 ppm	1.76^{d}	2.03^{de}	2.03^{f}	2.18^{e}	2.3^{f}
Dimethomorph 50% WDG 200 ppm	2.30^{b}	2.68^{b}	2.69^{d}	2.93^{d}	3.25^{d}
Mancozeb 75% WP 50 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Mancozeb 75% WP 100 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Mancozeb 75% WP 200 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Fenamidone 10% + Mancozeb 50% WDG 50 ppm	2 ^{c}	2.53^{bc}	3.68^{b}	4.35^{b}	5.03^{b}
Fenamidone 10% + Mancozeb 50% WDG 100 ppm	1.7^{de}	2.21^{cd}	3.17^{c}	3.73^{c}	4.21^{c}
Fenamidone 10% + Mancozeb 50% WDG 200ppm	1.56^{ef}	2.06^{de}	3.02^{c}	3.65 ^{c}	4.14^{c}
Tebuconazole 50% + Trifloxystrobin 25% WG 50 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Tebuconazole 50% + Trifloxystrobin 25% WG 100 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Tebuconazole 50% + Trifloxystrobin 25% WG 200 ppm	0 ^{g}	0 ^{f}	0 ^{g}	0 ^{f}	0 ^{g}
Chlorothalonil 75% WP 50 ppm	1.48^{f}	1.84^{e}	2.56^{de}	2.78^{d}	3.16^{de}
Chlorothalonil 75% WP 100 ppm	1.44^{f}	1.84^{e}	2.45^{de}	2.83^{d}	3.1^{de}
Chlorothalonil 75% WP 200 ppm	1.41^{f}	1.72^{e}	2.33^{ef}	2.7^{d}	3.01^{de}
SEM(+-)	0.06	0.11	0.11	0.12	0.11
LSD	0.18	0.31	0.31	0.33	0.31
CV	10.88	14.74	11.53	10.63	9.17
F test	201.99	201.38	188.34	199.79	199.28
Grand Mean	1.16	1.46	1.91	2.19	2.43
P value	<0.001	<0.001	<0.001	<0.001	<0.001

CV: Coefficient of variation, LSD: Least significant difference, Means followed by the same letter in a column are not significantly different by Duncan's multiple range test, SEM: Standard error of the mean, cm is centimeters

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. G-Tuphan (Dimethomorph 50% WDG) showed varied results, with the best performance at 100 ppm (41.42% to70.79%), which was better than at 50 ppm and 200 ppm, though still less effective than the top treatments. Sectin (Fenamidone 10% + Mancozeb 50% WDG) was the least effective in this study.

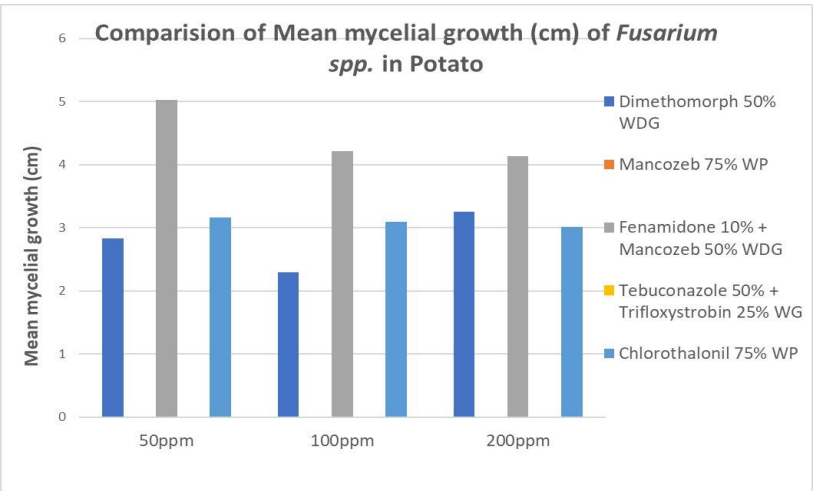

Figure 4. Bar graph showing percent growth of *Fusarium* spp. at different concentrations of chemical fungicides (Day 5), NPPRC, Lalitpur, 2025

Effect of commercial fungicides on the inhibition percentage of *Fusarium* spp.

Even at 200 ppm, inhibition reached only 47.32% on Day 5, and the lowest values (34.21% to 36.0%) were recorded at 50 ppm, indicating limited ability to suppress pathogen growth. Overall, Samradhi (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) stood out as the most effective fungicides, delivering complete and consistent inhibition of *Fusarium* spp. M-Control (Chlorothalonil 75% WP) and G-Tuphan (Dimethomorph 50% WDG), particularly at 100 ppm, offered moderate control, while Sectin (Fenamidone 10% + Mancozeb 50% WDG) showed comparatively weak performance under in vitro conditions.

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Table 2. Result of poisoned food technique showing mycelial growth inhibition percentage

Fungicides	Mycelial growth inhibition (%)				
	IP Day1	IP Day2	IP Day3	IP Day4	IP Day5
Control	0.00	0.00	0.00	0.00	0.00
Dimethomorph 50% WDG 50ppm	35.2^{e}	39.61^{de}	57.50^{c}	62.15^{c}	63.95^{c}
Dimethomorph 50% WDG 100ppm	41.42^{de}	49.44^{bc}	66.89^{b}	69.83^{b}	70.79^{b}
Dimethomorph 50% WDG 200 ppm	24.20^{f}	32.95^{e}	56.09^{cd}	58.60^{d}	59.62^{c}
Mancozeb 75% WP 50 ppm	100.00	100.00	100.00	100.00	100.00
Mancozeb 75% WP 100 ppm	100.00	100.00	100.00	100.00	100.00
Mancozeb 75% WP 200 ppm	100.00	100.00	100.00	100.00	100.00
Fenamidone 10% + Mancozeb 50% WDG 50 ppm	34.21^{e}	36.90^{de}	40.06^{f}	40.00^{e}	36.00^{f}
Fenamidone 10% + Mancozeb 50% WDG 100 ppm	44.07^{cd}	44.88^{cd}	48.37^{e}	48.55^{d}	46.43^{e}
Fenamidone 10% + Mancozeb 50% WDG 200 ppm	48.68^{cd}	48.57^{bc}	50.81^{de}	49.66^{d}	47.32^{e}
Tebuconazole 50% + Trifloxystrobin 25% WG 50 ppm	100.00	100.00	100.00	100.00	100.00
Tebuconazole 50% + Trifloxystrobin 25% WG 100 ppm	100.00	100.00	100.00	100.00	100.00
Tebuconazole 50% + Trifloxystrobin 25% WG 200 ppm	100.00	100.00	100.00	100.00	100.00
Chlorothalonil 75% WP 50 ppm	51.31^{bc}	54.11^{b}	58.30^{c}	61.65^{cd}	59.79^{c}
Chlorothalonil 75% WP 100 ppm	52.63^{b}	54.11^{b}	60.09^{c}	60.96^{cd}	60.55^{c}
Chlorothalonil 75% WP 200 ppm	53.61^{b}	57.10^{b}	62.05^{bc}	62.75^{cd}	61.70^{c}
SEM(+-)	2.6	2.9	1.9	1.7	1.5
LSD	7.3	8.1	5.4	4.9	4.3
CV	8.3	8.9	5.6	4.9	4.4
Grand Mean	61.5	63.6	68.7	69.6	69.1
P value	<0.001	<0.001	<0.001	<0.001	<0.001

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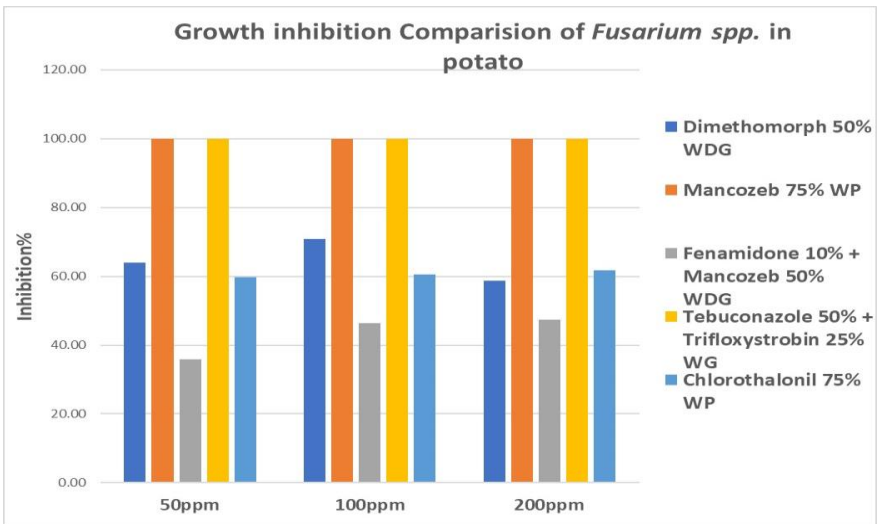

Figure 2. Bar graph showing the percent of inhibition of *Fusarium* sp. by various fungicides at different concentrations

CONCLUSION

By performing an in-vitro assessment of various fungicides against *Fusarium* spp., causative agent of potato dry rot, the results revealed that the tested fungicides at different concentrations (50, 100, and 200 ppm) using the poison bait technique had distinct variations in inhibitory efficacy. Samradhi (Mancozeb 75% WP) and Nativo (Tebuconazole 50% + Trifloxystrobin 25% WG) were the most effective treatments, continuously achieving 100% suppression of mycelial growth across all concentrations and observation days. Other fungicides, such as M-Control (Chlorothalonil 75% WP) and G-Tuphan (Dimethomorph 50% WDG), provided moderate inhibition and might be used as alternatives. On the other hand, Sectin (Fenamidone 10% + Mancozeb 50% WDG) shown relatively lesser efficacy. Crucially, the study determined economical ways to manage potato dry rot by identifying fungicides that effectively suppress the disease even at low concentrations. These results serve as a basis for the selection of effective fungicides and offer important data for upcoming field testing and integrated disease control strategies.

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SUGGESTIONS

For the long-term and sustainable control of *Fusarium* spp. integrated management strategies that combine chemical fungicides with cultural techniques (such as crop rotation, the use of healthy seed tubers, and appropriate storage conditions) can be suggested.

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