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Management of Black Scurf of Potato Caused by *Rhizoctonia solani* in Eastern Uttar Pradesh

C.N. Ram[1], Manoj Kumar Maurya[1], Pradeep Kumar Dalal[1], Sanjeev Singh[1], Anil Kumar[1] **10.18805/IJARe.A-6414**

ABSTRACT

Background: Black scurf of potato, caused by *Rhizoctonia solani* (Kuhn), is a significant soil-borne disease that hampers potato cultivation in Eastern Uttar Pradesh by reducing both tuber quality and yield. The pathogen's persistence in the soil and on the seed tubers necessitate effective disease management strategies, especially under field conditions where environmental factors favour disease development.

Methods: Field experiments were conducted during the rabi seasons of 2022-23 and 2023-24 at the Main Experimental Station, Vegetable Science and UAT, Kumarganj, Ayodhya. This study aimed to evaluate the efficacy of various fungicidal seed tubers treatments against black scurf using the variety Kufri Sindhuri. The study followed a randomized block design (RBD) with five treatments including Pencycuron 22.9 SC, Penflufen 22.43% FS, Thifluzamide 24.0 SC, a combination of Mancozeb 50%+ Carbendazim 25% WS and an untreated diseased tuber (control). Disease incidence, severity and tuber yield were recorded and statistically analysed.

Result: All tested fungicidal treatments significantly reduced black scurf incidence and severity compared to the untreated control. Among them, Pencycuron 22.9 SC was the most effective, reducing disease incidence to 5.20% and enhancing yield to 243.00 q/ha in the 2023-24 season. Thifluzamide 24.0 SC also demonstrated high efficacy, particularly in reducing the disease index to 5.36%. Although yield differences were not statistically significant in the second year, the overall trend indicated a positive correlation between disease suppression and yield improvement. These findings support the adoption of fungicidal seed tuber treatment, particularly with Pencycuron and Thifluzamide, as an integral part of black scurf management strategies in Eastern Uttar Pradesh.

Key words: Black scurf, Fungicide, Management, Potato, *Rhizoctonia solani.*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops globally, ranking fourth after maize, wheat and rice in terms of production and consumption. It is a staple crop with high economic and nutritional value. It is a nutritious tuber vegetable and rich source of starch, vitamins especially (C and B_1) and minerals (Zaheer and Akhtar, 2016). In India, it occupies a prominent place in vegetable production, particularly in the Indo-gangetic plains, including eastern Uttar Pradesh, which is a major potato-growing region (Singh *et al.,* 2021). One of the major biotic constraints affecting potato cultivation is black scurf, caused by the soil-borne fungal pathogen *Rhizoctonia solani* (Kuhn) also causes root rot, stem canker and damping-off disease complexes of potato crop (Bains *et al.,* 2002).

This disease is prevalent in almost all potato-growing areas and causes considerable yield and quality losses. In India, it is responsible for 10-25% yield loss (Sharma, 2015) and in severe cases, it can cause up to 50% yield reduction (Verma *et al.,* 2021). Yield loss is directly related to disease severity, with tubers having over 10% sclerotia coverage showing markedly reduced yields compared to healthy tubers (Jain *et al.,* 2024). Eastern Uttar Pradesh is one of the major potato-growing regions, share 18.5% area and contribute approximately 16.5% production in overall production of potato in Uttar Pradesh (Statistical Abstract, UP, 2023), where farmers face serious challenges due to black scurf and stem canker. This pathogen produces symptoms on both above and below-ground plant parts of potato. Black scurf appears as hard, black sclerotia on the surface of the tuber, which reduces marketability and yield, while stem canker affects underground stems, leading to poor crop stand, stunted growth and reduced tuber formation (Banville, 1989; Tsror, 2010). Temperature and soil moisture play an important role in disease development. The optimum temperature is 20-25°C and moisture is 20% for its growth (Kiptoo *et al.,* 2021). The shallow sowing of potato tubers resulting minimum black scurf incidence and severity compared to deep sowing. The disease is negatively correlated with evening soil temperature but positively correlated with morning temperature and soil moisture (Kumar *et al*., 2018).

[1]Department of Vegetable Science, Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya-224 229, Uttar Pradesh, India.

Corresponding Author: Manoj Kumar Maurya, Department of Vegetable Science, Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya-224 229, Uttar Pradesh, India. Email: drmanoj.pathovs@nduat.org
ORCID: 0009-0008-8084-0208

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The management of *R. solani* is challenging due to its broad host range, soil persistence and lack of resistant potato cultivars. Cultural practices and crop rotation alone are often insufficient in limiting the disease effectively under field conditions. Patel and Singh (2021) reported the use of organic approaches, such as bio-agents and organic amendments, for the management of black scurf of potato, however, their effectiveness remains limited. Among the various control strategies, chemical management through fungicidal seed (tuber) treatment remains one of the most effective and widely adopted practices (Nagaich *et al*., 2005; Dey *et al*., 2014). Several fungicides, including Pencycuron, Penflufen, Thifluzamid and combinations like Mancozeb + Carbendazim, have shown promising results in managing *R. solani* in different agro-climatic zones (Nema and Sharma, 2011; Lal *et al.,* 2020). However, data specific to eastern Uttar Pradesh, with its unique climate and soil conditions, are limited.

This study was undertaken to evaluate the comparative efficacy of tested fungicidal seed tuber treatments against black scurf of potatoes over two consecutive growing seasons in eastern Uttar Pradesh. The results aim to support region-specific chemical disease management strategies to improve potato productivity and tuber quality.

MATERIALS AND METHODS

The field experiments were carried out with various fungicides along with treated tubers and untreated diseased tubers (control) at Main Experimental Station (MES), Vegetable Science and UAT Kumarganj Ayodhya for two consecutive years (2022-23 and 2023-24) using a randomized block design (RBD) with five treatments (Table 1) to evaluate their fungicidal efficacy against black scurf. The black scurf affected tubers (Fig 1) were collected from field.

Tubers of variety, Kufri Sindhuri were dipped in solutions of tested fungicides for 30 minutes before sowing along with untreated diseased (control) Fig 2 and spread in shade till the tubers got dried completely. Tubers of potato variety Kufri Sindhuri were planted with 60 × 20 cm spacing. Each treatment had 3 m × 2 m plot in a randomized block design (RBD) with five replications. All the recommended and cultural practices were followed to raise the crop (Fig 3) up to 90 days after which the haulms were cut. The harvesting of tubers were carried out after 10 days of haulms cutting. The evaluation of efficacy of tested fungicides against black scurf disease was carried out according to 0-4 disease rating scale was used and crops were harvested at 100-105 days after sowing. After harvesting, 50 tubers were randomly selected from each treatment plot, tubers were washed and black scurf disease incidence, intensity (index) and tuber yields (q/ha) were recorded and then disease index was calculated as per the scale (Table 2) and method used by Somani (1986).

Per cent Disease Index/Intensity was calculated by-

$$\text{PDI (Index/Intensity)} = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of tubers examined} \times \text{Maximum rating}} \times 100$$

The per cent disease incidence (PDI) was calculated by using the formula proposed by Ahmad *et al*. (1995) as described below: -

$$\text{PDI} = \frac{\text{No. of tubers infected}}{\text{Total no. of tubers observed}} \times 100$$

Statistical analysis

The recorded data sets were statistically analysed using OPSTAT software (Sheoran, 2006) where the data sets were subjected to one way ANOVA at the 5% level of significance.

RESULTS AND DISCUSSION

The results of the field experiments carried out during the rabi seasons of 2022-23 and 2023-24 to assess the efficacy of tested fungicidal tubers treatments against black scurf in potatoes are presented in Table 3 and Table 4.

Per cent disease incidence (tubers infected by black scurf)

During 2022-23, a significant reduction in disease incidence was observed in all treated plots compared to the untreated control (T_1), which recorded the highest incidence at 65.33%. Among the treatments, T_2 (Pencycuron 22.9 SC @ 0.35%) recorded the lowest incidence at 27.31%, followed by T_3 (32.37%) and T_5 (33.06%). The treatment with Thifluzamid (T_4) also significantly reduced incidence to 38.61%. These differences were statistically significant at the 5% level (CD = 1.67%). In 2023-24, a similar trend was observed. T_2 once again resulted in the lowest disease incidence (5.20%), followed closely by T_4 (6.21%) and T_3 (8.10%). The control plot recorded 21.70% incidence. The differences among treatments were significant (CD = 1.90%),

Table 1: Treatments details of experiments during trial conducted.

T_1	Untreated diseased tubers (Control).
T_2	Tuber treatment with Pencycuron 22.9 SC @ 0.35%.
T_3	Tuber treatment with Penflufen 22.43% FS @ 0.1%.
T_4	Tuber treatment with Thifluzamid 24.0 SC @ 0.35%.
T_5	Tuber treatment with Mancozeb 50% + Carbendazim 25% WS @ 0.5%.



Fig 1: Black scurf affected tubers of Kufri Sindhuri.

confirming the consistent performance of the fungicidal treatments across both years.

Per cent disease index (tuber surface area covered by black scurf)

The per cent disease index was significantly affected by fungicidal treatments in both years. In 2022-23, the highest disease index was observed in the untreated control (45.66%), while T_2 recorded the lowest index (21.04%), followed by T_3 (22.48%), T_4 (26.78%) and T_5 (30.31%). The differences were statistically significant (CD = 1.07%). In 2023-24, the per cent disease index followed a similar pattern, with the lowest in T_4 (5.36%), followed by T_2 (7.50%), T_5 (8.60%) and T_3 (9.60%). The control plot showed a higher index of 32.50%. The results demonstrated significant improvement in disease suppression with all fungicidal treatments (CD = 1.39%).

Total tuber yield (q/ha)

In 2022-23, all fungicide-treated plots recorded significantly higher yields compared to the untreated control (183.40 q/ha). T_2 (Pencycuron) recorded the highest yield (233.40 q/ha), followed by T_5 (211.10 q/ha), T_4 (205.60 q/ha) and T_3 (194.50 q/ha). The differences were statistically significant (CD = 3.16 q/ha). In 2023-24, although statistical analysis revealed that yield differences among treatments were not significant (CD = NS), numerical trends were consistent with the previous year. T_2 yielded the highest (243.00 q/ha), followed by T_4 (237.00 q/ha), T_3 (235.50 q/ha) and T_5 (233.10 q/ha), compared to 220.40 q/ha in the untreated control. The increase in yield in treated plots can be attributed to effective disease suppression.

Among the various tested fungicides, Pencycuron 22.9 SC (T_2) consistently emerged as the most effective treatment, significantly reducing both the percent disease incidence and disease index, while simultaneously improving tuber yield. Pencycuron, a phenylurea fungicide, is known for its high specificity and effectiveness against *R. solani*, particularly in preventing hyphal growth and infection at early stages (Stevenson *et al*., 2001). Similar result found that treating potato seed tubers with either pencycuron at 0.057% active ingredient or a 3% boric acid spray before planting effectively controlled black scurf disease without hindering crop emergence (Arora, 2013). The lowest disease incidence and index recorded in T_2 during both years, along with the highest yield; reinforce its potential as a reliable fungicidal option in the integrated management of *R. solani*.

Thifluzamide (T_4), a SDHI (succinate dehydrogenase inhibitor) fungicide, also exhibited consistent and promising results, especially in the second year where it recorded the lowest disease index (5.36%). Thifluzamide interferes with fungal respiration, effectively limiting lesion development and sclerotia formation (Ajayi-Oyetunde and Bradley, 2018). Its performance in this study corroborates earlier findings by Yellareddygari *et al.* (2014), who reported strong efficacy of Thifluzamide against soil borne pathogens inciting *R. solani*. The performance of T_3 and T_5 treatments, while slightly lesser to T_2 and T_4, also contributed significantly to disease suppression and yield enhancement. These results suggest that a range of fungicidal options exists and the choice may be tailored based on availability, cost and local disease pressure. The substantial reduction in percent disease incidence from 65.33% in untreated control (T_1) to as low as 5.20% with T_2 in 2023-24, evaluate effectiveness of chemical seed/tuber treatment as a disease management strategy. Such reductions are critical not only for minimizing losses but also for improving tuber quality and marketability, which

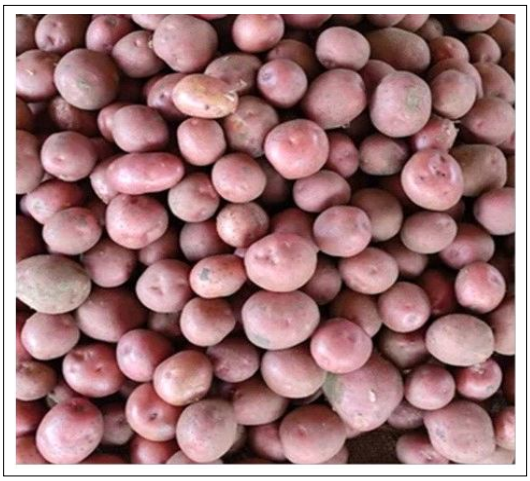


Fig 2: Treated tubers with tested fungicides.



Fig 3: Field trial conducted at MES vegetable farm of ANDUAT, Ayodhya.

Table 2: Disease rating scale observations to be determined by using 0 - 4 scale.

Rating scale	Description (Tuber surface area affected).
0	Healthy (Tuber surface area not affected).
1	Up to 25% Tuber surface area affected.
2	26 to 50% Tuber surface area affected.
3	51 to 75% Tuber surface area affected.
4	More than 75% Tuber surface area affected.

Table 3: Efficacy of fungicidal seed tuber treatments against black scurf of potato on disease incidence, disease index and tuber yield during 2022-23.

Treatment	% Disease incidence	% Disease index	Total yield (q/ha)
T_1	65.33	45.66	183.40
T_2	27.31	21.04	233.40
T_3	32.37	22.48	194.50
T_4	38.61	26.78	205.60
T_5	33.06	30.31	211.10
SE(d)	0.71	0.46	1.35
C.D.	1.67	1.07	3.16
C.V.	2.21	1.92	8.04

Table 4: Efficacy of fungicidal seed tuber treatments against black scurf of potato on disease incidence, disease index and tuber yield during 2023-24.

Treatments	% Disease incidence	% Disease index	Total yield (q/ha)
T1	21.70	32.50	220.40
T2	5.20	7.50	243.00
T3	8.10	9.60	235.50
T4	6.21	5.36	237.00
T5	10.30	8.60	233.10
SE(d)	0.89	0.65	2.27
CD (0.05)	1.90	1.39	NS
CV%	13.66	8.10	15.38

are heavily impacted by black scurf blemishes (Lees *et al.,* 2010).

Moreover, the yield enhancement observed in treated plots, although statistically non-significant in the second year, consistently followed the trend of reduced disease pressure. This aligns with previous studies which indicated that effective suppression of *R. solani* leads to improved plant vigor and resource allocation, resulting in better yield outcomes (Bandyopadhyay *et al.,* 2013). However, considering the potential for resistance development and environmental impact, periodic rotation of fungicides and integration with cultural and biological methods is recommended for sustainable disease management (FRAC, 2024).

CONCLUSION

Across both seasons, Pencycuron (T_2) consistently showed superior performance in reducing disease incidence and severity while improving tuber yield. Thifluzamid (T_4) and Penflufen (T_3) were also effective, with Thifluzamid showing excellent disease suppression in 2023-24. The combination treatment of Mancozeb + Carbendazim (T_5) showed intermediate results but was better than untreated control in both years. Overall, the data support the integration of fungicidal tubers treatment, particularly with Pencycuron and Thifluzamide, as an effective strategy in the holistic management of *R. solani* in Eastern Uttar Pradesh and similar agro-ecological regions.

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Disclaimers

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Author's contribution

All the authors mentioned above have significantly contributed to the work in a direct and intellectual manner and have given their approval for its publication.

Conflict of interest

The authors declare that there is no conflict of interest.

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