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Investigations on pathogenic fungi associated with Post harvest deterioration of onion (*Allium cepa* L.) bulbs and their management

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Abstract
Onion (*Allium cepa* L.) is a bulbous, biennial crop and it is one of the most important crops grown in India. Many diseases affect the onion crop, incurring quality and quantity losses. Onion suffers from many post-harvest diseases causing accountable losses of about above 50%. The studies revealed that *Aspergillus niger, Aspergillus flavus* and *Fusarium oxysporum* f. sp. *cepae* were found responsible for causing black mold and bulb rotting during storage. The pathogens were successfully isolated on potato dextrose agar and pathogenicity was their proved on healthy onion bulbs, under moist chamber by pin prick method. While in field trial systemic and non-systemic fungicides and bioagents were sprayed and analysed for disease incidence in storage. The studies revealed that Hexaconazole 5% EC has given good amount of disease control followed by Carbendazim 12%+Mancozeb 63% (Saff). It can be concluded that pre harvest sprays of Hexaconazole or Carbendazim 12% +Mancozeb 63% (Saff) reduce the disease incidence significantly. In present investigations, the effect of preharvest sprays of fungicides and bioagents were also studied for incidence of rot disease in onion and it revealed that hecaconazole was at par with Carbendazim 12% +Mancozeb 63% (Saff) were found to significant over other treatments.

Keywords: Onion, post-harvest diseases, *Aspergillus niger, Aspergillus flavus*, *Fusarium oxysporum* F. sp. *Cepae*, culture media, pre harvest sprays, fungicides, black mold, bulb rot

Introduction
Onion (*Allium cepa* L., 2n=2x=16) is a biennial, bulb-forming herb and one of the most important vegetable crops grown in India. It belongs to the Amaryllidaceae family and the Allium genus. Onion is believed to have originated in central Asia and is now widely cultivated due to its ability to grow in different climates and its high production potential. The reddish color of the onion's outer skin comes from compounds like catechuic acid, protocatechuic acid and other phenolic substances found in red onions, which also give them antifungal properties. Because of its usefulness in cooking and health, the onion is often called the "Queen of the kitchen."

India is the top producer, followed by China, Egypt, the USA and Turkey. India has approximately 1.3 million hectares under onion cultivation, with an estimated production of 27.5 million tonnes. The average productivity is around 21 tonnes per hectare, reflecting improvements in farming practices, irrigation systems and the adoption of high-yielding varieties. During 2021-22, the major onion-producing states included Maharashtra, which contributed the highest share at 43 per cent, followed by Madhya Pradesh (15%) and Karnataka (9%). Other significant contributors were Gujarat (8%), Rajasthan (5%), Bihar (4%), West Bengal (3%) and Andhra Pradesh, Tamil Nadu, Haryana and Uttar Pradesh, each accounting for 2% of the total production.

Onion bulbs are highly vulnerable to post-harvest diseases, mainly caused by fungal infections during storage. These infections often begin as latent infections in the field and, if not managed before harvest, can lead to significant losses after harvest. Around 35-40 per cent of post-harvest onion losses are due to storage diseases, with bulb rot alone causing about 15-30 per cent of the damage during storage. Several fungal and bacterial pathogens attack onion bulbs after harvest, including species of *Aspergillus*, *Botrytis*, *Fusarium*, *Colletotrichum*, *Penicillium*, *Rhizopus*, *Erwinia*, *Pseudomonas*, *Lactobacillus* and *Alternaria*.

Among these, *Aspergillus niger* is considered the most aggressive and damaging pathogen both in the field and during storage (Kumar, 2015) [8].

Aspergillus niger is a widespread fungus that primarily causes food spoilage and deterioration (Samson *et al*., 2004). Fusarium basal rot, caused by *Fusarium oxysporum* Schlechtend.: Fr. f. sp. *cepae* (H. N. Hans.) W.C. Snyder & H.N. Hans, is one of the most destructive diseases of onion, leading to significant yield losses in onion-growing regions worldwide (Brayford, 1996) [4].

The fungicide molecules are to be evaluated from time to time to find out superior fungicides to recommend an economical spray schedule with which the disease can be controlled. Pre-harvest fungicidal treatments can be an appropriate strategy for controlling onion bulb rots during storage (El-Shehaby *et al.,* 1997) [5] and (Rajapakse and Edirimanna, 2002) [11]. Post-harvest diseases are due to latent infection and if these infections are minimized before harvest, it is possible to reduce the post-harvest losses as well. Keeping this in view, an investigation was carried out to know the impact of pre-harvest sprays of some systemic, non-systemic fungicides in the management of post-harvest diseases of onion (Raju and Naik, 2006) [12].

Methodology

Isolation and identification of plant pathogen.

Pathogens were isolated from infected onion bulbs using tissue isolation techniques on Potato Dextrose Agar (PDA). Infected tissues were surface-sterilized with 0.1% $HgCl_2$, rinsed with sterile water, dried, and placed aseptically on PDA plates. The plates were incubated at 28±1 °C for four days to obtain pure mycelial growth. Fungal colonies were purified by the hyphal tip method, subcultured on PDA, and maintained on PDA slants for further study. Morphological characters of the fungus were studied by observing cotton blue stained slides under a compound microscope. The morphological characters like the shape of conidia, conidiophore and hyphae in *A. niger* and *A. flavus* and morphological characters such as septation, shape, colour, mycelium, micro and macro-conidia and chlamydospores in *F. oxysporum* f. sp. *cepae* were recorded from seven days old culture grown on PDA medium by the adoption of slide culture technique. Based on morphological characterization, the causal fungus was identified under the compound microscope at 100X magnification.

Pathogenicity test

The healthy onion bulbs were inoculated with the fungi by using the pinprick method of inoculation and then incubating at room temperature (28±1^{o}C) and observed for 7-30 days. The disease development symptoms were observed on bulbs and pathogens were re-isolated and identified satisfying Koch's postulates. The culture obtained was compared morphologically with the original one to confirm pathogenicity.

Impact of pre-harvest spraying of fungicides and bioagents: The spraying of fungicides were carried out 30 days, 20 days and 10 days before harvest along with control (water spray). Harvesting was done and the bulbs were cured for 3 -4 days in the field under leaf cover to dry the foliage before storage. Dried onion bulbs brought to laboratory and packed in perforated polythene bags. These bags will be stored for three months under ambient condition (27±1^{0}C) and observations were taken at fortnightly interval.

a) Percent Black Mold Bulbs

The percentage of blackening for each of the treatments were worked out as follows.

$$\text{Per cent black mold} = \frac{\text{Black mold bulbs}}{\text{Total number of bulbs}} \times 100$$

b) Blackening control

Black mold control (%) for each of the fungicidal treatments were worked out as follows:

$$\text{Per cent black mold control} = \frac{\text{\% black mold bulbs in control - \% black mold bulbs in treatment}}{\text{\% black mold bulbs in control}} \times 100$$

Statistical Analysis

Before analysing the data, percentages were converted into arcsine values. The data on disease index and infection percentages were analysed. Standard Error (SE) and Critical Difference (CD) at 5% level of significance were worked out. The treatment means were compared at 5% level of significance.

Results and Discussion

Present study entitled "Investigations on pathogenic fungi associated with post-harvest deterioration of onion (*Allium cepa* L.) Bulbs and their management" was undertaken during the summer season, 2024 - 25 on the aspects *viz*., isolation, symptomatology, pathogenicity test, morphological identification, impact of pre harvest spraying on post-harvest deterioration of onion bulbs.

Isolation and Pathogenicity

Pathogens were isolated from the infected onion bulbs collected from the local market. Standard tissue isolation method and hyphal tip isolation method was used to obtain a pure cultures *viz*., *Aspergillus niger*, *Aspergillus flavus* and *Fusarium oxysporum* f. sp. *cepae*. These fungi were repeatedly isolated and identified by the PDA (Potato Dextrose Agar) plate incubation method. The pure cultures were then transferred to slants and stored in a refrigerator for future research. Pathogenicity of the test pathogens *viz*., *A. niger, A. flavus* and *F. oxysporum* f. sp. *cepae* was proved by pinprick method by using healthy onion bulbs and kept for incubation in moist chamber.

Pathogenicity test revealed that, three pathogens such as *A. niger*, *A. flavus* and *F. oxysporum* f. sp. *cepae* are responsible for onion bulb deterioration. Further, re-isolation of the test pathogens were done and identified. The pathogenicity of *Aspergillus niger*, *Aspergillus flavus* and *Fusarium oxysporum* f. sp. *cepae* has been previously studied and confirmed by various researchers. The results of the present pathogenicity tests for *A. niger* are in agreement with the findings of Padule *et al.* (1996) [10], Srinivasan and Shanmugam (2006) [14] and Khatoon *et al.* (2017) [6]. Similarly, the results for *F. oxysporum* f. sp. *cepae* match those reported by Behrani *et al.* (2015) [3] and Ozoude *et al.* (2019) [9].

Identification

Aspergillus niger was identified by observing features such as conidiophores, conidia, foot cells and aspergilloid heads

with long metulae. *Aspergillus flavus* was identified through microscopic examination, which revealed the presence of conidiophores, conidia, vesicles and metulae. *Fusarium oxysporum* f. sp. *cepae* was identified based on its white to slightly pink, cottony mycelium, circular colony growth and the production of chlamydospores, macroconidia and microconidia.

Impact of pre harvest spraying on post-harvest deterioration of onion bulbs

a) Effect of pre harvest sprays of fungicides, bioagents on incidence of black mold in onion storage

The results of the pre-harvest sprays using fungicides and bioagents are presented in Table 4.4 and depicted in Plate 12 and Fig 4 which reveal that 15 days after storage (DAS), the highest disease incidence was observed in the untreated control, with 19.71%. The lowest disease incidence was recorded in hexaconazole 5% EC @ 0.1% (3.23%), followed closely by carbendazim 12%+ mancozeb 63% WP @ 0.15% (3.82%). Next in effectiveness were propiconazole 25% EC @ 0.1% (4.60%) and tebuconazole 25.9% EC @ 0.1% (4.87%). These four treatments were statistically at par. Azoxystrobin 23% SC @ 0.1% showed a disease incidence of 8.13%, followed by mancozeb @ 0.25% (11.31%). Among the bioagents, *T. harzianum and T. viride* recorded disease incidences of 13.32 and 12.37 per cent, respectively.

At 30 days after storage (DAS), the lowest disease incidence was observed in onions treated with hexaconazole 5% EC @ 0.1% (5.17%), followed closely by carbendazim 12%+ mancozeb 63% WP @ 0.15% (5.38%) followed by propiconazole 25% EC @ 0.1% (6.14%). These treatments were statistically at par. Tebuconazole 25. 9% EC @ 0.1% showed 7.03% disease incidence. Azoxystrobin 23% SC @ 0.1% resulted in 13.40% disease incidence, followed by mancozeb @ 0.25% (17.14%). Among the bioagents *T. viride* showed 21.51% incidence and *T. harzianum* showed 24.68 per cent incidence. In control the disease incidence was 28.16 percent.

At 45 DAS, hexaconazole 5% EC @ 0.1% again showed the lowest disease incidence at 6.03%, followed by carbendazim 12% +mancozeb 63% WP @ 0.15% (7.19%), propiconazole 25% EC @ 0.1% (8.47%) and tebuconazole 25.9% EC @ 0.1% (13.20%). While azoxystrobin 23 5 SC @ 0.1% and mancozeb @ 0.25% had 16.46 and 22.38 per cent, respectively. Among botanicals, *T. viride* recorded 30.28 per cent disease incidence, while *T. harzianum* showed the highest at 33.32 per cent. In control the disease incidence was 36.18 per cent.

At 60 days after storage (DAS), the lowest disease incidence among the chemical treatments was recorded in onions treated with hexaconazole 5% EC @ 0.1% (9.52%), compared to 45.86 per cent in the untreated control. This was followed by carbendazim 12% +mancozeb 63% WP @ 0.15% at 10.47%, propiconazole 25% EC @ 0.1% (12.97%), tebuconazole 25.9% EC @ 0.1% (16.28%), azoxystrobin 23% SC @ 0.1% (22.23%) and mancozeb @ 0.25% (28.80%). Among the bioagents, *T. viride* recorded 40.66 per cent disease incidence and *T. harzianum* showed 41.23 per cent.

At 75 DAS, the lowest disease incidence was observed in onions treated with hexaconazole 5% EC @ 0.1% **(**19.05%), followed by carbendazim 12% +mancozeb 63% WP @ 0.15% (22.85%) were statistically at par. Next in effectiveness were propiconazole 25% EC @ 0.1% (24.76%), tebuconazole 25. 9% EC @ 0.1% (27.24%), azoxystrobin 23% SC @ 0.1% (30.28%) and mancozeb @ 0.25% (35.16%) respectively. Among the bioagents, *T. viride* recorded 48.56% and *T. harzianum* 49.15 per cent disease incidence. The highest disease incidence was recorded in the untreated control, with 54.28 per cent.

At 90 days after storage (DAS), the lowest black mold incidence among chemical treatments was observed in onions treated with hexaconazole 5% EC @ 0.1% (30.92%), followed closely by carbendazim 12%+ mancozeb 63% WP @ 0.15% (31.59%). These two treatments were statistically at par. Propiconazole 25% EC @ 0.1% recorded 34.09% disease incidence, followed by tebuconazole 25.9% EC @ 0.1% (36.19%). Azoxystrobin 23% SC @ 0.1% resulted in 38.09 per cent incidence, followed by mancozeb @ 0.25% (41.95%)**.** Among bioagents, *T. viride* showed 52.37 per cent disease incidence and *T. harzianum* 53.32 per cent. The highest disease incidence was recorded in the untreated control, with 62.38 per cent.

Overall, 90 days after storage (DAS), hexaconazole 5% EC @ 0.1% showed 30.92 per cent disease incidence, while carbendazim 12% +mancozeb 63% WP @ 0.15% recorded a slightly higher incidence at 31.59 per cent. However, the difference was minimal and both were statistically at par. These findings support the earlier observations by Maheshwari *et al.* (1988), who reported carbendazim as the most effective fungicide for controlling *Aspergillus niger* for up to three months. The effectiveness of carbendazim as pre-harvest spray for black mold of onion is also noticed by Sinha *et al.* (1994) [13]. The findings are in confirmation with the work done by Raju and Naik (2006) [12] who found that carbendazim was the superior treatment in lowering the black mold of onion bulbs in storage followed by carbendazim 12% +manzozeb 63%. The effectiveness of carbendazim 12% +manzozeb 63% as pre-harvest spray for black mold of onion is also noticed by Ahir and Maharshi (2008) [1]. Similar results were obtained in the present investigation. The results are also consistent with Kim *et al.* (2002) [7], who observed that hexaconazole effectively inhibited mycelial growth and spore formation in the vapour phase on PDA medium.

b) Effect of pre harvest sprays of fungicides, bioagents on incidence of bulb rotting on summer season onions in storage

The impact of preharvest sprays of fungicides and bioagents on rotting of onion subsequently followed by black mold are presented in Table 4.5 and depicted in Fig. 5.

At 30 days after storage (DAS), the lowest onion rot incidence was observed in onions treated with hexaconazole 5% EC @ 0.1%, recording 1.90% rot, followed closely by carbendazim 12%+ mancozeb 63% WP @ 0.15% (2. 63%). Other treatments included propiconazole 25% EC @ 0.1% at 2.90%, tebuconazole 25.9% EC @ 0.1% (3.80%).

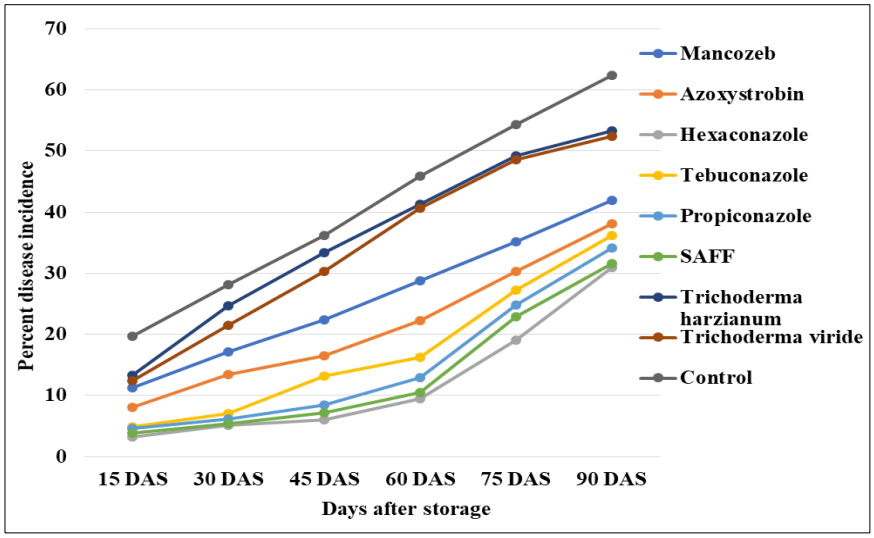

Fig 1: Effect of preharvest sprays of fungicides, bioagents on incidence of black mold caused in storage.

Table 1: Effect of preharvest sprays of fungicides, bioagents on incidence of black mold in storage

Tr. No.	Treatments	Conc.	Percent disease incidence						Percent Black mold Control
			15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	
T_1	Mancozeb	0.25%	11.31 (19.64)	17.14 (24.39)	22.38 (28.21)	28.80 (32.43)	35.16 (36.35)	41.95 (40.35)	32.83
T_2	Azoxystrobin 23% SC	0.1%	8.13 (16.52)	13.40 (21.46)	16.46 (23.91)	22.23 (28.12)	30.28 (33.36)	38.09 (38.09)	38.93
T_3	Hexaconazole 5% EC	0.1%	3.23 (10.35)	5.17 (13.14)	6.03 (14.11)	9.52 (17.92)	19.05 (25.85)	30.92 (33.76)	50.43
T_4	Tebuconazole 25.9% EC	0.1%	4.87 (12.71)	7.03 (15.30)	13.20 (21.29)	16.28 (23.78)	27.24 (31.44)	36.19 (36.96)	41.98
T_5	Propiconazole 25% EC	0.1%	4.60 (12.37)	6.14 (14.19)	8.47 (16.77)	12.97 (21.07)	24.76 (29.81)	34.09 (35.70)	45.35
T_6	Carbendazim 12% +Mancozeb 63%	0.15%	3.82 (11.08)	5.38 (13.38)	7.19 (15.50)	10.47 (18.83)	22.85 (28.54)	31.59 (34.17)	48.10
T_7	*Trichoderma harzianum*	5 g	13.32 (21.31)	24.68 (29.77)	33.32 (35.24)	41.23 (39.92)	49.15 (44.70)	53.32 (46.88)	14.52
T_8	*Trichoderma viride*	5 g	12.37 (20.40)	21.51 (27.61)	30.28 (33.36)	40.66 (39.60)	48.56 (44.16)	52.37 (46.34)	16.04
T_9	Control	-	19.71 (26.32)	28.16 (32.03)	36.18 (36.96)	45.86 (42.61)	54.28 (47.43)	62.38 (52.15)	-
	S.Em. ±	-	0.90	0.61	0.72	0.66	0.57	0.36	-
	CD at 5%	-	2.74	1.85	2.20	2.00	1.741	1.11	-

DAS = Days after Storage

These four treatments were statistically at par. Azoxystrobin 23% SC @ 0.1% and mancozeb @ 0.25% resulted in 5.44 per cent rotting and 5.61 per cent rotting respectively**.** Among bioagents *T. viride* had 6.66 per cent rot as compared *T. harzianum* that showed 6.72 per cent rot. The untreated control exhibited the highest rot incidence at 10.33 per cent.

At 60 DAS, the lowest onion rot incidence was observed in onions treated with hexaconazole 5% EC @ 0.1% recording 4.15% rot, followed by carbendazim 12%+ mancozeb 63% WP @ 0.15% at 5.17% rotting. Propiconazole 25% EC @ 0.1% showed 6.17% rotting and tebuconazole 25. 9% EC @ 0.1% resulted in 6.70% rotting. Azoxystrobin 23% SC @ 0.1% showed 8.41% rot while mancozeb @ 0.25% showed 10.95 per cent rot. The *T. viride* treatment exhibited 11.13 per cent rot and *T. harzianum* (12.86%). The untreated control had the highest rot incidence at 15.44 per cent.

At 90 DAS, hexaconazole 5% EC @ 0.1% again showed the lowest rot incidence at 8.07 per cent, followed by carbendazim 12%+ mancozeb 63% WP @ 0.15% (8.86%**)** which were statistically at par. The propiconazole 25% EC @ 0.1% and tebuconazole 25.9% EC @ 0.1% treatment showed 10.74 and 13.13 per cent rotting respectively. While the azoxystrobin 23% SC @ 0.1% and mancozeb @ 0.25% had rot incidence at 14.73 and 16.56 per cent respectively. Among bioagents *T. viride* showed incidence at 21.06 per cent and *T. harzianum* at 20.66 per cent. The untreated control exhibited the highest rot incidence at 24.43 per cent 90 days after storage, hexaconazole 5% EC @ 0.1% showed least rotting followed by carbendazim 12% +mancozeb 63% WP @ 0.15% but the difference the difference was minimal and the treatments were statistically at par. Rajapakshe and Edirimanna (2002) [11] found that storage losses of onions due to fungal pathogens could be reduced up to 40 per cent by spraying carbendazim 50% WP, as a pre harvest application two weeks before harvesting, which is tallying with the present finding. The findings are in confirmation with the work done by Raju and Naik (2006) [12] who found that carbendazim was the superior treatment in lowering the rot of onion bulbs in storage.

Summary and Conclusion

Onion (*Allium cepa* L.) is a bulbous, biennial crop and one of the most important vegetables grown in India. After harvest, onion bulbs are particularly vulnerable to fungal infections during storage. Among these, black mold is the most widespread and damaging. Overall, post-harvest diseases can cause a loss of about 35-40 per cent of the total onion yield, with fungal bulb rot alone accounting for 15-30 per cent of losses during storage.

Table 2: Effect of pre harvest sprays of fungicides and bioagents on onion bulb rotting in storage.

Tr. No.	Treatments	Conc.	Rotting percentage of onion bulbs during storage			Percent Rotting control
			30 DAS	60 DAS	90 DAS	
T_1	Mancozeb	0.25%	5.61 (13.69)	10.95 (19.30)	16.56 (23.97)	32.21
T_2	Azoxystrobin 23% SC	0.1%	5.44 (13.47)	8.41 (16.85)	14.73 (22.55)	39.70
T_3	Hexaconazole 5% EC	0.1%	1.90 (6.47)	4.15 (11.73)	8.07 (16.45)	66.96
T_4	Tebuconazole 25.9% EC	0.1%	3.80 (11.08)	6.70 (14.99)	13.13 (21.23)	46.25
T_5	Propiconazole 25% EC	0.1%	2.90 (9.80)	6.17 (14.37)	10.74 (19.10)	56.03
T_6	Carbendazim 12% +Mancozeb 63%	0.15%	2.63 (9.31)	5.17 (13.12)	8.86 (17.29)	63.73
T_7	*Trichoderma harzianum*	5 g	6.72 (15.01)	12.86 (20.98)	20.66 (27.02)	15.43
T_8	*Trichoderma viride*	5 g	6.66 (14.86)	11.13 (19.45)	21.06 (27.30)	14.67
T_9	Control	-	10.33 (18.72)	15.44 (23.11)	24.43 (29.60)	13.79
	S.Em. ±	-	1.10	0.39	0.34	
	CD at 5%	-	3.33	1.18	1.04	

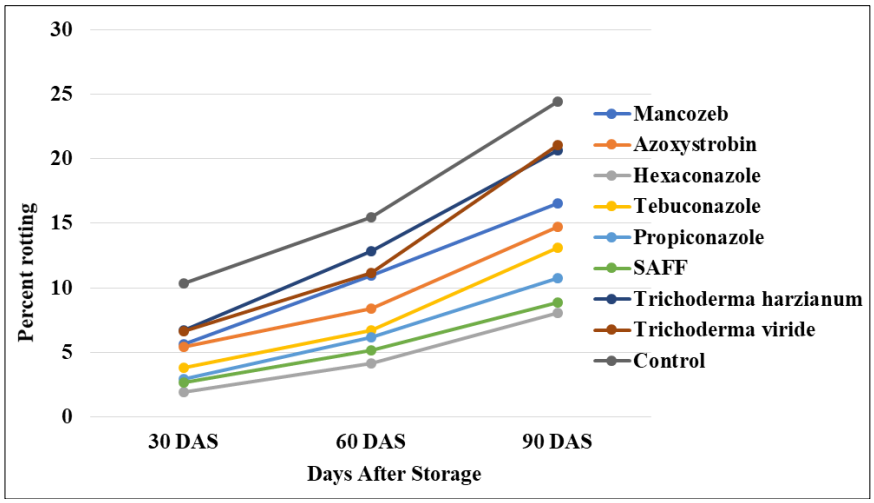

Fig 2: Effect of preharvest sprays of fungicides and bioagents on bulb rotting in storage.

The pathogens such as *A. niger*, *A. flavus* and *F. oxysporum* f. sp. *cepae* were isolated from infected onion bulbs. The colony of *A. niger* appeared carbon black to very dark brown in colour, with the reverse side of the plate usually remaining colourless. The *A. flavus* colony had a greenish colour and spread radially from the point of inoculation. *F. oxysporum* f. sp. *cepae* produced chlamydospores, macroconidia and microconidia. Initially, its colonies were white and cottony to slightly pink, which later turned creamy and had a non-smooth texture.

The pinprick method was used to test the pathogenicity of *A. niger*, *A. flavus* and *F. oxysporum* f. sp. *cepae*. After inoculating healthy onion bulbs, the same pathogens were re-isolated and the bulbs developed symptoms similar to naturally infected ones under laboratory conditions. This confirmed that all three fungi are capable of causing disease in onion bulbs and they were pathogenic. Based on microscopic examination of morphological features, the test pathogens were identified. *A. niger* was identified by observing its conidia, conidiophores, foot cells and aspergilloid heads with long metulae. *A. flavus* was identified based on the structure of its conidiophores, conidia, vesicles and metulae. *F. oxysporum* f. sp. *cepae* was identified by its cottony white to light pink circular colonies, along with the production of chlamydospores, macroconidia and microconidia.

Field trial was carried out to study impact of pre harvest spraying on post-harvest deterioration of onion bulbs. The study showed that hexaconazole 5% EC @ 0.1% provided the best disease control, with the lowest black mold incidence of 30.92%, followed by carbendazim 12% + mancozeb 63% WP @ 0.15%with 31.37% black mold incidence. Overall, both hexaconazole 5% EC @ 0.1% and carbendazim 12% +mancozeb 63% WP @ 0.15%were effective in reducing black mold. It can be concluded that pre-harvest sprays of hexaconazole 5% EC or carbendazim 12% + mancozeb 63% WP significantly reduce black mold in onion bulbs.

In present investigations, impact of preharvest sprays of using fungicides and bioagents on bulb rotting disease in onions was evaluated. The results showed that during, rabi season onion storage the hexaconazole 5% EC @ 0.1% showed 8.07% bulb rotting and carbendazim 12% + mancozeb 63% WP @ 0.15% showed 8.86% bulb rotting which were significantly more effective than the other treatments in reducing rotting incidence.

Conclusions

Based on the results of the research on "Investigations on pathogenic fungi associated with post-harvest deterioration of onion (*Allium cepa* L.) Bulbs and their management'', the following conclusions were drawn:

1. The major pathogens such as *A. niger*, *A. flavus* and *F. oxysporum* f. sp. *cepae* were found to be the cause of post-harvest bulb deterioration of onion.
2. Pathogen *A. niger*, *F. oxysporum* f. sp. *cepae* and and *A. flavus* were found to be pathogenic.
3. Preharvest spray @ 0.1% hexaconazole 5% EC and carbendazim 12% +mancozeb 63% WP @ 0.15% were found most effective among the fungicides and bioagents used for control.

4. Preharvest sprays of fungicides and bioagents were also studied for the incidence of bulb rotting and it revealed that hexaconazole 5% EC @ 0.1% and carbendazim 12% + mancozeb 63% WP @ 0.15% was found to be significantly superior over other treatments.

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