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POST-HARVEST PATHOGENS AND DISEASE MANAGEMENT OF HORTICULTURAL CROP : A BRIEF REVIEW

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Abstract

Post-harvest diseases are the major factors that contribute quality losses of the produce. In India, every year there is losses 25-30% of horticultural crop and 10-15% of vegetable crop wasted due to lack of post-harvest which resulted in huge losses of crores of rupees. During the post-harvest storage period, horticultural crops are subjected to different types of losses like sprouting, rotting, physiological weight loss, moisture loss, nutritional losses, etc. After the crop is harvested, it becomes vulnerable to various post-harvest diseases generally caused by fungal and bacterial pathogens. Generally, approximately 40 percent post-harvest losses have been reported during the supply chain and post-harvest handling of onions. The work on extending the storage life has also been done by deploying different temperature and humidity combinations, application of growth retardants (like cycocel, maleic hydrazide, etc.) and application of fungicides (like benomyl, streptocyclin and carbendazim etc.) to decrease the post-harvest sprouting and rotting of horticultural crop. The previous researchers have also informed that pre-harvest management is one of the vital steps for increasing the shelf-life of the onion as well as to reduce the post-harvest damages of onion bulb. In post-harvest storage under cold storage condition different fungi are responsible like *Penicillum purpurogenum, Penicillum griseofalvum, Penicillum citrinum* and *Aspergillus niger* under ambient storage condition causing maximum loss in horticulture produce. Mostly fungi and bacteria are responsible for disease and rotting of horticultural crops. Application of different synthetics and organic formulations are used for inhibition of post-harvest pathogens of horticultural crops.

***Keywords*:** Horticultural Crops, Storage Pathogens, Control Measures, *In-vitro*

Introduction

India is the leading producer of vegetables and fruits in the world (2nd largest vegetable, 3rd largest fruits). But the estimated losses are more and reached from 2 to 30 percent. Horticultural crops are facing maximum trouble during post-harvest storage. Among various entities responsible for post-harvest decay, many microorganisms have also been found responsible for rotting of horticultural crops and among various microorganisms' post-harvest fungi is the main causal agent for maximum spoilages of horticultural crops (Currah and Proctor, 1990). More than 40% post-harvest losses of horticultural crops have been reported on global level due to different fungal and bacterial diseases. The extensive losses in horticultural crops during marketing due to post-harvest diseases have also been reported by Fatima *et al.* (2015).

It is generally expected that fungi is responsible for post-harvest spoilages that the disease occurs severely during post-harvest storage because of due to different fungi, which spoils the harvested produce by moving from side to side lesions caused by topping, lastly damage the whole lots.

The majority of associated fungi (isolates) with rotting of horticultural produce have been found pathogenic (Jacobs *et al.*, 2008). The control of such fungal pathogen involves application of heavy doses of antifungal inorganic chemicals which poses severe health risks. As antifungal compounds from plant origin are less toxic and more environmentally friendly, these days' preferences to such organic compounds are given as compared to inorganic chemicals. Extracts from many plants have been derived and screened for their antifungal activities and valuable results have been achieved (Bansal and Gupta, 2000).

Mostly fungi and bacteria are responsible for disease and rotting of horticultural crops. Application of different synthetics and organic formulations are used for inhibition of post-harvest pathogens of horticultural crops.

Use of Neem formulation for post-harvest disease control of horticultural crop

Neem leaf extract holds at least 35 biologically active ingredients of which triterpenoides, e.g. Azadirachtin, Nimbidine and Nimbin, are the highest vigorous fungicidal and insecticidal ingredients Mondal *et al.* (2009). Neem extract has been used to prevent numerous fungal plant pathogens, such as *Aspergillus flavus, Alternaria alternata*, *Fusarium oxysporum, Fusarium solani, Sclerotinia sclerotiorum* and *Rhizoctonia solani* (Jatav and Mathur, 2005; Wang *et al.,* 2010; Obongoya *et al.*, 2010; Meena, 2012).

Neem (*Azadirachta indica* L.) has worldwide importance due to its varied range of medicinal characteristics Leaf of neem and its ingredients have been confirmed to show antifungal, anti-inflammatory, and antibacterial properties (Subapriya and Nagini, 2005).

Krishanti and Prianto (2017) studied five types of neem seed oil formulation which was sowing antifungal activity against fungi and they could prevent the growth of mycelial pathogenic fungi, *Fusarium oxysporum*, effectively.

The results indicated that neem seed formulations were potential to be developed as bio fungicide and it needs a further analysis about actives compound that shows important role in fungal overthrow.

Different formulation of neem cake gave the maximum efficacy in inhibition of mycelial growth of fungal pathogens (77.55%) afterward mustard cake and groundnut cake (73.53 and 67.25 respectively) extracts. Yadav *et al.* (2014) revealed that neem cake extract (30%) significantly prevented the fungal mycelial growth the over control.

Shrivastava and Swarnkar (2014) studied antifungal activity of leaf extract of *Azadirachta indica* (Neem) alongside different fungal pathogens of *Aspergillus flavus*, *Alternaria solani* and *Cladosporium* and Ethanolic and Methanolic formulations in different range (25%, 50%, 75% and 100%) was equipped and proven against test organisms using method used by disc diffusion.

To compare the toxicity of neem leaf extract and its antifungal activity ketoconazole was used. The ethanolic and methanol extract of *Azadirachta Indica* against *Alternaria solani*, *Aspergillus flavus*, and *Cladosporium* was found growth more inhibition, inhibition zone was found and measured size of ZOI.

Among all the extracts the most effective extract methanolic extract of *Azadirachta Indica* against *Aspergillus flavus* has been observed. In the same year Olufemi *et al.* (2014) revealed that the neem seed extract were maximum antifungal properties in *Curvularia sp.* (37.76% inhibition) afterward *Aspergillus sp.* (20.22% inhibition) and *Fusarium sp.* (7.56% inhibition). Although it did not showed any significant inhibitory effect against *Rhizopus sp.*

Gupta *et al.* (2012) investigated the effects of Neem formulations in different doses for managing of the black mould disease of onion. The doses applied for pathogen inhibition in vitro condition applied was (5.0ml/10g). Hussein *et al.* (2014) tested antagonistic ability of *Trichoderma harzianum and Tricoderma viride* against *B. allii*, causal agent of umbel "head" blight disease of onion. The treatment of *T. viride* demonstrated 30 to 45% reduction of disease severity in a 2-year test.

Mahmoud *et al.* (2011) tested the outcome of aqueous extracts of neem formulations on different fungal growth (*Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Aspergillus terreus and Microsporum gypseum Candida albicans*) *in vitro* at different range of concentration 5, 10, 15 and 20%. The neem extracts withdrawn the growth of fungal pathogens in dose dependent manner. Ghorbanian *et al.* (2008) tested the efficacy of leaf extract (aqueous neem) in varied concentrations of on development of fungus and due to production of aflatoxin by the fungi *Aspergillus parasiticus* at change in different time of incubation period.

The maximum inhibitions found 80-90% in the existence of 50% formulations when it was related with control condition were the significant ($p< 0.05$). The inhibitory effect of aflatoxin synthesis by plant based extracts initiate to be time and dose dependent. In organic alterations neem cake was gave the extreme operational for inhibition of the mycelial growth of storage fungi.

Ali *et al.* (1992) studied the effect of leaf extract and neem oil from *Azardiracta indica* along with Tecto-60 and boric acid, against *Pencillium italium, Altunaria altunala* and *Aspergillus niger* on decayed vegetables and fruits. The results revealed that neem oil was most effective comparable to thiabendazol in examination growth of storage fungi. Bansal and Sobti (1990) carried out study for the reduction of two species of *Aspergillus* on groundnut and observed that *Aspergillus niger* incidence was reduced significantly over check (24%) by neem extract.

Use of Panchgavya formulation for post-harvest disease control of horticultural crop

Panchgavya has been used for both pre and past harvest treatments of fungal developments. Sharma and Sharma (2016) investigated antifungal action of Panchagavya contrary to three fungal pathogens *Sclerotium rolfsii, Rhizoctonia solani*, *Fusarium oxysporium* by poisoned food technique. These fungus pathogens are related to diverse types of fungal diseases of nursery plants. The Panchagavya treatment has reduced the fungal development in poisoned plates as compared to control.

The laboratory experiments showed that Panchagavya treatment exhibited antifungal activities at varied concentrations *i.e.* 5, 10 and 15% against all the three fungal pathogens with maximum effect being produced at 15% resulting in 82% inhibition of *Fusarium oxysporium.*

Paul (2014) used organic inputs namely panchgavya against main fungal pathogens of bell pepper namely *Sclerotium rolfsii, Colletotrichum capsici*, *Fusarium solani*, *Phytophthora nicotianae*, *Sclerotinia sclerotiorum, Fusarium oxysporum* f.sp. *capsici* and *Rhizoctonia solani* in *in vitro* and *in vivo* conditions. The application of panchgavya was tested at different concentrations (ranging from 2.0 to 10.0 percent) *in vitro* and the results showed inhibition of whole mycelia of *S. sclerotiorum* and 99.0% inhibition in mycelia growth of *F. solani*, *P. nicotianae and S. rolfsii.*

Joseph and Sankarganesh (2011) reported antifungal properties of Panchagavya. They tested the application in bacteriological standard. For this, 10µl, 100µl, 500µl and 1000µl of panchagavya application was variegated with 1.5% agar medium and sterilized followed by incubation at room temperature for five days. After incubation period, the early lesser dilution resulted 100% reduction in fungal growth while intermediate dilutions showed moderate growth.

The higher dilution on the other hand has significantly reduced the fungal growth by restricting identical bacterial colonies and even no bacterial growth was observed. Moreover, 10 µl, 100 µl and 500 µl concentrations exerted less growth promotion thus higher antifungal activity. The maximum attenuations of panchagavya are promising basis for simple and naturally derived less expensive bacteriological media with antifungal efficacy with growth promotion.

Sugha (2005) reported the antifungal potential of Panchgavya against fungus pathogens *R. solani, S. rolfstt, S. sclerotiorum, F. solam* and *Phytophthora colocasiae*. The *in vitro* studies carried out with these pathogens revealed that Panchgavya inhibited mycelial growth by 90-100 per cent when the mycelial bits were dipped for more than 6 hrs. He further informed that damping-off of cauliflower was reduced to 82-95 per cent in Panchgavya treatment as compared to control and was superior to fungicide treatments.

Use of *Trichoderma spp* for post-harvest disease control of horticultural crop

Trichoderma spp wide range of application in *in vitro* inhibition of storage pathogens of horticultural crop. Many researchers have been used for fungal inhibition for last ten years. The effect of different species of *Trichoderma* on different storage fungi had shown significant results.

Cherkupally *et al.* (2017) evaluated the antagonistic activities of seven *Trichoderma* species, against fungal pathogen, *Fusarium oxysporum in vitro* conditions. The antagonistic activities of different *Trichoderma* species were selected *in vitro*. All the bio control agents showed considerable decrease in the growth of the fungal pathogens. Out of the seven fungal antagonists studied for their efficacy, *T. harzianum* showed maximum degree of inhibition 81.11%, followed by *T. koningii* 80.00%, *T. pseudokoningii* and *T. viride* 78.88% each, *T. virens*, T. *atroviride*, and *T. reesei* 77.77% each by nonvolatile compounds. The results suggested that *T. harzianum* had a highly antagonistic potential and *T. koningii* showed least antagonistic efficacy of 28.88%.

Triveni *et al.* (2012) evaluated different bio control agent's viz., *Trichoderma harzianum, T. pseudokoningii, T. polysporum, Gliocladium virens*, *Paecilomyces variotii* and *P. lilacinus* under *in vitro* condition and observed maximum mycelial inhibition of fungi *P. oryzae* by *P.lilacinus* followed by *Trichoderma* spp.

Reddy *et al.* (2014) reported antagonistic effect of different species of *Trichoderma* were evaluated *in vitro* against the most extensively plant pathogens viz., *Alternaria solani ,Fusarium oxysporum*, *Aspergillus niger* and *Macrophomina phaseolina* and identify *Trichoderma* strain with high aggressive potential.

Kumar *et al.* (2012) reported filamentous fungi of *Trichoderma spp*. isolated from different locations and identified 12 isolates, were capable of parasitizing several plant pathogenic fungi. *T. harzianum* was verified with maximum amount of β-1, 3-glucanase activities but the significant chitinase and β-1, 3-glucanase activities of all *Trichoderma* isolates has been noted in the fungal growth medium. *T. viride* was found with maximum chitinase whereas investigation resulted that chitinase and β-1, 3-glucanase enzyme activities were enlarged with the substitution of definite carbon source at 1% concentration.

Use of synthetic fungicide for post-harvest disease control of horticultural crop

Futane *et al.* (2018) evaluated *in vitro* antifungal activity against fungal pathogens pathogen. In *A. niger* pathogen the antifungal activity was most operational with significantly highest mycelial growth inhibitions were SAFF (94.55 per cent), mancozeb (90.98 per cent) and carbendazim (92.22 per cent). In *Fusarium oxysporum* fungicides viz., SAFF, mancozeb, hexaconazole and carbendazim were found most effective with significantly highest mycelial growth inhibition of 91.74 per cent, 91.38 per cent, 90.81 per cent and 88.42 per cent respectively.

Prajapati *et al.* (2016) studied the efficacy of systemic and non-systemic fungicides and it was verified *in vitro* by "Poisoned food technique method" against *Aspergillus niger* with changed applications (500, 1000, 1500 & 2000 ppm).

The remarks on per cent growth inhibition were recorded after 7 days of incubation. Studies were undertaken to control black mould rot of onion through synthetic fungicides *in vitro* and *in vivo*. Among the fungicides screened carbendazim, azoxystrobin (18.2%) + difenconazole (11.4%), carbendazim (12%) + mancozeb (63%), mancozeb (50%) + carbendazim (25%), trifloxystrobin (25%) + tebuconazole (50%) at 500 and 100 ppm and hexaconazole, propiconazole at 1000 and 1500 ppm concentrations completely inhibited the mycelial growth of *A. niger* over control.

In vitro studied of fungal mycelial revealed that there were significant differences between the inhibitory effects of sodium salts on the mycelial growth ($P \leq 0.05$) and 2% (w/v) concentrations of sodium metabisulfite and sodium fluoride completely inhibited mycelial growth of the fungus, while other salts did not. Turkkan and Erper (2014) investigated efficiency of different sodium salts as substitutes to synthetic fungicides for the control of onion basal rot caused by *Fusarium oxysporum*.

Gupta *et al.* (2012) investigated different fungicides for fungal pathogen control, *in vitro* condition Bavistin (Carbendazim 50% WP, 2.0%) proved to be most effective against *Aspergillus niger* pathogen followed by Thiram (80% WP, 2.5%), Captan (50% WP, 2.5%), Indofil M-45 (50% WP, 2.5%) and Topsin M (75% WP, 2.5%).

Dugan *et al.* (2007) isolated different fungal pathogens from the infected garlic, *A. niger*, *A. ochraceus*, *F. oxysporum* f. sp. *Cepae, Embellisia allii*, *B. porri*, *F. proliferatum* and *P. hirsutum*. Among these species, *F. proliferatum* and *F. oxysporum* f. sp. *cepae* were used in tests of pre-planting and postharvest dips.

For preplanting dip tests, fludioxonil, thiophanate-methyl dimethyl, and benomyl were used; for postharvest dips, benomyl was used. These synthetic fungicides protected hosts from diseases before severe contamination. However, very low control efficacy was observed when post-harvest disease was severe or when garlic had already been infected inside Dugan (2007).

Srinivasan and Shanmugam (2006) found that *Aspergillus nigerwas* predominantly related with black mould rot of onion during storage showed that among fungicides used carbandizim used 0.1% concentration was found to the most effective when applied either as a foliar spray in standing crop or as a post-harvest dip followed by sulphur oxides and acetic acid.

Fungal pathogen disease control using synthetic chemicals for post-harvest diseases of vegetable crops has been extensively studied by various researchers (Jaime *et al.*, 2001; McDonald *et al.*, 2004; Raju and Naik, 2006). Grinstein *et al.* (1992) reported that reduced-volume-spray (RVS) of imazalil, thiabendazole, iprodione, and mixtures diethofencarb and carbendazim could reduce the incidence of *Botrytis* and *Aspergillus spp*. Padule *et al.* (1996) determined the ability of post-harvest fungicides formulations, carbendazim (0.1%), mancozeb (0.25%), captain (0.2%), streptocycline 0.5% and fumigation with sulphur fumigation and carbendazim provided significantly superior control than extra treatments in term of per cent spoilage.

Conclusion

Now a day many bio based formulations are used for post-harvest disease management of horticultural crop. Among all the post-harvest control measures (i.e., synthetic, bio based, Nano-based) used for the inhibitions of storage pathogens of horticultural produce it was observed that different formulations has a range of *in vitro* inhibition rate.

Some fungicides used was found to the most effective when applied either as a foliar spray in standing crop with compared to *in vitro* application. Among systemic fungicides, carbendazim brought about highest reduction followed by hexaconazole, bitertanol and myclobutanil, respectively. Among non-systemic fungicides, the mancozeb was establishing the most effective followed by captan and zineb, respectively. The outcomes indicated that neem seed formulations were potential to be developed as bio fungicide and it needs a further analysis about actives compound that shows important role in fungal overthrow. It is also eco-friendly and non-toxic in nature.

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