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Meera Choudhary
Ph.D., Scholar, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

GS Rathore
Emeritus Scientist, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Lalita Lakhran
JRF, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Manisha Shivran
Ph.D., Scholar, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Tejpal Bajaya
Ph.D., Scholar, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Meera Choudhary
Ph.D., Scholar, Department of Plant Pathology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Pathological survey of blue Mould rot of orange in various fruit markets of Rajasthan

Meera Choudhary, GS Rathore, Lalita Lakhran, Manisha Shivran and Tejpal Bajaya

Abstract
Orange (*Citrus reticulata*) is the most important fruit crop grown extensively in tropical areas of India. Among different fungal post-harvest rots in orange, blue mould caused by *Penicillium italicum* is most serious symptoms of the disease appeared initially as soft, watery and slightly discoloured spots on the surface of fruit rind. During the survey of the disease, incidence of blue mould rot ranged between 4.35 to 13.93 per cent while fruit marketing at Jobner had maximum incidence of 13.93 per cent. In the seven isolates maximum incidence (14.02%) was recorded in the fruit market of Jobner, while minimum incidence (8.91%) recorded from Jhalawar fruit market.

Keywords: Orange, blue mould, incidence, citrus, *Citrus reticulata*, survey, *Penicillium italicum*

Introduction
Orange is the major fruit crop among the citrus group. forty per cent area is cultivated with orange among citrus fruits. It is a micronutrient loving fruit crop. In citrus blue and green mould become increasingly most important on post-harvest losses in India. During the harvesting season post-harvest results in low prices and marketing problems. In India, survey for the post-harvest spoilage of citrus fruits conducted by various workers revealed that several fungi such as *Penicillium italicum, P. digitatum, Geotrichum candidum, Alternaria alternata, A. citri, Botryotinia fuckeliana, Botryodiplodia theobromae,* and *Glomerella cingulata* are involved in causing different types of rots in this crop (Sharma, 2002; Naqvi, 2004 and Reddy *et al*., 2008) [12, 6, 9]. Average disease severity 49.63% caused by *Penicillium digitatum* in kinnow fruits recorded under ambient conditions (Alam *et al*. 2016) [1].
Patil *et al.,* 2017 [7] worked on survey of post-harvest penicillium mould on sweet orange during 2015-16 at Tamil Nadu and found that loss due to penicillium mould at wholesale market was 6%, at retail level was 24%, at farmers market was 20% and at consumer level was around 2% in locally cultivated fruits, while in rainy season it was recorded 50-60%. Saito and Xiao (2017) [10] identified major post-harvest disease affecting mandarin decayed fruits. On the stored fruits collected after cold storage, Green mold caused by *Penicillium digitatium* (36.3%) was observed most prevalent in mandarin fruits in California. Sonja *et al.* (2017) [15] reported *Penicillium italicum* and *P. expansum* are important pathogens causing decay in most fruits and vegetables in west Bengal. Sharma and Raj (2018) [13] reported pathological survey of disease of green mould of kinnow which losses was 16.5-27 per cent. Maximum severity of disease recorded in Paonta Sahib.
The fruits of citrus are highly perishable and easy to suffer a wide variety of post-harvest fungal diseases caused by *P. italicum, P. digitatum, Colletotrichum gloesporioides, Geotrichum citri-aurantii, Alternaria citri* etc. (Araujo *et al.,* 2019) [2].

Material and Methods
To find out the incidence and severity of post-harvest rots of orange fruits in Rajasthan market, seven locations Jaipur, Chomu, Sikar, Ajmer, Alwar, Jhalawar and local market of Jobner were selected and from each markets, infected and healthy fruit samples were collected. Survey was conducted at 30 days interval during the period January, 2020 to April, 2020. From each market location, three samples were selected at randomly. From each place, five samples comprising of 100 fruits were observed for disease incidence. The rotten fruits exhibiting different diseases were collected during each visit and brought to the laboratory for isolation and symptomatological studies.

Result and Discussion

Seven different locations *viz.*, Jaipur, Chomu, Sikar, Ajmer, Alwar, Jhalawar and local market of Jobner were selected for the observation of blue mould rot of orange fruits (*Penicillium italicum* Wehmer) prevalent during the survey period January to April (2020). The results of fruit market survey presented in Table 4.1 revealed that orange fruit were isolated from many fungal rots. Among these rots maximum incidence recorded due to blue mould rot of orange (14.02%). The incidence of these seven types of samples varied during the survey period. However, the blue mould rot was most predominant during Jan., 2020 to April, 2020 which ranged from 11.85 to 14.75 per cent while it was relatively less during the month of January. The overall incidence of the post-harvest blue mould rot in orange fruit was relatively less during month of January, 2020. Later on, the disease incidence gradually increased and it was highest during first fortnight of March to April, 2020. The average over all disease incidence of the seven samples was 7.18 per cent. The disease incidence also varied among the different fruit markets at different intervals.

The results of field survey presented in table 2 showed disease incidence of blue mould rot of orange varied in which maximum incidence was recorded from Jobner (15.26), while minimum disease incidence was of jhalawar fruit market (9.01%). The data presented in Table 2 revealed that the overall disease incidence of blue mould rot of orange was maximum in local fruit market of Jobner followed by Chomu fruit market. While, the average incidence of blue mould rot was least in Jhalawar district. Five different post-harvest rots *viz.*, blue mould rot (*Penicillium italicum*), green mould rot (*Penicillium digitatum*), sour rot (*Geotrichum candidum*), core rot (*Alternaria alternata*) and stem-end rot (*Botryodiplodia theobromae*) were observed in orange fruits during the survey period i.e. January, 2020 to April, 2020 in seven fruit markets of Rajasthan. The overall disease incidence in fruits was comparatively less during the month of January. The disease incidence gradually increased during the months of January and February and was highest during first fortnight of April. Although, certain fungi other than those causing major rots were also encountered, but their occurrence was very low and inconsistent. Therefore, main emphasis was given to record the incidence of five major rots prevalent in fruit markets of Rajasthan. The survey work revealed that the blue mould rot (*P. italicum*) was most predominant. Hence, it was selected for further studies during the present investigations. This agreement is similar with the investigations of Kaur and Verma (2002) [5] who recorded incidence of post-harvest rots during mid- January to second week of March in Punjab. They also observed that incidence of post-harvest rots like green mould, blue mould and black mould rot were highest in kinnow fruits in the month of March. Symptoms of five major post-harvest rots of orange fruits were recorded and reaffirmed after inoculation with pure cultures of respective pathogens isolated from rotted fruits during the survey. The identification of the fungi associated with rotted orange fruits were made on the basis of cultural and morphological characteristics of mycelium and spores (Dasgupta and Mandal, 1989) [3]. Rotting during post-harvest due to blue, green and grey mould diseases has been reported prominent cause, in which *Penicillium* spp. was reported to the most important fungal pathogen causing severe damage to citrus fruits (Singh *et al.*, 2003; Plaza *et al.*, 2004) [14, 8]. Iqbal *et al.* (2012) [4] reported that blue mould rot is one of the important post harvest disease on citrus fruits particularly in cold stored fruits. Sanzani *et al.* (2014) [11] investigated stored citrus fruits suffer from huge losses because of the development of green mould caused by *Penicillium digitatum*. Identification of major post-harvest disease affecting mandarin decayed fruits.

Table 1: Incidence of post-harvest fungal rots of orange fruits in different fruit markets of Rajasthan

Disease/Pathogen	Incidence of rots (%) recorded on				
	Jan. 2020	Feb. 2020	Mar. 2020	April 2020	Average incidence
Blue mould rot (*Penicillium italicum*)	14.25	16.75	13.25	11.50	13.93
Green mould rot (*Penicillium digitatum*)	7.50	5.75	6.80	8.40	7.11
Sour rot (*Geotrichum candidum*)	3.75	4.20	5.75	6.80	5.12
Core rot (*Alternaria alternata*)	3.80	4.75	3.60	5.25	4.35
Stem-end rot (*Botryodiplodia theobromae*)	4.60	5.90	4.80	6.20	5.37
Overall incidence	6.78	7.47	6.84	7.63	7.18

Table 2: Rot incidence of orange fruits in different markets with special reference to blue mould

S. No.	Market	Isolates	Disease incidence (%)				
			Jan. 2020	Feb. 2020	Mar. 2020	April 2020	Average incidence (%)
1	Local market (Jobner)	PI-1	14.75	16.25	13.25	11.85	14.025
2	Jaipur	PI-2	12.25	13.50	11.75	10.50	12.00
3	Chomu	PI-3	14.25	15.85	13.5	11.25	13.71
4	Sikar	PI-4	12.50	13.75	12.30	11.50	12.51
5	Ajmer	PI-5	13.25	12.15	11.70	10.25	11.84
6	Alwar	PI-6	11.25	12.20	11.60	11.25	11.57
7	Jhalawar	PI-7	9.15	9.85	8.85	7.80	8.91
Overall incidence			12.48	13.36	11.85	10.62	12.08

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