# Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley


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**(2013-A-959-M)**



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**Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir**


**2015**

# Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley

**Nisar Ahmad Ganie**
**(2013-A-959-M)**

**Thesis**

Submitted to

**The Faculty of Horticulture**
**Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir**

**in partial fulfilment of requirement for the award of the degree of**

**Master of Science in Horticulture**
**(Plant Pathology)**

**2015**

# Dedicated

# to "YOU"

**Sher-e-Kashmir**
**University of Agricultural Sciences & Technology of Kashmir**
**Faculty of Horticulture, Division of Plant Pathology**

## Certificate – I

This is to certify that the thesis entitled, **"Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture (Plant Pathology),** to the **Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Nisar Ahmad Ganie (Regd. No. 2013-A-959-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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We, the members of the Advisory Committee of **Mr. Nisar Ahmad Ganie (Regd. No. 2013-A-959-M)**, a candidate for the degree of **Master of Science in Horticulture (Plant Pathology)** have gone through the manuscript of the thesis entitled, **"Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of the degree.

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## Certificate – III

This is to certify that the thesis entitled, **"Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley"** submitted by **Mr. Nisar Ahmad Ganie (Regd. No. 2013-A-959-M)** to the **Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** in partial fulfilment of the requirements for the award of the degree of **Master of Science in Horticulture (Plant Pathology)** was examined and approved by the Advisory Committee and External Examiner on …………….........

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| Title of the Thesis | : | **"Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley"** |

## ABSTRACT

Phomopsis fruit rot is one of the most important diseases of brinjal (*Solanum melongena* L.) worldwide. The present study was, therefore carried out to know the status of the fruit rot in Kashmir valley and to evolve an effective management strategy. The disease is prevalent in all the brinjal growing areas of Kashmir valley surveyed, during the year 2014. The overall mean fruit rot incidence and intensity was 35.75 and 14.11 per cent, respectively. The maximum disease incidence of 42.25 and intensity of 16.24 per cent on fruits was observed in district Budgam and minimum disease incidence of 29.25 and intensity of 11.99 per cent was observed in district Pulwama. The pathogen associated with the disease was identified as *Phomopsis vexans* (Sacc. & Syd.) Harter. In earlier stages of the fruit rot development, spots are oval, light pale brown slightly sunken which later on turned dark brown in colour with irregular margins. Maximum fruit rot development in the field was observed during the month of August and spots attained maximum size of 26.7 mm dia. The pathogen produced white circular colony *in vitro* with profuse mycelium, which later turned to grayish white with compact mycelium. Pycnidia (177.5×152.0 µm) appears in concentric rings having hyaline, guttulated, elliptical, sub-cylindrical, one celled alpha conidia (6.2×2.4 µm) and hyaline, filliform, curved beta conidia(15.7×1.3 µm). Among the fungitoxicants, propiconazole 25 EC proved to be most effective as it indicated maximum per cent disease control, followed by carbendazim 50 WP, copper oxychloride 50WP and metalaxyl + mancozeb 68 WP in decreasing order of their efficacy. Among the mulches applied rice straw proved to be most effective followed by wheat straw over check. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check followed by carbendazim 50 WP + rice straw, propiconazole 25 EC + wheat straw, copper oxychloride 50 WP + rice straw, carbendazim 50 WP+ wheat straw, copper oxychloride 50WP + wheat straw, metalaxyl + mancozeb 68 WP + rice straw and metalaxyl + mancozeb 68 WP + wheat straw in decreasing order of their efficacy.

**Key words:** Brinjal, Phomopsis, Symptomatology, Fruit rot, Fungitoxicants, Management.

Signature of Student | Signature of Major Advisor

Dated: ___________ | Dated: ________________

## ACKNOWLEDGEMENTS

In the name of Almighty, "Allah", the most Beneficent and Merciful, peace and blessings be upon Holy Prophet (SAW). I bow in reverence to Almighty for giving me enough courage, patience and success in this venture.

*Research is an evolving concept. Any endeavour, in this regard is challenging as well as exhilarating. It implies the testing of our nerves. It brings to light our patience, vigour and dedication. Every result arrived at is a modest beginning for a higher goal and no work can be termed as a one-man show. It needs the close cooperation and guidance of experts in the field to achieve something worthwhile and substantial.*

*It is indeed a great honour and pleasure for me to express my deep sense of gratitude and indebtness to my major Advisor, Dr. Ali Anwar Professor, Division of Plant Pathology. His soft and sober attitude, inspiring guidance, whole hearted encouragement, facile suggestions and constructive criticism with a calm exposure, led this uphill task to its successful completion and shall remain a lifelong gifted memory for me.*

*It is my privilege to place on record my profound gratitude and thanks to the members of my Advisory committee viz., Dr. V. K. Ambardar Associate Professor, Division of Plant pathology; Dr. Aflaq Hamid, Assistant Professor, Division of Plant Pathology; Dr. P. K. Singh, Assistant Professor, Division of Vegetable Sciences; Dr. Shakeel Ahmad Mir; Professor & Head Division of Agri-statistics; Dr, G. M. Mir, Professor & Head, Division of Entomology (Dean PG Nominee).*

*It is a genuine opportunity to offer my sincere thanks to Dr. Qazi Nissar Ahmad, Professor and Head, Division of Plant Pathology, whose unceasing whole hearted support and time to time technically valuable suggestions could enable me to take this research to its logical conclusion.*

*My special thanks from core of my heart to Dr. G. H. Dar, Professor, Division of Plant Pathology; Dr. Mir Ghulam Hassan, Assistant Professor, Division of Plant Pathology; Dr. N. A. Khan, Professor, Division of Plant Pathology; Dr. Khurshid Ahmad, Professor, Division of Plant Pathology; Dr. F.A. Mohiddin, Dr. Ifat Shahhaz, Dr. B.A. Paddar, Dr. Mushtaq Ahmad, Dr. Najeed Mughal, Dr. Saba Banday, Dr. Ashraf Alam, Dr. M.D. Shah, Dr. Zahoor Ahmad, Dr. Z.A. Badri and Dr. F.A. Ahangar, Assistant Professor, Division of Plant Pathology for their learned advice, valuable guidance and help during the course of investigation, especially in laboratory of Mycology.*

*Sincere thanks are due to, Hilal Ahmad Bhat, Rayees Ahmad Ahanger, Ph.D scholars, Division of Plant Pathology for their timely help and constant encouragement.*

*Thanks are also due to technical and other staff members of Division of Plant Pathology, especially Manzoor Sahib, Muzafar Ahmad, Raju, and Gh. Ahmad Kumar, for their help and assistance from time to time during the course of my study.*

*I take this opportunity to thank my friends and other colleagues for their cooperation.*

*I am highly grateful to members of ARIS and Library staff of SKUAST-K for their constant encouragement, valuable suggestions and generous help during preparation of this manuscript.*

*I prendre pride on myself in being the son of great ideal parents, Late Mr. Mohammad Amin and Ms. Hafeeza whose everlasting desire, selfless sacrifice and untiring struggle paved my way to pink of perfection. I unfeignedly owe my parents a tremendous filial respect and gratitude for their unending love and affection. They have been instrumental in every success that I have achieved hitherto. The paradise of my dreams is assuredly beneath their feets. The essence of their pristine love is inexplicably unforgettable. Though it is beyond the worth of my pen but today, I record my everlasting indebtedness to them and salute their generosity and greatness. May Almighty Allah who is the giver of all things reward and bless you abundantly.*

*I am colossally grateful to the unconditional love and support of my loving family members Razia nisar, Hoorain, Zaid, Saroosh, Mehnaz, Muskaan, Azra, Sirhaan, Bazif and one and only one 'She' who have been the bliss of my life. Their presence in my life has been a solace of my eyes bestowed on me by my Lord, Allah, and the Almighty. My love increases for them with every passing day. I cannot put my feelings in words to thank these members who always patted my back through thick and thin.*

*Also express my gratitude to all those who care for me, are in my heart and mind and may not have got a mention, but none shall ever be forgotten.*

*Nisar Ahmad*

Place: Shalimar, Srinagar
Dated:

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**Chapter – 1**

# INTRODUCTION

Brinjal (*Solanum melongena* L.) is also known as eggplant due to the shape of fruit of some varieties which are white and shaped similarly to chicken eggs (Kalloo, 1993; Chen and Li, 2001 and Santos *et al.*, 2010). Brinjal is an important solanaceous crop of sub-tropics and tropics and warm temperate regions (Sihachakr *et al.,* 1994 and Rai, 1995). It is extensively grown in India, Pakistan, China, USA and Egypt (Beura *et al*., 2008). It is an inexpensive vegetable crop but major food component of human diet in the developing world particularly in India and China (Doganlar *et al.,* 2002). In India, it is one of the most common, popular and principal vegetable crops grown throughout the country except higher altitudes. India is considered to be the centre of origin and diversity of cultivated brinjal from where it spread to the other parts of the world (Thompson and Kelly, 1957; Chaudhury and Kalda, 1968). Mainly grown in Orissa, Bihar, Punjab, West Bengal, Karnataka, Maharashtra, Andhra Pradesh and Uttar Pradesh (Akhtar *et al.*, 2007). Asia has the largest brinjal production and comprises more than 90 per cent of the world production area and 87 per cent of the world production (Choudhary and Gaur, 2009).The total area under brinjal cultivation in the world is 1864.32 thousand hectares with annual production and productivity of 49728.16 thousand MT and 26.7 MT per hectare respectively. In India it is cultivated over an area of 711.30 thousand hectares with an annual production of 13557 thousand MT and productivity of 19.10 MT per hectare while in Jammu and Kashmir, it is cultivated over an area of 2.02 thousand hectares with an annual production of 45.24 thousand MT and productivity of 22.39 tonnes per hectare (Anonymous, 2014).

Besides, being used as an important vegetable, brinjal has been extensively exploited in traditional medicine for treatment of many diseases (Khan, 1979; Kashyap *et al.,* 2003). It is also valued for its medicinal properties and has got decholestrolizing property primarily due to presence of polyunsaturated fatty acids (linoleic and lenolenic) present in flesh and seeds of fruit in higher amount. The oblong-fruited eggplant cultivars are rich in total soluble sugars, whereas the long-fruited cultivars contain a higher content of free reducing sugars, anthocyanin, phenols, glycol alkaloids, dry matter, and amide proteins (Bajaj *et al*., 1979) and has been recommended as an excellent remedy for those suffering from liver complaints (Shukla and Naik, 1993). Although 92 per cent of the brinjal fruit is filled with water, it is a very good source of protein and dietary fiber. Also rich in potassium, manganese, copper, Vitamin B1, Vitamin B6, foliate, magnesium and niacin. Additionally, eggplants have been reported to contain reasonable amounts of antioxidants, antimutagenic, antimicrobials, antivirals and to be completely devoid of cholesterol (Ezine, 2009).

Now-a-days demand for brinjal as a fruit vegetable is increasing rapidly among the vegetable consumers in view of its better fruit colour, size and taste (Vijaya and Seethalakshmi, 2001). Brinjal is used in a variety of culinary preparartions since ancient times and is a staple vegetable in many tropical countries. Purple fruits have higher aminoacid content. It is highly productive and usually finds a place as “poor man’s crop” (Rajan and Markose, 2002).

Brinjal is attacked by many fungal, bacterial and viral diseases of which Phomopsis fruit rot, caused by *Phomopsis vexans* (Sacc. and Syd.) Harter, is considered to be the most destructive (Kumar, 1998) and one of the major constraints of brinjal cultivation (Das, 1998; Khan, 1999; Islam *et al*., 2010; Jayaramaih *et al*., 2013). Apart from causing leaf blight, it also causes fruit rot (Singh, 1992; Ashrafuzzaman, 2006). The disease affects the crop from seedling to maturity (Singh, 1992). Crop losses due to this disease are evident, loss ranges from 30-50 per cent (Bangladesh Bureau of Statistics, 2000). The seed borne fungal pathogen not only affect the market value of fruits but, also adversely affect the nutritive value (Bhale *et al.,* 2001). *Phomopsis vexans* may cause damping off symptoms if attacked at seedling stage. When the leaves are infected, small circular spots appear which become grey to brown with a light colour centre. The infected leaves may turn yellow and die. Lesions are also developed on petiole and stem causing blight in affected portions. In course of time, the spot enlarges and produces concentric circular area. Ultimately, the fruits become mummified and rotten (Kumar *et al*., 1986).

Eggplants are very important horticultural crops not only because of the nutritional and health benefits that can be derived from them but also because of their potential to diversify rural farm income and contribute to pervert reduction. Earlier on in 2002, Cristina identified Phomopsis blight as major disease of eggplant resulting in enormous losses of fruit yield of about 40 to 70 per cent of the total harvest under favorable environmental conditions. Phomopsis blight is an unsightly disease that not only harms eggplants, but makes them inedible and unmarketable which undermines their role in nutrition, health and income generation. The aim of this study therefore was to assess the incidence of Phomopsis fruit rot of brinjal and document its effects on brinjal yield using Kashmir as a case study in order to provide background information that can be used for further research on the diseases in Kashmir valley.

Little work has been done in Kashmir on the status and management of fruit rot. In the present review, attempts have been made to include status and management aspects which have direct bearing on problem under investigation. The present study was carried out under the following objectives:

- Status of Phomopsis fruit rot of brinjal
- Management of the Phomopsis fruit rot of brinjal

**Chapter - 2**

# REVIEW OF LITERATURE

Phomopsis blight is a fungal disease caused by *Phomopsis vexans* (Howard and David, 2007). It has also been referred as stem blight or canker, leaf blight or spot and fruit rot (Punithalingam and Holliday, 1972). Although tomato and pepper are in the same family with eggplant they were not affected by Phomopsis blight (Howard and David, 2007). It is mainly spread by spores which are usually released from a fungal fruiting body (pycnidia) and dispersed by splashing rain water, insects, and contaminated equipments. Spores germinate rapidly when free moisture is present on leaves, stems, or fruits. The fungus survives between eggplants on and in crop debris, seeds, and soil (Howard and David, 2007). The disease is difficult to manage because the slippery skin of the fruit does not allow good adhesion of sprays (Mark and Norman, 2010). Although the disease is of great economic importance but very limited work has been conducted in Kashmir. For the sake of convenience the text of the review has been made under various heads as follows:

## 2.1 Occurrence and economic importance

Various fungal species have been reported to cause fruit rot of brinjal. Out of 22 fungal pathogens causing brinjal fruit rot, *Colletotrichum, Fusarium* and *Phomopsis* species were more prevalent of all fruit rots, one due to *P. vexans* has been reported to be the most serious and destructive (Sherbakoff,1919 and Decker,1944). *P. vexans* causing fruit rot of brinjal has been known since long. Spegazzini (1881) described it as a new pathogen on eggplant. During the year 1892, Halsted first described the fungal organism of fruit rot of brinjal as *Phoma solani* in New Jersey. Since the name had been used for another fungus it was changed to *Phoma vexans* by Saccardo and Sydow in 1899 (Islam *et al.*, 2010*).* Harter transferred it to *Phomopsis vexans* (Sacc. and Syd.) Harter (Walker, 1952). It was later reported from Florida, Virginia, Porto Rico, Louisiana, Barbados, India and Italy, Cuba, Jamaica, Hungary, China, Brazil, New Calandonia, Mauritius, Sarawak, England and Bangladesh by Rolfs, 1894; Giese *et al, 1912*; Stevenson and Rose, 1917; Edgerton and Moreland, 1921; Bourne, 1923; Uppal *et al.*, 1935; Palo,1936; Smith, 1937; Moerz, 1938; Wei and Cheo, 1944; De-Frigueiredo and Pereira, 1944; Bognicourt *et al.*, 1954; Orian, 1951; Anonymous, 1976; Ellis, 1976; Fakir, 1983; Ahmad, 1987; Das, 1998 and Khan, 1999 respectively. It was also reported from Saudia Arabia for the first time by Abu Yaman and Abu Balam (1972). In India the disease was first reported from Gujrat in 1914 and since then from many parts of India (Hossain *et al*., 2013). The disease has also been reported from the state of Jammu and Kashmir (Mir, 1992 and Sharma *et al.,* 2011). According to Bourne (1923) severe outbreak of *P. vexans* on egg plants was recorded on the growers fields in Barbados as a large number of fruits rotted from stem end in the standing crop. The occurrence of the disease in epiphytotic proportions resulting in severe losses has been reported from Florida (Sherbakoff, 1917). A severe leaf bight and fruit rot of brinjal was observed at Ugar Belgaum district during winter, 1952 (Pawar and Patel,, 1957). Fruit rot due to *P. vexans* occurred in an epidemic form at Government Vegetable Farm Jalhander in 1962, causing extensive losses (Panwar *et al.*, 1970*).* An epiphytotic form of fruit rot of brinjal caused by *P. vexans* was reported in Mauritius in 1964 (Felix *et al., 19*65). The disease was reported in severe form in Bombay and Horticulture Division of Indian Agriculture Research Institute, New Delhi (Vasudeva, 1960).

Phomopsis blight in eggplant spreads by farming practices, variety used, time of sowing, transplanting, source of planting materials, spacing used, time of disease appearance and control measures. *Phomopsis vexans* has been reported from many areas in the warmer parts of most continents, but unknown in Europe except in Romania (Smith *et al*., 1988) and known in only a few African countries. It is probably native to southern Asia, the area of origin of the host *Solanum melongena* (Prance and Nesbitt, 2005) where it has also been reported to infect some wild Solanum species (Datar and Ashtaputre, 1988). It is readily transmitted in and on the seed of a crop which was only grown in limited areas causing lack of a continuous distribution in the tropics and subtropics (Porter, 1943; Vishunavat and Kumar, 1993). The fungal pathogen was introduced to a region within a seed lot, but then dies out when its presence discouraged continuous local cultivation of eggplant. Spore germination is optimal at 27°C, and pycnidial formation was found to be greatest between 30 and 35°C (Pawar and Patel, 1957). The optimum relative humidity for disease development has found 55 per cent relative humidity and above (Chaudhary and Hasija, 1979) but the optimum temperature for fungal growth was 28°C (Pawar and Patel, 1957). Fruit rot was maximum at 30°C and 50 per cent relative humidity in the growth chamber, temperatures of 5, 10 and 40°C were found unfavourable for disease development in inoculated detached fruits (Islam and Pan, 1990).

The losses to brinjal crop by *Phomopsis vexans* have been reported to range from 10 to 100 per cent in the United States of America (Sherbakoff, 1919; Chupp, 1925; Hyre, 1944). Nolla (1929) recorded up to 50 per cent losses in yield caused by this pathogen. According to De-Figueiredo and Pereira (1944) *Phomopsis vexans* causesd such devastating losses in brinjal as to render control measures impracticable. It is a destructive disease, causesd 10-25 per cent annual loss in fruit yield (Panwar *et al*., 1970). Phomopsis vexans is a major concern in brinjal production as it reduced yield and marketable value of the crop nearly 20-30 per cent (Jain and Bhatnagar, 1980; Kaur *et al*., 1985).

## 2.2 Symptomatology

Phomopsis fruit rot of brinjal has been treated as major constraint in the cultivation of brinjal (Das, 1998; Khan, 1999). The symptoms produced by *P. vexans* have been described by several workers (Halsted, 1892; Harter, 1914; Edgerton and Moreland, 1921; Nolla, 1929; Palo, 1936; Walker, 1952, Pawar and Patel, 1957; Singh, 1992; Ashrafuzzaman, 2006). The disease appeared as damping off, tipover and seedling blight in the nursery and fruit rot in the harvesting stage of the crop (Singh, 1992; Ashrafuzzaman, 2006). The symptoms range from poor germination and seedling blight to fruit rot. Post-emergence damping-off of seedlings has been resulted from infection of the stem just above the soil surface. The symptoms on leaves appeared more prominent during the early stages of plant growth. At first, the lesions were small, more or less circular, and buff to olive, later becoming cinnamon buff, with an irregular blackish margin (Pawar and Patel, 1957). Irregular spots result from coalescence. After transplanting, leaves coming into contact with the soil become infected directly or developed leaf spot due to infection by conidia. Lesions on the petiole or the lower part of the midrib resulted in death of the entire leaf. Affected leaves were dropped prematurely, and the blighted areas become covered with numerous black pycnidia. On stems and branches, elongated, blackish-brown lesions were formed, eventually containing pycnidia. The diseased plant bears smaller leaves and the auxiliary buds were often killed. When stem girdling occurs, the shoot above the infected area wilted and dried up and the plant were toppled by the wind (Edgerton and Moreland, 1921; Pawar and Patel, 1957; Sherf and MacNab, 1986). Pycnidia developed readily in lesions on young stems, but rarely on older ones (Harter, 1914). On the fruits the symptoms appeared first as minute sunken greyish spots with a brownish halo, which later enlarged and coalesced, producing concentric rings of yellow and brown zones. These spots increased in size and form large rotten areas on which conidiomata often developed concentrically, covering most of the rotten fruit surface. Pycnidia on fruit are larger than those on stems and leaves (Harter, 1914). When the infection entered the fruits through the calyx, the whole fruit became mummified due to dry rot (Pawar and Patel, 1957). Rot appeared in fruit, in transit after harvest (Sherf and MacNab, 1986).

Sharma *et al*. (2011) reported that Phomopsis blight of eggplant infected almost all aerial parts and caused damping off, seedling blight, tip over, leaf spots, stem blight and fruit rot. Stem symptoms of this disease include brown or dark sunken lesions, seedlings eventually collapsed and dried. The pathogen invaded leaves but older ones are more susceptible. Lesions exhibited typically circular, gray to brown, and developed a light centre. The pathogen remained on the seed coat and the cotyledons of seed causing various degree of seed discoloration and minute black pycnidial bodies were distinctly observed on the surface of the dry seed (Karuna *et al.*, 1994). Fruit spots were shown pale and sunken. The spots frequently originated on the calyx and expanded into the fruit pedicel and then into the fruit. Decayed fruits were soft and spongy which penetrated rapidly throughout the fruit (Chen *et al.*, 2002).

Ronald (2009) observed that fruit injury began as a pale, sunken, oval area(s) on the surface, subsequently enlarged and depressed. The fruit became unmarketable. The fruit rot of brinjal spreaded when spores were released from the pycnidia and dispersed by splashing rain. Propagules of *P. vexans* remained alive between crops in plant debris in the soil. Disease was favoured by hot and wet weather. Phomopsis blight was one of the most important biotic factors limiting eggplant production in Philippine and USA (Cristina, 2002; Howard and David, 2007*)*. The fungus had been seed-borne and survived in crop debris in the absence of the host. It caused seedling damping-off, leaf spot and stem canker on eggplant (Sherf and MacNab, 1986). The disease affected eggplant production severely and reduced fruit yield by 40 to 70 per cent of the total harvest (Cristina, 2002). The fungus produces abundant fruiting structures along the killed tissues and galls called pycnidia. It spreads when spores were released from the pycnidia and dispersed by splashing rain, insects, and contaminated equipment. Phomopsis blight attacks the stems of eggplant, causing plants to wilt. The disease also penetrated into fruit, creating a soft rot. It has infected above ground plant parts at all developmental stages of brinjal. The fungus survived for more than a year in fields where a diseased crop was grown and was mainly favoured by warm, wet weather (Howard and David, 2007).

### 2.3 Causal pathogen and its morphological characters

The casual fungus has been isolated from infected stem, fruit of eggplant by tissue planting and other methods. Lapis and Deangkinay (1967) isolated *Phomopsis vexans* from fruit of eggplant by tissue planting. They further reported that abundant pycniospores with very few stylospores were observed in the culture medium. *Phomopsis vexans* was constantly isolated from diseased parts of the brinjal fruit, leaves and seeds (Silveira, 1950; Suryanarayana and Bhombe, 1961; Panwar and Chand, 1969). This fungus has earlier been reported to cause fruit rot, leaf spot, stem blight and damping off by a number of workers (Harter, 1914; Edgerton and Moreland, 1921; Nolla, 1929; Palo, 1936 and Pawar and Patel, 1957). On the basis of characteristics features, the fungus associated with the disease has been identified as *P. vexans* (Sacc and Syd) Harter, (Harter, 1914; Edgerton and Moreland, 1921; Nolla, 1929; Palo, 1936 and Pawar and Patel, 1957).

Spegazzini (1881) reported *Phyllostica hortorum* on eggplant leaves which was later named as *Phoma solani* by Halsted (1892) and as *Phoma vexans* by Saccardo and Sydow (1899). Harter (1914) made a new combination *P. vexans* (Sacc. & Syd.) Harter on the basis of pycnidial characteristics. Harter (1914) observed the size of pycnidia on the leaves and fruits which were 60-200 and 120-350 μ respectively, pycniospores abundant, hyaline, sub- cylindrical, 5-8 × 2-2.8 μ; Stylospores filliform, curved, rarely straight, 13-28 μ. Edgerton and Moreland (1921) named the two types of spores of *Phoma vexans* as Phylosticta type, 6-8 × 3-4 μ and Phylactaenea type, 18-32 × 1-1.8 μ. They further reported that the pycnidial size and shape varied considerably depending upon whether they were sampled from leaves, fruits or stems, the pycnidia were 125-300 × 110-250 μ on leaves or fruits but slightly larger (700 × 800-950 μ) on stem. Nolla (1929) also reported two types of spores, the beta spore or stylospores were infrequent and the size of alpha spores or pycniospores ranged from 5-8 × 1.3-3 μ. Palo (1936) observed that hyphae varied from 1.5-3.3 μ in diameter and in artificial culture, some of the hyphal threads grew as large as 4.2 μ in diameter, the pycniospores varied in size from 5-8 × 1.7-3.6 μ and the stylospores from 13.3-18.3 × 1-1.7 μ but stylospores measuring up to 28.2 μ were found extremely rare Pawar and Patel (1957) reported that mycelium consists of fine hyaline septate hyphae measuring 2.7-3.9 μ in diameter .They also observed that pycnidia were flask shaped, minute, black and ostiolate, measuring 80-360 μ in diameter and the beak measures (22.2-293.1) μ in length. Sherf and Macnab (1986) also reported that *P. vexans* produced two types of spores in pycnidia, pycniospores and stylospores. The pycnidia were of various sizes with average size of about 100-200 × 110-220 μ. Pycnidia neck was 76 μ long in nature. Pycniospores were found single –celled elliptical colour less and they were from 5-8 × 1.7-3.6 μ. Stylospores were colour less, filliform, and generally curved, they were from 13-18 × 1-1.7 μ. Panwar and Chand (1968) studied the morphology of three isolates reported that isolate A had scattered and very few pycnidia measuring 561 × 733 μ, pycnidiospores 2.5 × 5.8 μ and stylospores 1.5 × 18.3 μ. Isolate C showed pycnidia 552 × 725 μ, pycnidiospores, 2.5 × 5.7 μ and stylospores 1.4 × 18.4 μ. While isolate I showed pycnidia 390 × 510 μ, pycniospores 2.5 × 5.7 and stylospores of 1.5 × 17.7 μ. The perfect stage of the fungus *P. vexans* (*Diaporthe vexans* Sacc. and Syd.) Gratz was found and described by Gratz (1942) in culture. He further reported that Perithecial stage of the fungus has not been observed on the host. Perithecia were usually produced in clusters measuring 130-350 μ in diameter and had beaked carbonaceous, sinuate and irregular ostioles. Asci were typically eight spored, hyaline, thinwalled with apex slightly, thickened and pierced by a narrow pore, clavate, sessile, narrowly ellipsoid to bluntly fusiod having one septa and constricted at the septum measuring 3-4 × 9-12 μ.

The optimum temperature for fungal growth was 29°C and grown well up to 32°C. Pan and Acharya (1995) observed that seed was the infection source of *P. vexans* and served as a substrate for pathogen survival. Islam (2005a) observed that the fungus produces whitish mycelial growth in cultured media with concentric pycnidia partially emerged. The pycnidia possessed both α and β conidia (Islam, 2005b). Singh (1992) recorded that the pycnidia were 60 to 200 μ in diameter on the leaves and 120 to 350 μ on fruits of brinjal crop. The pycnidia were globose to irregular with 20 to 50 μ wide ostiole. The conidiophores were found hyaline and 10 to 16 μ long. Conidia were hyaline, one-celled, sub-cylindrical, 5-9 × 2-2.9 μ in size. Another form of conidia, the stylospores (β-conidia) were filiform, curved, hyaline and aseptate. These spores did not germinate; they are 20-30 × 0.5-1.0 μ in size. He has also observed that the perfect or sexual stage of the pathogen was *Diaporthe vexans*. Sugha *et al.* (2002) have reported that α and β conidia were two forms of the same conidium. *P. vexans* produced only one type of conidia in its pycnidia, which were hyaline, one celled, sub-cylindrical and 5-9 × 2-2.8 μ in size during summer months, which gradually changed into the β form. Inoculation of host plants with beta conidia caused intraveinal necrosis, which progressed towards the leaf base and resulted in premature defoliation. Isolations from such leaves produced pycnidia with α conidia at 25$^{o}$C and β conidia at 16 $^{o}$C.

**2.4 Pathogenicity**

Edgerton and Moreland (1921) observed that symptoms easily produced after 7-9 days of inoculation in injured fruits. Similarly, Nolla (1929) also observed that the infection occurred through a wound and symptoms appeared on all aerial parts of the brinjal plants. The early symptoms of the fungus were detected after ten days of inoculation as reported by Palo (1936). Howard and Desrosiers (1941) observed that the pathogen enters the leaves of both susceptible and resistant varieties by direct penetration. Lapis and Deangkinay (1967) proved that pricked fruits developed symptoms as circular spots on the prickled points and mycelial growth of the fungus has been seen only at the prickled areas. They further stated that numerous pycnidia developed starting from the centre extending outward. Divimagracia (1972) observed that conidia of *P.vexans* germinated after 6 hours, entered the host after 12 hours and no symptoms were observed until 76 hours after inoculation. Chaudhary and Hasija (1979) concluded that the fungus to be a wound parasite. Lal *et al.* (1981) also reported that injury was essential for development of the disease and the ripe fruit was found to be more susceptible than the green ones. Quaiser (1987) observed that when fruits were inoculated with *P. vexans* by pin prick method and incubated for 15 days at 25 $^{o}$C have been found to be most suitable for fruit rot.

### 2.5 Disease management

Cultural as well as chemical management have been suggested by various research workers for the management of Phomopsis fruit rot of brinjal. To control fruit rot of eggplant caused by *P. vexans*, copper lime dust (16 per cent by weight dehydrated copper sulphate, 20 per cent calcium arsenate and 64 per cent hydrated lime) appeared to be promising substitute for Bordeaux mixture (Sayre, 1924 and Spencer *et al.,* 1924). Nolla (1929) recommended soil sterilization of seed bed with 2 per cent formaldehyde solution @ half gallon per square feet before raising brinjal seed crop. Whereas Martin (1930) recommended seed treatment with hot water (55 $^{o}$C for 15 minutes or 50 $^{o}$C for 30 minutes) for control of *P. vexans* causing leaf spot. Fermate (Ferric dimethyl dithio-carbamate) talc dust treatment was better and more effective than copper lime dust as reported by Porter (1943). Hot water treatment of seed, weekly dithio-carbamate sprayings of the crop along with crop rotation and the use of resistant varieties were suggested for the control of fruit rot of brinjal by Felix *et al.* (1965). Singh and Chakrabarti (1982) reported that treatments on brinjal seeds before sowing with the chemicals like captan, difolaton, benlate, thiram, calixin, bavistin and hot water did not have significant effect on the emergence and stand of the brinjal seedlings in nursery beds. In the spray treatments, the minimum fruit rot incidence and maximum seed yield were obtained from difolatan and captan treatments. Calixin was found phytotoxic to the crop even at lowest recommended concentration. Grewal and Jhooty (1987) reported that all the fungicides reduced the fruit rot significantly as compared to unsprayed fruits. Dithene Z 78 was the best fungicide as the per cent infected fruits were minimum followed by bordeux mixture, blitox, dithene M 45 and cuman L. Sinha (1989) observed that all the fungicides reduced fruit rot intensity as compared to the untreated plants amongst the treatments. Carbendazim as seed treatment followed by four sprays of copper oxychloride was found best as the fruit rot intensity was recorded minimum on fruits as compared to untreated fruits. Jacqua and Gerion (1989) reported that mixture of captafol plus carbendazim and maneb plus thiophenate methyl controled *P. vexans* when sprayed every 10-12 days interval.

Islam and Pan (1993) suggested that Phomopsis blight of brinjal can be managed by the spraying of bavistin and vitavax. Das (1995) also observed that Phomopsis blight of brinjal was managed by three foliar sprays of bavistin 50WP and indofil M-45. Sing *et al*. (2012) reported that the systemic fungicides were most effective than non-systemic fungicides for the management of fruit rot and it was possible to control the disease through the spraying of fungicides on brinjal

Singh and Agarwal (1999) reported that carbendazim @1 per cent concentration proved effective in controlling the disease. Beura *et al*. (2008) evaluated the six chemicals viz. carbendazim 0.1 per cent, mancozeb 0.3 per cent, propineb 0.25 per cent, tebuconazole 0.05 per cent, copper oxychloride 0.3 per cent and copper hydroxide 0.3 per cent and recorded that carbendazim proved most effective followed by tebucanozole in reducing fruit rot incidence of twig blight and fruit rot of brinjal. Similarly Sing *et al*. (2012) reported that bavistin (0.1%), vitavax (0.1%), blitox-50 (0.2%), and ridomil (0.15%) proved to be the most effective in inhibiting the growth of pathogen *in-vitro* and controlling the disease in the field. They further reported that nimbidine and indofil M-45 were found to be the next best in inhibiting the growth of pathogen. These were statistically at par and showing 97.05 and 94.17per cent inhibition over unsprayed, respectively. The captafol was recorded least effective fungicide. Sharma *et al.*, (2012) reported that Carbendazim recorded 100 per cent inhibition of *P. vexans* over control at 1 ppm concentration. Among the combination of fungicides, carbendazim 12 per cent + mancozeb 63 per cent was most effective than that of others.

Hossain *et al*. (2013) revealed that the seed treatment with carboxin 37.5 per cent + thiram 37.5 per cent (vitavax powder) @ 2 g/kg of seed and foliar application of copper oxychloride (blitox-50) @ 0.3 per cent increased the seed germination by 21.18 per cent and reduced seedling mortality, seedling blight and fruit rot infection by 90.25, 74.51 and 65.9 per cent, respectively. The improved germination and reduced disease infections helped to sustain 40.28 per cent higher yield (Pani *et al*., 2013).

Bavistin 50 WP (0.1%) alone or in combination with micronutrients (gypsum, ZnO and boric acid) could be used for management of Phomopsis blight and fruit rot of eggplant. According to Chen *et al*. (2002) crop rotation cycle of three to four years, use of resistant varieties and regular spray with a protective fungicide such as maneb or zineb managed the disease to a greater extent. Mulching and furrow irrigation reduced infection caused by water and soil splashing.

Mir (1992) carried out *in vitro* and *in vivo* comparative effect of different fungicides against *P. vexans* and observed that carbendazim 50WP at 50 ppm and mancozeb 75 WP at 200ppm were effective in suppressing the growth of the fungus. Under the field conditions the seed treatment of carbendazim 50WP @ 0.1 per cent + seedling dip with carbendazim 50WP @ 0.1 per cent + three foliar sprays with carbendazim 50WP @ 0.1 per cent at interval of 15 days was significantly superior in controlling *P. vexans* followed by seed treatment with ziram 80WP @ 0.3 per cent + seedling dip with mancozeb 75 WP @ 0.3 per cent + foliar spray with carbendazim 50WP @ 0.1 per cent.

Sing *et al*. (2012) reported that the foliar spray of bavistin @ 0.1 per cent, blitox @ 0.2 per cent and ridomil @ 0.15 per cent increased the yield over the check by 62.8 per cent, 62.8 per cent and 54.2 per cent respectively.

Chapter – 3

# MATERIALS AND METHODS

## 3.1 Status of Phomopsis fruit rot of brinjal

Survey of main brinjal growing areas in the districts of Budgam and Pulwama of the Kashmir valley was carried out during the second fortnight of August in the year 2014 to record the incidence and intensity of Phomopsis fruit rot of brinjal. In each district four locations were observed for fruit rot and in each location randomly four brinjal sites were surveyed. In all 32 sites were observed at 8 locations. Randomly 50 fruits from each of the site were collected to record the per cent incidence and intensity of Phomopsis fruit rot of brinjal.

### 3.1.1 Fruit rot incidence (%)

Per cent fruit rot incidence was calculated by using the following formula:

$$\text{Per cent fruit rot incidence} = \frac{\text{Number of diseased fruits}}{\text{Total Number of fruits observed}} \times 100$$

### 3.1.2 Fruit rot intensity (%)

The fruit rot intensity was recorded using 1-8 scale (Sharma *et al.*, 2011) with slight modifications. Eight categories were made on the basis of per cent fruit involved as per the following key:

| Grade | Numerical value | Fruit rot (%) |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 1 | 1-10 |
| 3 | 2 | 11-25 |
| 4 | 3 | 26-50 |
| 5 | 4 | 51-75 |
| 6 | 5 | 76-90 |
| 7 | 6 | 91-99 |
| 8 | 7 | 100 |

Per cent fruit rot intensity (PDI) was calculated as per the following formula:

$$\text{Per cent disease intensity} = \frac{\sum (n \times v)}{N \times G} \times 100$$

Where,

$\sum$ = Summation
n = Number of diseased fruits in each category
v = Numerical value of the category
N = Total number of fruits examined, and
G = Highest grade value

### 3.2 Symptomatology

Studies on the development of Phomopsis fruit rot of brinjal symptoms were carried out in brinjal fruits selected from research field trial established at Shalimar campus grown under natural epiphytotic conditions. Observations of the fruit rot were recorded after the first appearance of the symptoms on fruit till the peak period of the disease on highly susceptible cultivar (Pusa Purple Long) under natural epiphytotic conditions and inoculated with pin prick fruit injury method.

All the selected plants bearing fruits were tagged and were kept under constant observation throughout the growing season. The diseased fruits collected from the research field were further examined *in vitro* for the associated pathogen by teasing the diseased portion and observed under microscope. The fruits were also kept in moist chamber at 25°C for 36 hours and subjected to alternate light and dark periods to observe the fruiting bodies (pycnidia). These pycnidia were lifted with the help of teasing needle under stereoscopic microscope and temporary mounts in cotton blue, lactophenol and distilled water were prepared. Observations were recorded with respect to:

- Formation of lesions on fruit
- Sporulation of infected area
- Formation of fruiting bodies
- Colour and size of infected area.
- Per cent area covered by the disease

## 3.3 Isolation of pathogen

Brinjal fruits exhibiting typical Phomopsis symptoms collected from vegetable field at Shalimar campus during survey were used for isolation of the pathogen. For isolation of the pathogen the diseased fruits were first washed thoroughly under tap water for 20 minutes and dried with the help of a blotting paper. These fruits were then kept in moist chamber and incubated at 25±1°C for 24 hours. Small tissue bits of diseased along with healthy tissues were removed from these fruits. These bits were surface sterilized in 0.1 per cent mercuric chloride solution for about 30 seconds and were rinsed twice or thrice with sterilized distilled water in order to remove the excess of chemical if any. These bits were then placed in between the sterilized blotting paper to remove the droplets of water adhering to their surfaces. These were then transferred and placed aseptically over oat meal agar medium in petriplates and incubated at 25±1°C for 10 days. Fungal colonies were examined under microscope at 10x10X magnification. The advancing margins of these colonies were marked and hyphal tips were transferred to freshly prepared oat meal agar (OMA) slants. Pure culture of the fungus was obtained either by repeated transfer of hyphal tips or the culture was subjected to alternate light and dark periods for the formation of fruiting bodies (Pycnidia). At room temperature the ooze emerged from these pycnidia which contained spores. Spore suspension was prepared in sterilized distilled water by picking the spore which oozed from these pycnidia with the help of sterilized needle under stereoscopic microscope. The spore suspension thus obtained was used to flood the surfaces of plain agar medium in Petri plates and incubated at 25$^{o}$C for 48 hours. Single spore isolation were made by transferring aseptically the germinating spores to OMA (oat meal agar) medium and incubated at 25$^{o}$C and maintained at the alternate 12 hour cycle of light and darkness. The pure culture obtained was maintained by repeated sub-culturing at an interval of 30 days for further studies. The stock culture in oat meal agar (OMA) was stored in refrigerator at 4°C for further studies.

## 3.4 Pathogenicity test

To ascertain whether the fungus isolated was primary cause of the disease, it was subjected to Pathogenicity test (Koch's Postulate). The brinjal fruits were washed under tap water and surface sterilized with 0.1 per cent mercuric chloride followed by washing with sterilized distilled water two to three times. The fruits were constantly observed for 7 days to rule out any latent infection prior to inoculation. These fruits were then grouped into three sets. One set of fruits was given injuries with the help of sterilized teasing needle while as another set kept uninjured. These two sets were inoculated with seven days old culture by placing mycelial mat on injured and uninjured portions. The injured and uninjured fruits of third set were sprayed with sterilized water and served as a check. These fruits were incubated at 25±1°C for fifteen days. Each treatment had three replications. Fungus from affected portions was re-isolated for identification of the pathogen by comparison with the original culture. The pathogencity was proved by conforming Koch's Postulates.

## 3.5 Morphological characteristics of the pathogen

The morphological characters of the pathogen were studied on both host as well as culture in a laboratory. Semi-permanent slides were prepared from 14 days old culture stained with cotton blue and lacto phenol. The slides were examined under microscope (40 x and 100 x) with respect to following characters of the causal organism.

- Colour and septation of mycelium
- Colour, shape and size of fruiting bodies
- Colour, shape and size of spores.

The calibration of ocular micrometer was done with the help of stage micrometer. Ocular was placed inside the eyepiece of 10x and stage micrometer was brought into focus under the objective and ocular divisions of eyepiece were coincided and evaluation of fungal dimensions was made as per given formula:

$$\text{Calibration factor}(\mu m) = \frac{\text{No. of coincided divisions of stage micrometer}}{\text{No. of coincided divisions of occular micrometer}}$$

### 3.6 Identification of the pathogen

The casual organism was identified by studying its symptomatology, morphology, pathgencity and compared with authentic description from literature. (Harter, 1914; Edgerton and Moreland, 1921; Panwar and Chand, 1968; Sherf and Macnab, 1986; Singh, 1992; Sugha *et al.*, 2002).

### 3.7 Management of the Phomopsis fruit rot

The research field trial was established at SKUAST-K Shalimar and the total field was divided into 15 equal treatments/plots having three replications with size of each plot 3×2.4 m square. The brinjal plants of variety Pusa Purple Long were planted with a spacing of 60×60 cm square and Randomized Complete Block Design was used to layout the design of experiment. The following fungi toxicants and mulches were used *in vivo* against the fruit rot during fruiting stage crop.

**No. of fungi toxicants** : (1+4) = (05)

- $F_0$ = Control (water spray only)
- $F_1$ = Carbendazim 50WP@0.1 per cent
- $F_2$ = Copper oxychloride 50WP@0.3 per cent
- $F_3$ = Metalaxyl + mancozeb 68WP@0.15 per cent
- $F_4$ = Propiconazole 25 EC@0.15 per cent

No. of mulches : (1+2) = (03)

- $M_0$ = No mulch
- $M_1$ = Rice straw
- $M_2$ = Wheat straw

Total No. of treatments : 15

**Treatment combination details**

| Code | Symbol | Combination detail |
|---|---|---|
| $T_0$ | $F_0M_0$ | No chemical + No mulch (Control) |
| $T_1$ | $F_0M_1$ | No chemical + Rice straw |
| $T_2$ | $F_0M_2$ | No chemical + Wheat straw |
| $T_3$ | $F_1M_0$ | Carbendazim 50WP + No mulch |
| $T_4$ | $F_1M_1$ | Carbendazim 50WP + Rice straw |
| $T_5$ | $F_1M_2$ | Carbendazim 50WP + Wheat straw |
| $T_6$ | $F_2M_0$ | Copper oxychloride 50WP + No mulch |
| $T_7$ | $F_2M_1$ | Copper oxychloride 50WP + Rice straw |
| $T_8$ | $F_2M_2$ | Copper oxychloride 50WP + Wheat straw |
| $T_9$ | $F_3M_0$ | Metalaxyl + mancozeb WP +No mulch |
| $T_{10}$ | $F_3M_1$ | Metalaxyl + mancozeb 68 WP + Rice straw |
| $T_{11}$ | $F_3M_2$ | Metalaxyl + mancozeb 68 WP + Wheat straw |
| $T_{12}$ | $F_4M_0$ | Propiconazole 25 EC + No mulch |
| $T_{13}$ | $F_4M_1$ | Propiconazole 25 EC + Rice straw |
| $T_{14}$ | $F_4M_2$ | Propiconazole 25 EC + Wheat straw |

Each plot consisting of three replications was given a single treatment in the first week of august. The fungitoxicants were sprayed at the recommended concentrations against the target plot. The mulches were spreaded on the ground in the concerned plots to avoid the contact between the pathogen and the fruit. The control plot was kept without mulch and no fungitoxicant was sprayed to assess the extent of damage caused by the fruit rot pathogen. In each plot 50 fruits were selected to assess the fruit rot incidence, intensity and the disease control over the check. Further on an average 5 plants were selected in each plot and the number of fruits of these plants were counted. These fruits were weighed and the total yield and per cent yield loss was calculated.

Observations were recorded with respect to:-

1. Fruit rot incidence was calculated as mentioned at 3.1.1

2. Fruit rot intensity was calculated as mentioned at 3.1.2

3. The disease control over check was obtained by using the formula

$$\text{Disease control over check} = \frac{\text{Intensity in untreated plot} - \text{Intensity in treated plot}}{\text{Intensity in untreated plot}} \times 100$$

4. Yield per plot was calculated as per the formula :

Yield/plot = Avg. No. of fruits/plant × Avg. weight of each fruit (g) × No. of plants/plot

5. Per cent yield loss was calculated as per the following formula

$$\text{Per cent yield loss} = \frac{b-c}{c} \times 100$$

Where,

b = Total yield in treated plot

c = Total yield in control/untreated plot

## 3.8 Analysis of the data

The data of the various experiments were subjected to statistical analysis with the help of computer. The data was subjected to appropriate transformation wherever needed, as suggested by Gomez and Gomez (1984).

Chapter-4

# EXPERIMENTAL FINDINGS

## 4.1 Occurrence and distribution

The data regarding survey of Phomopsis fruit rot of brinjal during the year 2014 in two districts viz., Budgam and Pulwama for fruit rot incidence and intensity recorded is presented in Table 1.

### 4.1.1 Fruit rot incidence

The results obtained (Table 1) reveal that Phomopsis fruit rot of brinjal was prevalent in both the two districts surveyed. The fruit rot incidence observed on fruits was highest in district Budgam (42.25%) while as the district Pulwama (29.25%) exhibited the least fruit rot incidence. The data further revealed that the fruit rot incidence on fruits was highest (46.5%) in Narkara village of district Budgam followed by Badipora (44.5%) and Bogam (44%) locations of same district showing no significant difference. Kangan location of Pulwama district exhibited the fruit rot incidence of (35%) and did not differ significantly from that of Khag (34%) location of district Budgam and Kakapora (33%) location of district Pulwama. The least fruit rot incidence on fruits was observed in Rajpora (22%) followed by Awantipora (27%) locations of district Pulwama.

### 4.1.2 Fruit rot intensity

Observation (Table 1) regarding fruit rot intensity on fruits revealed that highest intensity of 16.24 per cent was recorded in district Budgam, which differ significantly from district Pulwama which exhibited fruit rot intensity of 11.99 per cent. The data further reveal that fruit rot intensity on fruits was highest at Narkara (20.35%) location of district Budgam followed by Bogam 15.99 per cent and was found to be statistically at par with Badipora 15.21 per cent location of same district. Khag location of district Budgam exhibited fruit rot intensity of 13.42 per cent

**Table-1 : Incidence and Intensity of Phomopsis fruit rot of brinjal during the year 2014**

| District | Location | Fruit rot incidence (%) Average | Disease intensity (%) Average |
|---|---|---|---|
| Budgam | Bogam | 44.00 (6.63) | 15.99 (4.00) |
| | Narkara | 46.50 (6.82) | 20.35 (4.51) |
| | Khag | 34.00 (5.83) | 13.42 (3.66) |
| | Badipora | 44.50 (6.67) | 15.21 (3.90) |
| Sub-Mean | | 42.25 (6.50) | 16.24 (4.03) |
| 95% C.I | | 36.35-48.15 | 13.99-18.48 |
| Pulwama | Kangan | 35.00 (5.92) | 13.28 (3.64) |
| | Kakapora | 33.00 (5.74) | 12.71 (3.57) |
| | Awantipora | 27.00 (5.20) | 12.92 (3.59) |
| | Rajpora | 22.00 (4.69) | 9.06 (3.09) |
| Sub-Mean | | 29.25 (5.41) | 11.99 (3.46) |
| 95% C.I | | 24.90-33.60 | 10.55-13.43 |
| Grand Mean | | 35.75 (5.98) | 14.11 (3.76) |
| 95% C.I | | 31.59-39.91 | 12.62-15.59 |

*Figures in parenthesis are square root transformed values

| C.D ($p \leq 0.05$) | | |
|---|---|---|
| District | 0.60 | 0.29 |
| Location | 0.53 | 0.23 |
| District × Location | 1.06 | 0.54 |

which was found to be statistically at par with the Kangan (13.28%), Awantipora (12.92%), Kakapora (12.71%) locations of district Pulwama. Rajpora location of district Pulwama exhibited least fruit rot intensity of 9.06 per cent.

## 4.2 Symptomatology

Periodical observations on symptomatological development were recorded at an interval of seven days on fruits. The disease was first observed in the 1st week of August and reached at its peak during late September (Table 2). Disease symptoms initially appeared as small, slightly sunken light pale brown, oval spots ranging from 0.5-1.0 mm with an average of 0.6 mm in size (Plate 1a). In the 2$^{nd}$ week of August the spots become more sunken, oval to circular and pale brown in colour and enlarge in size ranging from 1.0-6.0 mm with an average of 4.0 mm (Plate 1b). Latter on the spots turn circular, dull brown in colour with size ranging from 6.0-11.0 mm with an average of 9.4 mm and brownish hallow is formed in the centre of spots (Plate 1c) in the 3$^{rd}$ week of August. Spots collease together to form irregular patches and turn brown, circular to irregular with size ranging from 11.0-15.0 mm with an average of 13.2 mm and whitish centre is formed in the centre of spots (plate 1d) in the last week of August. During the first week of September the spots turn dark brown in colour with irregular margins, enlarge and merge to form rotten areas and produce concentric rings of yellowish and brownish zones with size ranging from 15.0-21.0 mm with an average of 19.6 mm. The lesions enlarge with size ranging from 21.0-25.0 mm with an average of 23.4 mm and asexual fruiting bodies the pycnidia are formed in Scattered or arranged manner on the rotten areas with concentric rings in the 2$^{nd}$ week of September (Plate-1e). Sporulation of infected area occurs and Pycnidia ooze out yellowish conidial mass in the 3$^{rd}$ week of September with lesion size ranging from 25.0-26.0 mm with an average with an average of 25.3 mm (Plate-1f). In the last week of September and onwards enlarging of lesions continues slowly with size ranging from 26.0-27.0 mm with an average of 26.7 mm and the sporulation from the pycnidia helps in further advancement of disease and with advancement the fruit turns into dry rot (Plate 1g).

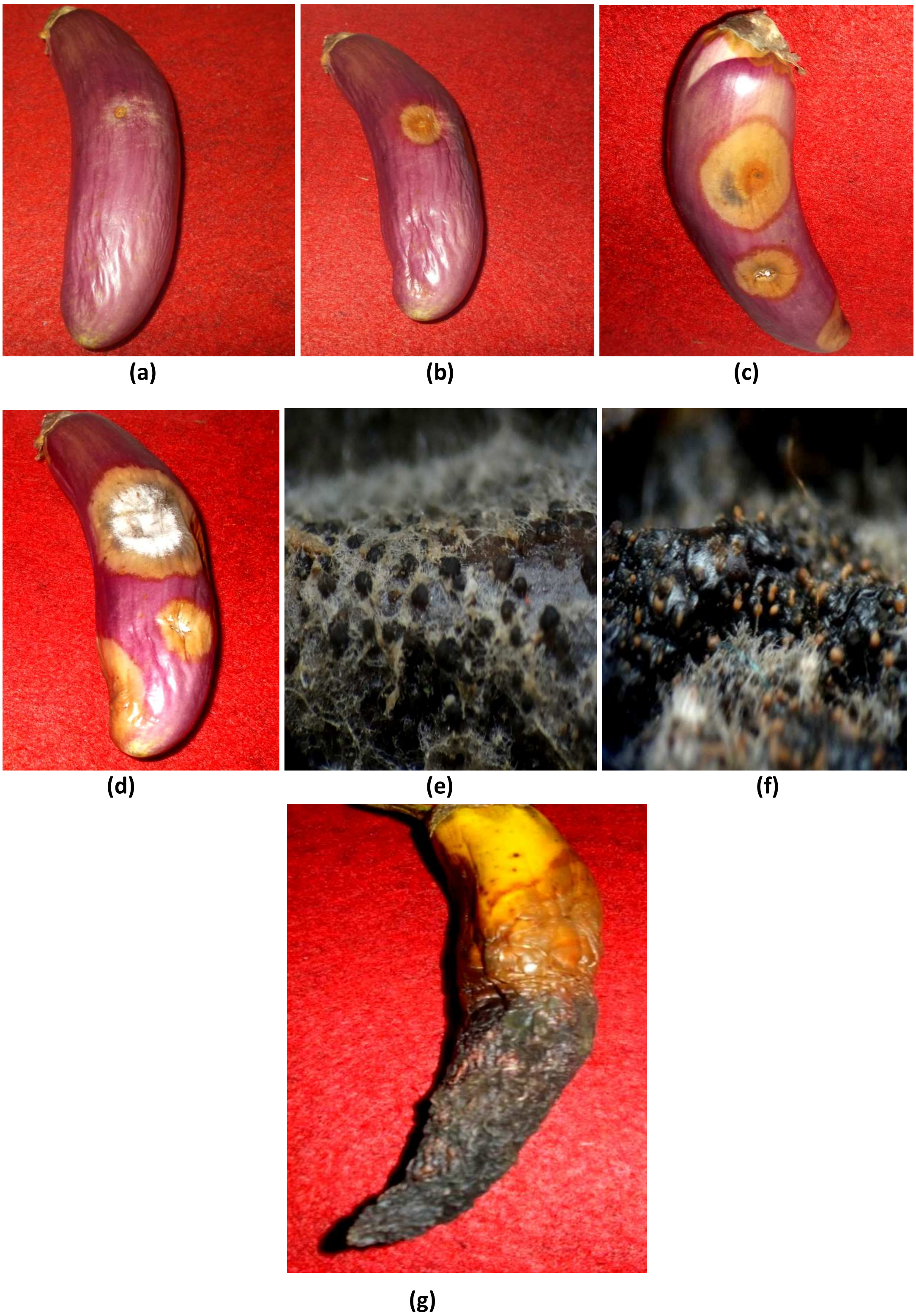



**Plate-1 : Characteristic symptoms of Phomopsis fruit rot of brinjal**

a) **Initial slightly sunken oval light pale brown lesion**
b) **Lesion increase in size forming larger areas**
c) **Lesion increase in size forming slightly irregular patches with brownish hallow in the centre**
d) **Lesion showing whitish centre**
e) **Pycnidia formation on fruit**
f) **Pycnidia releasing yellowish ooze**
g) **Fruit turns into dry rot**

**Table-2 : Symptomatology of Phomopsis fruit rot of brinjal caused by *Phomopsis vexans***

| Observations (weekly) | Lesions on fruit | | | | | |
|---|---|---|---|---|---|---|
| | Size Diameter (mm) | | Shape | Colour | Other characteristics | per cent area covered by disease |
| | Range | Average | | | | |
| 28-07-2014 | | | | | Disease free | 0 |
| 04-08-2014 | 0.5-1.0 | 0.6 | Oval | Light pale brown | Slightly sunken spots on fruits | 1-10 |
| 11-08-2014 | 1.0-6.0 | 4.0 | Oval to circular | Pale brown | Spots become more sunken and enlarge in size | 11-25 |
| 18-08-2014 | 6.0-11.0 | 9.4 | Circular | Dull brown | Enlarging of spots continues and brownish hallow is formed in the centre of spots | 26 -50 |
| 25-08-2014 | 11.0-15.0 | 13.2 | Circular to irregular | Brown | Spots collease together to form irregular patches with whitish centre | 51-75 |
| 01-09-2014 | 15.0-21.0 | 19.6 | Irregular | Dark brown | Spots enlarge and merge to form rotten areas and produce concentric rings of yellowish and brownish zones | 76-90 |
| 08-09-2014 | 21.0-25.0 | 23.4 | -do- | -do- | Asexual fruiting bodies the pycnidia are formed in Scattered or arranged manner on the rotten areas with concentric rings | 91-99 |
| 15-09-2014 | 25.0-26.0 | 25.3 | -do- | -do- | Pycnidia ooze out yellowish conidial mass. Sporulation of conodial mass from the pycnidia starts | 100 |
| 22-09-2014 and onwards | 26.0-27.0 | 26.7 | -do- | -do- | the sporulation from the pycnidia helps in further advancement of disease and with advancement the fruit turns into dry rot | -do- |

*No. of observations = 10

## 4.3 Isolation of pathogen

During the present investigation, isolation was made from diseased fruits showing typical symptoms (Procedure mentioned in 3.3) yielded repeatedly a fungus which proved pathogenic and main cause of Phomopsis fruit rot of brinjal disease under study. The fungal culture was raised on Oat meal agar for further studies.

## 4.4 Pathogenicity test

Observations regarding the pathogenicity of the test fungus revealed that the initiation of typical symptoms of the disease was recorded 7 days after inoculation on injured fruits. However, in case of uninjured fruits, the disease symptoms developed 16 days after inoculation. Re-isolation from infected fruits yielded the typical culture of the fungus, thus proved pathogencity of *P. Vexans* on brinjal fruits by Koch's postulates (Plate 2 a,b).

## 4.5 Morphological characters

The morphological characters of the pathogen were studied both on host as well as from culture and are presented in (Table 3).

### 4.5.1 On Host

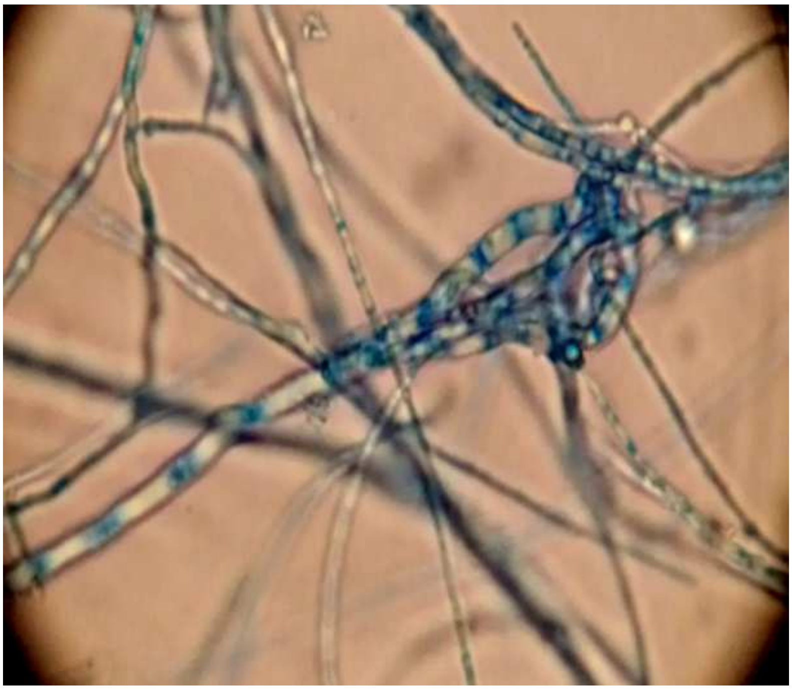
Microscopic observations of *P. vexans* (Table 3) revealed that the mycelium was branched, septate, slightly constricted at septa, spreading rapidly and hyaline measuring 2.25-3.5 µm in width with an average of 2.75 µm (Plate 3a). Alpha conidia were recorded numerous, hyaline, aseptate, guttulated, one celled, elliptical and sub cylindrical measuring 4.75-8.75 × 1.75-2.25 µm with an average of 6.15× 1.95 µm (Plate 3b). Beta conidia were found filiform, curved, hyaline and aseptate measuring 12.5-17.5 × 1-1.5 µm with an average of 14.5×1.3 µm (Plate 3b). Fruiting bodies (pycnidia) were observed flask shaped, minute, erumpent, osteolate brownish black in colour and measured 123.75-297.5 × 109-245 µm with an average of 193.25× 190.6 µm (Plate 1e).


**(a)**

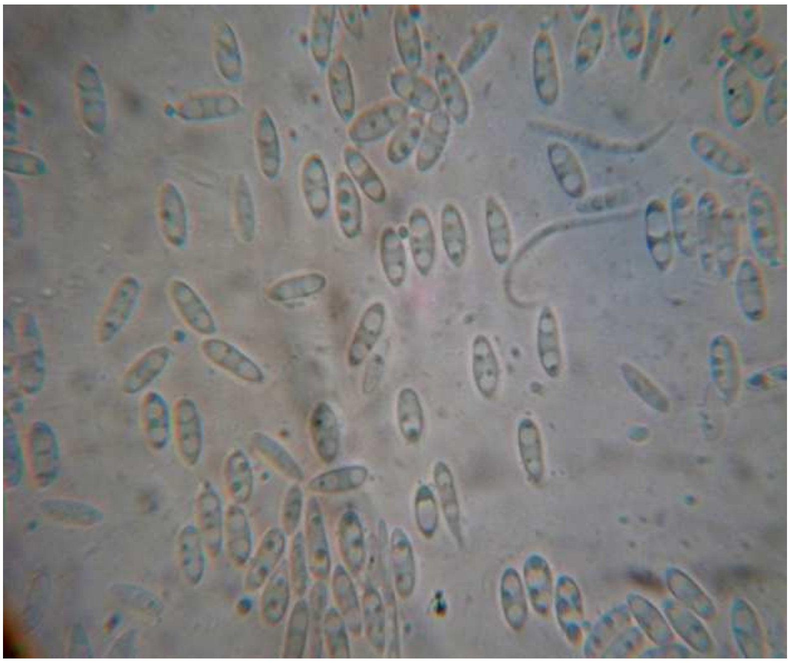

**(b)**

**Plate-2 : Establishment of pathogenicity of *Phomopsis vexans* on brinjal fruits**

a) **Control/uninjured**
b) **Control/injured**



(a)



(b)

## Plate-3 : Morphological characters of *Phomopsis vexans*

a) **Mycelium of *Phomopsis vexans* (400X)**
b) **Hyaline alpha and beta conidia (1000X)**

### 4.5.2 In Culture

#### 4.5.2.1 Colony characters

The petriplates inoculated with fungus, were critically observed for colony characters and the growth behaviour (Table 4). After 5 days of incubation at 25 ± 1$^{o}$C, the colony appeared as circular, whitish with profuse mycelium (18 mm dia) (Plate 4a), which later turned fluffy white measuring (55 mm dia) after 10 days (Plate 4b), compact white measuring (89 mm dia) after 15 days (Plate 4c) and slight grayish white measuring (90 mm dia) after 20 days of incubation (Plate 4d). After 25 days of incubation the colony appeared as grey white with development of minute black, flask shaped concentric pycnidia with well-defined margins (Plate 4e) and finally grey white/pale yellow mycelium with light yellow oozing from pycnidia were observed after 30 days of incubation (Plate 4f).

#### 4.5.2.2 Microscopic characters

Microscopic observations of the pathogen (Table 3) revealed that the mycelium was branched, septate, slightly constricted at septa, spreading rapidly and hyaline measuring 2.5-3.75 µm in width with an average of 3.0 µm. (Plate 3a). Alpha conidia were recorded numerous, hyaline, aseptate, guttulated, one celled, elliptical and sub cylindrical measuring 5.0-9.0 × 2.0-3.0 µm with an average of 6.2×2.4 µm (Plate 3b). Beta conidia were found filiform, curved, hyaline and aseptate measuring 13-17.5 × 1.0-1.75 µm with an average of 15.7 × 1.3 µm (Plate 3b) Asexual fruiting bodies (pycnidia) were observed flask shaped, minute, erumpent, osteolate brownish black in colour and measured 125-300 × 110-250 µm with an average of 177.5 × 152.0 µm (Plate 4e).

(a) (b)

(c) (d)

(e)

(f)

**Plate-4 : Cultural characteristics of *Phomopsis vexans***

**a) 5 days old colony**
**b) 10 days old colony**
**c) 15 days old colony**
**d) 20 days old colony**
**e) 25 days old colony**
**f) 30 days old colony**

**Table-3 : Morphological characters of *Phomopsis vexans* causing Phomopsis fruit rot of brinjal**

| **Propagule type** | **Colour** | **Size (µm)** | | **Shape/structure** | **Septation** |
|---|---|---|---|---|---|
| | | **In culture** | **On host** | | |
| Hyphae (width) | Hyaline | 2.5-3.75 (3.0)* | 2.25-3.5 (2.75)* | Branched spreading rapidly and slighty constricted at septa | Septate |
| Alpha conidia | Hyaline | 5.0-9.0 x 2.0-3.0 (6.2×2.4)* | 4.75-8.75 x 1.75-2.25 (6.15x1.95)* | Numerous, Guttulated, one celled, elliptical and sub cylindrical | Aseptate |
| Beta conidia | Hyaline | 13-17.5 x 1-1.75 (15.7x1.3)* | 12.5-17.5x 1- 1.5 (14.5x1.3)* | Filiform, curved | Aseptate |
| Pycnidia | Brownish black | 125-300 x 110-250 (177.5x152.0)* | 123.75-297.5 x 109-245 (193.25x190.6)* | Flask shaped, Minute erumpent and osteolate | - |

*Figures in parenthesis are average values of 20 observations

**Table- 4 : Cultural characters of *Phomopsis vexans* causing Phomopsis fruit rot of brinjal**

| Colony (No. of days) | Colour | Size (mm) | Shape/structure |
|---|---|---|---|
| 5 days old | White | 18 | Circular, whitish with profuse mycelium |
| 10 days old | White | 55 | Circular, whitish fluffy mycelium |
| 15 days old | White | 89 | Circular, whitish compact mycelium |
| 20 days old | Slight grey white | 90 | Circular, Slight grayish white compact mycelium |
| 25 days old | Grey white | | Development of minute black, flask shaped concentric pycnidia on grey white mycelium, with well-defined margins |
| 30 days old | Pale yellow | - | Grey white mycelium with Light yellow oozing from pycnidia |

*No. of observations = 5

## 4.6 Identification of the pathogen

On the basis of the morphological characters, pathogenicity test and comparison with authentic description, the causal pathogen of Phomopsis fruit rot of brinjal was identified as *Phomopsis vexans* (Sacc. & Syd.) Harter. The observation were confirmed by Dr. Ali Anwar, Professor, Dr.V. K. Ambardar, Associate Professor and Dr. G.H. Mir, Assistant Professor Division of Plant Pathology SKUAST-K Shalimar, Srinagar.

## 4.7 Management of the Phomopsis fruit rot

### 4.7.1 Fruit rot incidence

Analysis of the data (Table 5) revealed that all the treatments had significant effect on per cent fruit rot incidence of Phomopsis fruit rot of brinjal over check.Among the fungitoxicants, propiconazole 25 EC proved to be most effective as it reduced fruit rot incidence to 12.00 per cent compared to check exhibiting fruit rot incidence of 67.66 per cent, followed by carbendazim 50 WP, copper oxychloride 50 WP which was at par with metalaxyl + mancozeb 68 WP exhibiting fruit rot incidence of 14.00, 8.00 and 19.00 per cent respectively. Among the mulches applied rice straw proved to be most effective over check exhibiting fruit rot incidence of 64.00 per cent followed by wheat straw which exhibited fruit rot incidence of 66.00 per cent. A significant combination existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting fruit rot incidence of 2.66 per cent followed by propiconazole 25 EC + wheat straw (8.66%) which was at par with  carbendazim 50 WP+ rice straw (10.66%), carbendazim 50 WP + wheat straw (10.66) and copper oxychloride 50 WP + wheat straw(11.33). Moreover, copper oxychloride 50 WP + rice straw, metalaxyl + mancozeb 68 WP + rice straw and metalaxyl + mancozeb 68 WP + wheat straw exhibited fruit rot incidence of, 12.66, 15.33 and 16.66 per cent respectively.

### 4.7.2 Fruit rot intensity

Table 6 revealed that all the treatments had significant effect on per cent fruit rot intensity of Phomopsis fruit rot of brinjal over check.Among the fungitoxicants, propiconazole 25 EC and carbendazim 50 WP which are at par, proved to be most effective as they reduced fruit rot intensity to 5.52 and 5.66 per cent respectively compared to check exhibiting fruit rot intensity of 30.47 per cent, followed by copper oxychloride 50 WP which was at par with metalaxyl + mancozeb 68 WP exhibiting fruit rot intensity of 6.85 and 7.52 per cent respectively.Among the mulches applied rice straw proved to be most effective over check exhibiting fruit rot intensity of 21.13 per cent followed by wheat straw which exhibited fruit rot intensity of 25.52 per cent. A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting fruit rot intensity of 0.85 per cent followed by propiconazole 25 EC + wheat straw (2.85%) which was at par with carbendazim 50 WP + rice straw (2.85). Moreover, copper oxychloride 50 WP + rice straw exhibited fruit rot intensity of 4.47 per cent which was at par with, carbendazim 50 WP + wheat straw, copper oxychloride 50WP + wheat straw and metalaxyl + mancozeb 68 WP + rice straw exhibiting fruit rot intensity of 4.76, 4.85 and 5.80 per cent respectively. Metalaxyl + mancozeb 68 WP + wheat straw exhibited a fruit rot intensity of 7.23 per cent.

### 4.7.3 Disease control over check

Table 7 revealed that all the treatments had significant effect on per cent disease control of Phomopsis fruit rot of brinjal over check. Among the fungitoxicants, propiconazole 25 EC which was at par with carbendazim 50 WP proved to be most effective as they indicated a maximum disease control of 81.88 and 81.42 per cent compared to check, followed by, copper oxychloride 50WP which was at par with metalaxyl+ mancozeb 68WP exhibiting disease control of 77.51 and 75.31 per cent respectively. Among the mulches applied rice straw proved to be most effective over check exhibiting disease control of 30.65 per cent followed by wheat straw which exhibited disease control of 16.24 per cent.

A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting disease control of 97.21 per cent followed by propiconazole 25 EC + wheat straw (90.64%) which was at par with carbendazim 50 WP + rice straw(90.64). Moreover, copper oxychloride 50 WP + rice straw exhibited disease control of 85.23 per cent which was at par with carbendazim 50 WP+ wheat straw, copper oxychloride 50WP + wheat straw and metalaxyl + mancozeb 68 WP + rice straw exhibiting disease control of 84.37, 84.08 and 80.96 per cent respectively. Metalaxyl + mancozeb 68 WP + wheat straw exhibited a disease control of 76.27 per cent over check.

**Table- 5 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Fungicide | | Fruit rot incidence (%) Mulch | | | Mean |
|---|---|---|---|---|---|---|
| | **Treatment** | **Dosage (%)** | **No mulch** | **Rice straw** | **Wheat straw** | |
| 1. | Carbendazim 50 WP ($F_1$) | 0.1 | 14.00 (3.74) | 10.66 (3.26) | 10.66 (3.26) | **11.77 (3.43)** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 18.00 (4.24) | 12.66 (3.56) | 11.33 (3.37) | **14.00 (3.74)** |
| 3. | Metalaxyl + Mancozeb 68 WP ($F_3$) | 0.15 | 19.33 (4.40) | 15.33 (3.92) | 16.66 (4.08) | **17.11 (4.14)** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 12.00 (3.46) | 2.66 (1.78) | 8.66 (3.03) | **7.77 (2.88)** |
| 5. | Control/water spray ($F_0$) | - | 67.66 (8.23) | 64.00 (8.0) | 66.00 (8.12) | **65.89 (8.12)** |
| | **Mean** | | **26.20 (5.12)** | **21.06 (4.59)** | **22.66 (4.76)** | |

*Figures in parenthesis are square root transformed values

C.D ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.27 |
| Mulch | : | 0.10 |
| Mulch× Fungicide | : | 0.36 |

**Table- 6 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Fungicide | | Fruit rot intensity (%) Mulch | | | Mean |
|---|---|---|---|---|---|---|
| | Treatment | Dosage (%) | No Mulch ($M_0$) | Rice straw ($M_1$) | Wheat straw ($M_2$) | |
| 1. | Carbendazim 50 WP ($F_1$) | 0.1 | 5.66 (2.48) | 2.85 (1.83) | 4.76 (2.29) | **4.42 (2.10)** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 6.85 (2.71) | 4.47 (2.23) | 4.85 (2.31) | **5.39 (2.32)** |
| 3. | Metalaxyl+ Mancozeb 68 WP ($F_3$) | 0.15 | 7.52 (2.83) | 5.8 (2.51) | 7.23 (2.78) | **6.85 (2.71)** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 5.52 (2.45) | 0.85 (1.16) | 2.85 (1.83) | **3.07 (1.89)** |
| 5. | Control/ water spray ($F_0$) | - | 30.47 (5.51) | 21.13 (4.60) | 25.52 (5.05) | **25.70 (5.07)** |
| | **Mean** | | **11.20 (3.42)** | **7.02 (2.74)** | **9.04 (3.09)** | |

*Figures in parenthesis are square root transformed values

C.D ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.24 |
| Mulch | : | 0.18 |
| Mulch× Fungicide | : | 0.65 |

**Table 7 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Disease control over check (%) | | | | | |
|---|---|---|---|---|---|---|
| | Fungicide | | Mulch | | | Mean |
| | Treatment | Dosage (%) | No Mulch ($M_0$) | Rice straw ($M_1$) | Wheat straw ($M_2$) | |
| 1. | Carbendazim 50 WP ($F_1$) | 0.1 | 81.42 (9.02) | 90.64 (9.55) | 84.37 (9.22) | **87.74 (9.36)** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 77.51 (8.84) | 85. 23 (9.27) | 84.08 (9.20) | **84.46 (9.19)** |
| 3. | Metalaxyl + Mancozeb 68 WP ($F_3$) | 0.15 | 75.31 (8.72) | 80.96 (9.03) | 76.27 (8.77) | **78.62 (8.84)** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 81.88 (9.04) | 97.21 (9.89) | 90.64 (9.55) | **93.93 (9.51)** |
| 5. | Control/water spray ($F_0$) | - | - | 30.65 (5.61) | 16.24 (4.14) | **23.45 (3.58)** |
| | **Mean** | | **78.21 (7.30)** | **88.53 (8.67)** | **83.84 (8.18)** | |

*Figures in parenthesis are square root transformed values

C.D ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.14 |
| Mulch | : | 0.19 |
| Mulch× Fungicide | : | 0.33 |

### 4.7.4 Fruit weight

Table 8 and 9 revealed that all the treatments had significant effect on fruit weight of brinjal over check. Among the fungitoxicants, propiconazole 25 EC proved to be most effective as the average weight of fruits harvested was recorded to 103.66 g indicating an increase of 40.80 per cent compared to check exhibiting on an average weight per fruit to 69.66 g, followed by carbendazim 50 WP which was at par with copper oxychloride 50 WP exhibiting weight per fruit on an average to 98.33 and 97.66 g indicating an increase of 41.82 and 40.86 per cent respectively. Metalaxyl + mancozeb 68WP exhibited weight per fruit on an average to 96.33 g indicating an increase of 38.94 per cent. Among the mulches applied rice straw proved to be most effective over check as the average weight per fruit was recorded to 83.33 g indicating an increase of 19.62 per cent compared to check followed by wheat straw exhibiting on an average weight per fruit to 81.33 g indicating an increase of 16.75 per cent. A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + Rice straw proved to be most effective over check exhibiting on an average weight per fruit to 119.0 g followed by carbendazim 50 WP + rice straw (113.33 g), propiconazole 25 EC+ wheat straw (109.66 g), copper oxychloride 50 WP + rice straw (107.66 g) which was at par with carbendazim 50 WP + wheat straw (106.66 g) indicating an increase of 70.82, 62.69, 57.42, 54.55 and 53.11 per cent respectively. Moreover, copper oxychloride 50 WP + wheat straw exhibited on an average weight per fruit to 104.66 g followed by metalaxyl + mancozeb 68 WP + rice Straw (102 g) which was at par metalaxyl + mancozeb 68 WP + wheat straw indicating an increase of 50.24, 47.12 and 46.15 per cent respectively.

### 4.7.5 Fruit yield

Table 11 and 12 revealed that all the treatments had significant effect on fruit yield of brinjal over check. Among the fungitoxicants, propiconazole 25 EC proved to be most effective as the average fruit yield was recorded to 154.92 q/ha indicating an increase of 88.40 per cent compared to check exhibiting on an average fruit yield to 82.23 q/ha, followed by carbendazim 50 WP, copper oxychloride 50 WP and metalaxyl+ mancozeb 68WP exhibiting fruit yield on an average to 139.30, 130.50 and 121.22 q/ha indicating an increase of 69.40, 58.50 and 47.41 per cent respectively. Among the mulches applied rice straw proved to be most effective over check as the average fruit yield was recorded to 111.35 q/ha indicating an increase of 35.34 per cent compared to check followed by wheat straw exhibiting on an average fruit yield to 102.34 q/ha indicating an increase of 24.45 per cent. A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting on an average fruit yield to 215.20 q/ha followed by carbendazim 50 WP + rice straw (187.30 q/ha), propiconazole 25 EC + wheat straw (172.97 q/ha) which was at par with copper oxychloride 50 WP + rice straw (169.28 q/ha) indicating an increase of 161.70, 127.77, 110.34 and 105.86 per cent respectively. Carbendazim 50 WP + wheat straw exhibited on an average yield of 163.88 q/ha followed by copper oxychloride 50 WP + wheat straw (151.0 q/ha) which was at par with metalaxyl + mancozeb 68 WP + rice straw (144.50 q/ha) indicating an increase of 99.29, 83.63 and 75.72 per cent, respectively. Metalaxyl + mancozeb 68 WP + wheat straw (135.40 q/ha) indicating an increase of 64.66 per cent.

**Table-8 :** **Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Fungicide | | Mulch | | | Mean |
|---|---|---|---|---|---|---|
| | **Treatment** | **Dosage (%)** | **No Mulch ($M_0$)** | **Rice straw ($M_1$)** | **Wheat straw ($M_2$)** | |
| | | | **Fruit weight (g) of brinjal** | | | |
| 1. | Carbendazim 50 WP ($F_1$) | 0.1 | 98.33 | 113.33 | 106.66 | **106.10** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 97.66 | 107.66 | 104.66 | **103.32** |
| 3. | Metalaxyl + Mancozeb 68 WP ($F_3$) | 0.15 | 96.33 | 102.00 | 101.33 | **99.86** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 103.66 | 119.00 | 109.66 | **110.77** |
| 5. | Control/water spray ($F_0$) | - | 69.66 | 83.33 | 81.33 | **78.11** |
| | **Mean** | | **93.13** | **105.06** | **100.73** | |

CD ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.90 |
| Mulch | : | 0.69 |
| Mulch× Fungicide | : | 1.60 |

**Table-9 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Per cent increase over check on fruit weight (g) of brinjal | | | | | |
|---|---|---|---|---|---|---|
| | **Fungicide** | | **Mulch** | | | **Mean** |
| | **Treatment** | **Dosage (%)** | **No Mulch ($M_0$)** | **Rice straw ($M_1$)** | **Wheat straw ($M_2$)** | |
| 1. | Carbendazim 50 WP ($F_1$) | 0.1 | 41.82 (6.46) | 62.69 (7.92) | 53.11 (7.29) | **52.54 (7.24)** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 40.80 (6.39) | 54.55 (7.39) | 50.24 (7.09) | **48.54 (6.96)** |
| 3. | Metalaxyl + Mancozeb 68 WP ($F_3$) | 0.15 | 38.94 (6.24) | 47.12 (6.86) | 46.15 (6.79) | **44.07 (6.64)** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 48.8 (6.99) | 70.82 (8.42) | 57.42 (7.58) | **58.72 (7.66)** |
| 5. | Control/ water spray ($F_0$) | - | - | 19.62 (4.43) | 16.75 (4.09) | **12.13 (3.48)** |
| | **Mean** | | **34.08 (5.83)** | **52.96 (7.13)** | **44.73 (6.61)** | |

*Figures in parenthesis are square root transformed values

C.D ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.97 |
| Mulch | : | 0.68 |
| Mulch× Fungicide | : | 1.50 |

**Table - 10 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Fungicide | | Fruit yield (q/ha) of brinjal: Mulch | | | Mean |
|---|---|---|---|---|---|---|
| | Treatment | Dosage (%) | No Mulch ($M_0$) | Rice straw ($M_1$) | Wheat straw ($M_2$) | |
| 1. | Carbendazim 50 WP($F_1$) | 0.1 | 139.30 | 187.30 | 163.88 | **163.50** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 130.50 | 169.28 | 151.00 | **150.26** |
| 3. | Metalaxyl + Mancozeb 68 WP ($F_3$) | 0.15 | 121.22 | 144.50 | 135.40 | **133.70** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 154.92 | 215.20 | 172.97 | **181.03** |
| 5. | Control/water spray($F_0$) | - | 82.23 | 111.35 | 102.34 | **98.64** |
| | **Mean** | **-** | **125.63** | **165.52** | **145.12** | |

CD ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 4.80 |
| Mulch | : | 3.70 |
| Mulch× Fungicide | : | 8.40 |

**Table-11 : Effect of integrated disease management on fruit rot of brinjal (cv. Pusa purple long)**

| S. No. | Fungicide | | Per cent increase in fruit yield over check of brinjal — Mulch | | | Mean |
|---|---|---|---|---|---|---|
| | Treatment | Dosage (%) | No Mulch ($M_0$) | Rice straw ($M_1$) | Wheat straw ($M_2$) | |
| 1. | Carbendazim ($F_1$) | 0.1 | 69.40 (8.33) | 127.77 (11.30) | 99.29 (9.96) | **98.82 (9.94)** |
| 2. | Copper oxychloride 50 WP ($F_2$) | 0.3 | 58.50 (7.64) | 105.86 (10.28) | 83.63 (9.14) | **82.66 (9.09)** |
| 3. | Metalaxyl+ Mancozeb 68 WP ($F_3$) | 0.15 | 47.11 (6.88) | 75.72 (8.70) | 64.66 (8.04) | **62.60 (7.91)** |
| 4. | Propiconazole 25 EC ($F_4$) | 0.15 | 88.40 (9.40) | 161.70 (12.72) | 110.34 (10.50) | **120.14 (10.96)** |
| 5. | Control/water spray ($F_0$) | - | - | 35.34 (5.95) | 24.45 (4.94) | **19.93 (4.46)** |
| | **Mean** | | **52.74 (7.26)** | **101.27 (10.06)** | **76.47 (8.74)** | |

*Figures in parenthesis are square root transformed values

C.D ($p \leq 0.05$)

| | | |
|---|---|---|
| Fungicide | : | 0.21 |
| Mulch | : | 0.16 |
| Fungicide ×Mulch | : | 0.44 |

**Chapter – 5**

# DISCUSSION

Perusal of the literature revealed that the disease has also been reported from Kashmir but little work has been conducted on the status and management of fruit rot of brinjal and hence the present study was undertaken.

In the present study, survey conducted in two districts of Kashmir valley during 2014 indicated that Phomopsis fruit rot of brinjal was more or less prevalent in all the locations of both the districts. Similar results about the prevalence of the disease has also been reportedly observed in different brinjal growing areas of abroad (Edgerton and Moreland, 1921; Das, 1998; Khan, 1999 and Islam *et al.,* 2010) and India (Mir, 1992; Sharma *et al.,* 2011 and Hossain *et al*., 2013).

During the course of survey, significantly highest mean fruit rot incidence of 42.25 per cent and mean intensity of 16.24 per cent was recorded on fruits in district Budgam. Significantly least mean fruit rot incidence of 29.25 per cent as well as mean intensity of 11.99 per cent on fruits was observed in district Pulwama. These findings are confirmed with the established phenomenon of disease development i.e. more the fruit rot incidence more will be the intensity of disease (Fry, 1988). Maximum fruit rot incidence of 46.5 per cent with an intensity of 20.35 per cent on fruits was recorded at Narkara location of district Budgam while as, the minimum fruit rot incidence 22.00 per cent and intensity 9.06 per cent was recorded at Rajpora location of district Pulwama. Higher disease at some locations of districts could be attributed to use of infected seed, higher plant density leading to higher relative humidity in the microclimate of the plants, higher temperature during the growing season, besides non disposal of fallen diseased leaves/fruits/plant debris. These observations are supported by the findings of earlier workers (Porter 1943; Pawar and Patel, 1957; Chaudhary and Hasija, 1979; Islam and Pan, 1990b; Vishunavat and Kumar, 1993; Howard and David, 2007).

Observations recorded on disease development with respect to symptomatology of the disease revealed that first appearance of disease was observed on fruits in the 1st week of August. The lesions on the fruits appeared as small, oval, pale brown, slightly sunken lesions measuring 0.5 to 1.0 mm in dia. The lesions gradually increased in size and attained maximum size of 26 to 27 mm on fruits in the last week of September. Lesions on the fruits turned irregular in shape due to coalescing of lesions, resulting in the formation of irregular patches with whitish centre in the fourth week of August and produce concentric rings of yellowish and brownish zones in the 1st week of September. Small black pycnidia formed in arranged or scattered manner were visible on fruits in the second week of September which ooze out yellowish conidial mass in the 3rd week of September. The sporulation from the pycnidia helps in further advancement of disease and with advancement the fruit turns into dry rot. Similar type of symptoms on fruits caused by *Phomopsis vexans* were also observed by earlier workers (Harter, 1914; Pawar and Patel, 1957; Ronald., 2009; Sharma *et al.*, 2011).

The causal organism (*Phomopsis vexans*) involved in Phomopsis fruit rot disease of brinjal was isolated from diseased brinjal fruits collected during survey from vegetable field at Shalimar campus and subsequently maintained for further studies on oat meal agar medium. Morphological characteristics of *P. vexans* observed on the host as well as in the culture were almost identical, except that size of conidia (alpha and beta conidia), pycnidia and hyphae were slightly larger in culture as compared to that of host. After 5 days of incubation the fungal colony appeared as circular whitish with profuse mycelium (18 mm dia) which turned white compact (89 mm) after 15 days, grayish white (90.0 mm) after 25 days of incubation with development of black flask shaped pycnidia in concentric rings and finally Pycnidia ooze out yellowish conidial mass on greyish white mycelium after 30 days of incubation. The hyphae were branched, hyaline and septate, slightly constricted at septa measuring 2.50-3.75 µm in width with an average of 3.0 µm in culture and 2.25-3.50 µm with an average of 2.75µm on host. Alpha conidia were hyaline, numerous, guttulated, one celled, elliptical, aseptate and sub-cylindrical measuring 5.0-9.0 × 2.0-3.0 µm with an average size of 6.2×2.4µm (in culture) and 4.75-8.75 × 1.75-2.25 µm with an average of 6.15×1.95 µm (on host). Beta conidia were hyaline, few, filliform, curved, aseptate measuring 13-17.5 × 1-1.75 µm with an average size of 15.7 × 1.3µm (in culture) and 12.5-17.5 × 1- 1.5 µm with an average of 14.5×1.3 µm (on host). Pycnidia were brownish black, flask shaped, minute erumpent and osteolate measuring 125-300 × 110-250 µm with an average size of 177.5×152.0 µm (in culture) and 123.75-297.5 × 109-245 µm with an average of 193.25×190.6 µm (on host).The above morphological characters of the pathogen mostly resemble with the description given by earlier workers (Harter, 1914; Edgerton and Moreland, 1921; Panwar and Chand, 1968; Sherf and Macnab, 1986; Singh, 1992; Sugha *et al.,* 2000). On the basis of morphological characters, pathogenicity and comparison with the authentic description, the pathogen was identified as *Phomopsis vexans* (Sacc and Syd) Harter.

During the course of present study, no perfect stage of the pathogen was observed as reported by Gratz (1942). These findings are supported by similar results observed by several earlier workers (Harter, 1914; Edgerton and Moreland, 1921; Pawar and Patel, 1957; Sherf and Macnab, 1986; Singh, 1992; Islam *et al.,* 2010).

Integrated disease management is the frontline weapon against pathogen and is still one of the most widely used means of disease control. In present investigation, four fungitoxicants and two mulches were used *in vivo* against Phomopsis fruit rot of brinjal. The results revealed that all the treatments had significant impact on the Phomopsis fruit rot of brinjal over check. Among the fungitoxicants, propiconazole 25 EC which was at par with carbendazim 50WP proved to be most effective as they indicated a maximum disease control of 81.88 and 81.42 per cent compared to check, followed by copper oxychloride 50WP which was at par with metalaxyl + mancozeb 68WP exhibiting disease control of 77.51 and 75.31 per cent respectively. Among the mulches applied rice straw proved to be most effective over check exhibiting disease control of 30.65 per cent followed by wheat straw which exhibited disease control of 16.24 per cent. A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting disease control of 97.21 per cent followed by propiconazole 25 EC + wheat straw (90.64%) which was at par with carbendazim 50 WP + rice straw (90.64). Moreover, copper oxychloride 50 WP + rice straw exhibited disease control of 85.23 per cent which was at par with carbendazim 50 WP+ wheat straw, copper oxychloride 50WP + wheat straw and metalaxyl + mancozeb 68 WP + rice straw exhibiting disease control of 84.37, 84.08 and 80.96 per cent respectively. Metalaxyl + mancozeb 68 WP + wheat straw exhibited a disease control of 76.27 per cent over check.

Observations with regard to the average fruit yield per hectare revealed that among the fungitoxicants, propiconazole 25 EC proved to be most effective as the average increase in fruit yield per hectare was recorded to 88.40 per cent compared to check, followed by carbendazim 50 WP, copper oxychloride 50 WP and metalaxyl+ mancozeb 68WP exhibiting an increase of 69.40, 58.50 and 47.41 per cent respectively. Among the mulches applied rice straw proved to be most effective over check as the average increase in fruit yield was recorded to 35.34 per cent compared to check, followed by wheat straw exhibiting an increase of 24.45 per cent. A significant interaction existed between the test fungitoxicants and mulches. Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check, followed by carbendazim 50 WP + rice straw, propiconazole 25 EC + wheat straw, copper oxychloride 50 WP + rice straw), carbendazim 50 WP + wheat straw, copper oxychloride 50 WP + wheat straw), metalaxyl + mancozeb 68 WP + rice straw and metalaxyl + mancozeb 68 WP + wheat straw exhibited an increase of 161.70, 127.77, 110.34, 105.86, 99.29, 75.72

and 64.66 per cent respectively. Various workers have also reported the efficacy of carbendazim 50 WP, copper oxychloride 50 WP, metalaxyl and mancozeb 75WP for management of Phomopsis fruit rot of brinjal caused by *Phomopsis vexans* (Sinha, 1989; Mir, 1992; Islam and Pan, 1993; Singh and Agarwal, 1999; Chen *et al*., 2002; Beura *et al*., 2008; Sharma *et al.*, 2012 ; Sing *et al*., 2012).

**Chapter– 6**

# SUMMARY AND CONCLUSION

The investigations on “Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir Valley” were carried out during 2014-15. The results obtained during the course of this study are summarized as under:

The survey of the brinjal growing areas for Phomopsis fruit rot of brinjal in district Budgam and Pulwama revealed the prevalence of the fruit rot in both the districts surveyed with overall incidence irrespective of locations was 35.75 and overall intensity of 14.11 per cent on fruits. The maximum fruit rot incidence of 42.25 per cent and intensity of 16.24 per cent on fruits was observed in district Budgam and minimum fruit rot incidence of 29.25per cent and intensity of 11.99 was observed in district Pulwama.

Amongst the locations surveyed, Narkara location of district Budgam exhibited the highest fruit rot incidence of 46.5 per cent and intensity of 20.35 per cent on fruits, whereas, the least incidence of 22.00 per cent and intensity of 9.06 per cent on fruits were observed in Rajpora location of district Pulwama.

Disease under natural conditions was first noticed in first week of August and progressed steadily and reached its peak during late period of September. The symptoms first appeared on fruits as small, oval, light pale brown, slightly sunken lesions. The weekly changes in size, shape and colour of the lesions were noticed and finally enlarged upto 26 to 27 mm in diameter. Small brownish black pycnidia formed in arranged or scattered manner in concentric rings were seen on the surface of fruits which ooze out yellowish conidial mass and with the advancement the fruit turned into dry rot.

The pathogen was isolated from the diseased brinjal fruits collected during survey from vegetable field at Shalimar campus and subsequently maintained for further studies on oat meal agar media. After 5 days of incubation the fungal colony appeared as circular whitish with profuse mycelium which turned white compact and finally grayish white with development of brownish black flask shaped pycnidia in concentric rings oozing out yellowish conidial mass. Morphological characteristics of *Phomopsis vexans* observed on the host as well as in the culture were almost identical, except that size of conidia (alpha and beta conidia), pycnidia and hyphae were slightly larger in culture as compared to that of host. The hyphae were branched, hyaline and septate, slightly constricted at septa, alpha conidia were hyaline, numerous, guttulated, one celled, elliptical, aseptate and sub cylindrical. Beta conidia were hyaline, few, filliform, curved, aseptate and pycnidia were brownish black, flask shaped, minute erumpent and osteolate. The pathogenicity of the isolated fungus was established by proving Koch's postulates. The characteristic disease symptoms were produced after 7 days on injured fruits while as on uninjured fruits, the symptoms were produced after 16 days of inoculation.

On the basis of morphological characters, pathogenicity and comparison with authentic sources, the isolate was identified as *Phomopsis vexans* (Sacc and Syd) Harter.

Four fungitoxicants and two mulches were used *in vivo* against Phomopsis fruit rot of brinjal. The results revealed that all the treatments had significant impact on the Phomopsis fruit rot of brinjal over check. Among the fungitoxicants, propiconazole 25 EC proved to be most effective as it indicated maximum per cent disease control, average fruit weight and average yield compared to check, followed by carbendazim 50WP, copper oxychloride 50WP and metalaxyl + mancozeb 68 WP in decreasing order of their efficacy.

Among the mulches applied rice straw proved to be most effective exhibiting maximum per cent disease control, average fruit weight and average yield followed by wheat straw over check.

Among the interactions propiconazole 25 EC + rice straw proved to be most effective over check exhibiting maximum per cent disease control, average fruit weight and average yield followed by carbendazim 50 WP + rice straw, propiconazole 25 EC + wheat straw, copper oxychloride 50 WP + rice straw, carbendazim 50 WP+ wheat straw, copper oxychloride 50WP + wheat straw, metalaxyl + mancozeb 68 WP + rice Straw and metalaxyl + mancozeb 68 WP + wheat straw in decreasing order of their efficacy.

To conclude it is recommended that Phomopsis fruit rot of brinjal can be kept under check with the following measures:

1. Destruction of crop debris
2. Use of disease free seed
3. Raised bed cultivation
4. Crop rotation
5. Use of rice straw as mulch to avoid contact between soil and fruit
6. Spray of propiconazole @0.15% at fruit development stage of the crop.

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## CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. A.G. Najar, Ex Professor, Division of Plant Pathology, SKUAST-Kashmir during Viva-Voce examination held on October 29, 2015 have been incorporated in the manuscript entitled **"Status and management of Phomopsis fruit rot of Brinjal (*Solanum melongena* L.) in Kashmir valley"** submitted by **Mr. Nisar Ahmad Ganie (Regd. No. 2013-A-959-M)**.

**( Dr. Ali Anwar )**
Chairman
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