Biological Forum – An International Journal **14(2): 757-765(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Variability among the different isolates of *Sclerotium rolfsii* Sacc. causing Stem Rot of Indian Bean

Ravikumar G. Vaniya[1*], Pushpendra Singh[2] and A.J. Deshmukh[3]
[1]Department of Plant Pathology, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat), India.
[2]Department of Plant Pathology, College of Agriculture, NAU, Waghai (Gujarat), India.
[3]Department of Plant Pathology, College of Agriculture, NAU, Waghai (Gujarat), India.

(Corresponding author: Ravikumar G. Vaniya)*
(Received 26 February 2022, Accepted 01 May, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Indian bean is one of the most ancient and important pulse crop in India. It is infected by several biotic and abiotic factors. Among the biotic factors, fungal diseases are the major constraints in reducing the yield. Among the fungal diseases stem rot of Indian bean caused by *Sclerotium rolfsii* Sacc. is exerting a major threat on Indian bean growers in South Gujarat. *Sclerotium rolfsii* Sacc. is one of the most important soil-borne plant pathogen which causes severe loss at the time of seedling development. It also causes stem rot or collar rot in several crops and wild plants. Due to the variability in virulence of the pathogen, farmers face a major challenge when managing the disease on the farm. Hence, the present study was taken up to assess the occurrence and variability of stem rot in major growing areas of South Gujarat. According to the survey results, stem rot incidence ranged from 7 to 30 per cent depending on location. In Navsari district, the highest disease incidence (30%) was recorded at NAU farm, Eru (Jalalpore), while the lowest incidence (7%) was recorded in Jamanpada (Chikhli). There was a wide range of variation among the eight isolates of *S. rolfsii* with regards to the various characteristics examined. These includes mycelial growth diameter, sclerotial numbers on plates, sclerotial weights and the size, shape and color of sclerotia. According to pathogenic variability for GNIB-21 and GNIB-22 varieties of Indian bean, highest degree of virulence was recorded for SrERU isolate (10.00), which took less number of days (10) and SrERU isolate (7.58), which took less number of days (12) for disease infection to plant.

Keywords: *Sclerotium rolfsii* Sacc., Indian bean, Morphological variability, Pathogenic variability.

INTRODUCTION

Indian bean (*Lablab purpureus* L.) belonging to family *Fabaceae*, is one of the most ancient among the cultivated crops and is presently grown throughout the tropical regions in Asia, Africa and America. It is commonly known as Hyacinth bean, Dolichos bean, Avare (Kannada), Anumulu (Telugu), Avaria (Tamil), Indian bean, Lablab bean, Wal papdi (Gujarat) and Egyptian kidney bean. In India, the area under pulse crops is more than 176.17 lakh hectare and production is 93.14 lakh tonnes, with the productivity of 689 kg ha^{-1}, as per 1st advanced estimates (DAC & FW) 2020-2021.

Indian bean can be grown on a wide variety of soil types ranging from acidic to alkaline. Indian bean is primarily grown for green pods which are cooked as vegetables like others beans. The foliage of the crop provides nutritive hay, silage and green manure. It is also used in medicinal purpose (Smith, 1976).

Plant diseases are one of the major constraints in crop production with drastic losses in the quality and quantity of the yield. Stem rot of Indian bean caused by *Sclerotium rolfsii* Sacc. has become a limiting factor to get production in South Gujarat. The species was first described in 1911 by Italian mycologist Pier Andrea Saccardo, based on specimens sent to him by Peter Henry Rolfs who considered the unnamed fungus to be the cause of tomato blight in Florida in 1892. *S. rolfsii* is a soil-borne pathogen that commonly occurs in the tropics, sub-tropics and other warm temperate regions of the world causing root rot, stem rot, wilt and foot rot on more than 500 plant species including almost all the agricultural and horticultural crops (Aycock, 1996). It is one of the most destructive soil inhabiting pathogen and causes heavy loss to the crops in both *kharif* and *Rabi* season. It is common where high temperatures exist during the rainy season. The present study was carried out for evaluating the cultural, morphological and pathogenic variability among the different isolates of *S. rolfsii* Sacc. causing stem rot of Indian bean collected from the different growing pockets *viz*., Surat, Navsari and Bharuch districts.

MATERIALS AND METHODS

A. Survey and symptomatology of Indian bean stem rot caused by S. rolfsii

Survey. An intensive survey was conducted to know the incidence of stem rot of Indian bean in Indian bean growing areas of South Gujarat *viz.*, Surat, Navsari and Bharuch district. Random roving survey was followed for collecting the stem rot infected samples. The percent disease incidence (PDI) was calculated by following equation.

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

Four Taluka of three Districts *viz*., Olpad of Surat, Jalalpore and Chikhli of Navsari and Amod of Bharuch district were selected under survey. The infected samples and data were collected from randomly four to five fields of two villages of each taluka. The information like variety, planting material used for isolation, location and isolates designation was also collected and tabulated.

Symptomatology. The plants in the individual field were observed for the characteristic symptoms of stem rot caused by *S. rolfsii*. Indian bean plant showing the typical stem rot symptoms were collected and taken for further isolation.

B. Collection and isolation of diseased samples, identification, mass multiplication and pathogenicity of the pathogen

Collection and isolation of diseased samples. The isolation of fungus was done by following standard tissue isolation technique. The infected pieces were cut into small bits and then washing in running water. These bits were surface sterilized with 0.1 % Mercuric chloride ($HgCl_2$) solution for one minute followed by washing in distilled sterile water, then aseptically transferred to PDA (Potato Dextrose Agar) plate and incubated at room temperature for seven days. From this fungal growth hyphal tip was used for further purification. Same procedure was followed to obtain the pure culture of *S. rolfsii* from all locations. The pure cultures that obtained were further stored in refrigerator for further investigation.

Identification of the Pathogen. The pathogen was identified based on the characters mentioned below.

— Types of mycellial growth on PDA.

— In early stages of the growth, mycelium colour and luster.

— Sclerotial colour and shape of different sclerotial stages till maturity.

Maintenance of the pure culture. The fungus was sub-cultured on the PDA slants and allowed to grow at 27±1 ºC temperature for one week and later the culture was stored in refrigerator for further studies and was sub cultured periodically.

Mass multiplication of *S. rolfsii* isolates. The study on mass multiplication of *S. rolfsii* was also conducted. A total eight numbers of isolates were multiplied on sorghum grains (200 gm) which was soaked overnight in water. About 200 gm of soaked sorghum grains were taken in 500 ml capacity conical flask tightly plugged. The conical flasks were then sterilized at 121°C for 20 min. After sterilization the sorghum seeds in conical flask were inoculated with the different eight isolates mycelial discs of five mm diameter from seven day old pure culture of *S. rolfsii* and flasks were incubated at 27°C ± 2°C for 15 days for mycelial growth.

Pathogenicity of the pathogen. The potting mixture was prepared by thoroughly mixing soil, sand and farm yard manure at 1:1:1 ratio. The inoculum of *S. rolfsii* grown on sorghum grain based medium were separately mixed with the sterilized soil filled in 30 cm earthen pots at 10 days before sowing. Surface sterilized indian bean seeds were sown at the rate 5-10 seeds per pot and the pot without inoculum served as control. Soil moisture was maintained at moisture holding capacity of soil by adding sterilized water throughout the period. The typical wilting symptoms were observed after 15-20 day of inoculation. Reisolation was made from such infected plant tissue and compared with that of original isolates for conformity.

C. Variability among the different isolates of S. rolfsii

Studies on morphological variation of different isolates. The experiment was conducted in order to study the variation in the morphological characters of different isolates of *S. rolfsii*. For this purpose, 15 ml of potato dextrose agar was poured into sterilized petriplate. Mycelial disc of 7 day old culture of the respective isolates was placed at the centre of the PDA plate. Three replications of each isolate and allow to grown at room temperature (27±1°C) and colony characters, like diameter, radial growth and concentric rings were recorded. The radial growth of the each isolates (in mm) was measured four days after inoculation. The radial growth of each colony in two directions at right angles was measured. Visual observations on sclerotial formation were recorded. The total number of sclerotia produced per plate, sclerotial test weight, diameter of sclerotial bodies, size, colour and shape of sclerotia of individual isolates were also recorded and analyzed statistically.

Virulence of different isolates of *S. rolfsii*. A pot experiment was conducted in the glass house of Department of Plant Pathology, N. M. College of Agriculture, Navsari to find out virulence index of different isolates on two different varieties namely GNIB 21 and GNIB 22. Each treatment was replicate thrice. Observations were noted on PDI and number of days taken for stem rot symptoms (latent period). Percent disease incidence (PDI) was calculated by following this equation:

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

The numerical values of percent disease incidence and latent period were used to calculate the virulence index using the following equation (Thakur and Rao 1997).

Virulence index = Percent disease incidence × Latent period^{-1}.

RESULTS AND DISCUSSION

A. Survey and symptomatology of Indian bean stem rot caused by S. rolfsii

Survey of stem rot of Indian bean. The random roving survey was carried out at monthly interval to know the incidence of stem rot in Indian bean during the *kharif* season 2019-20 in randomly selected villages of different taluka of South Gujarat. The data revealed that the incidence of stem rot disease in Indian bean is endemic in nature as it was observed in more or less severe form in all the selected fields of all the selected villages (Table 1).

The percent disease incidence occurrence was ranged from 7 to 30 percent in different location (Table 1). Maximum disease incidence (30%) was recorded at NAU, farm, Eru (Jalalpore) while minimum disease incidence (7%) was recorded in Jamanpada (Chikhli). The variation observed in the disease incidence might be due to the prevalence of the strains of *S. rolfsii* with varied virulence in bean varieries and the environmental factors in the respective areas.

The present studies are similar to results reported by Amrutha *et al.* (2019), which carried out random roving survey for studying groundnut stem rot disease incidences in Andhra Pradesh. Daunde *et al.* (2018) also studied prevalence of collar rot of chilli in Marathwada region of Maharashtra. Rani and Hegde (2017), Sivakumar *et al.* (2016), Divya rani *et al.* (2016) and Muthukumar and Venkatesh (2013) also carried out survey for studied prevalence of stem rot disease in different crops at different locations.

Symptomatology of stem rot of Indian bean. First symptoms of stem rot indicated yellowing, browning and discoloration of leaf tissue followed by loss of vigour and premature death or wilting of lateral branches of Indian bean. If the main stem was attacked then the whole plant was affected and caused death of the plants. Moreover to this, there are formations of deep dark brown lesion on the stem region of the plant just near the ground. Advanced symptoms were developed when the lesion was covered by a radiating white mycelium with the rotting underneath it.

In later stages of infection, mustard seed like dark brown or tan coloured, spherical or round sclerotial bodies were formed, which adhered around the infected stem region and such bodies were produced abundantly on stem. The infected plant showed poor root growth and rotting of the stem region.

These types of symptoms are occurred at all the places from here those samples are collected; these symptoms are more or less similar.

The similar symptoms and signs were observed by Sivakumar *et al.* (2016), they collected the infected groundnut plants showing the typical symptoms of stem rot due to infection with *S. rolfsii* along with rhizosphere soil. Nagamma and Nagaraja (2015) also observed disease symptoms of *S. rolfsii* on chickpea plant and notice that the pathogen infected first at collar region.

Table 1: Survey for stem rot of Indian bean in South Gujarat Districts.

District	Taluka	Village	Isolates Code	Variety	Planting material used	PDI	Location
Surat	Olpad	Kudiyana	SrKUD	Manchhi, Local	Collar region	24%	21.37′84″ °N 72.75′39″ °E
		Kuvad	SrKUV	Pali, Bhothu	Collar region	21%	21.32′40″ °N 72.68′84″ °E
Navsari	Jalalpore	N.A.U Campus, Eru	SrERU	GNIB-21,22	Collar region	30%	20.93′28″ °N 72.89′39″ °E
		Kharsad	SrKHR	Katargam papdi, Surti papdi	Collar region	14%	20.94′86″ °N 72..89′73″° E
	Chikhli	Peladi bhervi	SrPEL	Local	Collar region	10%	20.60′88″ °N 73.10′54″3°E
		Jamanpada (Khergam)	SrJAM	Local	Collar region	7%	20.75′79″ °N 73.06′31″ °E
Bharuch	Amod	Bhimpura	SrBHM	Kadva val	Collar region	18%	21.95′95″ °N 72.88′91″ °E
		Ghamnad (Vagra)	SrGHM	Local	Collar region	12%	21.72′64″ °N 72.91′50″ °E

B. Collection and isolation of diseased samples, identification and pathogenicity of the pathogen

Collection and isolation of diseased samples. The stem rot infected samples of Indian bean were collected from the selected fields of different villages of different talukas from three districts *viz.*, Surat, Navsari and Bharuch (Plate: 1). The collected samples were brought to the laboratory, which were then subjected to microscopic examination followed by standard tissue isolation technique using PDA medium. The pure culture thus obtained was further purified by single hyphal tip isolation technique and maintained on PDA medium.

Identification of the Pathogen. The isolated pathogen was identified based on cultural and morphological characters as mentioned below.

The isolated fungus was found to produce white, dense radiating mycelial growth on PDA. The mycelium of the pathogen was septate and hyaline with conspicuous branching at acute angles. The well developed mycelium had cord-like strands. In early stages of growth, the mycelium was silky whitish in colour; it gradually lost its lustre and became dull in appearance and form radial growth colony. The initiation of sclerotial was observed from 6th day onwards.

At the initial stage, the sclerotial bodies were white in colour which was gradually turned into mustard seed like dark brown colour at maturity stage. Matured sclerotia were spherical to ellipsoidal (Plate: 2 and 3).

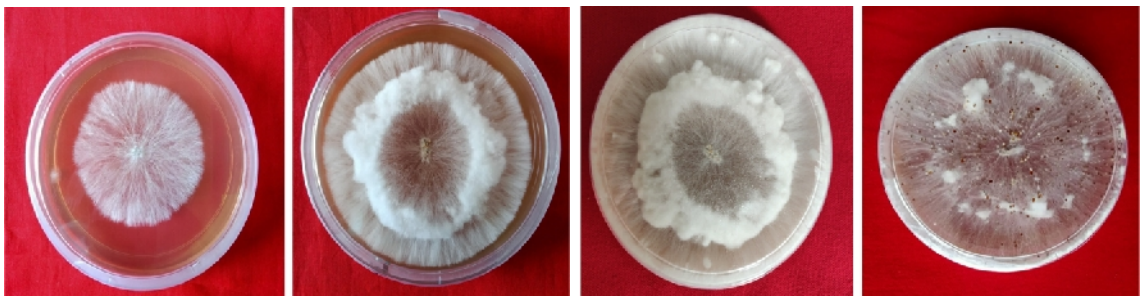
These types of morphological and cultural characteristics were observed in all the isolates of *S. rolfsii*. They all named as SrKUD (Kudiyana), SrKUV (Kuvad), SrERU (Eru), SrKHR (Kharsad), SrPEL (Peladi bhervi), SrJAM (Jamanpada), SrBHM (Bhimpura) and SrGHM (Ghamnad) with more or less similar cultural and morphological features.

Similar morphological characteristics of mycelial growth and sclerotial formation were observed by earlier workers, Kushwaha *et al.* (2019); Ghevariya and Patel (2019); Manu *et al.* (2018); Wavare *et al.* (2017); Sekhar *et al.* (2017).

Pathogenicity of *S. rolfsii*. The pathogenicity test of *S. rolfsii* was proved by soil inoculation method with giant culture (sorghum grain based medium inoculated with isolate of *S. rolfsii*). It was carried out under greenhouse conditions as per the procedure described in methodology.

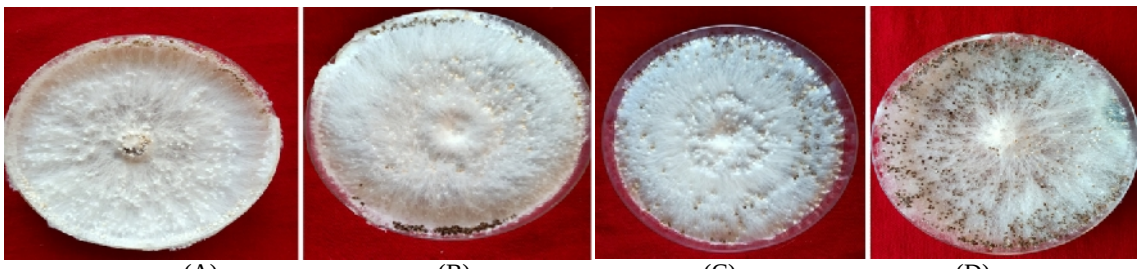
Pathogen infect first at collar region. Leaves of such infected plants become yellow. During the advanced stage of infection the white mycelium grew around the collar region and completely covered it. The base of the stem was constricted and turned brown. The plant gradually dried and toppled. The sclerotial bodies were formed on infected parts. Severely infected plants showed death of plant and diseased plant could be easily pulled out from the soil. The fungus was reisolated from infected plant tissue and compared with the original culture, the reisolated culture and original culture showed similar cultural and micro morphological characters and thus identified as same. Hence, the pathogenicity of isolated fungal pathogen was proved as per Koch's postulates showed in plate 4.

Plate 1. Collected samples overviews during survey of India bean stem rot.



(A) (B) (C) (D)

Plate 2. Mycellial growth of *S. rolfsii* at 24 hrs interval, (A). 02 Days after isolation; (B). 03 Days after isolation (C). 04 Days after isolation; (D). 05 Days after isolation (Sclerotia formation).



(A) (B) (C) (D)

Plate 3. Different stages of sclerotia formation, (A). Initial stage white coloured Sclerotia; (B). Light brown coloured Sclerotia; (C). Chocolate brown coloured Sclerotia; (D). Later stage dark brown coloured Sclerotia.

Plate 4. Pathogenicity of *S. rolfsii* on Indian bean plant. (A). Healthy (Non-inoculated) plant; (B). Pathogen inoculated plant (White mycelium and sclerotia developed at collar region near to soil); (C). Yellowing and drooping of infected plant; (D). Completely rotting of infected plant by pathogen.

B. Variability among the different isolates of *S. rolfsii*

Morphological variation in different isolates of *S. rolfsii* on potato dextrose agar. Morphological characters of each of the isolates of *S. rolfsii* on potato dextrose agar were studied and observations were recorded. The characters like, colony growth diameter, color of sclerotia, shape of sclerotia, position of sclerotia in culture, numbers of sclerotia formation per plate, diameter of sclerotia and test weight of sclerotia were recorded and are presented in Table 2 and 3.

Table 2: Mycelial growth and sclerotial formation in different isolates of *S. rolfsii.*

Isolates	Colony growth diameter 4 DAI (mm)	Growth rate mm/day	Sclerotial formation and colour					
			96 hr	120 hr	144 hr	168 hr	192 hr	216 hr
SrKUD	78.00	19.50	-	-	+	W	LB	B
SrKUV	86.00	21.50	-	+	W	LB	B	DB
SrERU	89.00	22.25	+	W	LB	B	DB	DB
SrKHR	83.00	20.75	+	W	LB	B	DB	DB
SrPEL	80.00	20.00	+	W	LB	B	DB	DB
SrJAM	74.00	18.50	-	+	W	LB	B	DB
SrBHM	87.00	21.75	-	+	W	LB	B	DB
SrGHM	79.00	19.75	-	+	W	W	LB	B
S Em. ±	**0.76**							
CD (p= 0.05)	**2.30**							
CV (%)	**1.61**							

DAI = Days after Inoculation, + = Sclerotial initiation, - = Nil, W = White, LB = Light brown, B = Brown, DB =Dark brown

Table 3: Variability in morphology of sclerotial bodies of different isolates of *S. rolfsii* on PDA.

Isolates	Morphology of sclerotia					
	Colour of Sclerotia	Shape of Sclerotia	Position of sclerotia in culture	Number of sclerotia formation in plate	Sclerotia size (mm)	Test weight of 100 sclerotia (mg)
SrKUD	LB	Round	Scattered all over plate	283.33	0.91	182.00
SrKUV	CB	Oval	Peripheral	176.99	0.84	165.33
SrERU	DB	Round	Scattered all over plate	300.00	0.99	226.33
SrKHR	DB	Round	Scattered	259.00	1.093	207.33
SrPEL	DB	Oval	Peripheral	189.33	0.96	166.66
SrJAM	CB	Round	Central	227.66	1.22	301.66
SrBHM	CB	Oval	Scattered all over plate	176.66	1.12	263.66
SrGHM	LB	Round	Peripheral	185.67	1.21	285.66
S Em. ±				4.09	0.02	3.08
CD (p= 0.05)				12.37	0.06	9.24
CV (%)				3.14	3.54	2.37

(A) Growth rate of colony

Wide range of variation was noticed among the eight isolates of *S. rolfsii* with respect to various attributes studied. Here highest colony growth diameter found in SrERU (89.00 mm) isolate. Whereas, isolate SrBHM (87.00 mm) was statistically at par with the SrERU isolate, which followed by SrKUV (86.00 mm), SrKHR (83.00 mm), SrPEL (80.00 mm), SrGHM (79.00 mm), SrKUD (78.00 mm) and SrJAM (74.00 mm) isolates. The growth rate was ranged from 18.50 to 22.25 mm per day.

(B) Time taken for sclerotial initiation

The isolates varied with respect to time taken for sclerotial formation. Isolates were grouped into three groups. Group I consisted of three isolates (SrERU, SrKHR and SrPEL) which took just four days for sclerotial initiation. Group II consisted of four isolates (SrKUV, SrJAM, SrBHM and SrGHM) in which

sclerotial initiation was noticed on 5th day. Group III consisted of one isolate (SrKUD) took maximum number of days (06) for sclerotial initiation. In all isolates sclerotial bodies were initially white, with time turned dark brown.

(C) Colour, shape and position of sclerotia

With regards to sclerotial colour, 3 types of colour were observed visually among the isolates. Isolates SrKUV, SrJAM and SrBHM had chocolate brown sclerotia, isolates SrKUD and SrGHM showed light brown coloured sclerotia and remaining isolates SrERU, SrKHR and SrPEL had dark brown coloured sclerotia.

Isolates SrKUD, SrERU, SrKHR, SrJAM and SrGHM showed round shape sclerotia whereas, others *viz.*, SrKUV and SrPEL and SrBHM showed oval shape sclerotia.

With respect to position of sclerotia, maximum isolates (SrKUD, SrERU, SrKHR and SrBHM) of sclerotia were produced irregularly scattered all over the petriplates. SrJAM produced sclerotia at centre in concentrated form. Whereas isolates like (SrKUV, SrPEL and SrGHM) produced sclerotia at the edges of petriplates (Plate: 5).

(D) Number of sclerotia formation in plate

Here the higher numbers of sclerotia recorded per plate in SrERU isolate (300) which followed by SrKUD (283.33), SrKHR (259), SrJAM (227.66), SrPEL (189.33), SrGHM (185.67), SrKUV (176.99) and SrBHM (176.66) isolate.

(E) Size of sclerotia

The variation in size of sclerotia of isolates under study was found significant. SrJAM isolate produced largest sclerotia with mean diameter of 1.22 mm, whereas SrGHM isolate (1.21 mm) was found statistically at par with SrJAM isolate, which followed by SrBHM isolate (1.12 mm), SrKHR (1.093 mm), SrERU (0.99 mm), SrPEL (0.96 mm), SrKUD (0.91 mm) and SrKUV (0.83 mm) isolates.

(F) Test weight of 100 sclerotia

The test weight of sclerotia revealed significant variation among all the isolates. Maximum test weight was recorded in SrJAM isolate (301.66 mg) followed by SrGHM (285.60 mg), SrBHM (263 mg), SrERU (226.33 mg), SrKHR (207.33 mg), SrKUD (182 mg), SrPEL (166.66 mg) and SrKUV (165.33 mg).

Pandi *et al.* (2017), Naresh *et al.* (2017), Mahato and Biswas (2017), Kakade *et al.* (2017), Ekka *et al.* (2016), Kuldhar *et al.* (2014), Rakholiya and Jadeja (2011) and Bagwan (2011) also carried out an experiment to study cultural and morphological variability in different isolates of *S. rolfsii* causing stem rot disease.

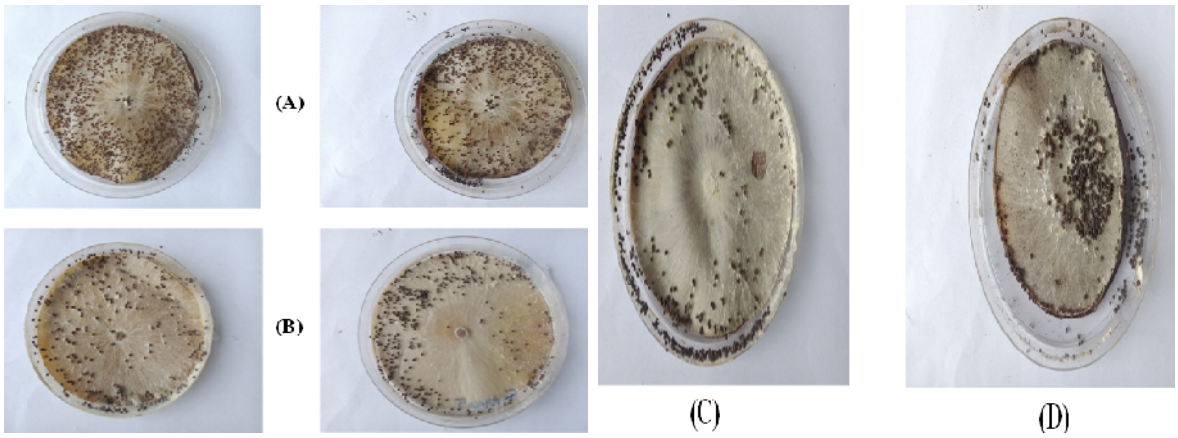


Plate 5. Sclerotial pattern of different isolates of *Sclerotium rolfsii* on PDA media. (A). Scattered all over the plate (B). Irregular pattern; (C). Peripheral (near the edge); (D). Central.

Virulence index. All the eight isolates were inoculated on two different varieties GNIB-21 and GNIB-22 of Indian bean to study the variation in pathogenicity.

Observations on percent disease incidence and number of days taken for stem rot symptoms (latent period) were recorded and presented in the Table 4 and 5.

For GNIB-21 variety of Indian bean, maximum degree of virulence was recorded in SrERU (10.00) which took less number of days (10) for disease infection to plant followed by SrKUD (7.49), SrKUV (6.23), SrPEL (4.93), SrKHR (4.00), SrBHM (3.41), SrJAM (2.84) and SrGHM (2.18) which required 12, 13, 15, 16, 17, 19 and 22 days for stem rot infection respectively. SrGHM was least virulent with minimum virulence index of 2.18 and required maximum period for completely rotting of plant. Isolates with maximum virulence index required less period of days for causing stem rot of plants presented in Table 4 and plate 6.

For GNIB-22 variety of Indian bean, maximum degree of virulence was recorded in SrERU (7.58) which took less number of days (12) for disease infection of plant followed by SrKUD (4.87), SrKUV (3.78), SrPEL (3.36), SrKHR (2.66), SrBHM (2.27), SrJAM (2.0) and SrGHM (1.53) required 16, 19, 19, 21, 22, 23 and 26 days for stem rot infection respectively. SrGHM was least virulent with minimum virulence index of 1.53 and required maximum period for completely rotting of plant. Isolates with maximum virulence index required less period of days for causing stem rot of plants presented in Table 5 and plate 7.

Table 4: Variability in virulence among the different isolates of *S. rolfsii* on GNIB-21 (Indian bean).

Isolates	Time taken for disease infection (Latent period $^{-1}$)	Percent disease incidence (PDI)	Virulence index
SrKUD	12	71.59* (90)	7.49
SrKUV	13	64.15 (81)	6.23
SrERU	10	89.05 (100)	10.0
SrKHR	16	53.11 (64)	4.00
SrPEL	15	59.32 (74)	4.93
SrJAM	19	47.27 (54)	2.84
SrBHM	17	49.58 (58)	3.41
SrGHM	22	43.83 (48)	2.18
Control	00	00.90 (00)	00.00
S Em. ±		**0.692**	
CD (p= 0.05)		**2.072**	
CV (%)		**2.253**	

*Figures outside parenthesis are Arc sine transformed value. Figures in parentheses indicate original value.

Table 5: Variability in virulence among the different isolates of *S. rolfsii* on GNIB-22 (Indian bean).

Isolates	Time taken for disease infection (Latent period $^{-1}$)	Percent disease incidence (PDI)	Virulence index
SrKUD	16	62.01* (78)	4.87
SrKUV	19	58.03 (72)	3.78
SrERU	12	72.58 (91)	7.58
SrKHR	21	48.42 (56)	2.66
SrPEL	19	53.11 (64)	3.36
SrJAM	23	42.30 (46)	2.00
SrBHM	22	44.98 (50)	2.27
SrGHM	26	39.21 (40)	1.53
Control	00	00.90 (00)	00.00
S Em. ±		**0.773**	
CD (p= 0.05)		**2.315**	
CV (%)		**2.865**	

*Figures outside parenthesis are Arc sine transformed value. Figures in parentheses indicate original value.

Plate 6. Studies on virulence of different isolates of *S. rolfsii* on GNIB 21 variety.

Plate 7. Studies on virulence of different isolates of *S. rolfsii* on GNIB 22 variety.

CONCLUSION

It is concluded that the Indian bean stem rot pathogen *S. rolfsii* possesses a wide range of cultural, morphological and pathogenic variability which helps it adapt and survive in diverse ecological situations and making it very difficult to manage during crop production which causing drastic losses to farmers.

Acknowledgement. The authors are thankful to the Department of Plant Pathology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, for providing the required experimental instruments for smooth conduct of the research work and providing the necessary facilities for the studies. The support and encouragement of the guide and research committee members, during the course of present investigation is gratefully acknowledged.
Conflict of Interest. None.

REFERENCES

Amrutha, G., Padmodaya, B., Jayalakshmi, R. S., Manjula, K. and Mohan, G. (2019). Survey for disease incidence of groundnut collar rot, stem rot and root rot in Ananthapur, Kadapa, Chitttoor, Kurnool and Nellore districts of Andhra Pradesh. *International Journal of Chemical Studies*, *7*(3): 4932-4934.

Aycock, R. (1996). Stem rot and other diseases caused by *Sclerotium rolfsii*: or the status of rolfs' fungus after 70 years. North carolina agricultural college, *Experimental Sustainable technology bulletin*, 174 - 202.

Bagwan, N. B. (2011). Morphological variation in *Sclerotium rolfsii* Sacc. isolates causing stem rot in groundnut (*Arachis hypogaea* L.). *International Journal of Plant Protection, 4*(1): 68-73.

Daunde, A, T., Apet, K, T., Suryawanshi, A, P. and Khandare, V, S. (2018). Prevalence of collar rot of chilli caused by *Sclerotium rolfsii* Sacc. under the agro-climatic zones of Marathwada region of Maharashtra. *Journal of Pharmacognosy and Phytochemistry*, *7*(4): 1905-1908.

Divya Rani, Hari Sudini, Narayan Reddy, Uma Devi and Vijay Krishna (2016). Survey for the assessment of incidence of stem rot and collar rot diseases of groundnut in major groundnut growing areas of Andhra Pradesh and Telangana States. *Annuals of Biological Research*, *7*(7): 6-8.

Ekka, S., Lal, N., Lal, H. and Barnwal, S. (2016). Morphological and pathogenic variability in *Sclerotium rolfsii* Sacc. *Journal of Mycology and Plant Pathology*, *46*(3): 259-265.

Ghevariya, T. V and Patel, P. R. (2019). Effect of light and pH on the growth of *Sclerotium rolfsii in vitro* on collar rot of Indian bean. *International Journal of Current Microbiology and Applied Sciences*, *8*(10): 1268-1274.

Kakade, D. S., Jadhav, S. B., Pawar, B. G., and Gaurav, S. B. (2017). Morphological variation among the isolates of *Sclerotium rolfsii*. *Bioinfolet A Quarterly Journal of Life Sciences*, *14*(1): 24-26.

Kuldhar, D. P., Suryavanshi, A. P. and Wagh, S. S. (2014). Cultural and morphological variability among the isolates of *Sclerotium rolfsii*, causing Stem/Pod Rot of Groundnut. *Trends in Biosciences*, *7*(24): 4167-4173.

Kushwaha, S. K., Kumar, S., Chaudhary, B. and Sahu, R. (2019). Effect of different media, pH and temperature on growth and sclerotia formation of *Sclerotium rolfsii* Sacc. causing collar rot of lentil. *Chemical Science Review and Letters*, *8*(29): 01-05.

Mahato, A. and Biswas, M. K. (2017). Cultural, Morphological and Pathogenic variability of different isolates of *Sclerotium rolfsii* obtained from Rice-Tomato-Rice cropping system of undulating Red and Lateritic zone of West bengal, India. *International Journal of Current Microbiology and Applied Sciences*, *6*(3): 1843-1851.

Manu, T., Nagaraja, A. and Manjunatha, S. (2018). Morphological and Cultural variability among the *Sclerotium rolfsii* isolates. *Journal of Pharmacognosy and Phytochemistry*, *7*(1): 904-907.

Muthukumar, A. and Venkatesh, A. (2013). Occurrence, virulence, inoculum density and plant age of *Sclerotium rolfsii* sacc. causing collar rot of peppermint. *Journal of Plant Pathology and Microbiology*, *4*(10): 1-4.

Nagamma G. and Nagaraja A. (2015). Efficacy of bio control agents against *Sclerotium rolfsii* causing collar rot disease of chickpea, under *in vitro* conditions. *International journal of plant protection*, *8*(2): 222-227.

Naresh, P., Ratan, V., Biswas, S. K., Kumar, V. and Kumar, U. (2017). Cultural and pathogenic variability among the Isolates of *Sclerotium rolfsii* causing Stem rot of chilli (*Capsicum annuum* L.). *International Journal of Bio-resource and Stress Management*, *8*(1): 129-133.

P. A. Saccardo. (1911). Notes Mycologicae. *Ann. Mycology*, *9*(1): 249-257.

Pandi, V. K., Gopalakrishna, C. and Janahiraman, V. (2017). Cultural and morphological variability in *Sclerotium rolfsii* causing Stem rot disease. *International Journal of Current Microbiology and Applied Sciences, 6*(6): 3090-3097.

Rakholiya, K. B. and Jadeja, K. B. (2011). Morphological diversity of *Sclerotium rolfsii. Journal of Mycology and Plant Pathology, 41*(4): 500-504.

Rani, N. and Hegde, Y. R. (2017). Survey for the incidence of Root rot/wilt of fenugreek in northern karnataka, India. *International Journal of Current Microbiology and Applied Sciences, 6*(5): 1564-1569.

Sekhar, Y, C., Ahammed, S, K., Prasad, T, N. and Jayalakshmi Devi (2017). Morphological and pathogenic variability of *Sclerotium rolfsii* isolates causing stem rot in groundnut. *International Journal of Pure Applied Bioscience, 5*(5): 478-487.

Sivakumar, T., Sanjeevkumar, K. and Balabaskar, P. (2016). Variability in *Sclerotium rolfsii* Sacc. causing stem rot of ground nut. *Bulletin of Environment, Pharmacology and Life Sciences,* (2): 92-99.

Smith, P. M. (1976). Evolution crop plants: edited by N. W. Simmonds, Food Policy, Elsevier, *2*(4): 343-343.

Thakur, R., P. and Rao, V., P. (1997). Variation in virulence and aggressiveness among patho types of *Sclerospora graminicola* on pearl millet. *Indian Phytopatho*logy, *50*(1): 41-47.

Wavare, S. H., Gade, R. M. and Shitole, A. V. (2017). Effect of plant extracts, bio agents and fungicides against *Sclerotium rolfsii* causing collar rot in chickpea. *Indian journal of Pharmaceutical Sciences, 79*(4): 513-520.

How to cite this article: Ravikumar G. Vaniya, Pushpendra Singh and A.J. Deshmukh (2022). Variability among the different isolates of *Sclerotium rolfsii* Sacc. Causing Stem Rot of Indian Bean. *Biological Forum – An International Journal, 14*(2): 757-765.