International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 247-258

Received: 20-06-2020
Accepted: 08-08-2020

NK Toorray
Assistant Professor, College of Agriculture and Research Station, IGKV, Marra, Durg, Chhattisgarh, India

PK Tiwari
Principal Scientist, CoA, IGKV, Raipur, Chhattisgarh, India

AS Kotasthane
HOD, Department of Plant Pathology, CoA, IGKV, Raipur, Chhattisgarh, India

OP Parganiha
Assistant Professor, College of Agriculture and Research Station, IGKV, Marra, Durg, Chhattisgarh, India

Corresponding Author:
NK Toorray
Assistant Professor, College of Agriculture and Research Station, IGKV, Marra, Durg, Chhattisgarh, India

Evaluation of aggressiveness of different isolates of *Rizoctonia solani* causing sheath blight disease of rice collected from different districts of Chhattisgarh

NK Toorray, PK Tiwari, AS Kotasthane and OP Parganiha

DOI: https://doi.org/10.22271/chemi.2020.v8.i5d.10304

Abstract
Awareness of the pathogenicity and aggressiveness nature of each pathogenic microbe is necessary not only to understand the expression of symptoms, but also contribute to the sheath blight disease control programme. The intensive survey of sheath blight infected farmers fields during the *kharif* 2015-16 at forty one locations of fifteen districts of Chhattisgarh plane were carried out and the disease samples were collected at maximum tillering stage of rice. Sheath blight and banded blight symptoms were examined for detail study. Naturally infected plant samples of sheath blight have been obtained from the fields in the laboratory for isolation and purification of sheath blight fungus. The pathogen was isolated on PDA and the subcultures were purified using a single hyphal tip cutting method and kept on PDA at 28 ± 2 °C. Samples infected with the sheath blight disease of paddy were collected from different districts of Chhattisgarh for systematic study of sheath blight symptoms in rice. The total number of fifty-eight isolates were confirmed by the proof of the Koch postulates and classified in the category as weakly aggressive, moderately aggressive, aggressive and highly aggressive. The seven isolates were recorded as highly aggressive and the maximum PDI 98.15 was shown by the isolate no. RS57.

Keywords: Sheath blight, rice, aggressiveness, 58 isolates, symptoms develpment, lesion length, PDI, disease control

Introduction

Rice (*Oryzae sativa* L.) is the staple food crop of over half of the world's population, and is also widely cultivated across the world, making it possibly the most valuable plant on earth (Shimamoto, 1995; Goff, 1999) [29, 9]. It provides 20 percent of the world's supply of dietary energy followed by maize and wheat. Rice grows in at least 114 countries and more than 50 have a capacity of 100,000 tons or more per year. The production of rice to be adept by 2020 is 128 Mt. to feed the growing population in India. This crop also suffers due to number of diseases accounting for severe losses. Of the several factors known to destabilize rice yields, pests and diseases account for 30-40 percent crop losses. Most parts of the country regularly encounter complete crop failure due to epidemics of pests and diseases. In Chhattisgarh, rice production is comparatively smaller than the national average production. A lot of fungal, bacterial, nematode, and viral diseases are attacked on rice. Serious incidences of diseases such as blast, sheath blight and bacterial blight have been reported from rice growing areas in Chhattisgarh regions. Sheath blight is one of India's widespread and harmful rice diseases. Rice sheath blight disease is causing significant loss, particularly in areas where high yielding varieties are cultivated. *Rhizoctonia solani* (Perfect stage-*Thanatephorus cucumeris*) which causes rice sheath blight in both soil and water borne. Miyake (1910) [19] stated that the sheath blight disease was first reported from Japan. Subsequently this disease was recorded from various global rice-growing regions, and particularly from major rice-growing countries. The presence of sheath blight disease in rice from several parts of India and beyond has been confirmed by workers of different parts of India. Butler made reference to the Indian disease as early as 1918. The presence of this disease has been confirmed by Andhra Pradesh, Assam, Jammu and Cashmir, Kerala, Tamil Nadu (Anonymous, 1971) [4], Orissa and West Bengal (Das, 1970) [6], Madhya Pradesh (Anonymous, 1975; Verma *et al.*, 1979) [2, 34].

The initial symptoms usually develop as lesions on sheaths of lower leaves close to the waterline, when plants are in the growth stage of late tillering or nearly internode elongation typically these lesions develop as oval to elliptical, green gray, just below the leaf collar, water soaked spots about 1⁄4 inch wide and 1⁄2 to 1⁄4 inch in length. The disease has been named as "sheath blight" because of primary infection on leaf sheath. High doses of nitrogen fertilizers, intensive cultivation of modern high yielding veriety, early maturation, high tillering rice varieties with double farming leads to increased severity of diseases, eventually yield losses of about 50% were recorded in Japan, Vietnam, South Korea, Taiwan, China, USA and India (Anonymous, 1988) [3]. Several workers reported, yield loss ranging from 20-50% in highly susceptible cultivars (Lee and Rush, 1983; Rajan and Naidu, 1986; Mizuta, 1956; and Hori, 1969) [16, 25, 20, 11]. Ou (1972) [21] also reported a grain yield loss of 25 per cent due to sheath blight. The disease is common in areas where there is high temperature (30±32 ºC) and relative humidity (> 95 percent) and in intensive cultivation areas.

Awareness of the pathogenicity and aggressiveness nature of each pathogenic microbe is necessary not only to understand the expression of symptoms, but also contribute to the sheath blight disease control programme. Similar symptoms on rice sheaths are caused by a variety of fungal species and often difficult to distinguish by visual observation (Matsumoto 2003) [18]. Several researchers have observed differences in the length of the lesion among different isolates of *Rhizoctonia solani* (Sneh *et al.* 1996; Vidhyasekaran *et al.* 1997; Chaijuckam *et al.* 2010) [31, 35, 5]. However, the soil-borne nature of pathogen and the sustained persistence of its sclerotia complicate the chemical regulation of this disease. Saxena (1997) [26] reported that three characters were significant. In the first group isolates can cause different types of diseases and symptoms, in the second group the state of aggressiveness can differ and in the third group the host between the isolates can shift from limited to very far. Sriram *et al.* (1997) [32] investigated pathogenic variations in seven isolates of the *R. solani* rice sheath rot that had been collected in seven large rice growing areas in southern India since 1994. The isolate was collected from Thiruvanantapuram (RS7) and was highly aggressive.

Materials and method

Symptoms of sheath blight disease

The initial signs typically develop as lesions on sheaths of lower leaves near the waterline while plants are in the growth stage of late tillering or nearly internodal elongation. These lesions usually grow as oval to elliptical, green gray, just below the leaf collar, water soaked spots about 1⁄4 inch wide and 1⁄2 to 1⁄4 inch long. The disease has been named as "sheath blight" because of primary infection on leaf sheath. The fungus attack the crop from tillering to heading stage and leaf blade symptoms also observed. The presence of several large lesions on leaf sheath causes death of whole leaf and in several causes all the leaves of a plant blighted. The infection spreads to inner sheath resulting death of entire plant. These types of symptoms are popularly called as banded blight. In the banded blight phase, the flag leaf and panicle infection prevented the normal emergence and expansion of the ears and caused poor filling of the grains.

Collection of disease samples

The disease samples were collected from naturally infected rice plants from farmers field of district *i.e.* Rajnandgaon, Bemetara, Mahasamund, Balod, Raipur, Dhamtari, Kabirdham, Gariyaband, Durg, Kanker, Narainpur, Raigarh, Jaspur, Korea, Korba of Chhattisgarh during *kharif* 2015-2016 at maximum tillereing stage of rice crop. The detail about the survey is presented under the table given:

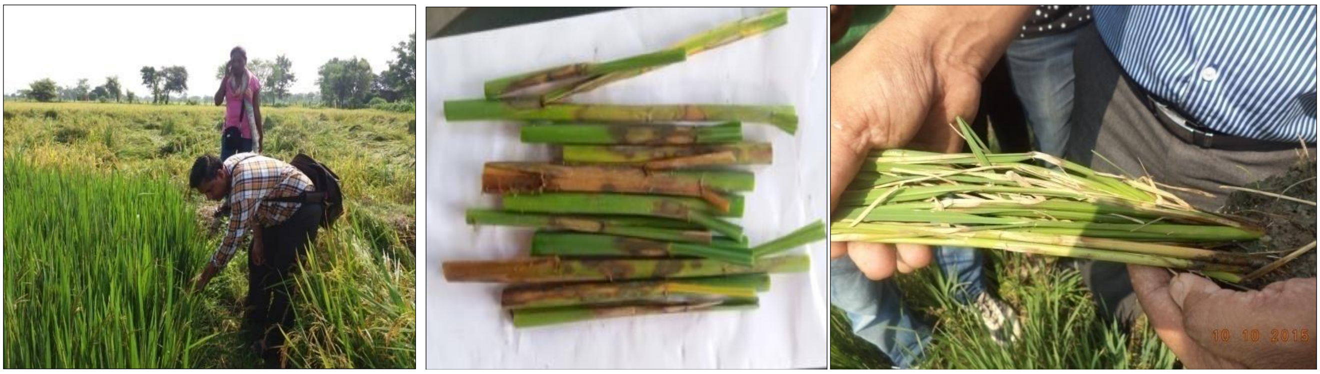


Fig 1.1: Collection and isolation of sheath blight disease samples

Isolation of the pathogen

The disease affected samples obtained from the different localities were separately washed thoroughly with tap water. Small portion of the infected parts containing healthy as well as diseased tissues were cut in to 0.5 cm pieces with the help of sterilized scalpel blade. These pieces were then surface sterilized with 1 percent sodium hypochlorite solution for 1 minute with 3 subsequent changes in sterilized water to remove traces of the chemical. The pieces were then transferred aseptically to petri dishes containing sterilized Potato Dextrose Agar (PDA) and incubated at 28±2ºC under BOD incubator. The petri dishes were examined at regular time intervals for fungal growth radiating from the infected pieces and the 58 isolates were isolated.

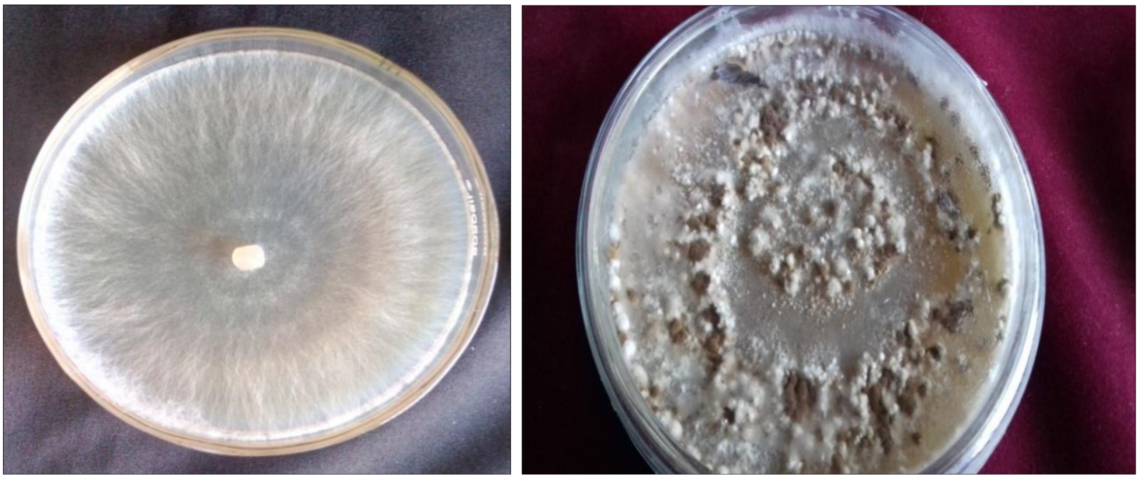


Fig. 1.2: Plate No. 1.1 and 1.2 Pure culture of *R. solani*

Purification

After supplementing with a pinch of streptomycin sulphate, about 20 ml of PDA medium was poured into each petri-dish to prevent bacterial contamination. One 8 mm mycelial disc from a freshly isolated culture was transferred aseptically to the solidified PDA in each petri dish by hyphal tip cut method. The dishes were incubated at 28±2ºC in BOD incubator. Adequate numbers of sub culture transformation were separately made for further purification and all the collected 58 isolates were purified and confirmed to the current species concept of *R. solani* (Parmeter and Whitney, 1970) [22] and maintained under deep freezer at -20^{0}C.

Mass multiplication of inoculums

Stems of 35-40 days old rice plants were cut in to pieces of about 2 cm size and filled in to 500 ml Erlenmeyer flasks up to one third. Flasks were autoclaved at 15 pound per square inch for 30 minutes. Mycelial discs of 5 mm diameter cut from the margin of 48 hrs old culture of the pathogen were inoculated into the flask and incubated at 28±2ºC up to fifteen days for full growth of fungus and sclerotia formation. For artificial inoculation, rice plants at maximum tillering stage were taken for inoculation.

Fig 1.3: Mass multiplication of *R. solani*

Inoculation

Rice stem bits (*Rhizoctonia solani* mycelium profusely grown) and sclerotia from 7-9 days old culture were used for inoculation of the rice plants at the maximum tillering stage. The primary tillers of each hill were tagged and gently inoculated by punching and pushing into the sheath a single sclerotium or rice stem bit just 1 ½ to 2 ½ cm above the water surface level as per the sheath location. After 12 hours plants were examined for symptoms. The disease severity (lesion length) was assessed 21 days after inoculation.

Fig 1.4: Artificial Inoculation

Evaluation of aggressiveness of different isolates of *R. solani*

This experiment was conducted under pot condition in completely randomyzed design (CRD) with four replications during *kharif* 2016 and 2017. Artificial inoculation was done at the maximum rice tillering stage using mycelial block of 5-day-old culture. To study the aggressiveness, sclerotia and stem bits were inoculated in to rice plants for development of symptom, mycelial growth and sclerotial production to record aggressiveness of *Rhizoctonia solani* isolates. Observations for disease initiation and lesion length were recorded regularly at 24 h interval after inoculation upto 3 weeks of the study period in *kharif* season. All the collected isolates were measured for aggressiveness based on the disease symptoms development, 24 hours incubation period after inoculation up to three weeks. Obsrevation on the Lesion lenght, Relative lesion height, Percent disease severity and Percent Disease Index was recorded and also calculated. The control plants were not inoculated with sclerotia and they did not show any symptom.

Incubation period

The experiment was conducted under pot condition to observe the incubation period of the different isolates of *R. solani* inoculated on rice cultivar Swarna. The data were recorded after 12 h of inoculation.

Lesion height

The lesion height was recorded 21 days after inoculation of different isolates of *R. solani* on the rice cultivar.

Plant height

The plant height was recorded 75 days after transplanting (DAT).

Relative Lesion Height

The Relative Lesion Height (RLH) was recorded 21 days after inoculation (DAI) of different isolates of *R. solani* on the rice cultivar. The relative lesion height (cm) in each tiller was calculated by using the formula given by Sharma *et al.* (2013) [27]:

RLH = Maximum height at which lesion appear/Plant height x 100.

Disease severity

Each plot was observed in number of infected tiller and each tiller was observed plant height and symptoms length of sheath blight of rice. The disease development was recorded and disease severity was calculated as standard evaluation system (SES), IRRI (2014) [12]. Observations were recorded 21 days after inoculation and graded as per 0-9 SES scale. The sheath blight scale was as follows:

Table 1.1: Standard evaluation system (SES), IRRI (2014) [12]

Disease rating scale	Response	Description
0	Immune	No Infection
1	Highly Resistant	Vertical spread of the lesions up to 20% of plant height
3	Resistant	Vertical spread of the lesions up to 21-30% of plant height
5	Moderately Resistant	Vertical spread of the lesions up to 31-45% of plant height
7	Susceptible	Vertical spread of the lesions up to 46-65% of plant height
9	Highly Susceptible	Vertical spread of the lesions up to 66-100% of plant height

The disease severity was calculated as:

$$\text{Disease severity} = \frac{\text{Total lesion length}}{\text{Total length of sheath}} \times 100$$

Percent Disease Index (PDI)

PDI was calculated 21 days after inoculation by the formula given by Wheeler.

$$\text{PDI} = \frac{(\text{Sum of all ratings} \times 100)}{(\text{Total no. of observations} \times \text{Maximum rating scale})}$$

Categorization of Aggressiveness

Aggressiveness of all the isolates of *R. solani* was categorized into 4 classes *i.e.* Weakly Aggressive (WA), Moderately Aggressive (MA), Aggressive (A) and Highly Aggressive (HA). PDI% (2-21)=WA; PDI% (22-43)=MA; PDI% 44-65%=A; PDI% (66-87)=HA.

Results and discussion

The extensive survey was done (presented in table 1.3) and the diseased samples were collected from 58 farmer fields from 41 locations of (Mohad, Jungleswer, Somni, Mokhala, Dewada, Kaketara, Ratepayali, Ghumka, Odiya, Haldi, Chhichhanpahri, Tolagaon, Kanhe, Dharmapur, Surgi, Mohbhatta, Mahasamund, Saloni, Khadgaon, Sanesara, Gathala, Kumarda, Muretitola, Bhathasakri, Kutelikhurd, Jogidalli, Matri, Hirapur, Dhamtari, Surajpura, Nagdha, Singhola, Kirwai, Borsi, Pakhanjur, Narainpur, Lailunga, Jaspur, Korea, Utai and Pali) situated in fifteen districts *i.e.* Rajnandgaon, Bemetara, Mahasamund, Balod, Raipur, Dhamtari, Kabirdham, Gariyaband, Durg, Kanker, Narainpur, Raigarh, Jaspur, Korea, Korba of Chhattisgarh during *kharif* 2015-16 at maximum tillereing stage of rice crop under natural conditions.

Table 1.2: Survey and collection of *R. solani i*solates collected from different locations of Chhattisgarh in *kharif* year 2015-16 at maximum tillering stage of rice.

S. No	Village/location	Block	District	Cropping pattern	Variety	Name of the Isolates	Pathogenic
1	Mohad	Rajnandgaon	Rajnandgaon	Rice-Wheat- Fellow	Swarna	RS1	+
2	Mohad	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS2	+
3	Mohad	Rajnandgaon	Rajnandgaon	Rice- Wheat-Rice	Swarna	RS3	+
4	Jungleswer	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS4	+
5	Jungleswer	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS5	+
6	Jungleswer	Rajnandgaon	Rajnandgaon	Rice-Wheat- Fellow	Swarna	RS6	+
7	Jungleswer	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Mahamaya	RS7	+
8	Somni	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS8	+
9	Mokhala	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS9	+
10	Dewada	Rajnandgaon	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS10	+
11	Kaketara	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS11	+
12	Ratepayali	Dongergaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS12	+
13	Ghumka	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS13	+
14	Odiya	Chhuikhadan	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS14	+
15	Odiya	Chhuikhadan	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS15	+
16	Haldi	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS16	+
17	Haldi	Rajnandgaon	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS17	+
18	Haldi	Rajnandgaon	Rajnandgaon	Rice	Swarna	RS18	+
19	Haldi	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS19	+
20	Chhichhanpahri	Ambagarh-chowki	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS20	+
21	Tolagaon	Khairagarh	Rajnandgaon	Rice-Wheat- Fellow	Swarna	RS21	+
22	Kanhe	Ambagarh-chowki	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS22	+
23	Dharmapur	Khairagarh	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS23	+

24	Surgi	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS24	+
25	Surgi	Rajnandgaon	Rajnandgaon	Rice-Wheat- Fellow	Swarna	RS25	+
26	Mohbhatta	Berla	Bemetara	Rice-Fellow- Fellow	Swarna	RS26	+
27	Mahasamund	Mahasamund	Mahasamund	Rice	Swarna	RS27	+
28	Saloni	Rajnandgaon	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS28	+
29	Saloni	Rajnandgaon	Rajnandgaon	Rice-Fellow- Fellow	Mahamaya	RS29	+
30	Saloni	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS30	+
31	Khadgaon	Manpur	Rajnandgaon	Rice-Fellow- Fellow	Mahamaya	RS31	+
32	Khadgaon	Manpur	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS32	+
33	Sanesara	Dongergaon	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS 33	+
34	Gathala	Rajnandgaon	Rajnandgaon	Rice-Wheat- Fellow	Mahamaya	RS 34	+
35	Kumarda	Dongergaon	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS 35	+
36	Muretitola	Ambagarh-chowki	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS 36	+
37	Bhathasakri	Saja	Bemetara	Rice-Fellow- Fellow	Swarna	RS 37	+
38	Kutelikhurd	Chhuikhadan	Rajnandgaon	Rice-Fellow- Fellow	Swarna	RS 38	+
39	Jogidalli	Rajnandgaon	Rajnandgaon	Rice-Fellow- Rice	Swarna	RS 39	+
40	Matri	Dondilohara	Balod	Rice-Fellow- Fellow	Swarna	RS 40	+
41	Hirapur	Dharsiwa	Raipur	Rice-Fellow- Fellow	Swarna	RS 41	+
42	Dhamtari	Dhamtari	Dhamtari	Rice-Fellow- Rice	Swarna	RS 42	+
43	Surajpura	Kawardha	Kabirdham	Rice-Fellow- Fellow	Swarna	RS 43	+
44	Nagdha	Nawagarh	Bemetara	Rice-Fellow- Fellow	Swarna	RS 44	+
45	Singhola	Khairagarh	Rajnandgaon	Rice-Gram- Fellow	Swarna	RS 45	+
46	Singhola	Khairagarh	Rajnandgaon	Rice-Fellow- Rice	Mahamaya	RS 46	+
47	Singhola	Khairagarh	Rajnandgaon	Rice-Wheat- Fellow	Swarna	RS 47	+
48	Kirwai	Fingeshwer	Gariyaband	Rice-Fellow- Fellow	Swarna	RS 48	+
49	Borsi	Durg	Durg	Rice-Wheat- Fellow	Swarna	RS 49	+
50	Pakhanjur	Kanker	Kanker	Rice-gram- Fellow	Swarna	RS 50	+
51	Narainpur	Narainpur	Narainpur	Rice-Fellow- Fellow	Swarna	RS 51	+
52	Lailunga	Raigarh	Raigarh	Rice-Fellow- Fellow	Swarna	RS 52	+
53	Jaspur	Jaspur	Jaspur	Rice-Fellow- Rice	Swarna	RS 53	+
54	Korea	Korea	Korea	Rice-Gramm- Rice	Swarna	RS 54	+
55	Utai	Durg	Durg	Rice-Fellow- Fellow	Swarna	RS 55	+
56	Pali	Katghora	Korba	Rice-Fellow- Rice	Swarna	RS 56	+
57	Kirwai	Fingeshwer	Gariyaband	Rice-Fellow- Rice	Mahamaya	RS 57	+
58	Kirwai	Fingeshwer	Gariyaband	Rice-Gram- Fellow	Swarna	RS 58	+

Related results in the agreement with Swain *et al.* (2005) [33], Xiao *et al.* (2008) [36] and Prasad, V.R. (2014) [24] who surveyed and collected the samples of sheath blight disease at maximum rice tillering stage.

Isolation and purification of pathogen

In the present study isolates were assigned code numbers such as RS1, where "RS" nemed *Rhizoctonia solani* and "1" denote the serial number of the isolate. Similarly, the other fifty-eight isolates were also referred to as RS1, RS2, RS3, RS4, RS5, RS6, RS7, RS8, RS9, RS10, RS11, RS12, RS13, RS14, RS15, RS16, RS17, RS18, RS19, RS20, RS21, RS22, RS23, RS24, RS25, RS26, RS27, RS28, RS29, RS30, RS31, RS32, RS33, RS34, RS35, RS36, RS37, RS38, RS39, RS40, RS41, RS42, RS43, RS44, RS45, RS46, RS47, RS48, RS49, RS50, RS51, RS52, RS53, RS54, RS55, RS56, RS57, RS58 were listed in Table No. 4.1. The sheath blight causing the *R. solani* pathogen was isolated and purified by a single hyphal tip / single sclerotial method. Cultures were kept in test tubes on sterile PDA slants maintained in 4°C to further investigate the variability. Similar results for isolation, purification and identification have been reported by Parmeter and Whitney (1970) [22].

Systematic classification

The causative agent of sheath blight, now commonly known as *R. solani* Kühn, and *Thanatephorus cucumeris* (Frank) Donk, a teleomorph (perfect stage). The teleomorph of the pathogen *Thanatephorus cucumeris* belongs to the family of the Ceratobasidiaceae of the order Tulasnellales in the form class Hymenomycetes, subclass Holobasidiomycetidae of the class Basidiomycetes. The anamorph *R. solani* comes under the class Deuteromycotina, form class Deutromycetes and order Aganomycetales (Dasgupta, 1992) [7].

Identification of the test fungus

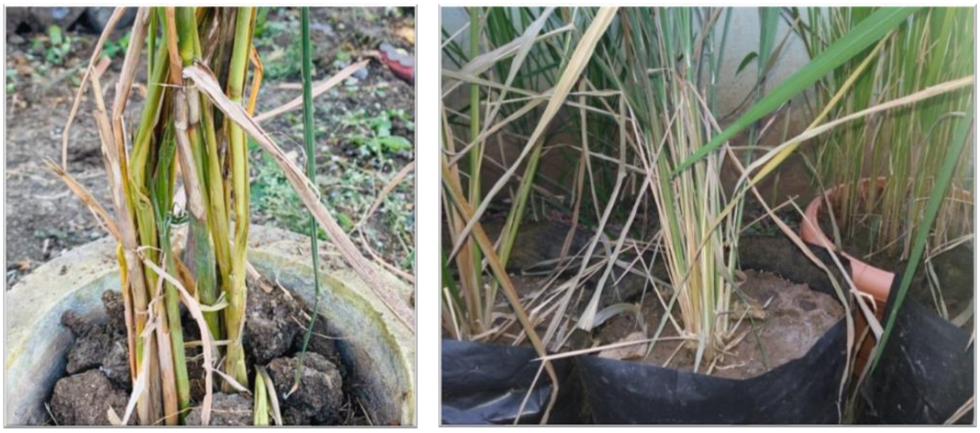
The isolated fungus was then identified based on the following morphological properties. *R. solani* does not form vegetative spores and is present as a mycelium and sclerotia. The isolate had typical characteristics of *R. solani*: (I) It creates a shade of brown hyphae. (II) Branches at right angles beside the distal septum of the cell in young hyphae. (III) formation of a septum in the branch beside the point of origin, (IV) narrowing at the branch point, dolipore septum, (V) moniloid cells, (VI) undifferentiated sclerotia and (VII) absence of rhizomorphs (VIII) clamp connection absent. Undifferentiated Sclerotia, aggregations of thick-walled cells, small (1-4 mm diameter) irregularly shaped brown to black structures (Guttierez *et al.* 1997) [10]. A similar result in identification was reported by Doman and Flentje (1970) [8], Sherwood (1970) [28].

Evaluation of Aggressiveness of different isolates of *Rizoctonia solani* in pot condition

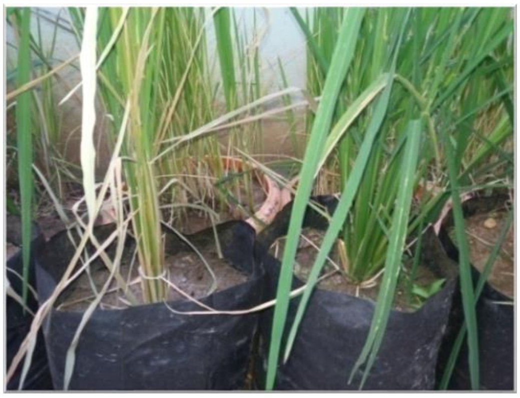
The pot culture experiment was conducted with various *R. solani* isolates collected from different rice growing regions of Chhattisgarh to determine its aggressiveness on susceptible rice cultivar Swarna in *kharif* 2016 and *kharif* 2017.

Highly aggressive isolates

Aggressive isolates



Moderately aggressive isolates



Weakly aggressive isolate

Fig 1.10: Aggressiveness test (pot condition) and variation in sheath blight disease symptoms

In *kharif* 2016, the data shown in table 1.4 and fig. 1.10 showed that the 58 isolates were divided into four groups: weakly aggressive (WA), moderately aggressive (MA), aggressive (A) and highly aggressive (HA). The majority of the isolates were weakly aggressive (21), followed by moderately aggressive (17), aggressive (12) and highly aggressive (8) against the susceptible Swarna variety of fifty-eight isolates. The results showed that the PDI was between 11.11% and 100% among all 58 isolates. The maximum PDI (100%) was recorded in isolate RS 3, followed by RS-57 (96.29%), RS 4 (94.44%) and RS-5 (92.59%), while isolates RS8, RS9, RS 20, RS22, RS23, RS32, RS33, RS35, RS36, RS37, RS44, RS48, RS 49 and RS 55 showed the lowest PDI value (11.11). Reviewing the data showed significant differences in the aggressiveness of the isolates. The isolates showed varied incubation period, lesion lengths, relative lesion heights, disease severity and percent disease index.

Table 1.3: Evaluation of Aggressiveness of different isolates of *Rizoctonia solani* under pot condition in *kharif* 2016

Isolates	Incubation period	Lesion length (c.m.)			Relative Lesion Height (cm)	PDI (%)
		1 week	2 weeks	3 weeks		
RS 1	1.41	10.35	16.81	22.24	51.22	72.21
RS 2	1.24	8.32	16.59	23.73	53.95	77.77
RS 3	1.08	15.60	26.71	36.61	81.30	100.0
RS 4	1.16	10.85	21.89	32.29	71.75	94.44
RS 5	1.16	15.46	22.66	30.65	71.31	92.59
RS 6	1.24	4.81	9.67	17.45	44.54	55.56
RS 7	1.0	4.66	7.77	12.30	32.16	37.18
RS 8	8.0	0.0	2.35	5.23	16.86	11.11
RS 9	4.25	1.24	3.44	4.90	15.15	11.11
RS 10	1.0	5.86	11.18	17.12	38.83	55.56
RS 11	1.24	2.54	6.65	9.81	22.69	16.66
RS 12	2.0	7.52	15.08	24.64	53.24	77.77
RS 13	1.0	4.51	8.43	13.18	29.70	35.18
RS 14	1.08	6.59	12.56	18.62	40.30	55.56
RS 15	1.24	5.71	11.73	18.92	40.64	55.56
RS 16	1.08	5.21	11.35	18.22	40.73	51.84
RS 17	1.25	4.86	10.70	17.46	37.73	53.69
RS 18	3.0	2.96	6.77	11.56	25.33	31.47
RS 19	1.58	4.41	9.16	19.01	39.74	51.84
RS 20	1.0	3.47	5.50	7.94	17.54	11.11
RS 21	2.25	3.07	5.95	8.45	18.68	25.92
RS 22	1.08	1.96	3.89	5.91	10.16	11.11
RS 23	5.0	0.19	1.63	3.28	9.72	11.11
RS 24	3.0	0.91	4.86	8.07	17.42	12.96
RS 25	1.16	7.89	12.34	18.29	37.67	53.69
RS 26	1.41	4.89	8.09	12.14	26.68	31.37
RS 27	1.0	4.48	7.25	11.47	24.89	33.33
RS 28	3.50	2.15	7.13	11.81	26.94	29.62
RS 29	1.75	3.38	7.36	11.52	25.80	24.07
RS 30	2.50	3.42	7.22	12.99	28.02	33.33
RS 31	1.16	3.99	6.65	9.65	21.12	18.51
RS 32	4.66	0.37	2.69	4.08	10.57	11.11
RS 33	3.16	1.00	3.23	5.31	13.24	11.11
RS 34	1.0	11.83	20.35	29.35	59.90	80.55
RS 35	3.08	0.74	3.9	5.88	14.86	11.11
RS 36	4.58	0.26	2.21	3.59	10.37	11.11
RS 37	6.50	0.0	2.42	3.42	9.37	11.11
RS 38	3.08	2.06	4.23	6.51	15.83	12.96
RS 39	1.25	7.25	11.48	15.86	33.87	44.44
RS 40	1.0	4.25	8.41	12.87	28.33	33.33
RS 41	1.08	5.82	9.08	13.03	28.83	33.33
RS 42	1.24	4.78	8.40	11.93	25.84	33.33
RS 43	1.33	5.11	9.27	16.10	37.44	51.85
RS 44	3.50	0.96	1.91	2.87	8.74	11.11
RS 45	1.0	3.33	6.99	10.32	22.70	24.06
RS 46	3.33	1.58	4.62	6.79	16.41	16.67
RS 47	1.25	3.63	6.92	9.41	21.13	14.81
RS 48	3.25	1.69	4.54	6.98	16.64	11.11
RS 49	2.75	1.74	4.74	7.08	13.29	11.11
RS 50	1.0	9.74	16.68	24.02	45.54	61.11
RS 51	1.0	3.49	6.60	8.76	19.62	14.81
RS 52	1.33	3.95	7.26	10.97	24.75	29.62
RS 53	4.0	0.66	5.60	11.31	25.22	33.33
RS 54	1.25	3.03	5.96	10.06	22.63	22.21
RS 55	1.24	2.61	5.73	8.12	18.71	11.11
RS 56	3.24	2.22	7.21	9.36	22.66	20.36
RS 57	1.0	11.93	22.07	31.48	67.04	96.29
RS 58	1.08	4.92	11.08	17.22	39.93	57.39
Mean	2.10	4.49	8.84	13.42	30.09	36.44
CD					4.8283	8.1831
SEm					1.7298	2.9317

In *Kharif* 2017, the data shown in table 1.5 showed weak aggressiveness (WA), moderately aggressive (MA), aggressive (A) and high aggressiveness (HA) on susceptible variety Swarna. The majority of the isolates were weakly aggressive (25), followed by moderately aggressive (18), aggressive (9) and highly aggressive (6). The percent disease index was between 11.11% and 100%. Among all 58 isolates, a maximum PDI of 100% was recorded in isolates RS 57, followed by RS 5 (92.59%) and RS 3 (77.78%), while isolates RS8, RS9, RS20, RS 21, RS22, RS23, RS24, RS 27 RS 31, RS32, RS33, RS35, RS36, RS37, RS38, RS44, RS45, RS46, RS48, RS49 and RS51 showed the lowest PDI value (11.11). The isolates have different incubation period, lesion lengths, relative lesion heights, disease severity and percent disease index. The perusal of data showed significant differences in the aggressiveness of the isolates.

Table 1.4: Evaluation of Aggressiveness of different isolates of *Rizoctonia solani* under pot condition in *kharif* 2017

Isolates	Incubation period	Lesion length (c.m.)			Relative Lesion Height (cm)	PDI (%)
		1 week	2 weeks	3 weeks		
RS 1	1.24	9.40	15.79	23.56	53.36	70.37
RS 2	1.08	6.64	13.97	25.31	51.32	72.22
RS 3	1.16	11.12	19.63	26.62	56.63	77.78
RS 4	1.0	9.30	15.31	21.38	46.62	55.56
RS 5	1.24	14.26	23.42	33.20	68.67	92.59
RS 6	1.0	7.56	13.76	19.04	41.94	55.56
RS 7	1.24	6.41	9.32	13.04	29.06	33.33
RS 8	1.08	3.40	5.59	7.06	17.60	11.11
RS 9	2.83	0.96	2.89	5.47	13.59	11.11
RS 10	1.0	8.13	11.85	16.34	35.33	50.0
RS 11	1.91	2.00	5.54	9.65	22.69	14.81
RS 12	1.16	4.42	8.19	14.19	31.31	35.18
RS 13	1.41	4.31	9.24	13.48	29.61	33.33
RS 14	1.0	6.42	11.33	16.98	36.02	50.0
RS 15	1.24	6.72	12.44	19.57	41.65	55.56
RS 16	1.49	5.33	9.70	14.58	32.28	40.74
RS 17	1.08	4.54	8.31	14.37	31.43	35.18
RS 18	1.83	4.99	7.63	14.53	32.13	38.88
RS 19	1.0	6.41	11.44	18.38	39.38	55.56
RS 20	1.0	4.15	6.56	7.52	17.11	11.11
RS 21	1.08	2.25	4.56	6.79	17.08	11.11
RS 22	1.50	2.83	4.76	6.85	17.60	11.11
RS 23	1.0	1.76	3.36	4.63	13.26	11.11
RS 24	2.0	2.56	5.62	7.98	18.81	11.11
RS 25	1.24	9.27	13.38	18.44	39.00	55.56
RS 26	1.0	4.11	8.26	12.51	27.13	33.33
RS 27	1.25	3.13	6.30	8.58	19.51	11.11
RS 28	1.24	4.47	8.16	11.42	24.63	31.47
RS 29	1.75	4.36	7.20	9.78	21.70	20.36
RS 30	1.25	6.30	10.01	12.81	29.92	35.18
RS 31	2.0	2.56	5.63	8.50	21.70	11.11
RS 32	1.0	2.31	3.69	4.73	15.23	11.11
RS 33	4.50	1.16	3.67	6.09	16.71	11.11
RS 34	2.08	4.95	9.27	16.89	37.57	51.85
RS 35	1.0	3.12	5.79	8.53	20.48	11.11
RS 36	2.14	2.07	3.09	3.55	11.71	11.11
RS 37	3.0	1.06	2.02	3.68	12.74	11.11
RS 38	2.25	2.16	4.38	6.25	17.08	11.11
RS 39	1.0	5.74	8.05	13.09	30.38	33.33
RS 40	1.24	5.44	10.97	14.73	32.78	40.74
RS 41	1.0	5.50	10.43	15.12	34.96	40.74
RS 42	1.25	4.82	8.27	11.72	26.91	29.62
RS 43	1.25	5.79	11.32	16.42	33.51	38.88
RS 44	3.0	1.05	2.41	3.32	10.58	11.11
RS 45	4.75	1.96	4.15	8.72	21.57	11.11
RS 46	1.75	2.70	5.26	7.46	19.54	11.11
RS 47	1.0	3.57	7.55	11.31	26.21	33.33
RS 48	1.50	2.96	5.13	6.79	17.90	11.11
RS 49	1.08	1.21	3.28	6.13	17.22	11.11
RS 50	1.08	7.53	13.87	21.67	44.21	66.67
RS 51	1.0	4.26	5.83	8.70	19.81	11.11
RS 52	1.0	3.38	6.93	10.33	24.45	20.36
RS 53	1.0	4.36	8.86	13.17	31.85	33.33
RS 54	2.08	4.11	7.60	11.18	26.25	27.77
RS 55	3.16	2.92	8.15	11.07	26.41	33.33
RS 56	1.16	3.04	6.16	9.15	22.21	12.96
RS 57	1.08	15.53	27.70	35.54	72.17	100.00
RS 58	1.08	6.28	11.81	17.06	39.29	55.56
Mean	1.53	4.81	8.70	12.84	29.10	32.66

CD					3.5057	6.9671
SEm					1.2560	2.4961

The pooled *kharif* data for 2016 and 2017 are listed in table 1.6. The aggressiveness quality (Fig. 4.12) was divided into the following four categories: weakly aggressive (WA = PDI% 2-21), moderately aggressive (MA = PDI% 22-43), aggressive (A = PDI% 44-65)) and highly aggressive (HA=PDI percent 66-87) with a susceptible Swarna variety. The result showed that among the fifty-eight isolates, twenty two weakly aggressive isolates (RS8, RS9, RS11, RS20, RS21, RS22, RS23, RS24, RS31, RS32, RS33, RS35, RS36, RS37, RS38, RS44, RS45, RS46, RS48, RS49, RS51 and RS56) followed by seventeen moderately aggressive isolates (RS7, RS13, RS18, RS26, RS27, RS28, RS29, RS30, RS39, RS40, RS41, RS42, RS47, RS52, RS53, RS54 and RS55), twelve aggressive isolates (RS6, RS10, RS12, RS14, RS15, RS16, RS17, RS19, RS25, RS43, RS50 and RS58) and seven highly aggressive isolates (RS1, RS2, RS3, RS4, RS5, RS34 and RS57). The PDI of the isolates was between (11.11 - 98.15%). All isolates were found to be aggressive to rice and could develop lesions on leaves, leaf sheaths and susceptible stems of rice. The results showed that significant differences were found in the aggressiveness of isolates. The isolates varied depending on the lesion height, incubation period, relative lesion height, severity of the disease and percent disease index.

Of all 58 isolates, a maximum PDI of 98.15 percent was shown with RS57 isolate, followed by RS 5 (92.59 percent) and RS 3 (88.89 percent), while RS8, RS9, RS20, RS22, RS23, RS32, RS33, RS 35, RS36, RS37, RS44, RS48 and RS 49 isolates showed the lowest PDI value (11.11). The incubation period was between 1.0 and 4.75 days. The minimum incubation time (1.0 days), indicated by RS10, RS20 and RS51 isolates, and the maximum incubation time (4.75 days), indicated by RS37 isolate. The RS5 isolate (69.99 cm) showed the highest relative lesion height, while the RS44 (9.66 cm) showed the lowest. The results of a pooled data analysis showed the isolates of *R. solani* were variable. These results are in agreement with the results of Madhavi *et al.* (2012) [17] and Jayaprakashvel and Mathivanan (2011) [13]. Adhipathi *et al.* (2013) [1], Pavani *et al.* (2018) [23], Singh *et al.* (2001) [30] and Kumar *et al.* (2008) [15] reported similar observations.

Table 1.5: Evaluation of Aggressiveness of different isolates of *Rizoctonia solani* under pot condition (Pooled data of year 2016 and 2017)

Isolates	Incubation period	Lesion length (c.m.)			Relative Lesion Height (cm)	PDI (%)
		1 week	2 weeks	3 weeks		
RS 1	1.33	9.88	16.30	22.89	52.29	71.29
RS 2	1.16	7.48	15.28	24.52	52.63	75.00
RS 3	1.12	13.36	23.17	31.62	68.97	88.89
RS 4	1.08	10.08	18.60	26.84	59.19	75.00
RS 5	1.20	14.86	23.04	31.93	69.99	92.59
RS 6	1.12	6.19	11.72	18.25	43.24	55.56
RS 7	1.12	5.54	8.55	12.67	30.61	35.26
RS 8	4.54	1.70	3.97	6.15	17.23	11.11
RS 9	3.54	1.10	3.17	5.19	14.37	11.11
RS 10	1.00	7.00	11.52	16.73	37.08	52.78
RS 11	1.58	2.27	6.10	9.73	22.69	15.74
RS 12	1.58	5.97	11.64	19.42	42.28	56.48
RS 13	1.21	4.41	8.84	13.33	29.66	34.26
RS 14	1.04	6.51	11.95	17.80	38.16	52.78
RS 15	1.24	6.22	12.09	19.25	41.15	55.56
RS 16	1.29	5.27	10.53	16.40	36.51	46.29
RS 17	1.17	4.70	9.51	15.92	34.58	44.44
RS 18	2.42	3.98	7.20	13.05	28.73	35.18
RS 19	1.29	5.41	10.30	18.70	39.56	53.70
RS 20	1.00	3.81	6.03	7.73	17.33	11.11
RS 21	1.67	2.66	5.26	7.62	17.88	18.52
RS 22	1.29	2.40	4.33	6.38	13.88	11.11
RS 23	3.00	0.98	2.50	3.96	11.49	11.11
RS 24	2.50	1.74	5.24	8.03	18.12	12.04
RS 25	1.20	8.58	12.86	18.37	38.34	54.63
RS 26	1.21	4.50	8.18	12.33	26.91	32.35
RS 27	1.13	3.81	6.78	10.03	22.20	22.22
RS 28	2.37	3.31	7.65	11.62	25.79	30.55
RS 29	1.75	3.87	7.28	10.65	23.75	22.22
RS 30	1.88	4.86	8.62	12.90	28.97	34.26
RS 31	1.58	3.28	6.14	9.08	21.41	14.81
RS 32	2.83	1.34	3.19	4.41	12.90	11.11
RS 33	3.83	1.08	3.45	5.70	14.98	11.11
RS 34	1.54	8.39	14.81	23.12	48.74	66.20
RS 35	2.04	1.93	4.85	7.21	17.67	11.11
RS 36	3.36	1.17	2.65	3.57	11.04	11.11
RS 37	4.75	0.53	2.22	3.55	11.06	11.11
RS 38	2.67	2.11	4.31	6.38	16.46	12.04
RS 39	1.13	6.50	9.77	14.48	32.13	38.89

RS 40	1.12	4.85	9.69	13.80	30.56	37.04
RS 41	1.04	5.66	9.76	14.08	31.90	37.04
RS 42	1.25	4.80	8.34	11.83	26.38	31.48
RS 43	1.29	5.45	10.30	16.26	35.48	45.37
RS 44	3.25	1.01	2.16	3.10	9.66	11.11
RS 45	2.88	2.65	5.57	9.52	22.14	17.59
RS 46	2.54	2.14	4.94	7.13	17.98	13.89
RS 47	1.13	3.60	7.24	10.36	23.67	24.07
RS 48	2.38	2.33	4.84	6.89	17.27	11.11
RS 49	1.92	1.48	4.01	6.61	15.26	11.11
RS 50	1.04	8.64	15.28	22.85	44.88	63.89
RS 51	1.00	3.88	6.22	8.73	19.71	12.96
RS 52	1.17	3.67	7.10	10.65	24.60	24.99
RS 53	2.50	2.51	7.23	12.24	28.54	33.33
RS 54	1.67	3.57	6.78	10.62	24.44	24.99
RS 55	2.20	2.77	6.94	9.60	22.56	22.22
RS 56	2.20	2.63	6.69	9.26	22.44	16.66
RS 57	1.04	13.73	24.89	33.51	69.61	98.15
RS 58	1.08	5.60	11.45	17.14	39.61	56.48
Mean	1.82	4.65	8.78	13.13	29.60	34.55
CD					2.9093	5.3383
SEm					1.0423	1.9125

The result showed that among fifty eight isolates, most of the isolates *i.e.* twenty two isolates were categorized as weakly aggressive, seventeen isolates were moderately aggressive, twelve isolates were aggressive and seven isolates were found highly aggressive. The PDI of the isolates was ranged between 11.11 - 98.15%, a maximum PDI of 98.15 percent was shown with RS57 isolate.

References

1. Adhipathi P, Singh V, Meena SC. Virulence diversity of *Rhizoctonia solani* causing sheath blight disease in rice and its host pathogen interaction. The Bioscan. 2013; 8(3):949-952.
2. Anonymous. Rice Disease Survey. Rice Pathology News Letter. IRRI, Los Banos, Philippines. 1975; 1/75:8.
3. Anonymous. Sheath blight: Losses cost $ 67 million a year. Rice J. 1988; 41:5-8.
4. Anonymous. Progress Report. India Council of Agricultural Research, New Delhi. 1971; 3:1-7.
5. Chaijuckam P, Baek JM, Greer CA, Webster RK, Davis RM. Population structure of *Rhizoctonia Oryzae-sativae* in California rice fields. *Phytopath*. 2010; 100:502-510.
6. Das NP. Resistance of some improved varieties of rice (*Oryza sativa* L.) to sheath blight caused by *Rhizoctonia solani* Kuhn. Indian J Agric. Sci. 1970; 40:566-568.
7. Dasgupta MK. Rice sheath blight: The challenge continues in: Plant Diseases of *Int.* Importance: Diseases of cereals and pulses. New India Publishing Agency. 1992, 115 pp.
8. Dodman RL, Flentje NT. The mechanism & Physiology of Plant penetration by *Rhizoctonia solani* In: Parmeter J R (ed) *Rhizoctonia solani*, Biology & Pathology. University of California Press, Berkeley, 1970, 149-160.
9. Goff SA. Rice as a modle for ceral genomics. Curr. Opin. Plant Biol. 1999; 2:86-89.
10. Guttierez WA, Shew HD, Melton TA. Sources of inoculum and management of *Rhizoctonia solani* damping-off on tobacco transplants undergreenh ouse conditions. Pl. Dis. 1997; 81:604-606.
11. Hori M. On forecasting the damage due to sheath blight of rice plants and the critical point for judging the necessity of chemical control of disease. Rev. Pl. Prot. Res. Tokyo. 1969; 2:70-73.
12. IRRI. The *Int.* Rice Testing program (The *Int.* Rice Research Institute) Los Banos, Laguna, Phillipinnes, 2014.
13. Jayaprakashvel M, Mathivanan N. Morphological and pathological variations of rice sheath blight inciting south Indian *Rhizoctonia solani* isolates. Archives of Phytopath. and Plant Protec. 2012, 455-467 pp.
14. Kipsumbai, Pixley Kiptui. Population dynamics and pathogenic behaviour of *Rhizoctonia solani* Kühn in response to rice based cropping system of Punjab. M.Sc. (Ag.) thesis, Panjab Agricultural University, 2015.
15. Kumar M, Singh V, Singh KN, Vikram P. Morphological and virulence characterization of *Rhizoctonia solani* causing sheath blight of rice. Environ. and Ecology. 2008; 26(3):1158-1166.
16. Lee FN, Rush MC. Rice sheath blight: A major rice disease. Pl. Dis. 1983; 67:829-832.
17. Madhavi M, Reddy PN, Reddy RR, Sudarshan MR. Evaluation of maize genotypes against banded leaf. and sheath blight disease incited by *Rhizoctonia solani f.sp.sasakii* (Khun) Exner. J of Res. ANGRAU. 2012; 40(4):20-23.
18. Matsumoto M. A qualitative baiting technique for selective isolation and DNA diagnosis of *Rhizoctonia* spp., causal agents of rice sheath diseases. Soil J Fac Agr Kyushu Univ. 2003; 48:13-20.
19. Miyake I. Studies uber die Pilze der Reispflanzen in Japan. J Coll. Agric. Tokyo. 1910; 2:237-276.
20. Mizuta H. On the relation between yield and inoculation times of sheath blight *Corticium sasakii* in the earlier planted paddy rice. Ass. Pl. Prot. Kyashu. 1956; 2:100-102.
21. Ou SH. Rice diseases. Commonwealth Mycological Institute. Kew, Survey, England, 1972, 368.
22. Parmeter JR, Whitney HS. Taxonomy and nomenclature of the imperfect state- *Rhizoctonia solani*. In: (Ed. *J*.R. Parmeter). Biology and Pathology. University of California Press, Berkley University of California Press, Berkelay, Los Angeles and London, 1970.
23. Pavani Lalitha S, Singh Vineeta. Assessment of Virulence Diversity of *Rhizoctonia solani* Causing Sheath Blight Disease in Rice from Eastern Up. Current J

of Applied Science and Technology. 2018; 26(6):1-10. Article no. CJAST. 41052.
24. Prasad VR. Integrated management of sheath blight disease of rice. M.Sc. (Ag.) thesis, Department of Plant Pathology College of Horticulture, Vellanikkara, Thrissur, Kerala, India, 2014.
25. Rajan CPD, Naidu VD. Sheath blight damage to seven rices. Int. Rice. Res. Newsl. 1986; 11(1):6.
26. Saxena SC, Agnihotri VP, Sarbhoy AK, Singh DV. Banded leaf and sheath blight of maize. In: Management of threatening plant diseases of National importance. Malhotra publishing house, New Delhi. 1997, 31-50.
27. Sharma L, Goswami S, Nagrale DT. Culture and physiological variability in *Rhizoctonia solani*, responsible for foliar and lesions on aerial part of soybean. J of Applied and Natural Sci. 2013; 5(1):41-46.
28. Sherwood RT. Physiology of *Rhizoctonia solani*. In: *Rhizoctonia solani*. Biology and Pathology. University of California Press. Berkeley, 1970, 69-92.
29. Shimamoto K. The molecular biology of rice. Science. 1995; 270:172-173.
30. Singh A, Rohila R, Singh US, Savary S, Willocquel L, Duvoillor E. An improved inoculation technique for sheath blight of rice caused by *Rhizoctonia solani*. Canadian J Plant Pathology. 2001; 24:65-68.
31. Sneh B, Jabaji-Hare S, Neate S, Dijst G. *Rhizoctonia* species: taxonomy, molecular, biology, ecology, pathology and disease control. Dordrecht (The Netherlands): Kluwer Academic Publishers, 1996, 331-340.
32. Sriram S, Raguchander T, Vidhyasekaran P, Muthukrishnan S, Samiyappan R. Genetic relatedness with special reference to virulence among the isolates of *Rhizoctonia solani* causing sheath blight in rice. *Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz*. 1997; 104(3):260271.
33. Swain NC, Chhotray AK, Mahapatra SS. Pathogenic variability of *Rhizoctonia solani* causing sheath blight of rice and its management. Jour. of Pl. Prote. and Enr. 2005; 1:96-99.
34. Verma ML, Agrawal KC, Upadhyay AR, Patel RK. Observation on rice disease and insects in Madhya Pradesh, India. Int. Rice Res. Newsl. 1979; 4(1):11.
35. Vidhyasekaran P, Ponmalar TR, Samiyappan R, Velazhahan R, Vimala R, Ramanathan A *et al*. Host-specific toxin production by *Rhizoctonia solani*, the rice sheath blight pathogen. Biochem cell Biol. 1997; 87:1258-1263.
36. Xiao Y, Liu M, Li G, Zhou E, Wang L, Tang J *et al*. Genetic diversity and pathogenicity variation in *Rhizoctonia solani* isolates from rice in Sichuan Province, China. Rice Sci. 2008; 15:137-144.