UMYU Scientifica, Vol. 1 NO. 2, December 2022, Pp 138 – 146
https://doi.org/10.56919/usci.1222.017
ISSN: 2955 – 1145 (print); 2955 – 1153 (online)
A periodical of the Faculty of Natural and Applied Sciences, UMYU, Katsina

ORIGINAL RESEARCH ARTICLE

Effects of Salinity on the Incidence and Severity of Sheath Blight Disease Caused by *Rhizoctonia solani* (Kuhn) on Some Varieties of Rice (*Oryza sativa* L.)

Mustapha Tijjani*, Ahmad Shehu Kutama, Mohammed Isa Auyo, Mai-Abba Ishyaku Abdullahi
Department of Biological Sciences, Federal University, Dutse, Nigeria.

ABSTRACT

As Rice (*O. sativa*) becomes one of the world's most important cereal crops, its cultivation in arid and semi-arid countries relies heavily on irrigation, and soil salinity remains an environmental or abiotic danger in those regions. Aside from abiotic threats, *R. solani*-caused sheath blight is one of the most significant fungal diseases restricting global rice output. Because there is a strong link between environmental conditions and plant diseases, determining the effect of salinity on sheath blight disease will be critical. The mycelial block approach was employed to inoculate three rice varieties (Faro44, Faro52, and *Jamila*) subjected to varying levels of saline treatment. The incidence of sheath blight disease was determined and expressed as a percentage, and plant image analysis (*Pliman*) was used to measure and determine the severity of sheath blight disease on the affected plant parts. The results revealed that the disease incidence in Faro44 and Faro52 was greater at 8 dSm^{-1}, while *Jamila* had the highest disease incidence at 6 dSm^{-1}. The disease severity increases with rising salinity level in all varieties, and becomes quite severe when the salinity level exceeds 4 dSm^{-1}. The study concluded that, salt stress is a severe hazard to rice cultivation, and the effect of sheath blight disease can worsen as soil salinity increases.

ARTICLE HISTORY

Received November 24, 2022
Accepted December 12, 2022
Published December 30, 2022

KEYWORDS

Soil salinity, Sheath blight, Rice, Disease incidence, Severity

INTRODUCTION

As more than fifty percent population of the world, commonly people in developing countries, consumes Rice as a staple food (Maraseni *et al.*, 2018), sheath blight disease of Rice (*Oryza sativa*) caused by *Rhizoctonia solani* Kuhn remains one of the major biotic constraints limiting crop production producing areas around the world (Noman *et al.*, 2022). However, *R. solani* is pathogenic to economically important crops such as rice, wheat, maize, cotton, potato, bean, vegetables and grasses (Shi *et al.*, 2007; Hu *et al.*, 2010). This fungus is responsible for root rot, stem-foot rot, and seedling blight (Slaton *et al.,* 2003; Tan *et al.,* 2007). The rice varieties currently in cultivation have polygenic resistance to sheath blight disease but become susceptible after a few years (Kunihiro *et al.*, 2002; Park *et al.*, 2008; Prabhukarthikeyan *et al.* 2020). However, AG1-IA is the most economically important plant disease-causing organisms among the *R. solani* anastomosis groups (AG) (Zheng *et al.*, 2013).

Sheath blight often prevails in rice fields with high plant density and high application rate of nitrogen fertilizer; besides, with the extension of semi-dwarf, high-yielding, and multi-tiller cultivars, this disease has been aggravated, and becomes the most critical disease in rice regions (Yang *et al.*, 2008). When there are favorable environmental factors for sheath blight disease establishment, more than 50% yield loss can be observed; and for example, in major Rice producing areas of Asia, sheath blight disease due to *R. solani* claimed over 20 million hectares accounting a grain loss of a 6million tons of Rice (Bernardes-de-Assis *et al.*, 2009; Zheng *et al.*, 2013).

In arid and semi-arid regions, Rice is commonly cultivated under irrigation, and the irrigation water must be brought to the land to increase crop production. However, irrigation water quality, inadequate soil drainage and improper use of inorganic fertilizer often result in the accumulation of salts in the soil. In rice production however, salinity is one of the environmental stress aggravated by climate change due to rising sea levels which causes flooding and affects most of the low land areas (Soares *et al.*, 2021). The presence of high and intolerable levels of chlorides and sulphates of Sodium makes agricultural soil to be saline, and this induces salt stress in plants growing on that particular soil; and the effects of salinity on plants are a concern as a result of irrigation, improper drainage, and salt accumulation in arid and semiarid regions (Tuteja *et al.*, 2012).

Correspondence: Mustapha Tijjani. Department of Biological Sciences, Federal University, Dutse, Nigeria
✉ tijjanimustapha488@gmail.com; +2348039150014

How to cite: Mustapha Tijjani, Ahmad Shehu Kutama, Mohammed Isa Auyo and Mai-Abba Ishyaku Abdullahi. (2022). Effects of Salinity on the Incidence and Severity of Sheath Blight Disease Caused by *Rhizoctonia solani* (Kuhn) on Some Varieties of Rice (*Oryza sativa* L.). UMYU Scientifica, 1(2), 138 – 146. https://doi.org/10.56919/usci.1222.017

Various abiotic or environmental factors influencing plant diseases may act singly or in combination; some may cause diseases directly, while several enhance the disease attack by phytopathogens (Ravichandra, 2013). In the disease triangle, the environment plays a significant role in developing any disease in a plant community; the host's susceptibility and the virulent pathogen are the two earlier key factors that the environment has the tendency to influence (Kutama *et al.*, 2022). Under salinity stress, ions such as Na^+ and Cl^- penetrate the hydration shells of proteins and interfere with their function. In addition, ionic toxicity, osmotic stress, and nutritional defects caused by salinity stress leads to metabolic imbalances and oxidative stress; which subsequently affect the general physiology of plants and hinders metabolism and synthesis of biomolecules, and thus, generally affect the overall plant performance in terms of disease tolerance (Tuteja *et al.*, 2012).

Climate change is expected to increase the salinity of soils in many parts of the world, particularly in coastal areas (Sudratt and Faiyue, 2023). This could have a significant impact on the incidence and severity of sheath blight disease in rice crops. Research on the effects of salinity on this disease can help us to anticipate and mitigate the effects of climate change on rice production. However, understanding how environmental factors like salinity affect plant diseases is an important area of research. Furthermore, studies on the effects of salinity on sheath blight disease of rice can contribute to our broader understanding of how environmental factors affect plant diseases and can help to inform the development of strategies for disease management in other crops. Overall, research on the effects of salinity on the incidence and severity of sheath blight disease of rice is important for improving crop yields (Machado and Serralheiro, 2017) , mitigating the effects of climate change, understanding ecological impacts, and advancing scientific knowledge on the interaction between biotic and abiotic stress factors (Montoya and Raffaelli, 2010). Investigating the influence of salinity on sheath blight disease of rice for exploitation towards improving the rice performance is pertinent and therefore, this paper was aimed at determining the effects of salinity on the incidence and severity of sheath blight disease on some varieties of rice.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out under screen house condition at the Botanical Garden of the Department of Biological Sciences, Federal University Dutse which is located at the geographical coordinates of 11°42'20''N 9°22'13''E.

Soil Sample Collection, Sterilization and Pot Filling

Soil sample (Sandy-Loam) was collected from the University Farm of Federal University Dutse, following the composite technique described by Zhang and Arnall (2013). Prior to pot filling, the collected soil sample was sterilized through the process of soil solarization as described by Agrios (2005). Briefly, the soil sample was spread on a wide polythene bag and moist with water, which was then covered with another polythene bag to maintain the temperature. The soil was kept moist by spraying water regularly throughout the solarization period of 7 days to get rid of soil borne pathogens. The solarization was carried out in April, when there was full sun light and high temperature. The soil mixture was used to fill the pots sized 15cm x 28cm (diameter x height), leaving about 2-3cm top of the pots for water accommodation (Soares *et al.*, 2021). The bottom of the pots was punched to make a hole allowing excess water drainage from the pot.

Treatment Combinations and Experimental Design

A total of five levels of sodium chloride (0, 2, 4, 6 and 8 dSm^{-1}) including control were used. A total of 45 pots representing the 5 treatments and 3 varieties (Faro 44, Faro 52 and *Jamila*) replicated three times were arranged in Completely Randomized Block Design (Kamai *et al.*, 2020). Different salinity levels were prepared according to the protocol described by Hardie and Doyle (2012). Treatments were applied at two weeks of transplanting and continued weekly (Soares *et al.*, 2021).

Source of Inoculum and Sterilization of Materials

A field survey was carried out in some selected rice fields and identified rice plants showing sheath blight disease. Symptoms of the disease mentioned in park *et al.* (2008), Moni *et al.* (2016) as well as Uppala and Zhou (2018) were used as an identification guide for the collection of *R. solani* infected plants. The collected diseased plant materials and equipment used were subjected to surface sterilization to remove contaminants as described by Senanayake *et al.* (2020).

Isolation of *R. solani*, Sub-Culturing and Purification of Isolates

The pathogen was isolated through direct plate method as described in Park *et al.* (2008) and Senanayake *et al.* (2020). Based on the morphological features, colonies suspected to be *R. solani* were sub-cultured and purified according to the standard protocol of hyphal tip culture technique described in Moni *et al.* (2016) and cultivated on freshly prepared PDA plates to obtain the pure isolate. Plates were repeatedly sub-cultured until uniform pure isolate of *R. solani* was obtained.

Identification of Pathogen and standardization of inoculum

To identify the pathogen microscopically, slide culture technique was employed in order to avoid mycelial distortion and to obtain proper and clear mycelial view under the microscope (Senanayake *et al.*, 2020). Microscopic identification involved the observation of the features described by Moni *et al.* (2016) and Watanabe (2018) and was made from the observation of colony morphology, mycelial color, superficial sclerotia and texture described in Moni *et al.* (2016). Standardization was done using the protocol adopted by Park *et al.* (2008).

DATA COLLECTION

Pathogenicity Test

The pathogenicity test of the pathogen was carried out through artificial inoculation following mycelial ball method using 5-day old culture of the pure isolate (Singh *et al*., 2002, Park *et al*., 2008).

Disease Incidence Determination

The disease incidence in each case was determined and expressed in percentage using the relation described by Chaudhary *et al.* (2020). Thus;

$$\text{Disease Incidence} = \frac{Number\ of\ infected\ plants}{Total\ number\ of\ plants\ visited} X100\%$$

Determination of Disease Severity

The severity of sheath blight disease was measured using a digital software called as R (R Core Team 2022). Plant Image Analysis (*pliman*) package developed by Olivoto *et al.* (2022) was used to detect the disease severity on the randomly collected plants showing sheath blight infection. It measured the severity on a target image based on RGB information contained on the image palettes. Three palettes representing three sub-areas in the image were build and used in the image analysis, leaf background (B), the symptomatic (S) and healthy (H)area of the leaf were differentiated using their respective colors and the severity were determined by expressing the ratio of symptomatic and the asymptomatic portion of the plant material and expressed in percentage.

Statistical Analysis

Data obtained in this research were subjected to two-way Analysis of Variance (ANOVA), and means were separated using Duncan Multiple Range Test (DMRT). All statistical analyses were performed using IBM-SPSS Statistical software at P≤0.05.

RESULTS

Effect of Different NaCl Concentrations on the Incidence (%) of Sheath Blight Disease on Faro44, Faro52 and *Jamila* Rice Varieties at 7 and 14 Days After Inoculation (DAI)

The disease incidence (Table 1) results showed that at 7 days after inoculation (DAI), the highest disease incidence on Faro44 was recorded at salt concentrations of 4 and 8 dSm^{-1}, with 40.0 and 41.0% incidence, respectively. This is followed by a lower incidence of 36.3% at 6 dSm^{-1} and 24.7% at 2 dSm^{-1} the control group had the lowest sheath blight disease incidence, with a percentage incidence of 16.2. The highest disease incidence of 75.2% was recorded 14 days after inoculation at the highest salt concentration, followed by 57.0% at 6 dSm^{-1} salinity level. Lower incidence of 45.1% was recorded at 4 dSm^{-1} and 34.7% at 2 dSm^{-1}; in contrast, the control group had the lowest level of disease incidence, valued at 26.2%. However, at 7 DAI, the disease incidence was highest (51.7%) at 8 dSm^{-1} and higher at 4 dSm^{-1} in faro52. A 38.0% incidence was recorded at a salt concentration of 2 dSm^{-1}, a 30.3% incidence was recorded at a salt concentration of 6 dSm^{-1}, and the lowest incidence was associated with the control group. At 14DAI, the highest incidence of 84% was found at 8 dSm^{-1} salt concentration, followed by 60.3% at 4 dSm^{-1} salt concentration. A salinity level of 6 dSm^{-1} had a 54.7% incidence, and a lower incidence of 43.7% at 2 dSm^{-1}; the control group had the lowest incidence of 36.3%.

At 7 DAI, salinity levels of 4 and 6 dSm^{-1} resulted in the highest disease incidence, with 42.8 and 40.0 percent incidence recorded in Jamila. Lower incidence (38.0%) was recorded at 8 dSm^{-1} and 25.0% at 2 dSm^{-1}, with the lowest sheath blight disease incidence (16.5%) recorded in comparison to the control. At 14 DAI, the highest incidence was 88.0% at 6 dSm^{-1} salt concentration, followed by 70.6% at 8 dSm^{-1} salt concentration. Lower incidence was observed at 2 and 4 dSm^{-1}, with incidences of 63.0 and 61.3% recorded. The lowest incidence was found in the control group, where it was 30.8%. Statistically, the effects of different NaCl concentrations on the sheath blight disease of different rice varieties were significant.

Table 1: Effects of Different NaCl Concentrations on Disease Incidence (%) on Faro44, Faro56 and Jamila Rice Varieties at 7 and 14 Days After Inoculation (DAI).

Varieties	**Concen-trations (dSm^{-1})**	**Days After Inoculation (DAI)**	
		7	**14**
Faro44	0	16.2 ± 3.6^{a}	26.2 ± 3.5^{a}
	2	24.7 ± 2.1^{b}	$34.7\pm2.0^{a,c}$
	4	40.0 ± 1.0^{c}	$45.1\pm2.9^{c,d}$
	6	$36.3\pm1.5^{d,c}$	57.0 ± 1.0^{d}
	8	$41.0\pm4.3^{e,c}$	72.2 ± 2.7^{e}
Faro52	0	$24.7\pm2.3^{a,b}$	36.3 ± 1.5^{a}
	2	38.0 ± 1.7^{b}	$43.7\pm0.8^{a,b}$
	4	$48.3\pm5.6^{b,c}$	60.3 ± 1.9^{b}
	6	$30.3\pm4.8^{a,b}$	$54.7\pm1.2^{a,b}$
	8	51.7 ± 2.8^{d}	84.0 ± 1.0^{c}
Jamila	0	16.5 ± 0.4^{a}	30.8 ± 1.8^{a}
	2	25.0 ± 3.0^{b}	63.0 ± 2.0^{b}
	4	42.8 ± 1.7^{c}	$61.3\pm1.2^{c,b}$
	6	$40.0\pm2.0^{d,c}$	$88.0\pm2.0^{d,e}$
	8	$38.0\pm3.0^{e,c}$	$70.6\pm2.2^{e,b}$
P-Value <0.05			

Means±Standard deviation followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Main Effects of NaCl Concentrations, Varieties and their Interaction on Percent Incidence of Sheath Blight Disease

The effect of salt concentrations (Table 2) revealed that the highest incidence was recorded at 7 DAI at 4 and 8 dSm^{-1} salt levels, with 43.72 and 43.56% incidence, respectively. The incidence was lowest at 2 and 6 dSm^{-1} salt levels, with incidences of 29.22 and 35.54% recorded. The control group, which received non-saline water in the experiment, had the lowest incidence of sheath blight disease at 7 DAI. The highest incidence of 75% was observed at 8 dSm^{-1} at 14 DAI, followed by 66.55% at 6 dSm^{-1}. Lower incidence was recorded at 2 and 4 dSm^{-1} salt concentrations, with 47.11 and 55.56% incidence, respectively. The lowest sheath blight incidence was recorded at 0 dSm^{-1}, with a 29.22% incidence. Faro44 had the lowest disease incidence among the varieties at 7 DAI, followed by Jamila, and Faro52 had the highest disease incidence. Jamila had the highest sheath blight incidence of 62.74% 14 days after inoculation, followed by Faro52 with a 55.08% incidence and Faro44 with the lowest severity of 47.01%. The interaction effects between different NaCl concentrations and varieties were statistically significant at both periods of disease assessment after inoculation.

Table 2: Main Effects of NaCl Concentrations (dSm-1) and Varieties on Sheath Blight Disease Incidence (%) at 7 and 14 Days After Inoculation (DAI).

		Days After Inoculation (DAI)	
		7	**14**
Concentrations (dSm^{-1})	0	19.10^{a}	29.22^{b}
	2	29.22^{b}	47.11^{b}
	4	43.72^{c}	55.56^{c}
	6	35.54^{d}	66.55^{d}
	8	43.56^{c}	75.59^{e}
Mean		34.23	55.18
S.E±		0.45	1.14
Varieties	Faro44	31.63^{a}	47.01^{a}
	Faro56	39.59^{b}	55.08^{b}
	Jamila	32.46^{a}	62.74^{c}
Mean		34.56	55.18
S.E±		0.79	1.98
Interactions			
Concentrations x Varieties		*	*

*Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT. *= Significant.*

Effect of Different NaCl Concentrations on the Severity (%) of Sheath Blight Disease on Faro44, Faro52 and *Jamila* Rice Varieties at 7 and 14 Days After Inoculation (DAI)

According to the results of disease severity assessments (Table 3), a salinity level of 8 dSm^{-1} imposed the highest disease severity of 37.02% at 7 DAI. This is followed by 4 and 6 dSm^{-1}, with severity values of 31.29 and 32.09%, respectively. Plants treated with 2 dSm^{-1} had a disease severity of 16.91%, while the control group had the lowest severity value. At 14 DAI, the severity was highest (55.53%) at 8 dSm^{-1}, followed by 6 dSm^{-1} (48.13%), and the plant groups treated with 4 dSm^{-1} salt concentration (44.94%). At 2 dSm^{-1}, the lower severity of 25.36% was recorded, while 0 dSm^{-1} appeared to be the lowest severity, with 17.81% recorded. Faro52 had a similar result, with the highest salinity level at 7 DAI being 8 dSm^{-1} with 50.99% severity, followed by 32.56% at 6 dSm^{-1} salinity level. A salt concentration of 4 dSm^{-1} results in a severity of 22.56%, while the control group showed the lowest percentage severity of 12.78. At 14 DAI, the highest severity was 86.70% at 8 dSm^{-1} and 55.40% at 6 dSm^{-1}. The severity appeared to be lower at 2 and 4 dSm^{-1}, with 24.68 and 38.36% recorded, respectively. The control group appeared to have the least severity (21.72%). However, at 7 DAI, the highest severity was observed in jamila at a salt concentration of 8 dSm^{-1}, whereas higher severity was observed at a salt concentration of 6 dSm^{-1}. Salinity levels of 2 and 4 dSm^{-1} resulted in 13.76 and 13.42%, respectively, with 0 dSm^{-1} being the treatment group with the least severity. At 14 DAI, the highest severity was 43.27% at 8 dSm^{-1}, with 30.55% at 6 dSm^{-1}. However, at 4 dSm^{-1}, 25.25% severity was recorded, with lower severity at 2 dSm^{-1} and the control group showing the lowest.

Table3: **Effects of Different NaCl Concentrations on Sheath Blight Disease Severity (%) at 7 and 14 Days After Inoculation (DAI) on Different Varieties of Rice (O. sativa).**

Varieties	Concen-trations (dSm-^{1})	Days After Inoculation (DAI)	
		7	**14**
Faro44	0	11.87±0.7^{a}	17.81±1.0^{a}
	2	16.91±1.8^{b}	25.36±2.6^{b}
	4	31.29±1.3^{c,d}	46.94±1.9^{c,d}
	6	32.09±1.4^{d}	48.13±2.1^{d}
	8	37.02±0.6^{e}	55.53±0.2^{e}
Faro52	0	12.78±0.7^{a}	21.72±1.2^{a}
	2	14.51±0.5^{a}	24.68±0.9^{a}
	4	22.56±1.2^{b,c}	38.36±2.1^{b,c}
	6	32.56±1.3^{c}	55.40±2.2^{c}
	8	50.99±1.8^{d}	86.70±3.0^{d}
Jamila	0	9.01±2.0^{a}	12.72±2.0^{a}
	2	13.76±1.6^{a}	17.56±1.6^{a}
	4	13.42±1.9^{b,c}	25.25±0.3^{b,c}
	6	23.50±1.7^{c}	30.55±2.2^{c}
	8	33.28±2.3^{d}	43.27±3.0^{d}
P-Value ≤0.05			

Means±Standard deviation followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT.

Main Effect of Concentrations, Varieties and their Interaction on the Severity of Sheath Blight Disease

The effect of salt concentrations (Table 4) revealed that at 7 DAI, the salinity level of 8 dSm^{-1} was associated with the highest severity (40.43%). Following that are 29.39% at 6 dSm^{-1} and 24.43% at 4 dSm^{-1}. Lower disease severity was obtained at 2 dSm^{-1}, while the control group had the lowest disease severity. Similarly, the highest severity at 14 DAI was 61.83% at 8 dSm^{-1}, followed by 44.69% at 6 dSm^{-1}. Lower severity of 36.85 and 22.53% was recorded at 4 and 2 dSm^{-1}, with the control group having the lowest severity. The effects of varieties revealed that, at 7 DAI, Faro52 had the highest severity, followed by Faro44, and finally Jamila. Furthermore, at 14 DAI, Far52 still had the highest severity, Faro44 had the lowest severity, and Jamila had the least severity. At both 7 and 14 DAI, the interactions between salinity levels and varieties were statistically significant

Table 4: **Main Effects of NaCl Concentrations (dSm^{-1}) and Varieties on Sheath Blight Disease Severity (%) at 7 and 14 Days After Inoculation (DAI)**

Varieties	Concen-trations (dSm-^{1})	Days After Inoculation (DAI)	
		7	**14**
Concentrations (dSm^{-1})	0	11.22^{a}	17.42^{a}
	2	15.06^{b}	22.53^{b}
	4	24.43^{c}	36.85^{c}
	6	29.39^{d}	44.69^{d}
	8	40.43^{e}	61.83^{e}
Mean		24.11	36.67
SE±		0.4	0.7
Varieties	Faro44	25.84^{a}	38.75^{a}
	Faro52	26.69^{a}	45.37^{b}
	Jamila	19.79^{b}	25.87^{c}
Mean		24.11	36.67
SE±		0.4	0.5
Interactions			
Concentrations x Varieties		*	*

*.Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT. *= Significant.*

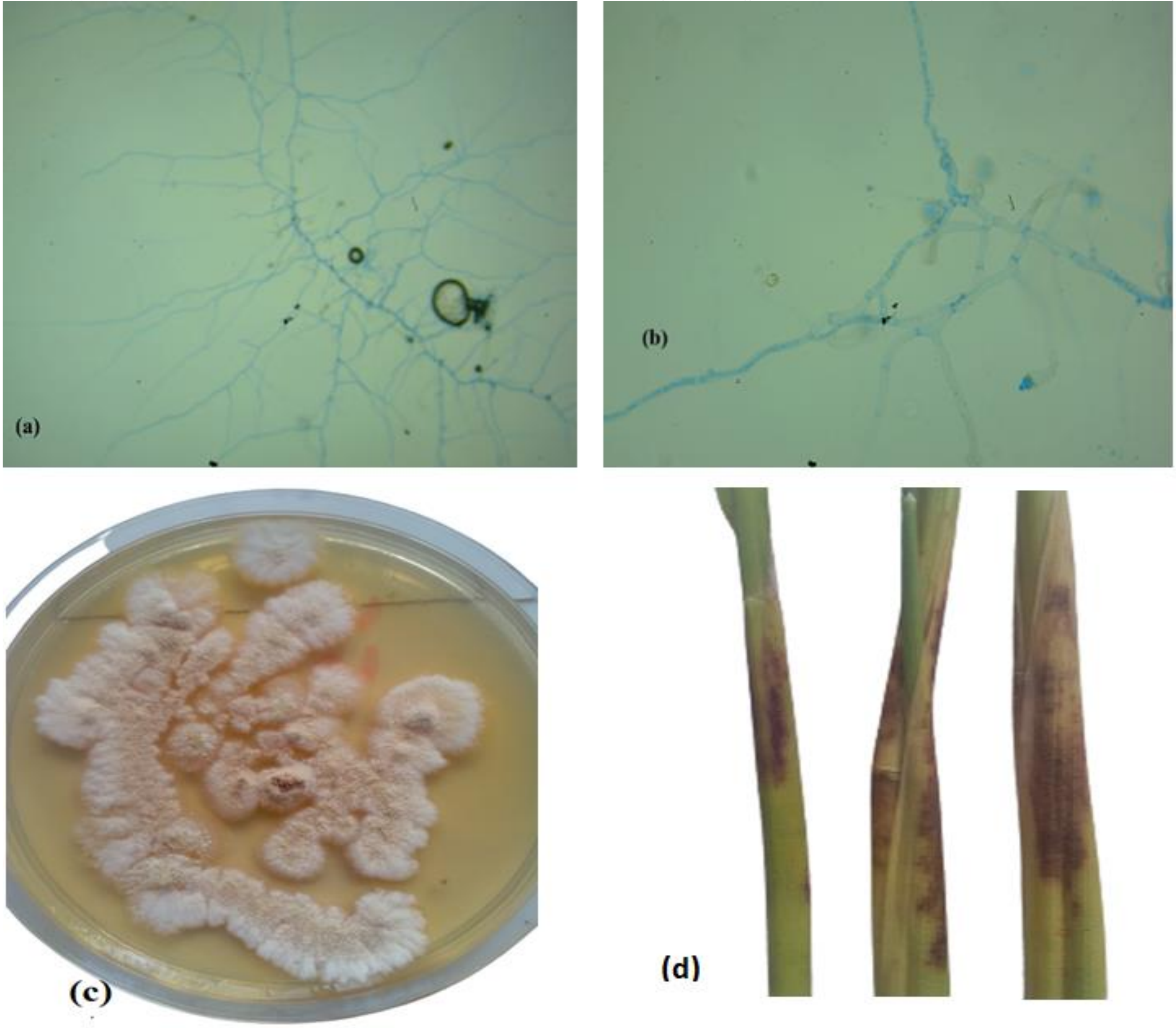

Plate 1: (a) Morphology of *R. solani* showing Microscopic view at X10 and (b) X40 objectives. (c) = Macro morphology with mycelial view on PDA and (d) Sheath blight symptoms after pathogenicity test.

DISCUSSIONS

Plants are subjected to a variety of stressors, including both biotic (pathogens) and abiotic (salinity) factors, and clearly, abiotic stress factors can influence plant susceptibility to pathogens either positively or negatively (Bai *et al*., 2018). Despite the efforts of several researchers to improve crops for disease resistance or tolerance, adverse effects of environmental factors such as soil salinity, which are exacerbated by current scenarios such as flooding due to climate change, could neutralize those efforts due to their effects on plant immunity to diseases. Thus, rice susceptible to salinity can become less resistant to other biotic stressors, such as diseases and insects (Quais, *et al*., 2020; Soares *et al*., 2021).

The microscopic identification of *R. solani* (Plate 1a) revealed the presence of septate hyphae with hyphal branching at perpendicular of about 45°. In the macroscopic identification of the isolate on PDA media (Plate 1b), a rapidly growing mycelia with whitish to creamy colony was observed. The sclerotial color after 12 days of inoculation at room temperature revealed a pale-brown sclerotia that is sparsely distributed on the plate. This explains and confirmed the pathogen as *R. solani* that is responsible for sheath blight disease on rice, and it is in line with the findings of Moni *et al* (2016) and Desvani *et al.* (2018).

The sheath blight disease incidence (Table 1) in this study shows that Faro 44 and Faro52 were the most susceptible varieties after 7 days of pathogen inoculation, with the effect being stronger at 4 and 8 dSm^{-1} salinity levels. The high disease incidence on Faro44 and Faro52 can be attributed to their high tillering capacity, which results in dense plant growth and creates a conducive and favorable microclimate that influences disease establishment. This is consistent with the findings of Yang *et al.* (2005) and Yong *et al.* (2008), who found that dwarf and semi-dwarf multi-tiller rice varieties had a higher incidence of sheath blight disease.

However, disease incidence increases with time after inoculation in all varieties, with *Jamila* showing the highest incidence at 6 dSm^{-1} salt concentrations while Faro44 and Faro52 showed the highest disease incidence at 8 dSm^{-1} salt concentrations. This could be due to the effects of salinity on plant pathogenic fungi, as several studies have found that rising salinity levels increase pathogen virulence and pathogenicity. Eydoux and Ferrer (2020), for example, reported an increase in pathogenicity when rice plants were inoculated with *Fusarium solani*, which further supports the theory that increased disease incidence with increased salinity levels can be attributed to the effects of salinity in enhancing the virulence and pathogenicity of the pathogen. However, increased salinity has been found to hasten disease progression (Dikilitas, 2003), while other studies have found that salinity increases pathogen inoculum production (Besri, 1993; Daami-Remandi *et al.*, 2009). The main effects of salinity levels and varieties (Table 2) were found to be significant at 7 and 14 days after inoculation in this study. This is because disease incidence increases with increasing salinity levels, and each tested variety responds differently.

Because disease severity is defined as the degree of disease intensity in or on a specific organ or plant part, the sheath blight disease severity (Table 3) in this study increases as the salinity level increases. The degree of infection was statistically significant ($P<0.05$) at 7 and 14 days after inoculation, with the highest severity recorded on all varieties at the 8 dSm^{-1} salinity level. The results also showed that Faro52 was the most affected variety in terms of disease severity, followed by Faro44 and *Jamila*. The most detrimental effect of salinity on the severity of sheath blight disease in this study were found to be the salinity levels above 4 dSm^{-1}, and this shows that Faro52 is the most susceptible variety to the sheath blight disease at 8 dSm^{-1} level of salinity. This further validates the report of Soares *et al.* (2021), that in rice, the threshold salinity level is 3 dSm^{-1}, and salinity level greater than this value exposes rice plant to salt stress.

The primary effect of salt stress on plants is nutrient imbalance, and NaCl can cause potassium (K) deficiency while increasing Sodium (Na), Calcium (Ca), Magnesium (Mg), and Chloride (Cl) in rice plants (Chrysargyris *et al.*, 2019). This redox-related salt imbalance can cause oxidation damage, particularly to nucleic acids, fats, and protein (Soares *et al.*, 2021). The disease severity on the tested rice varieties increases over time, with progression when salinity increases, with less severity at the start. Disease severity in other plant disease was found to increase with an increasing salinity level or salt stress (Mustapha *et al.*, 2022). This could be because, at the beginning of salinity stress, the plants respond to the induced salt stress by releasing antioxidant enzymes and osmoprotectants to prevent the effects of toxins and oxidative residue on their tissues (Soares *et al.*, 2021); and as the salt stress persists, the plants lose the ability to mitigate the stress (Ahmad *et al.*, 2019).

The plant cell wall, on the other hand, acts as a physical barrier to plant pathogens. Salinity causes significant changes in the architecture of the plant cell wall, exposing the plant to pathogen invasion (Huller *et al.*, 2020). Salinity stress softens and remodels the cellulose-pectin cross linking in the cell wall, allowing the pathogen or its inoculum to easily penetrate the cell (Feng *et al.*, 2018). Salinity, on the other hand, has been shown to suppress the expression of defense genes, reduce antioxidant activity, and weaken G-protein-mediated signaling, all of which reduce plant resistance to infection (Maharshi *et al.*, 2022).

CONCLUSION

Salinity had recorded significant effects on the incidence and severity of sheath blight disease. Faro52 and Jamila were the most susceptible varieties when compared to Faro44. The degree of infection rises when the salt concentration increases, and this shows that soil salinity as an environmental factor had a significant contribution in the sheath blight disease development. However, this study project that in an agricultural fields where salinity level is beyond 4 dSm^{-1} and salt intolerant varieties of rice are in cultivation, sheath blight disease could become very severe.

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