International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 9, Issue 3 -2022

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2022.09.03.003

# Why Rice Sheath Rot Disease Become Major Threat of Lowland Rice Production in Fogera Plains, Ethiopia?

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## Abstract

In the Fogera plain, Ethiopia, sheath rot disease is the major threat of rice production with overall average prevalence, incidence and severity of 100, 47 and 44%, respectively. The objective of this paper was to review predisposing factors and conducive conditions for rice sheath rot disease development in Fogera plain. Existing agricultural practices and agroecological conditions of Fogera plain, favorable for the disease were revied in detail. High level of nitrogen fertilizer, using of old and susceptible cultivar, poor seed system, poor farm management, conducive weather conditions for disease development, and unavailability and inaccessibility of disease management methods are the major reasons for disease development in the area. Therefore, emphasis should be given to avoiding of the predisposing factors,development of resistant varieties and other management methods for the area.

**Keywords:** Rice, Sheath rot, Fogera plain, Rice disease, Disease development, production constraint

## Introduction

Rice is the most widely consumed staple food for over half of the world's human population, especially in Asia and Africa. Moreover, it is a strategic commodity for food security in Africa. Rice has recent introduction and cultivation history in Ethiopia, around 1970s. Despite of its recently introduction history, the rice production is expanded dramatically in to different parts of the country and improves the lively hood of many agrarian communities especially in the Fogera plain due to agroecological suitability and the overall potential of the area (Dawit 2019).

Surprisingly, the Fogera plain accounts 68% of total rice area coverage and 71% of rice production volumein Ethiopia (CSA, 2020). This is due to the compatibility of rice cultivation in wetlands of the Fogera plain in which other crops do not grow well, its compatibility with traditional foods and the rapid increase in domestic rice consumption(Mulugeta et al, 2021).However, regardless of both the crop and the area's potentials, currently rice production in

Fogera plain is faced a threat of many diseases of which sheath rot is the major one with overall average prevalence, incidence and severity of 100, 47 and 44%, respectively, and cause considerable amount of yield loss (Desalegn et al., 2020; Tekalign et al., 2019a).

Rice sheath rot is a disease complex that can be caused by various fungal and bacterial pathogens. Major pathogens associated with rice sheath rot are fungi such as *Sarocladium oryzae* and *Fusarium sp.* belonging to the *Fusarium fujikuroi* complex and the bacterial pathogen *Pseudomonas fuscovaginae* (Bigirimana et al., 2015). *Sarocladium oryzae* is the major fungal rice sheath rot pathogen which was originally described as *Acrocylindrium oryzae*, the first organism to be associated with rice sheath rot symptoms isolated in Taiwan in 1922 (Mew and Gonzales, 2002). Later on, the genus *Sarocladium* was established in 1975 by Gams and Hawksworth (1975).

Furthermore, Bigirimana et al. (2015) described that the *Fusarium fujikuroi* complex currently divided in to three large clades, the African clade, the Asian clade and the American clade. From which, the main organisms associated with rice are *F. verticillioides* from the African clade and the closely related species *F. proliferatum* and *F. fujikuroi* from the Asian clade. In addition to the two fungi pathogens (*Sarocladium oryzae* and *Fusarium sp.*), *Pseudomonas fuscovaginae* is the most important bacterial pathogen associated with rice sheath rot.

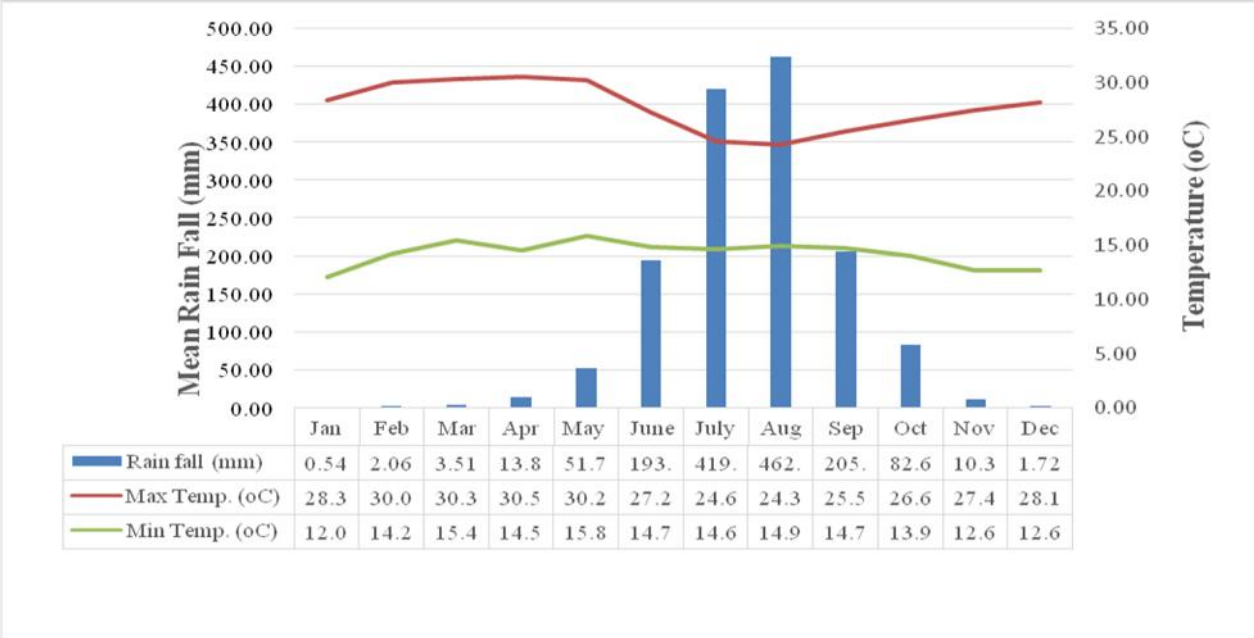
According to Bigirimana et al. (2015), rice sheath rot was considered as a minor and geographically limited disease for many years, which is only recently that it gained momentum and became widespread. Accordingly, the question is, why it become a major rice production threat globally in general and in Ethiopia specifically?In fact, sheath rot is yet not well studied in Ethiopia. Consequently, the associated factors that predispose the rice crop for high level of sheath rot infection are not clearly understood by many of rice production engaging stakeholders. Therefore, the objective of this paper was to review the predisposing factors and conducive conditions for rice sheath rot disease development in Fogera plain, Ethiopia.

To come up with correct conclusion, the existing agricultural practices and agroecological conditions of Fogera plain that could be coincide with conducive conditions for sheath rot development are analyzed. Moreover, the relation between sheath rot and rice cultivation practices, environmental conditions conducive for sheath rot development, sheath rot disease cycle and transmission, resistance mechanisms in rice genotypes and effective sheath rot management recommendations are also reviewed in detailed.

## *Weather conditions*

The intensity of sheath rot incidence and severity of damage caused by pathogen are profoundly influenced by temperature and relative humidity. The disease development is favored by hot and humid weather. Moreover, temperature of 20 to 30 °C and relative humidity in the range of 65 to 85% favor the development of sheath rot (Sakthivel, 2001).Similarly, other researchers also reported that the fungus grows best at 20-28°C (Yadav et al., 2016). The disease development is maximal when the minimum temperature is 17-20°C and the minimum relative humidity 40-50% at flowering, while relative humidity in association with the number of cold days (nicto temperature below 20°C) favored the disease development(Singh and Dodan, 1995).

In Fogera plain rice is sown starting mid-June (depending on the onset of the rainfall) and harvested early November. Meaning that booting and heading/flowering also appear around mid to end of September when the minimum and the maximum temperatures are 14.74 and 25.58 °C respectively (Fig.1). According to the above cited researchers, these temperature ranges are favorable for sheath rot disease development. Therefore, the conducive weather conditions of Fogera plain during the booting, heading and flowering periods of the rice crop could expose it for sheath rot damage.




| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rain fall (mm) | 0.54 | 2.06 | 3.51 | 13.8 | 51.7 | 193. | 419. | 462. | 205. | 82.6 | 10.3 | 1.72 |
| Max Temp. (oC) | 28.3 | 30.0 | 30.3 | 30.5 | 30.2 | 27.2 | 24.6 | 24.3 | 25.5 | 26.6 | 27.4 | 28.1 |
| Min Temp. (oC) | 12.0 | 14.2 | 15.4 | 14.5 | 15.8 | 14.7 | 14.6 | 14.9 | 14.7 | 13.9 | 12.6 | 12.6 |

Figure 1. Mean monthly total rainfall, and monthly average minimum and maximum temperatures of Fogera plain for the period2001-2020
Source: The author analysis from meteorological data

### *Nitrogen Fertilizer*

Of all the nutrients, nitrogen (N), phosphorus ($P_2O_5$), and potassium ($K_2O$) remain the major nutrients for increased and sustained rice productivity. The fertilizer use trend in rice indicates the highest consumptions of N fertilizer followed by $P_2O_5$and $K_2O$ fertilizers with imbalanced fertilizer use (i.e., very high use of N, less use of $P_2O_5$, and negligible use of $K_2O$, S, and micronutrients), increased soil nutrient mining, and decreased soil organic matter and soil fertility (Rao et al., 2017).

Naturally, most rainfed lowland rice fields of Fogera plains are labeled thatobviously receiveand absorb large amount of important plant nutrients come from the upper areas, around mount Gna, through erosion every rainy season. Nevertheless, farmers use high amount of synthetic nitrogen fertilizers believing that their crop will be vigorous while applying high dose of nitrogen fertilizer.Moreover, researchers recommended that application of 184kg $ha^{-1}$nitrogen and 46 kg $ha^{-1}$phosphorous ($P_2O_5$)fertilizers are economical for lowland rice production in the Fogera plain (Tilahun et al., 2020).

Contrarily, application of high dose of nitrogen fertilizers increased the susceptibility of the host by decreasing the phenolic content. Cognizant of this, lots of researchers agreed that application of excess nitrogen in rice fields aggravates the sheath rot disease development and severity (Yadav et al., 2016; Bigirimana et al., 2015; Sakthivel, 2001). Therefore, one of the reasons why sheath rot remains major rice production constraint in the area could be high dose of nitrogen fertilizer.

### *Agricultural practices*

Sheath-rot infection occurs due to predisposing factors such as high amounts of nitrogen, high relative humidity, insect injury, presence of entry points, and dense crop growth and leaf canopy that favors sheath rot development (Yadav et al.,2016).

Many researchers reported that crop intensification practices such as increased plant density, a high rate of nitrogen fertilizers and the use of semi-dwarf and photoperiod-insensitive cultivars favor the susceptibility of rice to sheath rot complex disease (Bigirimana et al., 2015). Similarly, Sakthivel (2001) explained that sheath rot has been a common problem on densely planted, nitrogen-responsive, high yielding semi-dwarf as well as tall rice cultivars.

Furthermore, the context of an ever-increasing population with shrinking natural resources imposes to adopt sustainable production methods, responding to the increasing food demand but also using efficiently and sustainably key resources (Savary et al., 2000; Mew et al., 2004).

In Ethiopia rice is considered as one of the food security crops. As the country is investing huge amount of foreign currency, there is a huge interest to expand total production to satisfy the growing local demand (Desalegn et al., 2019). It is true that the plan of satisfying the growing demand through surplus production is believed to be achieved by intensive rice production using proper agricultural inputs. On theother hand, unless rice intensification is aligned with proper field management, it could pose the rice crop to the rice disease threats such as sheath rot.

Field sanitation, crop residue management, control of weeds and pathogenfree seed may enhance the effectiveness of sheath rot control. However, in Fogera plains these field management practices are not applied correctly by all farmers. There is a common practice of relay cropping of grass pea with rice and mow the matured rice above the gras pea while leaving the rice debris covered by the grass pea in the field. Although this practice is encouraged in the aspects of double benefitof farmersand soil fertility point of view, the rice debris could serve for sheath rot pathogen to survive, speared and as source of inoculum for the next cropping season in the pathology perspectives. Moreover, the knownalternate weed hosts for *S. oryzae* fungus such as *Echinochloa colona* and *Cyperus iria* (Sakthivel, 2001) are also found inrice fields of Fogera plains (Tekalign et al., 2019b).

In addition, most farmers access their desired rice seed through farmer-to-farmer seed exchange regardless of its quality while sheath rot is seed born disease. Furthermore, they use high seed rate in broadcast methods,although the sheath rot disease is more prevalent in densely planted fields.Therefore, the possible reasons could be: poorfield sanitation, crop residue management, seed source, sowing method, high seed rate and the presence of alternate weed hosts in Fogera plains make sheath rot the worst rice disease in the area.

### *Disease cycle and Transmission*

*Sarocladium oryzae* is seed-borne and seed transmitted disease. The fungus also survives as mycelium ininfectedplant residues, weed hosts, and soil. Wind, stem-borer,mites,and mealy bugs disseminate the conidia (Yadav et al., 2016).All of these natures of the pathogen and survival as well as transmitting agents could be reasons for the disease to occur in the Fogera lain every cropping season and increase its damage label year after year.

As it was explained in elsewhere above, using of susceptible cultivar, poor seed system, poor farm management practices, conducive weather conditions for disease development and alternate weed hosts are common phenomena in Fogera plain. Moreover, insect vector such as: Stem borer, and weed hosts are also present in the area (Geteneh et al., 2021, Tekalign et al., 2019).

The availability of conducive conditions for pathogen survival and common transmitting agents in the area perpetuate the disease to continue its cycle (Fig.2 and 3). Therefore, uninterrupted disease cycle could be one of the reasons why sheath rot continued major rice production constraint in Fogera plain.

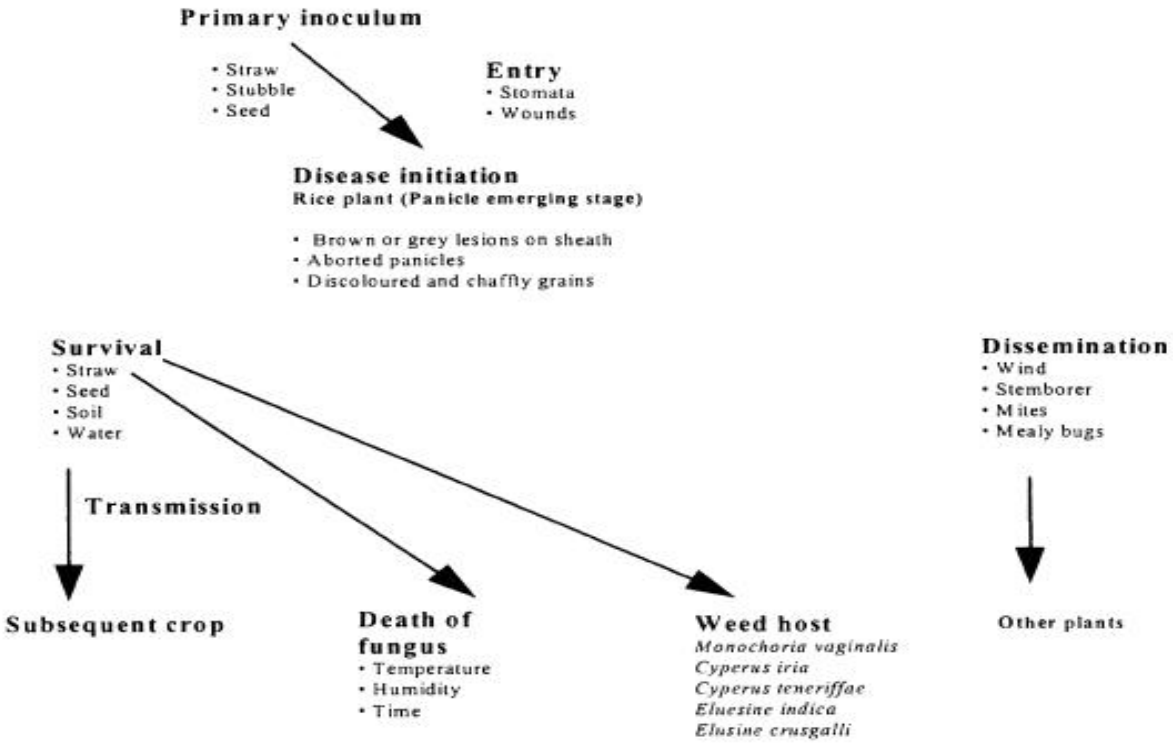
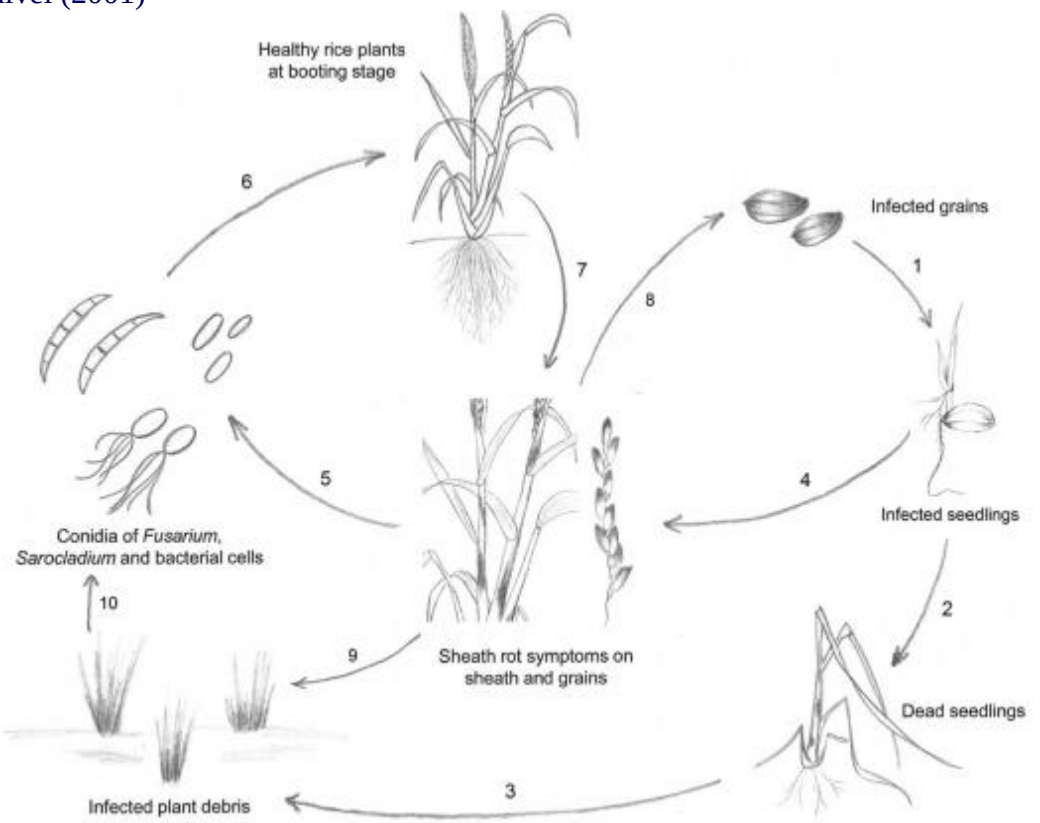



Figure 2. Disease cycle and epidemiology of *Sarocladium oryzae*
*Source:* Sakthivel (2001)




Fire 3.Disease cycle of sheath rot caused by *S. oryzae*,*Fusariumsp.*or *Pseudomonas fuscovaginae.*
Source: Bigirimana et al. (2015).

### *Resistant cultivars*

All high yielding international rice cultivars are highly susceptible to sheath rot disease. Therefore, considerable effort needs to be made to screen for resistant cultivars Sakthivel (2001). Furthermore, although number of resistant varieties have been developed in different countries, none of them has been developed and available in Ethiopia generally and in Fogera plains particularly (Desalegn et al., 2020).

According to our previous work, out of 80 introduced rice genotypes for sheath rot resistant screening, only three genotypes were totally resistant while others were exhibited different level of sheath rot severity and reaction category (Desalegn et al., 2020). Moreover, out of the four widely cultivated check cultivars, only two showed <10% sheath rot severity while the rest two had >20% severity value (Table 1).

Table 1.Sheath rot severity value and host reaction classification of selected immune genotypes along check cultivars

| s/n | Genotype | Designation | Percent severity | Host reaction |
|---|---|---|---|---|
| 1 | Erib | Check | 5.83 | R |
| 2 | Idget | Check | 20.90 | MR |
| 3 | X-jigna | Check | 30.13 | MS |
| 4 | Wanzaye | Check | 4.07 | R |
| 5 | SCRID014-1-1-1-1 | Test line | 0.00 | I |
| 6 | SCRID037-4-2-2-5-2 | Test line | 0.00 | I |
| 7 | YUNLU N0.33 | Test line | 0.00 | I |

Source: Author's analysis from previous work (Desalegn et al., 2020)

As shown in the table, X-Jigna cultivar is susceptible for sheath rot disease with the highest severity value of 30.13% as compared other released varieties and test lines. Furthermore, it is the first cultivar adaptedin 1980s inFogera plain,nearly40 years ago and it is still under production (Misganaw, 2022; Tilahun, 2020; Mulugeta et al., 2021).Regardless of its susceptible ness and old ness, farmers in Fogera plain widely used this cultivar although other varieties are released and recommend for the area.

Moreover, Mulugeta et al. (2021) explained that X-Jigna cultivar has 81% adoption rate in the Fogera plain. Meaning that, most of the rice farmers in the area cover their land by this cultivar. Therefore, using of susceptible cultivar could be one of the major reasons why sheath rot is a major rice production constraint in the area.

### *Availability of management methods*

The development of sound control practices against rice sheath rot is hampered by the fact that rice cultivation is relatively new phenomena in Ethiopia as compared with other crops hence this disease is poorly understood.Contrarily, the research findings,(Muluadam et al., 2021; Desalegn et al., 2020; Zeleke et al., 2020), are not widely addressed and accessed by majority of rice producers. Therefore, in availability and inaccessibility of effective management methods also play significant role the disease to remain major problem of rice production in the area.

## Conclusion and Recommendations

Sheath-rot infection occurs due to predisposing factors such as high amounts of nitrogen, high relative humidity, insect injury, presence of entry points, and dense crop growth and leaf canopy that favors sheath rot development. Agricultural practices and weather conditions in Fogera plain such as: high level of nitrogen fertilizer, using of old and susceptible cultivar, poor seed system, poor farm management, conducive weather conditions for disease development, and unavailability and inaccessibility of disease management methods are the major reasons why

sheath rot become and remain major rice production problem in the area.

Therefore, to alleviate the problem caused by this disease, emphasis should be given to avoid the predisposing factorsthat are favorable for sheath rot development. Moreover, an effort should be applied to develop resistant varieties and other management methods for the area.

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How to cite this article:
Desalegn Yalew Fetene. (2022). Why Rice Sheath Rot Disease Become Major Threat of Lowland Rice Production in Fogera Plains, Ethiopia?. Int. J. Adv. Res. Biol. Sci. 9(3): 20-27.
DOI: http://dx.doi.org/10.22192/ijarbs.2022.09.03.003