

Research Article

# Examination of Rice Blast Incidence and Severity Caused by *Magnaporthe oryzae* (*M. oryzae*) in Tanzania Selected Rice Growing Regions

Herman Mkamilo<sup>1, 2, 3, \*</sup> , Constantine Busungu<sup>3</sup> , Ibrahim Juma<sup>4</sup> 

<sup>1</sup>Tanzania Agricultural Research Institute (TARI), Dodoma, Tanzania

<sup>2</sup>Research and Innovation, Morogoro, Tanzania

<sup>3</sup>Department of Crop Science and Beekeeping Technology, University of Dar es Salaam, Dar es Salaam, Tanzania

<sup>4</sup>Department of Food Science and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania

## Abstract

Rice blast disease, caused by *Magnaporthe oryzae* (*M. oryzae*) is one of the most devastating diseases in rice production worldwide, causing high yield losses. In Tanzania, the disease exhibits significant impacts, largely due to limited diagnostic knowledge, resistant varieties, and poor control measures. This research study carried out during 2024/2025 aim to determine the incidence and severity of the disease across five representative rice-growing regions (Morogoro, Tanga, Kilimanjaro, Mwanza, and Mbeya). Disease incidence and severity from selected hundred (100) rice rice-growing farms were studied and recorded, while the symptomatic blast leaves were collected for isolation and morphological identification of the pathogen. The results revealed that both incidence and severity across regions, villages varied significantly at  $P < 0.05$  given that, Morogoro region showed the highest incidence (60.68% and severity (66.32%), and the lowest in Mwanza (46.52%, 51.95%). The study also detected Dakawa village has attacked more (61.29%), while Mvumi both from Morogoro was more infested (68.38%). Rice cultivars showed the significant differences in disease susceptibility levels, given that the variety TXD 306 (Saro 5) was relatively tolerant, with low incidence and severity (40.33%, 44.84%), whereas kalamata was highly susceptible (62.15% incidence and 67.71% severity). The noted significant regional difference ( $P < 0.001$ ) in disease pressure from the studied region could be influenced by different climatic factors, ecology, and varieties grown. Overall, this finding highlights the significant threat posed by rice blast disease in Tanzania and suggests an urgent need for modern management measures and the adoption of resistant rice varieties.

## Keywords

Disease Management Options, *Magnaporthe oryzae*, Disease Incidence Disease Severity, Rice Cultivars, Tanzania

\*Correspondence: Herman Mkamilo (mkamilo89@gmail.com)

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## 1. Introduction

Rice (*Oryza sativa*) is a food crop belonging to the Poaceae family that is cultivated in diverse climates worldwide. It is one of the most important crops worldwide and serves as a principal food source for over half of the world's population, especially in Asia and Africa [8]. The crop has the potential to feed more people worldwide; the Food and Agriculture Organization considers it a deliberate crop for food security in the world [7]. Tanzania is among the top three rice producers in Africa holding 22nd position worldwide [3] and ranked second in rice production in Sub-Saharan Africa (SSA) after Madagascar [16]. In Tanzania, population growth has been increasing yearly with the increase in rice production since the 1960s, but its consumption goes beyond production due to low rice productivity, changing dietary habits, and urbanization [34].

The average rice yield in Tanzania is about 3 tonnes per hectare, which is lower compared to other African countries, such as Madagascar, where the average yield is approximately 4.4 tonnes per hectare [23, 24]. Similarly, [3] highlighted the global rice production trends and noted that Tanzania still produces below the world's average of 4.5 tonnes per hectare, with an estimated national average of only 2 tonnes per hectare. Despite the importance of the crop, its production faces different challenges, causing low productivity (biotic, abiotic, and socioeconomic challenges). Rice blast disease caused by *Magnaporthe oryzae* (*M. oryzae*) is a biotic constraint and devastating disease that causes severe rice yield loss [21, 39]. [4] reported that the disease contributes to an overall reduction in rice productivity in Tanzania. The disease can infect all crop growth and plant parts, such as leaves, collars, necks, nodes, and grains, and the severe infection of the neck (neck blast) causes yield losses of up to 80-100% [35]. This study revealed that the leaves are the most affected plant part, followed by the panicle, collar, and nodal parts of the rice plant.

The disease was first reported in China in 1637 and later in Africa in 1922 [12], and now spread widely and affects most rice-growing regions worldwide. In sub-Saharan Africa, the disease is considered a major constraint to achieving optimal rice yield, with losses reaching up to 80%-100% if not managed effectively [26]. In Tanzania, the disease is highly devastating in many rice-growing areas and significantly affects plant health, seed quality, and the production potential of rice crops [25].

Using conidia, the fungus causing the disease spreads asexually, affecting the aboveground tissues of plants [6]. *M. oryzae* begins to infect rice plants by producing spores that settle on the leaves, panicles, and nodes, before penetrating the plant using specialized structures called appressoria [9]. Later, *M. oryzae* continued to infect the plant as its fungal spores attached using mucilage. After penetrating the plant cell, the fungus generates invasive hyphae that immediately colonize living host cells and produce effector molecules that suppress the host's immune system, preparing it for infection [10]. The

fungus reproduces rapidly through mitosis, nuclear migration, and death of conidia originating from the initial infection, producing appressoria and hyphal structures that infect the aerial parts of the plant and its roots, respectively [5].

The life cycle of *M. oryzae* involves infection, colonization, and sporulation. Favorable environmental conditions of 25–28°C and relative humidity of 92–96% are conducive for pathogen sporulation and lesion development [15, 29]. Under these favorable conditions, the disease cycle can be completed within a week, with a single lesion capable of producing many spores [17]. The pathogen can survive in both infected seeds and plant residues, whereas the disease can spread through infected seeds and airborne spores [27]. Lesions formed by the fungus on leaves reduce green pigmentation, decrease the photosynthetic area, and disrupt normal physiological processes during rice growth [2]. The reduction in the photosynthetic area hampers photosynthesis, leading to decreased crop productivity.

Disease infection is characterized by different features (symptoms), for example, spindle-shaped lesions with whitish centers and brown margins appearing on the leaves, leading to leaf blight and premature death [36, 40]. Rotting of the panicle is another key characteristic of panicle blast, resulting in empty grains, whereas collar and nodal infections can cause lodging of rice plants. In seeds and roots, the disease reduces germination and seedling vigor (International Rice research Institute [13]. Together with favorable climatic conditions (temperature, rainfall, and humidity), these symptoms contribute to significant yield losses [20]. Research has reported yield a loss of up to 90–100% under severe disease pressure [35]. Globally, rice blast disease destroys rice, which could otherwise feed approximately 60 million people, making it one of the most devastating threats to productivity and food security [6, 38].

The incidence and severity of the disease are influenced by multiple factors (host genotype, pathogen population, and favorable climatic conditions). According to [30], temperatures (25–28°C), relative humidity above 80%, frequent dew formation, and closed rice plant spacing are among the factors influencing disease incidence and severity. It is very important to be aware of the disease incidence and severity because it helps in identifying the disease spot area, planning for management measures, and designing a breeding program for the development of resistant cultivars. [31].

The effects of the disease depend on the variety, environmental conditions, and agronomic practices, given that local varieties are more susceptible to rice blast disease than improved varieties, which are relatively tolerant to disease. Similarly, [24] reported that locally available rice-grown materials are vulnerable and susceptible to rice blast disease. While there is no single resistant rice variety with observed variation in disease attack based on different rice cultivars, it is im-

portant to occasionally examine the disease incidence and severity caused by the fungus *M. oryzae*. With all the information provided from different rent studies, this paper aims to examine the incidence and severity of rice blast disease caused by the fungus *M. oryzae* from Tanzania's rice agro-ecologies, which will provide insights to rice breeders and scientists to develop broad-spectrum and long-term strategies for disease management.

## 2. Materials and Methods

### 2.1. Description of the Study Site

This study was conducted in Morogoro, Tanga, Kilimanjaro, Mwanza, and Mbeya regions, which were selected because of their long history of rice blast disease prevalences. Mvomero and Kilosa districts represented Morogoro region are located at 6°15'40"S and 37°32'36"E, and 6°36'1"S and 37°13'4"E, have altitudes of 341 m and 394 m, respectively. The average temperature in Mvomero is 26.8°C in April and 25.9°C in May, whereas Kilosa records an average of up to 23°C during both months. Morogoro Region experiences bimodal rainfall: autumn from November to late January and the spring season from March to May (165 mm), with a relative humidity of 80–85%.

Kyela and Mbarali districts, located at 9°43'25"S, 33°45'47"E, and 8°36'20"S and 34°13'33"E, have altitudes of 503 m and 1,049 m above sea level, respectively. When compared with Kyela district, Mbarali is generally hotter, with an average temperature of 24°C from March to May, and the highest temperature 31°C during June, while in Kyela temperatures reaches up to 29°C. The relative humidities in Mbarali and Kyela were 88% and 77%, respectively. Mbeya Region also receives two rainfall seasons: a short season from November to January (102 mm) and a long (spring) season from March to May. During spring season, Mbarali receives an average of 250 mm, while Kyela receives approximately 170 mm and 125 mm during autumn.

Misungwi and Kwimba districts, representing Mwanza Region, are located at 2°46'2"S and 32°47'13"E with altitude 1,125 m, and Kwimba located on 3°7'58"S and 33°30'47"E and elevated at 1,170 m. Misungwi receives an average rainfall of 200 mm during April and May, and 40 mm in June, while in Kwimba, the heaviest rainfall reaches 203 mm in April and drops to 34 mm in June. The average temperatures in Misungwi and Kwimba were 27°C and 24°C, respectively, from March to May. The warmest temperatures, up to 33°C, occur in June, and both districts experience relative humidity levels around 68% from March to June when rainfall peaks.

The Tanga Region, represented by the Korogwe and Muheza districts, is located at 5°12'56"S and 38°44'48"E and 5°9'24"S and 38°32'24"E, with altitudes of 383 m and 488 m, respectively. Korogwe experiences average temperature of approximately 27°C, rainfall of 151 mm, and relative humidity

ranging from 78–86% during March–May. Muheza experiences warm condition of 26.1°C with rainfall of 185 mm and between 69–80% relative humidity over the same period.

Moshi Rural and Same districts representing Kilimanjaro Region are located at 3°22'48"S and 37°20'50"E at an altitude of 744 m, and 4°22'0"S and 38°33'0"E, respectively, elevated at an altitude of 535 m above sea level. Moshi Rural experiences average temperature of 25°C in March and April, whereas the region becomes cooler (22°C) from May to June, with daytime peaks of up to 32°C. The area receives bimodal rainfall with short rains (October–December) and long rains (March–late May), averaging 175 mm, and relative humidity of 85% from March to May. The Same Districts (Ndungu and Hedaru villages) recorded temperatures of 27°C in March and 23°C in May, with prolonged rainfall of 130–220 mm from and a sharp decrease to 20 mm in June, while relative humidity ranged from 65–75% during March and April, and 73–78% during May and June.

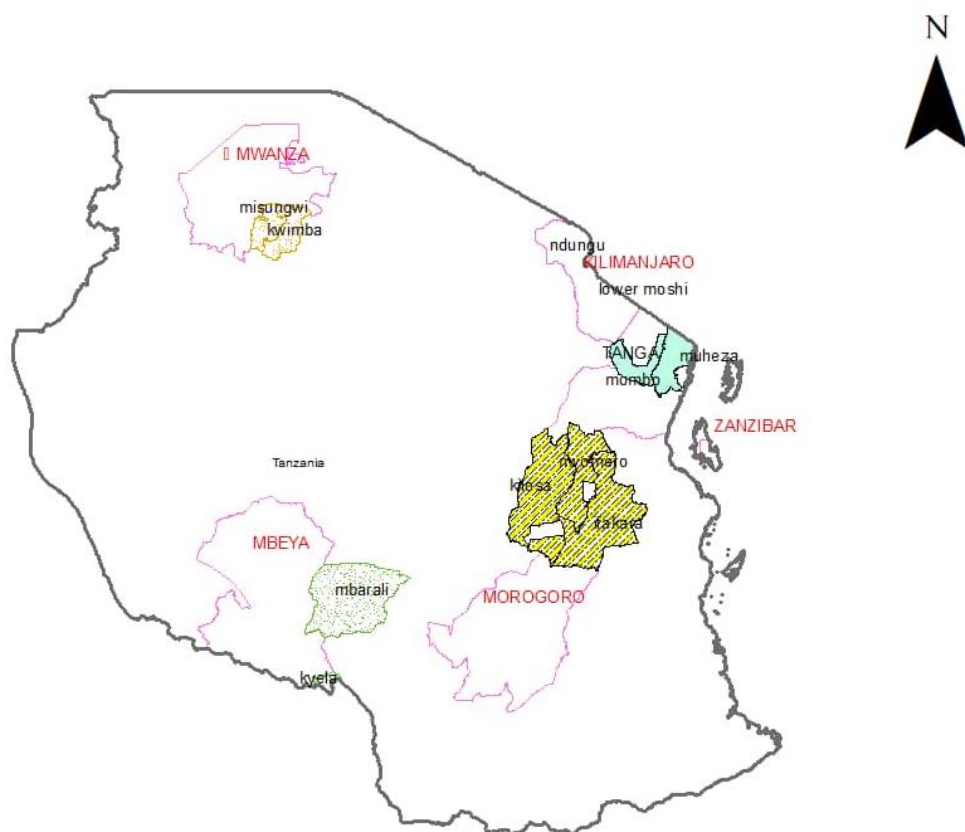
Climatic patterns across these regions strongly determine the prevalence and severity of rice blast disease. Warm temperatures within the range of 24–29°C, combined with high relative humidity above 80% and frequent rainfall during spring and autumn seasons, create ideal microclimatic conditions for *M. oryzae* infection. Prolonged leaf wetness periods caused by dews and rainfall facilitate conidial germination and appressoria formation, accelerating host penetration and lesion expansion. Regions such as Morogoro, Mbeya, and Tanga, with sustained humidity and rainfall, provide favorable conditions for pathogen sporulation and survival. In contrast, areas with sporadic dry spells, such as Mwanza and Kilimanjaro, experience regular climatic fluctuations, but recurrent disease outbreaks as inoculum persists in infected residues are reactivated under favorable conditions. Overall, the dynamics of temperature, rainfall, and humidity across these agro-ecological zones with rice-growing regions and rice cultivars influence the regional variability in rice blast disease pressure in Tanzania.

### 2.2. Determination of the Sample Size

A total four (4) villages were randomly selected from each region (Morogoro, Tanga, Kilimanjaro, Mwanza, and Mbeya). Selection of these villages was done based on rice production intensity and their long history of rice blast disease. From each village, a sample of five (5) rice fields was chosen randomly to make a total of hundreds (100) rice farmers' fields for the entire study.

### 2.3. Materials

During the field observation, a photo of rice blast-infected leaves, ruler, notebooks, and white paper was used as tools for the assessment and measurement of disease incidence and severity, while a cool box was used to keep the collected samples before taken the laboratory for laboratory analysis.



**Figure 1.** A Tanzania map showing the studied sites.

## 2.4. Assessment of Rice Blast Disease Incidence and Severity

During the cropping season 2024/2025, Field surveys were conducted to assess rice blast disease incidence and severity across five major rice-growing regions in Tanzania namely Morogoro, Tanga, Kilimanjaro, Mwanza, and Mbeya. Four (4) villages were selected based on rice production intensity and agro-ecological representation. The selected villages included Dakawa, Mkindo, Mvumi, and Ilonga (Morogoro); Misozwe, Masimba, Jitengeni, and Chekelei (Tanga); Kahe, Chekeleni, Ndungu, and Hedaru (Kilimanjaro); Nyakasanga, Nyahororo, Mahiga, and Malya (Mwanza); and Chimala, Makwale, Isitu, and Mahenge (Mbeya). Five rice fields were randomly selected from each village making a total of 100 surveyed rice fields. The selected fields included popular cultivated rice varieties (TXD 306, Wahiwahi, Kalamata, Supa, and Mbawambili). Using a systematic diagonal sampling method as Design,

12 plants were examined at intervals of approximately every 10 paces, and representative severely infected leaves were collected from each sampled plot/field as outlined by [32, 35, 41]; Disease assessment was performed on visibly infected plants within a representative half-acre plot in each field.

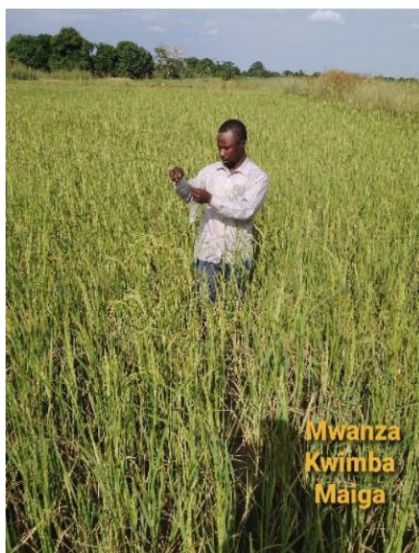
Observation of the area and the proportion of infected plants relative to the total number of plants assessed per field was used to study the incidence while the disease scoring scale was used to study the disease severity of the infected leaf. Representative five (5) Infected leaf samples from each studied field were collected, placed in a well labelled bag, stored in a cool box and kept in a refrigerator approximately 20°C. The stored samples were then taken to the Department of Molecular Biology and Biotechnology (DMBB) at the University of Dar es Salaam for laboratory studies. Data on disease incidence and severity were documented through measurement and visual evaluation of symptoms caused by *M. oryzae* [29].

Rice blast disease incidence across the field was calculated using the formula described by [11].

$$\text{Disease incidence(\%)} = \frac{\text{Number of infected plants with disease}}{\text{Total number of plants studied}} \times 100$$

Disease incidence is the proportion or percentage of infected plants in a given population showing how far the disease occurs in the field while disease severity is the intensity of infestation of the plant leaves caused by the Pathogen *M.*

*oryzae* showing the seriousness effects of the disease resulting in yield loss. Severity is a good indicator for assessing both the effects of the disease and the control measures taken.



**Figure 2.** Rice blast disease observation and sample collection.



**Figure 3.** Rice blast disease symptomatic leaves.

*Photo by H. Mkamilo. Morogoro and Mwanza*

Different techniques have been used to study the disease severity, including visual/categorical rating (scoring) using the scoring scale developed by IRRI [13, 14] Many researchers have used this method because it is simple, realistic, and inexpensive for a large survey. In this study during the survey, the disease severity of the plant was assessed using visual scoring method based on the Standard Evaluation System for Rice as modified by [13, 14]. Severity scoring was based on lesion number, size, and the percentage of leaf area affected.

According to [11], rice blast disease severity will be calculated using the following formula:

$$\text{Disease severity (\%)} = \frac{n \times v}{N \times V} \times 100$$

where “n” is the number of leaves infected by the blast, “v” is the value of the score of each category attack, “N” is the number of leaves observed, and “V” is the highest score.

Given a scoring scale of 1-9. The Scale 1= small, brown, specks of pinhead size; 3 = small roundish to slightly elongated, necrotic, gray spots approximately 1-2 mm diameter; 5

= typical blast lesion infecting <10% of the leaf area; 7 = typical blast lesions infecting 26-50% of the leaf area; 9 = typical blast lesion infecting >51% of the leaf area and many leaves dead.



**Figure 4.** Estimation of rice blast disease severity.

KEY: 1- small brown lesion (no effect) 3-small roundish to slightly elongated (no effect), 5- typical blast lesion (affects 10%), 7- typical blast lesion affects (26-50%), 9-typical elongated blast lesion (affects >50%) as shown in Figure 4 above.

## 2.5. Morphological Characteristics/Features of *M. oryzae*

*Isolation, culturing and pure culture*



**Figure 5.** Isolation process of fungal isolates.



**Figure 6.** Sub-culturing of fungal isolates.



**Figure 7.** Microscopic feature of *M. oryzae*.

Infected leaf samples collected from representative rice fields were preserved separately and transported to the laboratory for further analysis. Isolation of the pathogens was performed by cutting the tissue into small pieces and sterilizing them by submerging them in hydrogen peroxide ( $H_2O_2$ ) to remove surface contamination, rinsing them several times with sterile distilled water and later air drying. Culturing the isolates using Potato Dextrose agar (PDA) were followed. Incubation process was performed at a room temperature ( $25-27^\circ C$ ) for 24 hours to promote fungal growth and sporulation followed by subculturing to get pure culture. Subculturing process were repeated to ensure pure culture of the isolate. Using a microscope, the mycelium was presumed, followed by placing the sterile needle on the sporulating blast lesion in plates containing PDA. Following the procedures developed by [22] and [28], the presence of *M. oryzae* was simultaneously confirmed using light microscopy based on the mycelial characteristics, morphology, and pyriform, three-celled conidia, as shown in Figure 5, Figure 6 and Figure 7. For observation, spores were carefully picked using a sterile needle from sporulating cultures and mounted on microscope slides.

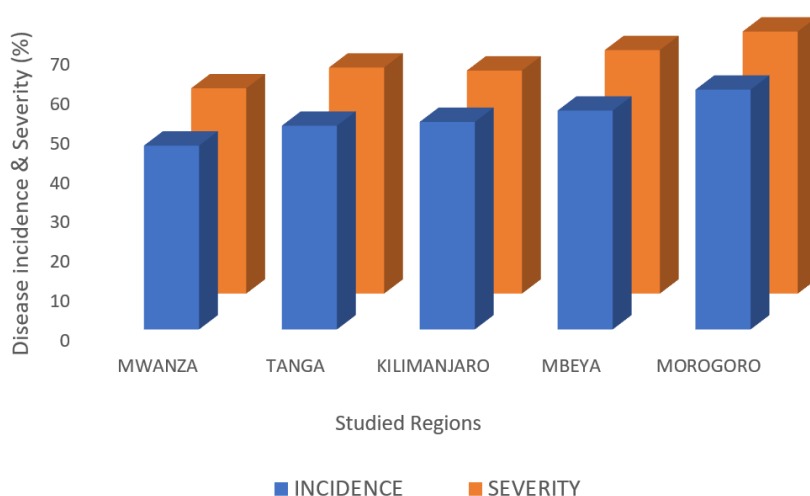
## 2.6. Data Analysis

The data on disease incidence and severity were analyzed using ANOVA with GenStat® executable release 14 statistical analysis software, and the results were interpreted. The means from each site surveyed were computed and compared using Duncan's multiple range test (DMRT) at 5% probability.

## 3. Results and Discussion

### 3.1. Disease Prevalence Across the Studied Regions

Rice blast disease incidence and severity of across the studied regions, districts, and villages varied significantly ( $P < 0.001$ ), and symptomatic rice blast leaves from all studied regions were clearly observed. The results showed that rice blast disease incidence and severity from the studied regions (Mwanza, Tanga, Mbeya, Kilimanjaro, and Morogoro) were statistically significantly different although when comparing prevalences in the Kilimanjaro and Tanga regions, the disease pressure varied relatively ( $P < 0.05$ ) as shown in Table 1. Morogoro region had the highest both in disease incidence and severity, followed by Mbeya (60.68%, 66.32% and 55.38% and 61.62%) In contrast, Mwanza exhibited the lowest incidence (46.52%) and severity (51.95%), indicating relatively lower disease pressure. The observed variation in disease incidence and severity across regions indicates a strong association with environmental conditions, especially temperature rainfall, and relative humidity. Regions with high rainfall and relative humidity like Morogoro and Mbeya, has increased blast disease levels compared to relatively drier regions such as Mwanza.



**Figure 8.** Histogram showing variation of disease pressure across the studied regions.

**Table 1.** Rice blast incidence and severity into 5 different rice growing regions in Tanzania.

REGION	Incidence (%)	Severity (%)	Temperature (°C)	Rainfall (mm)	R. H (%)
MWANZA	46.52a	51.95a	23-24	129.6	70-75
TANGA <sup>o</sup>	51.55b	57.21b	22-30	121	77-81
KILIMANJARO	52.51bc	56.44b	24-33	117	79-82.2
MBEYA	55.38c	61.62c	16-27	256	86-90
MOROGORO	60.68d	66.32d	21-31	220	85-89
Fpr.	<0.001	<0.001			
CV (%)	17.3	18.2			
LSD (%)	3.3	3.8			

Means of the same column followed by the same letter are not significant different by Duncan's multiple range test at  $P < 0.05$ .

Fpr = probability value, CV (%) percent of coefficient of variation

### 3.2. Disease Prevalence Across Different Studied Villages and Ecologies

There is noted significant difference in rice blast disease incidence and severity from the studied villages ( $P < 0.001$ ) at  $P < 0.05$ . the highest disease incidence observed in Dakawa (61.29%) and the lowest in Malya (42.03%) while the highest disease severity (68.38%) was recorded in Mvumi and the lowest in Mahiga. Villages such as Dakawa, Ilonga, and Mvumi recorded the highest disease incidence and severity, indicating high disease pressure, whereas Malya and Mahiga showed relatively lower values. The observed variability reflects the influence of local environmental conditions, management practices, and agro-ecological differences.

**Table 2.** Rice blast incidence and severity across different studied villages.

Village	Ecology	Incidence (%)	Severity (%)
Malya	Rainfed	42.03 a	48.27 ab
Mahiga	Irrigated	43.51 ab	46.78 a
Nyakasanga	Irrigated	46.3 abc	50.28 abc
Jitengeni	Irrigated	48.16 abcd	53.55 abcd
Chekeleni	Irrigated	49.16 abcde	50.92 abc
Chekelei	Irrigated	50.38 bedef	55.97 bcde
Kahe	Irrigated	50.43 bedef	52.73 abc
Makwale	Irrigated	51.41 cdef	57.54 cdef
Misozwe	Rainfed	53.12 cdefg	57.76 cdef
Chimala	Irrigated	53.43 cdefgh	55.42 bcde

Village	Ecology	Incidence (%)	Severity (%)
Ndungu	Irrigated	53.69 cdefghi	55.73 bcde
Nyahororo	Rainfed	54.23 defghi	62.47 efg
Masimba	Rainfed	54.54 defghi	61.54 defg
Hedaru	Rainfed	56.75 efghi	66.37 g
Mahenge	Rainfed	57.19 fghi	65.43 fg
Isitu	Rainfed	59.5 ghi	68.11 g
Mkindo	Irrigated	59.65 ghi	65.41 fg
Mvumi	Irrigated	60.8 hi	68.38 g
Ilonga	Irrigated	61 hi	65.23 fg
Dakawa	Irrigated	61.29 i	66.27 g
Fpr		0.001	0.001
CV		16.8	18.7
LSD		6.4	7.1

Means of the same column followed by the same letter are not significant different by Duncan's multiple range test at  $P < 0.05$ .

Fpr = probability value, CV (%) percent of coefficient of variation.

### 3.3. Disease Incidence and Severity Across Different Agro-ecologies from the Studied Region in Tanzania

In Tanzania rice production is practiced in two main ecologies: rainfed (upland and lowland) and irrigated lowlands. The results showed a relative association of rice blast disease incidence and relatively significant differences in disease severity across studied rice agro-ecologies in Tanzania (Table 3). Av-

eragely, the rainfed ecosystems showed higher disease severity (61.42%) higher than in irrigated ecosystem (57.25%) while incidence was nearly similar between the two systems (53.9% and 53.66%, respectively). In rainfed ecosystems, Isitu showed the highest disease severity (68.11%) and its lowest in Malya (48.27%), whereas in irrigated ecosystems, Mvumi led by 68.38% and the lowest in Mahiga 46.78%

**Table 3.** Relationship of rice agro-ecologies and rice blast disease prevalences in Tanzania.

Agro-ecology	Incidence (%)	Severity (%)
Rainfed	53.9	61.42
Irrigated	53.66	57.25
CV	21.76	22.18
LSD	5.68	6.7

Means of the same column followed by the same letter are not significant different by Duncan's multiple range test at  $P < 0.05$ .

Fpr = probability value, CV (%) percent of coefficient of variation.

### 3.4. Field Assessment of Rice Cultivars for Disease Incidence and Severity

The results (Table 4) revealed a statistically significant difference ( $P < 0.001$ ) among rice cultivars in response to rice blast disease. Kalamata and supa, the popular available local

rice varieties, exhibit high susceptible to rice blast disease (62.15%, 67.2% and 57.5%, 63.9%) incidence and severity, respectively, compared to improved rice variety TXD 306 exhibited relatively low disease incidence (40.33%) and severity (44.84%). Wahiwahi and Mbawambili showed intermediate levels of susceptibility.

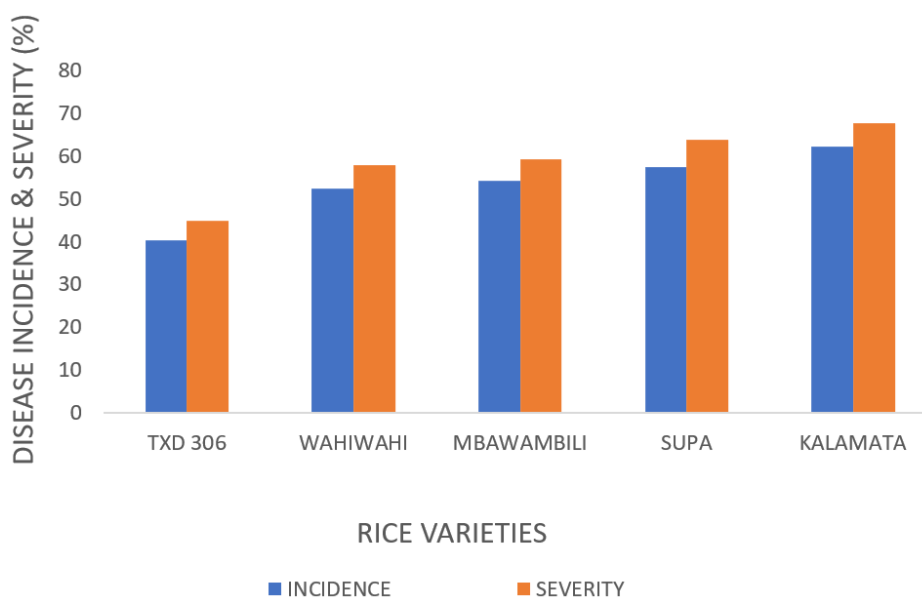
In contrast, local varieties such as Kalamata and Supa showed the highest susceptibility, with incidence and severity values of 62.15% and 67.71% (Kalamata), and 57.48% and 63.87% (Supa), respectively.

**Table 4.** Rice blast disease pressure against five (5) popular rice cultivars.

Variety	Incidence (%)	Severity (%)
TXD 306	40.33 a	44.84 a
WAHIWAHI	52.43 b	57.84 b
MBAWAMBILI	54.27 b	59.29 b
SUPA	57.48 c	63.87 c
KALAMATA	62.15 d	67.71 d
CV	13.7	15
LSD	2.6	3.1

Means of the same column followed by the same letter are not significant different by Duncan's multiple range test at  $P < 0.05$ .

Fpr = probability value, CV (%) percent of coefficient of variation



**Figure 9.** A bar chart showing responses of 5-rice cultivars against rice blast disease.

## 4. Discussion

The significant regional differences in disease prevalences ( $P < 0.001$ ) observed in this study could be attributed to variations in climatic conditions such as temperature, rainfall distribution, and relative humidity, which directly influence the development and spread of rice blast disease. For example, the highest rice blast disease incidence recorded in humid and rainfall-prone zones, such as Morogoro and Mbeya, was associated with favorable climatic conditions for pathogen survival (25 – 27°C) with relative humidity of 85 – 89% and average monthly rainfall of above 200 mm. Morogoro region had the highest both in disease incidence and severity, followed by Mbeya (60.68%, 66.32% and 55.38%, and 61.62%,) respectively (Table 1). This finding agreed with the study conducted by [18] reported that, temperatures 23-26°C promotes the growth of the pathogen *M. oryzae* and disease development. The lowest disease incidence and severity (46.52%, 51.95%) (Figure 8) respectively observed in Mwanza region could be attributed to less favorable environmental conditions for *M. oryzae* development and survival. This finding is in agreement with the study by [33], which showed that the development and spread of the disease is affected by poor climatic conditions that limit pathogen development and survival.

Tanga and Kilimanjaro had intermediate values for both incidence and severity due to the moderate (similar) climatic profile evidenced by temperatures that ranged from 22 to 33°C, with relative humidity, which influences the growth of the pathogen compared to Mbeya and Morogoro. The similarity of disease pressure in the Tanga and Kilimanjaro regions indicates that these two regions may have to share relatively comparable environmental conditions influencing disease outbreaks, while the variation in severity points to potential variations in varietal susceptibility level, control measures taken, or microclimatic conditions within the zone. Generally, on the monthly average climatic conditions (24 – 28°C, 77-90%, and 200 – 270 mm) play a significant role in influencing and accelerating the infection rates of the fungi. Such information is important in designing region-specific disease control programs and guiding agricultural extension officers to support farmers with preventive and management practices based on prevailing climatic risk profiles.

The results revealed significant differences ( $P < 0.001$ ) in rice blast disease pressure across the villages. Comparing the villages, Malya showed low incidence (42.03%), whereas Mahiga village showed lower disease severity (48.76%). Conversely, Dakawa, Mvumi, and Ilonga showed the highest disease pressures (Table 2) which associated with persistence moisture levels whereas the lowest in Mahiga and Malya which experienced low humidity limiting disease development. This variation suggests that no single factor can influence disease pressure; combination factors such as favorable environmental and ecological conditions, varietal characteristics, and management practices can increase rice blast disease incidence and severity. Average temperature 25-32°C, rainfall

100-400 mm and relative humidity of up 87% from the villages Dakawa, Mvumi, and Ilonga influenced the disease attack and accelerated infestation. The study conducted by [33] agreed that favorable climatic conditions play an important role in disease development and progression.

Generally, the observed differences in both disease incidence and severity across the studied regions suggest the critical influence of environmental attributes especially rainfall temperature and relative humidity. These climatic factors are positively consistent with the existing the knowledge that the pathogen *M. oryzae* survive under favorable conditions (high moisture and moderate temperature) favors their spread and infection.

With all the villages, different rice agro- ecologies and cultivation systems behaved similar level of rice blast incidence with slight in disease severity: rainfed (53.9%, 61.42%) and irrigation (53.7%, 57.25%) (Table 3). Although rice ecologies contribute to disease prevalence differently, this study indicated that there was no significant difference in disease incidence with a moderately significant variation in disease severity (Table 3). This study revealed that variations in both atmospheric and soil moisture can reduce plant moisture and weaken its defense mechanism (natural immunity) against diseases. This is supported by [37], reported that, fluctuating soil moisture and humidity levels can weaken the natural defense of plants while enhancing pathogen infection.

The similar levels of disease incidence in both ecosystems indicate that the disease is not limited only by moisture levels, but rather by the environmental conditions and varieties grown, which may support inoculum survival and spread. This observation aligns with previous studies showing that both rainfed and irrigated environments can cause disease outbreaks when the temperature and humidity are within optimal ranges for pathogen activity [19]. Variations in the incidence and severity of diseases in villages within the same agro-ecological zone suggest that microclimate, soil type, and farming practices, such as planting density, crop variety, and fungicide use, also play critical roles in shaping disease outcomes. Again, the near-similar incidence between the rainfed and irrigated systems suggests that pathogen prevalence is general, but disease severity is more responsive to microclimatic conditions and agronomic practices.

In addition, the study revealed that, poor agronomic practices, especially improper use of nitrogenous fertilizer, could influence disease incidence and severity in rice farms because overfertilization of nitrogen in plants promotes greenly leaves, leaf wetness, and heavy shade, which facilitates *M. oryzae* development and conducive conditions for pathogen survival. Farmers from the studied regions mentioned that one of the factors that could accelerate the occurrence and spread of the disease in the field was the excessive use of fertilizers. They reported that some farmers apply excessive urea up to four times during a single production season, using approximately 125 kg/ha each time, which may promote dense vegetative

growth and create favorable conditions for rice blast development. This finding was also reported by [33] that “Continuous overfertilization of nitrogenous lead to influence the pathogen survival.” Timing and fertilizer application regimes were also found to affect normal physiological processes by making plants more tender and succulent, which later affects their natural defense against disease attack.

Rice varieties is among the important factor influencing disease pressure, this study showed that, local varieties Kalamata and supa were more susceptible to rice blast disease compared to Wahiwahi, mbawambili, and improved rice variety TXD 306 (Table 4 & Figure 9). Their Susceptibility could be attributed to their long-term cultivation without modern resistance breeding. In contrast, TXD 306 is relatively resistant to rice blast disease by limiting *M. oryzae* invasion and lesion development, which may be attributed to their intensive improvement. This finding aligned with that reported by [1] “improved varieties showed lower attacked and infested by the disease due to enhanced resistance traits and stress tolerant genes. However, the relative incidence and severity of TXD 306 stipulates that the resistance is not sufficiently expressed; therefore, disease management measures are still an essential tool to reduce yield loss in the rice growing regions (Figure 1, 2 & 3).

The moderate disease incidence and severity observed in Wahiwahi and Mbawambili may reflect partial resistance that slows disease progression and corrupts the entire plant. This can be used as a starting point for plant breeders to use these genetic materials to breed durable and long-term rice blast-resistant varieties. Inclusively, these results indicate that regions with high humidity rainfall are at closer risk of rice blast disease outbreaks, suggesting the need for long-term intervention measures such as the use of broad-spectrum resistant rice varieties, proper management measures, and seasonal training to raise awareness of farmers on disease occurrence and management practices. The observed critical differences among rice cultivars proves that the genetic resistance genes of a given rice cultivars play an important role in disease outcome given that TXD 306 attacked low showing disease resistance while Kalamata was highly affected indicating poor gene resistance.

## 5. Conclusion

Most rice-growing areas in Tanzania are vulnerable to rice blast disease, although disease pressure levels differ depending on the individual zonal factors. Favorable temperature, rainfall, and relative humidity significantly affect the occurrence, development, spread, and survival of the disease. Morogoro and Mbeya, characterized by humid and high rainfall regions, exhibited high disease incidence and severity, whereas the Mwanza region was recognized as having lower rice blast disease pressure caused by poor environmental conditions for pathogen development. This research findings affirm the favorable temperature (23-28°C), higher rainfall, and

relative humidity 80 – 90% impart an optimal environment for pathogen infection and spread. Similarly, rice cultivars are the major component influencing the disease pressure given that kalamata and supa were susceptible, while TXD 306, the improved variety, was relatively low for both incidence and severity. To secure society by maintaining food security, a combination of integrated disease management (IDM) approaches, such as adjusting irrigation scheduling, improving drainage, implementing timely disease control measures, possible agronomic practices, and expanding farmers’ knowledge and awareness, are urgently required to reduce crop loss and ensure sustainable rice production. Importantly, these findings underscore the importance of variety selection for managing crop diseases. Differences in disease expression observed among the rice varieties highlight the potential of utilizing resistant genotypes, such as TXD 306, as part of integrated disease management strategies. For rice blast disease management, this study is finally recommending the adoption of integrated, environment-based approach, multiple resistant varieties, modern and improved agronomic practices which will ensure not only food safety and security but also increase Tanzania households’ income.

## Abbreviations

ANOVA	Analysis of Variance
CV	Coefficient of Variation
DMBB	Department of Molecular Biology and Biotechnology
Fpr	False Positive Rate
IDM	Integrated Disease Management
IRRI	International Rice Research Institute
LSD	Least Significant Difference
<i>M. oryzae</i>	<i>Magnaporthe oryzae</i>
PDA	Potato Dextrose Agar
R. H	Relative Humidity
SSA	Sub-saharan Africa

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## Author Contributions

**Herman Mkamilo:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing

**Constantine Busungu:** Data curation, Investigation, Meth-

odology, Supervision, Validation, Visualization, Writing – review & editing

**Ibrahim Juma:** Data curation, Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing

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## Data Availability Statement

Data sharing is not applicable to this manuscript as no datasets were generated during the current study. However, for the purposes of this study, the data supporting the results will be made available by the corresponding author upon reasonable request and for security purposes.

## Conflicts of Interest

There is no noted potential conflicts of interest was reported by the authors.

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## Biography



**Herman Mkamilo** is a Research Officer at the Tanzania Agricultural Research Institute (TARI) with over ten years of professional experience in agricultural research, crop improvement, and seed systems development. His work is strongly oriented toward strengthening food security through applied research, innovation, and farmer-centered solutions. He holds a Bachelor's degree in General Agriculture from Sokoine University of Agriculture (SUA), where he developed a strong background in agronomy, crop science, and plant breeding. At TARI, Herman has been actively involved in crop breeding and varietal development, contributing to the development of improved, resilient, and high-yielding crop varieties adapted to diverse agro-ecological zones in Tanzania. Throughout his career, Herman has collaborated with a wide range of national and international development partners, including USAID, FAO, World Vision, and VSO. In 2014, he played a significant role in organizing and registering farmer groups under FAO-supported programs, enhancing farmers' access to agricultural technologies and institutional support. In 2015, he contributed to the development of constitutional frameworks and by-laws for VSO-supported farmer organizations, promoting good governance, accountability, and long-term sustainability. Herman has extensive technical experience in the establishment, management, monitoring, and evaluation of field, greenhouse, and laboratory-based research experiments. He has worked closely with the Agricultural Seed Agency (ASA) and private seed companies such as Syngenta and Tansed Ltd, gaining valuable expertise in seed production, quality assurance, and public-private partnerships. Notably, he served as Section Leader for the maize seed program, where he successfully supervised all operational activities, coordinated research and production processes, and provided technical leadership to multidisciplinary teams. Between 2023 and 2025, Herman conducted a large-scale field survey across seven regions of Tanzania—Morogoro, Tanga, Kilimanjaro, Mwanza, Mbeya, Kagera, and Rukwa—focusing on major rice diseases, particularly rice blast disease and rice brown spot disease. His research aimed to assess the relative destructiveness and emerging trends of these diseases under farmers' field conditions. The findings revealed rice brown spot as an emerging and increasingly widespread disease, while rice blast remained the most destructive threat to rice production. Based on these results, Herman emphasized the need for immediate and targeted disease management interventions to protect rice yields and safeguard national food security.



**Constantine Busungu** is a senior Lecturer and researcher at the Department of Crop Science and Beekeeping Technology at the University of Dar es Salaam (UDSM), Tanzania. He holds a BSc in Agriculture General (SUA), MSc Crop Science/Biotechnology (SUA), Tanzania, and PhD of Bioresource Production at the Kagoshima University in Japan. His research interest is based on mutation breeding, seed systems, crop wild relatives, plant genetic resources management, climate change adaptation, and the development of resilient, high-yielding crop varieties to support sustainable agriculture and food security.



**Ibrahim Juma** is a lecturer at the University of Dar es Salaam, Tanzania with a PhD in Plant Breeding, MSc and bachelor's degrees in Molecular Biology and Biotechnology. His research focuses on plant genetics, molecular biology, crop improvement, and sustainable agriculture. His work includes studies on avocado genetic diversity and sustainability prediction for cultivation in Tanzania, as well as research on indigenous edible mushrooms and plant-associated microorganisms aimed at improving agricultural productivity and food security.