

(RESEARCH ARTICLE)



## Reaction of some rice (*Oryza sativa* L.) varieties to brown spot disease caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker

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### Abstract

In Africa, rice is produced and is a source of food energy in most developing countries. But its cultivation faces to brown spot disease, caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker, which is a serious seed-borne and seed transmitted disease of rice worldwide. The aim of this study was to screen rice varieties for resistance to brown spot disease in field conditions in Yaoundé. A completely randomized Fisher block design with three repetitions was used during 2 growing seasons (2015 and 2016). Growth, yields and disease (incidence and severity) parameters were evaluated on four rice varieties (Nerica 3 and 8, White rice and Kamkou). Results show that height of the Nerica 8 variety (86.03cm) and the number of tillers of Kamkou variety (21.66) were significantly highest compared to others varieties ( $P < 0.05$ ) at 59 Days After Sowing (DAS). There was no significant difference on disease incidence for the different rice varieties at the end of rice plant cycle. However disease severity was lower on Nerica 3 (2.71%) and Nerica 8 (2.05%) varieties and higher on White variety (4.57%). Hence, Nerica 3 and 8 varieties were more tolerant to brown spot disease than others varieties. Overall, Nerica 3 (3.68 t ha<sup>-1</sup>) and Kamkou (3.51 t ha<sup>-1</sup>) varieties resulted in higher yields than white rice 28.93 t ha<sup>-1</sup>.

**Keywords:** *Oryza sativa*; Varieties; Disease; Resistance; Yield

### 1. Introduction

Rice (*Oryza sativa* L.) is one of the most widely grown cereals and is the staple food of more than half of the world's population; more than 3.5 billion inhabitants depend on rice for obtaining 20% of their daily calorie intake [1]. In Africa, rice is produced and is a source of food energy in most developing countries. Despite this production, Africa continues to depend on rice imports in order to meet the population increasing demand [2]. Due to its significant demographic growth, its rapid urbanization and the evolution of the eating habits of its population [3], Cameroon in particular depends enormously on rice imports because of biotic, abiotic and edaphic constraints that limit productivity, as well as the use of low-yielding varieties and unsuitable farming practices [4]. Losses due to field diseases vary from 15 to 50% of the total annual production in Cameroon. One of the most severe rice disease brown spot caused by fungus *Bipolaris oryzae*. Brown spot disease is widely distributed and represents the second most damaging rice disease after blast disease [5]. The incidence of this disease reduces the number of tillers and stem growth, as well as the seed weight

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and quality [6]. The chemicals that are available to reduce the effects of brown spot disease on young plants effectively and extensively, but field application of these chemical fungicides may not always be desirable. Despite the high cost of these products, their excessive use poses a threat to human, animal and environmental health. The best option is usually the use of resistant genotypes. Rice varieties with resistance to Brown spot disease in Cameroon are not yet known. The aim of this work was to screen rice varieties for resistance to brown spot disease in field conditions.

## 2. Material and methods

### 2.1. Experimental site

The experiment was carried out in the experimental station of the University of Yaoundé I, located in the humid forest with bimodal rainfall agro ecological zone of Cameroon. The climate is made of four seasons: a long rainy season from august to November, a short rainy season from mid-March to June, a long dry season from December to February and a short dry season from mid-June to august.

### 2.2. Plant material

The plant material consisted of four varieties of rice, which were different susceptibility to brown spot disease. Two improved rice varieties, Nerica 3 and Nerica 8, were obtained from Institute of Agricultural Research for Development (IRAD Nkolbisson). Two local varieties of upland rice (White variety and Kamkou variety) farmers in Tonga (Western highlands agroecological zone). The characteristics of these varieties are shown in (Table 1).

**Table 1** Characteristics of the four varieties of rice used

Varieties	Origin	Length of cycle in days	Grain colour	yield(t/ha <sup>-1</sup> )
NERICA 3	IRAD de Nkolbisson	110 to 130	white	3 to 4.5
Kamkou	Tonga	120 to 160	white	-
Nerica 8	IRAD de Nkolbisson	120	white	3 to 4
White rice	Tonga	-	white	-

### 2.3. Experimental design and culture conditions

An open field experiment in 2016 and 2017 was conducted using a completely randomized Fisher block design with four varieties of rice. Each variety had three repetitions. The experimental design included twelve experimental units (4m x 4m) separated by 1.5m apart. The sowing was done with 6 rice seeds per pocket at a depth of 3cm at 0.25m x 0.25m spacing within each experimental unit. Weeding was done throughout the experiment according to the abundance or not of weeds using hand hoes.

### 2.4. Parameters measurement

#### 2.4.1. Emergence rate

The emergence rate was evaluated from the first week after sowing precisely every two days until the 14<sup>th</sup> DAS. It was determined according [7].

$$Er (\%) = \frac{n}{N} \times 100$$

Where Er (%) = emergence rate; n = number of plants raised; N = total number of seeds sown.

### 2.5. Evaluation of plant growth

Plant growths were evaluated on 30 plants randomly labeled in the experimental units.

The height of the plants (cm) was collected using a meter from 4 weeks after sowing (WAS). Data were collected 30, 45 and 60 days after sowing (DAS). The number of tillers produced recorded at two weeks intervals from the beginning of tillering by counting the tillers in 30 selected pockets.

## 2.6. Evaluation of yield parameter

The flowering rate of rice varieties were evaluated by counting the flowering tillers in 30 selected potted. The mass of the 1000 grains of rice varieties were evaluated, yield were evaluated according to the formula proposed by [8]

$$\text{Yield (t ha}^{-1}\text{)} = \frac{\text{TW} \times \text{NS}}{\text{TNP}}$$

Where Yield (t ha<sup>-1</sup>) = yield in ton per hectare, TW= Total weight per variety, NS= number of seedlings per hectare and TNP = Total number of plants per variety.

## 2.7. Collection of meteorological data

The temperature and relative humidity data were measured using a thermo-hygrometer. Those related to rain fall and sunshine were obtained at the central meteorological station of Yaoundé

## 2.8. Assessment of brown spot disease

Disease parameters included incidence and severity of brown spot disease on 30 plants per plot. The number of infected plants were recorded at 7 days intervals from 78 to 110 DAS and used to calculate the disease incidence using the following formula: [9],

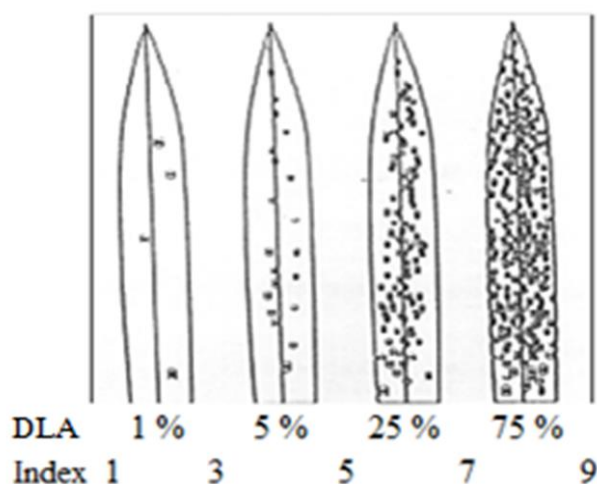
$$P = \frac{n}{N} \times 100$$

P = disease in the plot (expressed in%), n = number of infected plants in the plot, N = total number of plants (sick and healthy) in the plot.

The severity of the disease was determined by estimating the percentage of diseased leaf area (DLA) from the rating scale of IRRI, (1996) (Fig. 1) and calculated according [10] formula:

$$S = \sum \frac{a \times b}{n}$$

S is infection intensity in (%) is the number of diseased plants; b is the infection rate and n the total number of diseased plants.



**Figure1** Scale of severity of foliar attack on the rice plant [11] (DLA: diseased leaf area)

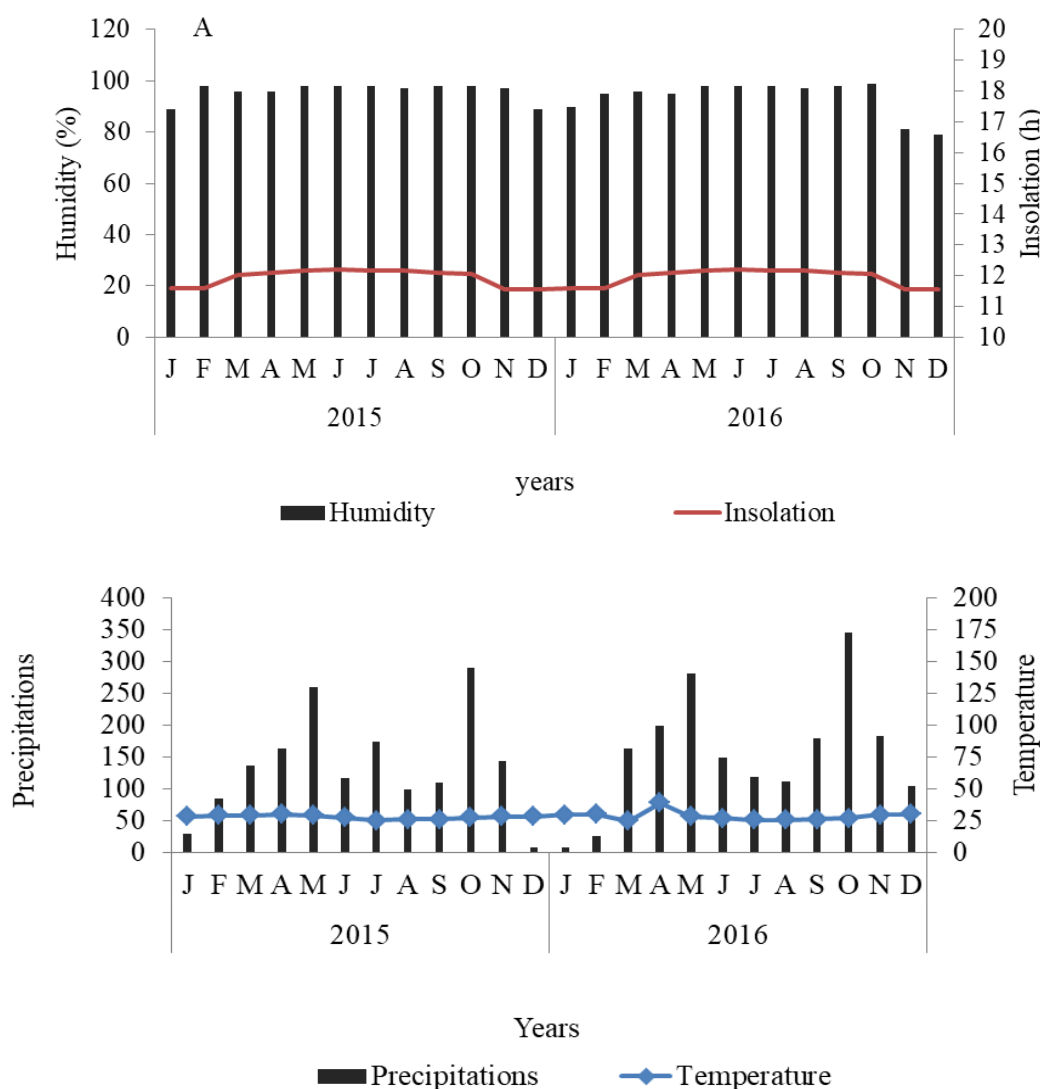
## 2.9. Statistical analysis

The data obtained for the different parameters studied were subjected to one-way analysis of variance (ANOVA) using SPSS 16.0 software. The means of each variety were compared with one another by using Duncan's multiple range test ( $\alpha = 0.05$ ).

## 3. Results

### 3.1. Evolution of environmental parameters

The climatic data that prevailed during the experiments are illustrated in Fig.2. The average temperature hover around 25°C during the 2016 campaign. The moisture remained high during the two campaigns (near 90%), except in January, November and December (Figure 2A). March and October were the rainiest months, during the two campaigns, with rainfall of about 300mm of water (Fig. 2B).



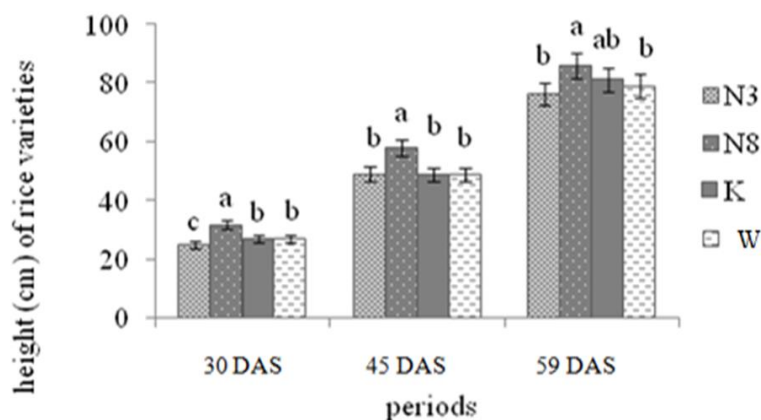
**Figure 2** Climatic parameters: (A) Humidity and insolation and (B) Umbro-thermal diagram.

### 3.2. Emergence rate

The average emergence rate from the two rice seasons (2016 and 2017) had a significant effect according to Duncan's test at the 5% threshold. Fourteen (14) DAS an emergence rate of 84.86%; 93.33%; 85.99% and 94.59% respectively for the varieties Nerica 3 (N3), Kamkou(K), Nerica 8 (N8) and the white variety (W).

### 3.3. Plant height

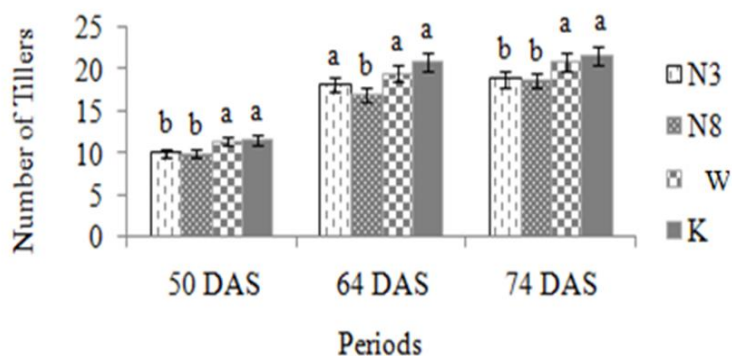
A significant ( $P < 0.05$ ) difference between the varieties of rice was obtained during the two campaigns of experimentation. The Nerica8 variety presented the highest plant height with respective values 31.56; 86.03 and 57.94 cm at 30, 45 and 59 DAS (Fig. 3). At 30 DAS, the Nerica 3 variety gave the smallest plant height, 24.77cm. In addition, the Kamkou variety and the White variety gave respective average height of 26.86 and 27.02cm. The average heights of 49.06; 48.88 and 48.81cm were recorded respectively for varieties Kamkou, White and Nerica 3 at 45 DAS.



**Figure 3** Variation in the average plant height of rice varieties over time

### 3.4. Number of Tillers

The analysis of variance between the mean values of the different varieties revealed a significant difference ( $P < 0.05$ ) on the number of tillers over the time. The White and Kamkou varieties (11.53 and 11.54 tillers) recorded higher number of tillers as compared to the Nerica 3 and Nerica 8 varieties (10.11 and 9.98 tillers) which presented lower number of tillers at 50 DAS. At 74 DAS, the number of tillers was respectively 18.91; 18.07; 20.98; 21.66 tillers for the Nerica3, Nerica8, White and Kamkou varieties (Fig. 4).



**Figure 4** Variation in the average tiller number of rice varieties over the time

### 3.5. Effect of brown spot disease

Brown spot disease was observed from 78 DAS (fig. 5). The results showed no significant difference ( $P > 0.05$ ) between the varieties for disease incidence. The incidence values obtained varied from 96.82 to 98.80% at 110 DAS respectively for the varieties Nerica8 and Kamkou respectively (Table 2).



**Figure 5** Symptom of brown spot disease

**Table 2** Evaluation of the incidence of the disease

Varieties	Incidence (%)		
	78 DAS	94 DAS	110 DAS
Nerica 3	9.33±2.12a	91.67±2.89a	98.12±1.57a
Nerica 8	9.33±2.36a	89.67±2.52a	96.82±3.12a
White rice	11.33±1.6a	83.83±2.02a	98.78±1.07a
Kamkou	10.67±1.89a	93.30±1.70a	98.80±1.91a

The values with different letters are significantly different in the same column according to Duncan's test ( $p < 0.05$ ). These values are the averages of the two campaigns.

### 3.6. Severity of brown spot disease

A significant difference ( $P < 0.05$ ) was observed between the different rice varieties at 78 DAS for disease severity. Varieties White and Kamkou showed the highest disease severity (1.33 and 1.12% respectively), as compared to Nerica 8 and Nerica 3 varieties which showed relatively low disease severity values of 0.95 and 0.95% respectively. At 94 DAS, the attack degree on plants of the White variety (4.12%) was high and middle on plants of Nerica 3 (2.2%). The varieties Nerica 8 (1.21%) and Kamkou (1.46%) recorded a low attack degree. However, at 110 DAS, the Kamkou variety and the white variety presented a severity of 4.57% and 3.39% respectively. However, the severity was low on the Nerica 3 and Nerica 8 varieties, at 2.72% and 2.05% respectively (Table 3).

**Table 3** Evaluation of the parameters of severity

Varieties	Severity (%)		
	78 DAS	94 DAS	110 DAS
Nerica 3	0.95±0.01c	2.20±0.9b	2.72±1.07c
Nerica 8	0.95±0.02c	1.21±0.31d	2.05±0.73d
White rice	1.33±0.01a	4.12±1.32a	4.57±0.78a
Kamkou	1.12±0.06b	1.46±0.23c	3.39±0.41b

The values with different letters are significantly different in the same column according to Duncan's test ( $p < 0.05$ ). These values are the averages of the two campaigns.

### 3.7. Evaluation of yield parameter of the rice varieties screened

The results showed that the highest flowering rate was observed in the Nerica8 (97.55%) varieties followed by Nerica 3 (95.85%) and White variety (95.85%). The average flowering rate was 85.58% on the Kamkou variety (Table 4). A significant difference ( $P < 0.05$ ) between the varieties was recorded.

### 3.8. Mass of 1000 grains

The mass of the 1000 grains (g) showed a significant difference between the varieties at the 5% threshold. The White (28.98g) and Kamkou (30.5g) varieties recorded the highest mass of 1000 grains. On the other hand, the varieties Nerica8 (25.5g) and Nerica3 (26.07g) had masses of 1000 weak grains (Table 4).

### 3.9. Yield

Statistical analysis of the data revealed a significant difference ( $P < 0.05$ ) between the varieties. The results obtained show that the Nerica 3 and Kamkou varieties are the most productive with 3.68 and 3.51 t ha<sup>-1</sup> than the White and Nerica 8 varieties which recorded a low yield (3.09 and 2.9 t ha<sup>-1</sup>) (Table 4).

**Table 4** Assessment of productivity parameters

Varieties	Rate of flowering (%)	Weigh of 1000 seeds (g)	yield (t/ha)
Nerica 3	95.85±1.02a	25.20±0.43b	3.68±0.04a
Nerica 8	97.55±0.6a	26.07±0.65b	3.08±0.4b
White rice	95.85±1.05a	28.93±0.93a	2.89±0.44b
Kamkou	85.58± 2.67b	30.02±0.18a	3.51±0.08a

The values with different letters are significantly different in the same column according to Duncan's test ( $p < 0.05$ ). These values are the averages of the two campaigns.

## 4. Discussion

Growth parameters, disease (incidence and severity) and yield were collected in order to evaluate the behavior of rice varieties with regard to brown spot disease during two campaigns of experiment.

There were no significant differences in the emergence rate of the varieties used. This is due to the fact that the soil has been previously plowed before sowing. Indeed, [12,13] have shown that direct seeding has a significant impact on the rate of emergence compared to the conventional plowing system because of the regularity of the sowing depth and the good adhesion of the seed with soil. In addition, the seed health status would also have had a negative influence on the seedling emergence rate. It is necessary to disinfect the seed before sowing it.

The results obtained on the evolution of the height of the rice varieties tested as function to the days after sowing (DAS) showed that the Nerica 8 variety obtained the highest plant than the White, Nerica3, and Kamkou varieties. This is in disagreement with the work of [14] who obtained a medium height among the Nerica. The great height observed in the Nerica 8 plant results from the influence of the genotypic variations existing between the varieties tested. Furthermore, [15] have shown that the height of plant is the result of the expression of its genome.

Regarding the number of tillers, the local varieties White and Kamkou obtained the highest number of tillers. This is explained by the fact that the local varieties have a long vegetative cycle while the Nerica 3 and Nerica 8 plants have a short cycle. These results are in agreement with those of [16] who showed that the number of tillers produced by a variety of rice is linked to the stage of development and strictly linked to the variety.

The flowering rate obtained after collecting data on the Kamkou variety was average because this period experienced low rainfall. While the Nerica3, White and Nerica8 varieties were high, it may be due not only to the fact that their genetic program gives them a certain adaptive capacity to stress [7] but also to the amount of water supplied to plants during irrigation that could satisfy their root plate. This difference in flowering rate can be attributed to the genetic improvement of new rain-fed rice varieties [16].

All the varieties tested during this work developed the characteristic symptoms of brown spot disease. Brown spot disease was very widespread at the site. At 78 DAS, the incidence was less than 10% for all varieties. From 94 DAS, this

value increased from more than 80% to more than 95% in all varieties. This increase would be due to the fact that certain environmental factors such as temperature, rainfall, relative humidity the level of soil fertility and the light which were favorable to the development of the pathogen. During the month of October, sunshine was above 12 hour, a humidity of 98.5%, a high precipitation and a variation of one degree (1°C) compared to the previous months. These parameters can thus explain the spread of *Bipolaris oryzae* in the study site. These factors influence the expression of the aggressiveness of the strains of *Bipolaris oryzae* [17]. In addition, [18] had shown that an increase in temperature of 1°C could induce an increase in the incidence of the disease. Despite this high incidence, the analysis of variance showed that brown spot disease was not too severe. This result could be explained by the fact that rice had not been cultivated in previous years in the study site, which would limit residues of rice, a reservoir of primary inoculum playing an important role in the transmission of the disease. Ouedrago [19] obtained a similar result in Burkina Faso by evaluating the impact of brown spot disease on the development of some varieties of rice in natural condition. According to [20], climatic conditions including rainfall and humidity could explain the low degree of severity at the Yaoundé I site. The leaf attack degree of the White variety was high (4.57%) compared to the varieties Kamkou, Nerica3 and Nerica8. This could be explained once again by the absence of genotypic resistance genes between the varieties used.

The mass of 1000 grains varied significantly from variety to variety. The masses of the Kamkou and White varieties were high (30.02g and 28.93g respectively). This character depends on the height of the grains, their filling, and their volume. This is explained by the fact that these two varieties are long-cycle varieties. Kukupula [21] have shown that the longer a variety has a longer cycle, the more it stores nutrient reserves.

The yield depends on the length of the panicles, the number of fertile tillers, and the mass of the 1000 seeds. Kasongo [22] consider the weight 32g as the minimum required for good production. The production with 3.7 t ha<sup>-1</sup> of the Nerica3 variety was high this is justified by the genetic improvement of the plant capable of resisting the disease. The low productivity (2.89 t ha<sup>-1</sup>) of the White variety is justified by poor grain filling which is a consequence of climatic parameters. The crop was protected from pests such as birds by using nets to cover the entire field surface. Protection against weeds was carried out by weeding the field as soon as weeds appeared.

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## 5. Conclusion

The main objective of this study was to evaluate the response of rice varieties screened against brown spot disease in natural condition. After analyzing the various agronomic parameters, it appears that the Nerica 3 and Kamkou varieties were the most productive. Their yields are 3.7 t ha<sup>-1</sup> and 3.51 t ha<sup>-1</sup> respectively. The Nerica 8 and Nerica 3 varieties were more tolerant (with a severity of 2.72% and 2.05% respectively) compared to the other two which were less tolerant of the conditions of the middle.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

Authors states that they have no conflict of interest.

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