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Evaluation of Three Rice (Oryza Sativa) Varieties Adaptability to Biotic and Abiotic Stress Climatic Conditions of Bugarama Rice Scheme

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Abstract: Rice (*Oryza sativa L.*) is among the most important food crops that provide staple food for nearly half of the world's population. Rice production is affected by different types of stresses, includes biotic and abiotic. Biotic stresses have insect pests, fungus, bacteria, viruses, and herbicide toxicity, while abiotic stresses are drought, cold, and salinity are also well studied in rice. High-quality seed is an essential factor during crop production, which is necessary for sustainable food security and poverty reduction. Rice varieties are genetically different in terms of Various genes, cloned, and characterized as can contribute to resistance to both types of stresses and protect rice crops. This study evaluates three different rice varieties (Basmati 370, IB26 known as Buryohe, and IR64 known as Mfashingabo) on both biotic and abiotic stresses of open field conditions. So that it will provide the necessary information related to rice varieties adaptability for both stresses (biotic and abiotic factors) to farmers; however, the production can be increased by reducing environmental pollution risk due to the use of chemical pesticide and fertilizers the farmers. The study was carried out at Bugarama marshland precisely in zone I located in Rusizi District, Western Province of Rwanda. Complete Randomized Block Design (CRBD) has been used, and the main parameters to be observed were seed germination, plant height, plant tiller, Number of panicles, plant vigor, the weight of 1000 seeds, and the yield (t/ha). The results are significant differences for all varieties on adaptability to biotic and abiotic factors.IR64 type has higher adaptability for all studied parameters ended by high yield production of 5.477t/ha. This variety can be used by the farmer for increasing productivity and also suggesting other researchers forward on evaluating the impact of fertilizers on those varieties and apply this research in different marshland.

Keywords: *Marshland, biotic, diseases, abiotic, Oryza sativa L, varieties, yield, IR64, Basmati370, and IB26*

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I. INTRODUCTION

Rice (*Oryza sativa L.*) is one of the oldest and most important cereal crops, and rice has been produced for 8,200–13,500 years [1]. Rice (*Oryza sativa L.*) is the second consumable important crop globally after wheat, with production around 522 m tonnes produced from 148 m hectares in 1990. Asia dominates the high average rice production with an average percentage of the total rice world 94% [2]. Rice was introduced in Rwanda in the 1960s by missionaries from South Korea and Taiwan. Rwanda rice consumption is high compared to production, and Rice markets in urban areas still sell imported rice. The country imports an average of 38,168 t/year of milled rice from elsewhere, which puts strain on the country's foreign exchange and trade balance [3]. Improved use contributes significantly to increasing production by accelerating traditional farming changes to modern agriculture [4].

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Rwanda, a research institute in 1988 has been initiated the coordination of rice two research programs to improve rice quality. From that moment, rice has become one of the major food crops grown in Rwanda [5]. The rice production in Rwanda is affected by many factors, including the informal seed, farming technology, biotic, abiotic factors, and land fragmentation. Rice may be produced by the farmer or farmer organizations. The rice field and types of irrigation depend on the land slop, types of soil, and irrigation method-based rice varieties types [6]. Therefore, farmers' selection of new seeds is essential in determining which varieties they will adopt [7, 8]. Even though All abiotic stresses significantly influence ecological and agricultural systems. [9] has reported that pest and disease stress (abiotic stress) causes a decrease in plant growth rate, resulting in poor productivity. [10] also shown that both abiotic and biotic stress may cause to decreasing in production compared to the output obtained under good agriculture farming.

High-quality seed variety can be used as one solution for rice productivity and food security. The substantiality of the yield is based on biotic and abiotic factors resistance varieties. According to [11], the farmer contribution for new crop varieties and agriculture new technology adoption has the most significant impact on improving production. However, most new agriculture technologies have not fully achieved the desired goals [12]. Therefore, this observation has spawned numerous studies about agricultural technology adoption and their impact on smallholders' welfare in developing countries in recent years [13, 14]. Rwanda focuses on increasing rice production on the limited land and insufficient water supply by promoting intensive agricultural inputs such as high-yielding fertilizers and tolerant varieties on low water supply [15]. This study aims to evaluate the adaptability of different rice varieties (Basmati 370, IB26 known as Buryohe, and IR64 known as Mfashingabo) on both biotic and abiotic stresses of open field conditions in Bugarama marshland. It has around 1500 ha cultivable rice land, and it is localized in the hot climatic region with an average temperature of 28^0C. The rainfall varies between 970 to 1400mm while the acidity of the soil is ranged 6.1- 6.6 pH.

II. MATERIALS AND METHOD

The study was carried out in the marshland of Bugarama, located in Rusizi district, Western province of Rwanda. Farmers are using this marshland under the supervision of RSSP-Rusizi (Rural Sector Support Project). Randomized Complete Block Design (RCBD) was conducted during this study, and Each plot had a surface of 3m x 1.45m. The plots separated by 50cm and 1 m between blocks, the experimental borders of 1m provided around the experimental field. Thus, the total area will be 39.15m2; this means 0.003915 ha. The fertilizers used in this study are UREA, Organic Manure, and N.P.K. The seed for each variety was germinated after being imbibed in the water bath for 24 hours. The seeds were placed at room temperature until radicle emergency up to 2-4 mm, which takes two days after imbibition. The seeds were used for seedling preparation in the nursery, taking approximately 15 to21 days to be transplanted in the field. After the seedling transplanted, some of the agronomic practice will be followed, such as weeding, fertilizer application, pest and disease control, and irrigation; after that, the collected data were entered in Microsoft Excel and analyzed using the GenStat 14th edition program.

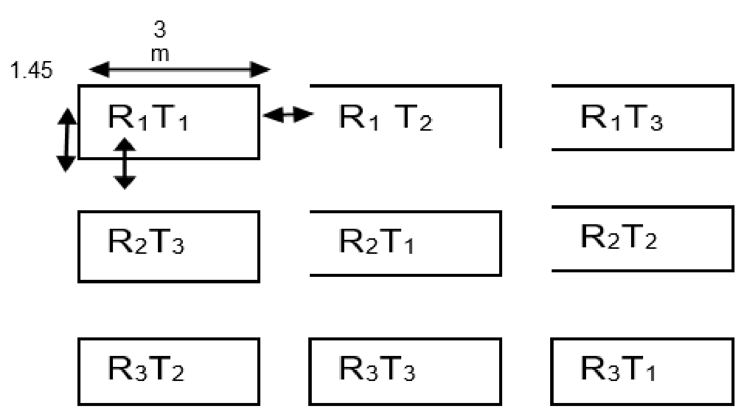

Fig. 1. Means-objectives network

Information: R: bloc and T: means treatments T_1 = IR64 (Mfashingabo variety) T_2 = IB 26 (Buryohe variety) T_3 = Basmati 370 variety

Different data collected such as:

- Germination percentage
- Height (cm) collected after, 4,8 and12 weeks before harvesting.
- Tillers were collected 4, 8, and12 weeks before harvesting.
- Other data like plant vigor was collected after 1 and 2 months
- Yield (t/ha): This parameter was collected after harvesting by weighting the output of each corresponding plot

III. RESULTS AND DISCUSSION

A. *Germination Percentage*

The results show that the mean germination rate ranges from 90 to 96%, with a general mean of 92.66%. Fig. 2 shows the difference between varieties. According to [16], water absorption, optimum temperature, imbibition rate can stimulate germination, and germination can be affected by seed quality, including viability and dormancy. According to [17] shown the germination has been affected by soil pH in milkweed vine seed. [17] reported that seed germinated best between pH 6 and 7.5 means that the germination differs from one place to another depending on the difference in alkalinity and acidity.

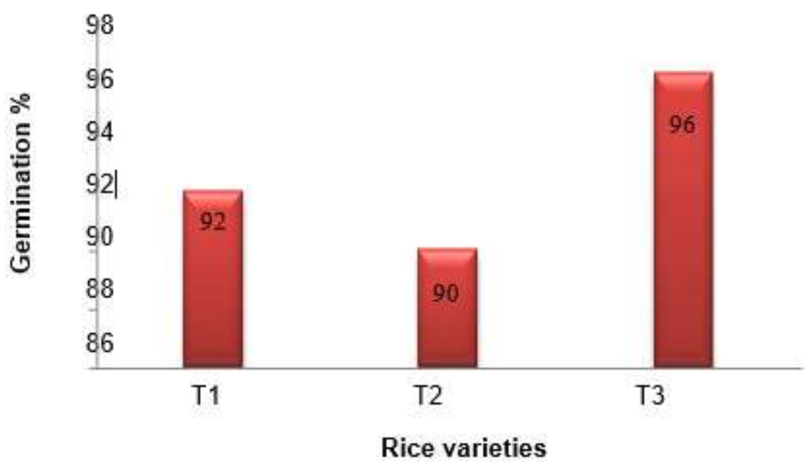

Fig. 2. Effect of biotic and abiotic factors on rice varieties germination

T1: IR64 (Mfashingabo)
T2: IB26 (Buryohe)
T3: Basmati 370

B. *Plant Vigor*

The field plant performance (plant vigor) has been collected on the 30th of transplanting. The result has shown that plant vigor is ranged from 3.803 to 4. 273. The analysis of variance on rice plants has demonstrated significant differences between treatments at 95% of the confidence interval on the 30th day of the planting as there aren't varieties that share the same letter. That approved by [18] reported that the impact of seed vigor is seen during seedling establishment in the variable of seedbed environment. Plant vigor at 60th showed no significant difference between variety IB26 and Basmati370, but those significantly differed from variety IR64 as they didn't share the same letter. On another side, the IR64 variety type didn't show any significant difference with Basmati370 at 60th. The plant vigor can be affected differently by both abiotic factors and biotic factors.

TABLE 1
SHOWS PLANT VIGOR AT 30TH AND 60TH D.A.T

Varieties	Plant Vigor at 30th Day	Plant Vigor at 60th Day
T2	3.953 a	4.273 a
T3	3.780 b	4.073 ab
T1	2.973 c	3.803 b
l.s.d =	0.1330	0.2674
Grand mean =	3.569	4.049
Cv% =	0.4	1.5

The means with the different letters are statistically different

C. *Plant Tillering*

Tillering marks the end of the seedling stage. It starts when the fourth true leaf has fully emerged. The nodes are all "compressed" close to the ground at this stage—the length between nodes (internode length) is less than 0.04 inches. The data has been corrected three-time mean after 30, 60, and 90 days of planting. The analysis of variance by using one-way ANOVA on plants tillering shows a significant difference between treatments at 5%. The data was collected at day intervals (30,60, and 90 days) of planting so that there is heterogeneity distribution in the results concerning the Plant tillering. At 30 days, the general mean of 4.467 tillers and the highest value was in T3 (Basmati 370) with 4.867 tillers while T2 (Buryohe) lowest with 4.133 tillers mean value.

At 60 days, Table 3 results from the general mean of 11.18 tillers with the higher treatment value recorded in T1 (Mfashingabo) with 12.07 plant tillering mean and T3 (Basmati) the lowest with 10.13 plant tillering mean. At 90 days after planting, the result ranged between 17.47 tillers to 21.00 tillers, with the lowest mean T2 (Buryohe) with the general means being 19.58 tillers. The highest mean on Plant tillering at 90 days after planting has been observed for T3 (Basmati). Luis Espino confirms those obtained results (2012) reported that the tillering capacity of rice plants varies with variety, plant spacing, fertility, weed competition, and damage from pests. Some varieties are intrinsically better at tillering than others, and these differences can make a variety more "plastic," adapting better to thin or dense stands. Late maturing varieties have more extended periods of tillering than early maturing varieties.

TABLE 2
DIFFERENCE IN PLANT TILLERING BETWEEN RICE VARIETIES AT 30, 60, AND 90 DAYS

Varieties	Tillering 30th day	Tillering 60th day	Tillering 90th day
T3	4.867a	10.13 b	21.00 a
T1	4.400 ab	12.07 a	20.27a
T2	4.133 b	11.33 ab	17.47b
Grand mean =	4.467	11.18	19.58

The means with the same letters are not statistically different.

D. *Plant Height*

E. *Number of Panicles Per Plant*

The result on plant varieties panicle are presented in Table 4, and there is no significant difference between varieties treatments. The mean for panicle number of plants ranges with a general mean of 19.47. The highest value was observed for T3 (Basmati) with 20.80, while T2 (Buryohe) has the lowest value with 18.33. The mean comparison allowed us to classify treatments in one homogeneous group a. research has shown that even though the plant environment condition contributes a lot to Plant panicle number even though genetic traits are also involved [15, 19]. That can explain the homogeneity group obtained in this experiment result between different rice varieties. In general, the phenotypical panicle length character cannot be correlated with the Number of panicles per Plant but with the genetic trait [20].

TABLE 3
EFFECT OF SEED VARIETY ON PLANT HEIGHT (CM) AT 30, 60, AND 90 DAYS

Varieties	Height at 30th Day	Height at 60th Day	Height at 90th Day
T3	50.93 a	101.96 a	137.0 a
T2	40.73 b	75.19 c	86.4 c
T1	34.47 c	83.54 b	107.5b
Grand Mean	42.04	86.90	110.30

The means with the same letters are not statistically different.

TABLE 4
EFFECT OF SEED VARIETY ON NUMBER OF PANICLES PER PLANT

Variety	Panicles per Plant	Homogeneous
T3	20.80	a
T1	19.27	a
T2	18.33	a
Grand mean	19.47	

The means with the same letters are not statistically different.

F. Plant Blast Diseases Resistance (%)

The primary disease observed during our experimentation was Blast disease in this Bugarama Rice Scheme. The analysis of variance on plants' disease resistance presented in the appendix10,11 and 12 shows a significant difference between treatments at 5% for all phases (tillering, reproductive, and ripening) with the coefficient variations of 2.6, 1.4, and 0.6, respectively. The coefficient variation for each stage shows a homogeneous distribution in result concerning the rice yellow mottle virus per Plant. Table 5 mentioned above indicates that T1 (Mfashingabo) is less resistant than others, followed by T2 (Buryohe) and finally T3 (Basmati) is the highest resistance to rice blast disease. The difference in genetic character indicates the significant difference for resistance to infection in rice production as quantitative trait loci (QTLs) is a valuable resource for rice disease resistance improvement [21].

TABLE 5
PLANT VARIETIES RESISTANCE ON BLAST DISEASES DURING TILLERING, REPRODUCTIVE AND RIPENING PHASES

Varieties	Tillering	Reproductive Phase	Ripening Phase
T3	100.00 a	100.00 a	100.00 a
T2	70.33 b	75.33b	90.00 b
T1	58.67 c	65.67c	76.33 c
Grand Mean	76.33	80.33	88.78

The means with the same letters are not statistically different.

G. Plant Yield (t/ha)

Table 6 that the mean for plant yield ranges from 4.723to 5.477 with a general mean of 5.190 tones and no significant difference between T1 and T3. The highest value was observed for T1 (Mfashingabo) with 5.477tone/Ha, While T2 (Buryohe) takes the lowest value of 4.723tone/Ha.

H. Weight of 1000 Seeds (g)

The results of ANOVA illustrated that there is a significant difference between treatments at 5%. With a general mean of 18.11. The highest value was observed for T2 (Buryohe) with 22.0, while T3 (Basmati) has the lowest mean value of 15. The treatments are classified

TABLE 6
EFFECT OF BIOTIC AND ABIOTIC FACTORS FOR THREE RICE VARIETIES ON THE YIELD (T/HA)

Variety	Means	Homogeneous Groups
T1	5.477	A
T3	5.371	A
T2	4.723	B
Grand Mean	5.190	

The means with the same letters are not statistically different

into three groups which a, b and c. Research that confirmed genetic trait and environment factor affects plant height, growth period, tillering ability, panicle length, seed length, seed setting rate, and grains per panicle as well as direct traits like panicle number per unit area and per Plant, filled grains per panicle and 1000- grain-weight that explain the significant difference in seed varieties weight of 1000seeds [15, 19].

TABLE 7
EFFECT OF SEED VARIETIES ON THE WEIGHT OF 1000 SEEDS (G)

Variety	Means	Homogeneous Groups
T2	22.0	a
T1	17.33	b
T3	15.00	c
Grand Mean	18.11	

The means with the same letters are not statistically different

IV. DISCUSSION

The result showed differences between observation variables for three varieties of treatments on the adaptability for both biotic and abiotic factors during this experiment. The germination result ranged from 90 to 96%, and that difference was confirmed by other research, which showed that environmental factors such as temperature, light, pH, and soil moisture affect seed germination [22, 23]. Plant vigor was significantly different for the data collected on the 30th and 60th day for all varieties. [24] reported that genetic differences exist among types to acquire and maintain good seed quality in stressful environments. Still, these differences appear to be small compared to the effect of stress itself. According to [25], seed physiological maturity and chemical composition may contribute as perimeters to consider plant field performance apart from biotic and abiotic factors.

The varieties' resistance to disease was independent of the other observable parameter where Basmati370 and IB26 more resistant, followed by IR64. That difference in resistance to blast rice disease is due to the Pi-ta gene's inequality [26, 27]. [28] reported that the resistance of race varieties to blast might be due to the Transgenic of Rir1b genes.

Generally, the result obtained on Plant tillering, panicles, and height has shown significant difference, and all dominated by Basmati370, IR64, and IB26 varieties, respectively, and that continue to the yielding gotten. That confirmed with further research, such as [29] reported that genetic and crop growing conditions determine the growth of tiller buds in rice production. Rice varieties showed significant differences in tillering ability that implicated that the telling is specific depending on types [16]. The result obtained during this research has been proof confirmed by The result of [30] reported that yield depends on both environment factor and planting genetic trait which can determine the plant height, growth period, tillering ability, panicle length, seed length, and grains per panicle

V. CONCLUSION AND RECOMMENDATIONS

This research was undertaken to compare three different rice varieties (*Oryza sativa*) on growth parameters and yield under climatic conditions of Bugarama marshland. Many unexpected essential factors to be considered, such as chlorophyll content, leaves index, and plant dry matters, but due to limited time and finances, weren't coved. The study results found that the variety IB26 (Buryohe) is not effectively adapt to Bugarama condition to provide sufficient yield even if it is growing faster than others. The farmer can be adopted for using Basimati370 as it has high productivity comparing to the other varieties. I can encourage other researchers to forward this research to different marshlands as the crops adapt differently and test the effect of fertilizer on that varieties; this can help increase production by reducing the unnecessary cost of production (fertilizers and pesticides) by protecting the environment.

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