International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Field Evaluation of Fortem Bio-Fungicide against Dirty Panicle Disease in Rice Under Wet Season Conditions[1]

Ronaldo T. Alberto[2]

[2]Professor V1 (Ret.) and Accredited BAFS Researcher

Abstract: ***This study evaluated the field efficacy of FORTEM, an organic bio-fungicide, in managing fungal diseases of rice, specifically Dirty Panicle disease caused by Curvularia lunata, Alternaria padwickii, and Fusarium moniliforme. Trials were conducted during the 2023 wet season in two sites in the Philippines. Among five treatments, FORTEM applied at 250ml/200L showed the lowest disease severity and highest yield, significantly outperforming both control plots and market standards. No phytotoxicity or harm to beneficial insects was observed. Although Sheath Blight, Leaf Blast, and Panicle Blast did not occur during the study, FORTEM demonstrated potential as a safe and effective alternative to synthetic fungicides for Dirty Panicle management.***

Keywords: bio-fungicide, dirty panicle, rice disease management, FORTEM, organic agriculture

1. Introduction

Rice as the staple food of the Filipinos and grown in almost all parts of the Philippines still remains to suffer from wide range of pests and diseases that seriously affect the quantity and quality of its yield. According to the International Rice Research Institute (IRRI, 2023), disease damage to rice can greatly reduce yield. They are mainly caused by bacteria, viruses, or fungi. Among the most destructive diseases are *Magnaporthe oryzae* (Rice Blast), *Xanthomonas oryzae* pv. *oryzae* (Bacterial Leaf Blight), *Rhizoctonia solani* (Sheath Blight), Tungro (Tungro Virus) to name a few. In recent years, however, it was observed in India and other rice growing countries in Asia that as the rice matures the rice panicles exhibit abnormal discoloration of the rice grains. At first, it is considered as a minor disease, but through the years it became a major disease due to its severity and significant yield loss it caused in both quantity and quality (Koncharoen, et.al. 2020), It was identified as "Glume Discoloration or Dirty Panicle of Rice" (Figure 1) which can now be found in most rice growing countries in Asia including the Philippines (Balgude, et.al. 2016).

Figure 1: Heavily discolored and dirty looking panicles of rice also termed as "Glume discoloration"

It is caused by multiple plant pathogenic fungal species, namely: *Curvularia lunata, Cercospora oryzae, Helminthosporium oryzae, Fusarium semitectum, Trichoconis padwickii, Sarocladium oryza*. Primarily it affects the rice grains and panicle. Infection starts at the early booting stage and results in dirty brown black discoloration of the grains, poor grain quality and germination and empty/shriveled grains, thus, reducing its appeal to traders and consumers (Charoenrak, et.al. 2016).

Use of synthetic or inorganic fungicides still remains to be the most popular and effective approach in rice disease management in spite of the negative effects it caused to the target pathogens and environment. Due to these negative effects, the use of organic fungicides is highly encouraged as an alternative in neutralizing its negative effects to the target pathogens and environment. And because of its popularity and effectiveness, many companies ventured in manufacturing fungicides of organic in nature and released in the market to keep the pathogens at bay.

A new bio-fungicide product called Fortem is already in the Philippines, it is an environment friendly bio-fungicide extracted from the mushroom offal which is effective in disease suppression on virus diseases and physiological disorders of crops. This product contains 16 trace elements such as amino acid, zinc, iron, copper, calcium, etc. that is needed by the plants during its growth and development. Furthermore, it has the following features e.g. effectively passivate the infectious activity of virus, suppress its reproduction and enhanced the plants' fastness. It has a good control efficiency on epidemic disease of plants, it enhanced yield of crops and improve the quality of the produce, also, it has a wide coverage, no residue, no harm to animals or human beings and no pesticide resistance.

Since the disease is caused by a number of fungal plant pathogens of different mode of actions, efficacy of different fungicides including the organic fungicide Fortem in managing the fungal disease of rice must be carried out to determine the sensitivity or resistance of the pathogens to this bio-fungicide. However, formal investigations on its effects

[1] A collaborative research with Agrigrowth International Corporation, 268 National Highway Antonino, Alicia, Isabela

against those pathogens, and its proper dose and timing of application has not yet been carried out, thus, this study was conducted.

This study aims to determine the efficacy and optimal application rate of FORTEM bio-fungicide in managing key fungal diseases affecting rice, particularly Dirty Panicle disease.

The findings of this study are significant in promoting environmentally friendly disease management practices in rice cultivation. By demonstrating the effectiveness of a bio-fungicide over market-standard treatments, this research contributes to sustainable agriculture and food safety

2. Objectives

1) To evaluate the bio efficacy of Fortem Against Leaf and Panicle Blast, Sheath Blight and Dirty Panicle Disease of rice
2) To determine the best application rate of the fungicide that will provide the most effective management of Leaf and Panicle Blast, Sheath Blight and Dirty Panicle in rice.
3) To generate bio-efficacy data of the fungicide as support in application for full registration of Fortem in rice with BAFS

3. Materials and Methods

The experimental sites were located in San Rafael, Zaragoza, Nueva Ecija (Site 1, Figure 2) and in Caramutan, La Paz Tarlac (Site 2, Figure 3). The standard field preparation for rice i.e clearing and weeding the field, pre-irrigation, first ploughing or tilling, harrowing, flooding and levelling were carried out to prepare the study sites. The experimental area was laid out following the Randomized Complete Block Design (RCBD) (ANNEX 1). It was divided into four blocks and each block was subdivided into five (5) plots with a dimension of 4m x 5m representing the different treatments. On May 20, 2023, each experimental plot In Site 1 was directly seeded with susceptible rice variety NSIC 2015 Rc404H, LP 2096. On June 7, 2023, all the plots in Site 2 were transplanted with NSIC 2016 Rc 480. Irrigation water level was around 3 cm initially and gradually increases to 5-10 cm (with increasing plant height) and remained until the field is drained 7-10 days before harvest.

The first treatment application commenced on May 20, 2023 in Site 1 and July 21 2023 in Site 2. The succeeding treatment applications were carried out every 7 days thereafter. The rate and time of application of the fungicide tested is shown in Table 1. No fungicide was applied except for FORTEM for disease management.

Table 1: Rate and time of application of the fungicides used in the trial.

Treatment	Rate of Application (ml./200 L)	Time of Application (DAS/T)[1]
T1. Control	0.00	-
T2. FORTEM (RR)	250	45
T3. FORTEM (Not more than RR)	200	45
T4. FORTEM (Not more than RR)	150	45
T5. Market Standard	Use as per label	45

[1]Days After Seeding/Transplanting (DAS/T)

Figure 2: The experimental set –up in Site 1-San Rafael, Zaragoza, Nueva Ecija

Figure 3: The experimental set –up in Site 2 - Caramutan, La Paz, Tarlac.

Bio-efficacy Assessment:

Disease Severity (%). A rating scale and a formula were used to compute the Percent (%) Disease Severity. Panicle/s were assigned to any of the infection categories depending on the appearance of the panicle in the rating scale below:

Scale	Description (% Area)
0	No infection
1	1-5% of panicle infected
3	6-15% of panicle infected
5	16-25% of panicle infected
7	26-50% of panicle infected
9	More than 50% of panicle infected

Disease Severity (%) was calculated from the data and the % panicle infected were taken using the formula below:

$$\%\,D.S. = \frac{n(0)+n(1)+n(3)\ldots+n(9)}{N \times 9} \times 100$$

Where:
n = number of infested plants classified by grade (scale)
N = total number of samples

Phytotoxicity. Crop injury due to the test compound were recorded at 10-15 days after each application using the scale below:

Scale	% Crop Injury
1	None
3	1-10
5	11-20
7	21-30
9	More than 31

Yield. The grain yield was taken from a 3m x 4m sample area at the center of each treatment plot at harvest time. The grains were sun dried for 1 day and weighed. The yield (t/ha) at 14% moisture content was calculated using the following formula:

$$\text{Corrected plot yield (kg) (CPY)} = \frac{\text{Weight of harvest (kg)}}{\text{No. of hills harvested}} \times \text{No. possible hills /plot}$$

$$\text{Yield (t/ha)} = \frac{\text{CPY}}{1{,}000\text{g/kg}} \times \frac{10{,}000\text{sq. m/ha}}{\text{harvested plot area}} \times \frac{1\text{mt}}{1{,}000\text{kg}} \times \text{MF}^*$$

*Moisture Factor is equal to 1 at 14% moisture content

Data Analysis. All the data generated were subjected to the analysis of variance (ANOVA) and compared using Least Significant Difference (LSD).

Meteorological Factors

Meteorological data were provided by PAGASA-CLSU Station which is several kilometers away from the test sites. In Site 1, the data showed an increase in rainfall from 0.00 - 60.50mm in July i.e. due to monsoon as intensified by Typhoon Egay which is about to hit the Northern Luzon and temperature from 23.5°C to 35.5°C and increase in % Relative Humidity from 72% to 95% (ANNEX 2). Since it is typhoon season coupled with monsoon rains (Habagat), it is expected that rainfall is very high (76mm Max). The presence of high temperature, high RH (%) in the surrounding areas in the succeeding month i.e August, 2023 makes it very conducive for the occurrence of dirty panicle disease as the causal pathogens of this fungal plant disease needs abundant moisture and high temperature to penetrate and develop in their host which were present in the rice ecosystem when the trial was conducted. On the other Site, decrease in rainfall was observed after typhoon Egay in the early part of August, 2023 to early part of September, 2023 (0.00mm-0.30mm) but still with high temperature range of 24.62°C-30.88°C and high relative humidity ranging from 87%-94%. (ANNEX 2)

4. Results and Discussion

Disease Severity (%)

After the last disease assessment in Site 1, results showed that fungicide application play a very crucial role in managing fungal diseases in rice as shown by poor performance of control plot in non-treated plots devoid of fungicide application (Table 2, Figure 4). It is where the highest percent severity of 73.95% of the panicle was recorded as compared to plots applied with FORTEM 250ml/200L (RR). Among the treatments, FORTEM 250ml/200L (RR) (T2) shows its suppressive effect against dirty panicle from the early part of the season up to harvesting period as shown by the very slow disease progress and very low disease severity (25.08%) prior to harvest (Figure 5). Far behind are the plots applied with the Market Standard (T5) with 49.56%. This rate of FORTEM i.e., 250ml/200L demonstrated effective disease suppression over the Market Standard.

It is worth mentioning, however, that there were sudden increase in % Disease Severity readings in most of the treated and control plot i.e., during the 3rd assessment and subsequently on the 4th assessment as these are the period when the area experienced continues heavy rainfall and high humidity for more than a week due to enhanced monsoon rains due to typhoon Egay when most of the panicles have already developed. Such condition heavily favors the occurrence and development of fungal diseases like Dirty Panicle in rice (Lee, et.al. 1986,). And in as much that the grains are wet and the disease is caused by multi-fungal pathogen species, the pathogens easily infect the grains all together at the same time, thus, developing the symptoms much faster than when the plant is infected by a single pathogen. On the other hand, even the conditions for disease development are favorable, plants in plots applied with FORTEM 250ml/200L (RR) still showed slow disease progress and low % disease severity. In other plots, the disease continues to progress especially in the control plots as well as in the surrounding fields.

Table 2: Disease severity (%) of dirty panicle of rice at different levels of FORTEM 250ml/200L application. Site 1-San Rafael, Zaragoza, Nueva Ecija (Wet Season, 2023).

TREATMENTS	MEANS			
	1st Assessment	2nd Assessment	3rd Assessment	4th Assessment
T1- Control	6.86^{a}	27.43^{a}	57.38^{a}	75.96^{a}
T2- FORTEM 250ml/200L (RR)	3.56^{bc}	11.93^{b}	23.18^{c}	24.98^{d}
T3- FORTEM 200ml/200L	4.17^{bc}	17.45^{b}	41.06^{b}	53.82^{bc}
T4- FORTEM 150ml/200L	4.78^{b}	17.88^{b}	56.16^{a}	68.58^{a}
T5- Market Standard	2.69^{c}	14.50^{b}	37.85^{b}	49.56^{bc}

**Means with the same letter are not significantly different at 5% level of significance.*

Figure 4: Discolored and dirty looking panicles in the control plot prior to harvest (Site 1).

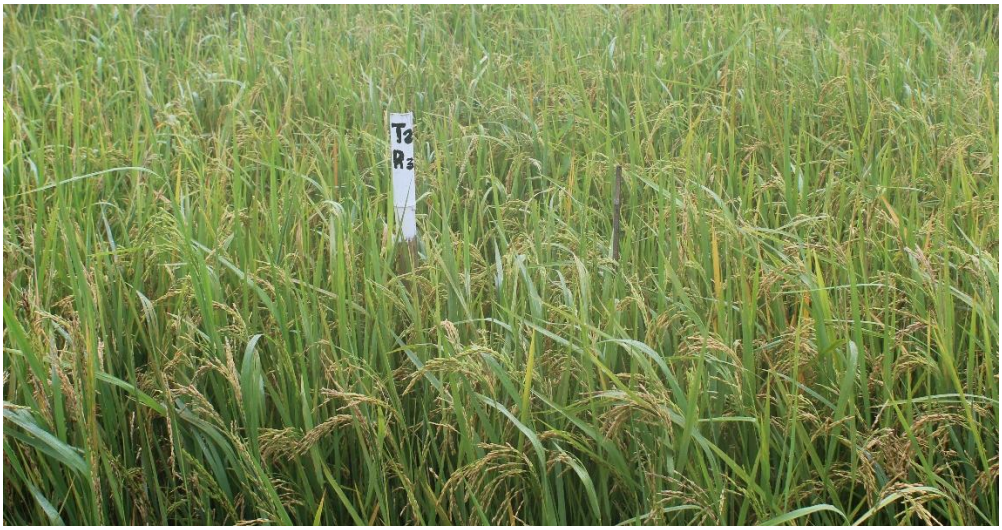

Figure 5: Low intensity of glume discoloration in plots applied with FORTEM 250ml/200L, RR (Site 1).

In Site 2, i.e., after the 4th Assessment, dirty panicle control is also at its best in plots applied with FORTEM 250ml/200L RR with disease severity of 5.21% (Table 3, Figure 6), distantly followed by disease severity readings in plots applied with FORTEM 250ml/200L (T3) with disease severity readings of 15.63%. The highest disease severity was

observed in the control plot of 34.29% was recorded (Figure 7). Plots applied with the Market Standard didn't perform well as expected.

Table 3: Disease severity (%) of dirty panicle of rice at different levels of FORTEM 250ml/200L application. Site 2 - Caramutan, La Paz, Tarlac (Wet Season, 2023).

TREATMENTS	MEANS			
	1st Assessment	2nd Assessment	3rd Assessment	4th Assessment
T1- Control	1.30[a]	3.82[a]	14.32[a]	34.28[a]
T2- FORTEM 250ml/200L (RR)	0.34[b]	0.52[a]	1.91[c]	5.21[d]
T3- FORTEM 200ml/200L	0.34[b]	1.04[a]	8.07[b]	15.63[c]
T4- FORTEM 150ml/200L	0.52[b]	3.82[a]	12.76[ab]	20.14[bc]
T5- Market Standard	0.17[b]	2.43[a]	10.68[ab]	23.43[b]

**Means with the same letter are not significantly different at 5% level of significance.*

Figure 6: Low intensity of glume discoloration in plots applied with FORTEM 250ml/200L (RR), (Site 2).

Figure 7: Discolored and dirty looking panicles in the control plot prior to harvest (Site 2).

Overall observations in two sites showed that the disease severity in Site 1 (planted with NSIC 2015 Rc404H, LP 2096) is higher than Site 2 (planted with NSIC 2016 Rc 480). In Site 2, the booting stage and panicle initiation started after typhoon Egay when rainfall was low (3-27.8mm), though the humidity (88% – 94%) and temperature (23°C – 31.5°C) is still high (Annex 3), the presence of low and continues rainfall minimized but did not prevent the occurrence and development of Dirty Panicle disease because the prevailing condition is still humid coupled with high temperature and

intermittent rain due to thunderstorms especially in the afternoon, thus, it pre-disposed and induced the occurrence of the disease, not only in the experimental site but also in the surrounding fields. These observations only show that NSIC 2015 Rc404H, LP 2096 and NSIC 2016 Rc 480 are both susceptible to the disease. Furthermore, this study also shows the role or how weather factors influence the occurrence, progress and severity of the disease (Lee, 1986, et.al.) as the two (2) Sites have experienced different prevailing weather conditions during booting and panicle stages. Site 1 actually experienced high temperatures ranging from 23°C-31.5°C, high humidity (88%-94%) and high rainfall (3mm-76mm) due to monsoon rains enhanced by typhoon Egay (Annex 3), a highly favorable condition for Dirty Panicle disease development, as compared to weather conditions in Site 2 wherein high and continues rainfall were absent during panicle development stage.

Based from the observations, the disease started to occur as early as the booting stage and continue to progress to finally develop a brown discoloration of grains resulting to dirty looking panicles or glume discoloration. The severity of the disease continues to develop and progresses towards the end of the season.

Phytotoxicity

Tables 4 and 5 shows the overall assessment of FORTEM 250ml/200L in both sites on its phytoxicity to the test plant which was recorded at 10 days after each of application. The results showed that no crop injury was observed every after-treatment application on the rice plant.

Table 4: Phytoxicity due to the test Bio-fungicide (Site 1)

TREATMENTS	MEANS			
	1st Assessment	2nd Assessment	3rd Assessment	4th Assessment
T1- Control	0	0	0	0
T2- FORTEM 250ml/200L (RR)	0	0	0	0
T3- FORTEM 200ml/200L	0	0	0	0
T4- FORTEM 150ml/200L	0	0	0	0
T5- Market Standard	0	0	0	0

Table 5: Phytoxicity due to the test Bio-fungicide (Site 2)

TREATMENTS	MEANS			
	1st Assessment	2nd Assessment	3rd Assessment	4th Assessment
T1- Control	0	0	0	0
T2- FORTEM 250ml/200L (RR)	0	0	0	0
T3- FORTEM 200ml/200L	0	0	0	0
T4- FORTEM 150ml/200L	0	0	0	0
T5- Market Standard	0	0	0	0

Beneficial Insects and Arthropods

Three species of beneficial insects and one species of spider were observed in numbers in the field after four applications of fungicides, namely: *Cheilomones sexmaculatus* (Lady Bird Beetle) *Fabricius*, *Ischnura senegalensis Rambur* (Damselfly), *Pachydiplax longipennis* (Dragon Fly) and Spider (Figure 8). An indication that the test fungicide doesn't have harmful effects in the beneficial insects and arthropods in the rice ecosystem.

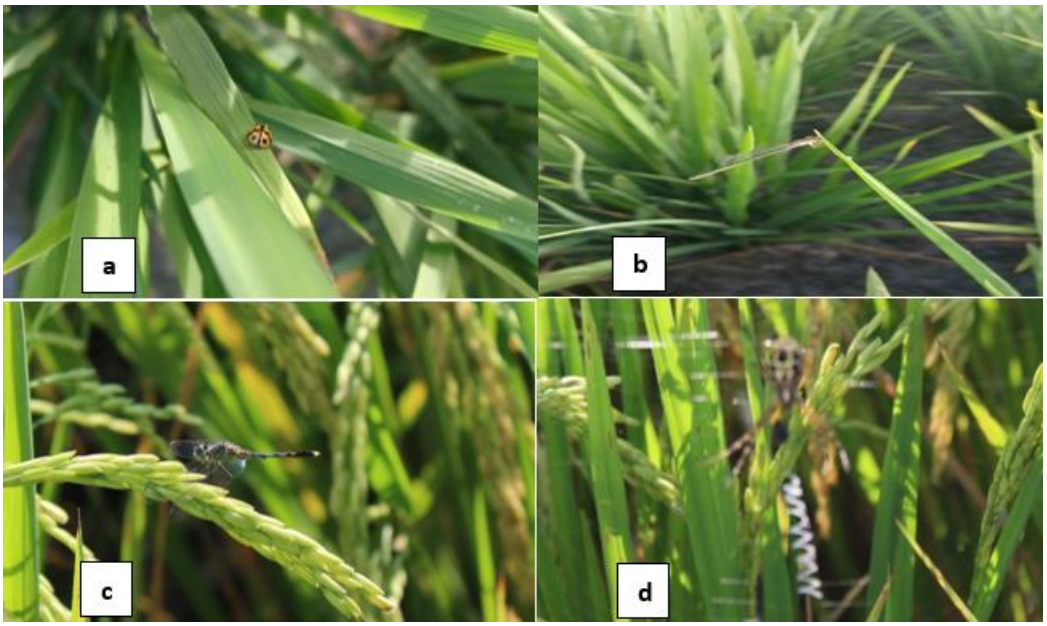

Figure 8: Beneficial insects and arthropods observed in the field. (a) Lady Bird Beetle (b) Damsel fly (c) Dragonfly (d) Spider

Yield

In Site 1, The highest yield (6,133.33t/ha) was recorded in plots treated with FORTEM 250ml/200L RR (T2) followed by the plots treated with Market Standard with 5,043.75 t/ha (T5) and by FORTEM 200ml/200L with 4,708.33t/ha (T3). The average yield in the control plot (3,585.42 t/ha) is the lowest among the treatments (Table 6). Similar result was also observed in Site 2, whereby the highest yield was also recorded in plots treated with FORTEM 250ml/200L RR (T2) with 8,894.44 t/ha then by the plots treated with Market Standard with 7,556.25 t/ha (T5). It is also in the control plot (T1) where the lowest yield was recorded (5,156.25t/ha).

Table 6: Yield (t/ha) response of the rice plants under different fungicide application (Wet Season, 2023).

Treatments	SITES	
	SITE 1 (Zaragoza, Nueva Ecija)	SITE 2 (La Paz, Tarlac)
T1- Control	3,585.42^{d}	5,156.25^{c}
T2- FORTEM 250ml/200L (RR)	6,133.33^{a}	8,894.44^{a}
T3- FORTEM 200ml/200L	4,708.33^{bc}	6,825.00^{b}
T4- FORTEM 150ml/200L	4,470.83^{c}	7,218.75^{b}
T5- Market Standard	5,043.75^{b}	7,556.25^{b}

Yield comparison in both sites shows that the yield in Site 2 is generally higher than in Site 1 for reasons that Site 2 was not exposed to adverse environmental conditions and high disease pressure during booting and panicle stage, amidst those factors, the performance of FORTEM 250ml/200L (RR) in both sites are relatively the same.

FORTEM 250ml/200L (RR) can even outperform the Market Standard in terms of fungal disease suppression in rice. In this study, it shows that organic based fungicide can be at par or even outperform the inorganic fungicide in managing the disease. And through this approach, the chances of the pathogen to develop resistance against the newly developed product will be checked or it will take some time for the pathogen to overcome the effect of the new product and at the same time giving excellent protection to the crop. Overall, the performance of FORTEM 250ml/200L RR demonstrated effective diseases suppression and has the potential to play a vital role in rice fungal disease management in the future.

Other Target Diseases

Sheath Blight, Leaf Blast and Panicle Blast were not observed to occur in both study sites.

5. Summary and Conclusion

The experiment was carried out in the rice fields of San Rafael, Zaragoza, Nueva Ecija (Site 1) and in the rice fields of Caramutan, La Paz, Tarlac (Site 2). It aims to evaluate the efficacy of FORTEM against Sheath Blight, Leaf Blast, Panicle Blast and Dirty Panicle diseases of rice. The treatments were applied four (4) times starting at 45 DAT and every week thereafter. Also, this study was conducted to determine the best possible rate of application of FORTEM.

The present study established that FORTEM, when applied at the recommended rate of 250ml/200L, effectively suppresses Dirty Panicle disease in rice and significantly enhances grain yield. Its performance was consistent across different environmental conditions and superior to that of a market-standard fungicide. Importantly, the treatment caused no phytotoxic effects and preserved beneficial arthropods in the field. These results position FORTEM as a sustainable and promising alternative to conventional fungicides in integrated rice disease management.

6. Recommendation

In as much as the study was conducted during rainy season, whereby rainfall as enhanced by typhoon Habagat is very intense and beyond our control, it is suggested that a separate trial be conducted during the second cropping season. The wet and dry seasons have a totally different environmental conditions that greatly influence the occurrence of pests and diseases in the field. By doing so, the performance of the test fungicide in managing the disease under two different environmental conditions/seasons can be fully ascertained.

References

[1] Balgude, Y. S., et. al. 2016. Integrated Management of Grain Discoloration Disease in Paddy. *J. Rice Res.* **9**, 59–62.

[2] Charoenrak, P., et. al. 2016. Efficacies of Wettable Pellet and Fresh Culture of *Trichoderma asperellum* Biocontrol Products in Growth Promoting and Reducing Dirty Panicle of Rice. *Agric. Nat. Resour.* **50**, 243–249

[3] IRRI. 2023. Rice Knowledge Bank. Extracted from http://www.knowledgebank.irri.org/step-by-step-production/growth/pests-and-diseases/diseases

[4] Koncharoen, N., et. al. 2020. Efficacy of Fungicides in Controlling Blast and Dirty Panicle Diseases in Thailand. Scientific Reports. ISSN 2045-2322. Extracted from https://www.nature.com/articles/s41598-020-73222-w

[5] Lee, S.C., et. al. 1986. Insects and Pathogens Associated with Rice Grain Discoloration in the Philippines. UNL Digital Commons. University of Nebraska – Lincoln. Extracted from https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1958&context=entomologyfacpub

Annex 1


EXPERIMENTAL LAYOUT
Location:
Site 1: San Rafael, Zaragosa, Nueva Ecija
RCBD
I
II
III
IV
T3R1
T5R2
T2R3
T5R4
1.5
4
1
5
T2R1
T3R2
T5R3
T4R5
F
T1R1
T4R2
T1R3
T3R4
T4R1
T1R2
T4R3
T2R4
T5R1
T2R2
T3R3
T1R4
Location:
Site 2: La Paz, Tarlac
RCBD
I
II
III
IV
T1R1
T4R2
T3R3
T5R4
1.5
4
1
5
T2R1
T3R2
T5R3
T4R4
F
T3R1
T5R2
T4R3
T3R4
T4R1
T2R2
T1R3
T2R4
T5R1
T1R2
T2R3
T1R4
T1 Control Plot
T2 Fortem 2.5
T3 Fortem 2.0
T4 Fortem 1.5
T5 Commercial Std
A = No. Replication 4
B = Plot size
Length 5 m
Width 4 m
Area 20 sqm
C = Distance between Plots 1.5 m
D = Distance between Blocks 1 m
E = Distance between Rows
F = Distance between Hills
G = No. of Rows per Plot:
H = No. Plants per Row:
I = No. of Plants per Plot (G x H):
J = No. of sample plants per plot

Annex 2
Meteorological data from June to September 6, 2023

MONTH (2023)	Temperature (˚C) (Minimum)	Temperature (˚C) (Maximum)	Relative Humidity (%)	Rainfall (mm)
June	22.06	23.60	68-91	0.00-40.20
July	23.50	35.50	72-95	0.00-60.50
August	24.20	34.50	78-94	0.80-31.00
September (1-6)	24.62	30.88	87-94	0.00- 0.30

Source: PAGASA-CLSU Station

Annex 3

Fertilizer Application Schedule. A week thereafter, application of 1 bag of 14-14-14 at 0-14 DAT or 1-14 days after sowing (DAS) and 1 bag urea and 0.5 bag 0-0-60 at 28-32 DAT. Cypermethrin was applied 60 and 75 days after seeding/transplanting. Management of weeds is by hand weeding at 30 and 60 days after seeding/transplanting. Cypermethrin was applied 30 DAS/T and the succeeding application is at 50 DAS/T.

Annex 4

Irrigation Management. A 2-liter capacity hand held sprayer was assigned in each treatment and used specifically on its assigned treatment. Plastic barrier between plots was in placed during spraying to avoid spray drift. Moreover, considering that the study coincides with rainy season, hoestick (sticker-spreader) was added to the spray solution prior to treatment application.