Growth performance and resistance of four superior rice cultivars against stem borer (Lepidoptera, pyralidae) in Subak Guama, Tabanan, Bali

Ida Bagus Kade Suastika[1]*, *I Ketut* Kariada[2], *Made* Adi Wahyuni[3], *Muhammad Ace* Suhendar[1], *Made* Budiartana[4], *Ni Ketut* Winantari[5] *and Muchamad* Yusron[2]

[1*]Research Centre for Food Crops, National Research and Innovation Agency, Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor, West Java, Indonesia 16911
[2]Research Centre for Estate Crops, National Research and Innovation Agency, Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor, West Java, Indonesia 16911
[3]Food Crops and Food Security Service, Bali Province, Indonesia
[4]Research Centre for Ecology and Ethnobiology, National Research and Innovation Agency, Jl. Raya Jakarta-Bogor Km. 46, Cibinong-Bogor, West Java, Indonesia 16911
[5]Research Organization for Technology and Material, National Research and Innovation Agency, Jl. Raya Jakarta-Bogor Km. 46, Cibinong-Bogor, West Java, Indonesia 16911

Abstract. The aim of the study was to determine the growth performance and resistance of four new superior varieties (NSV) against rice stem borer (RSB). The variables observed were agronomic and yield components, harvested dry grain (HDG), the incidence and attack rate of RSB every 2 weeks. The research was designed on a randomized block design (RBD) by using four NSV, namely Inpari 16, 32, 33, and Ciherang as control with 6 replications. The data were analyzed using Analysis of Variance (ANOVA), if there was a difference between the mean values, it was continued with a 5% LSD test. The research results showed that the use of Inpari 16, 32, and 33 increased crop yield by up to 6,9% to 30,9%. The highest yield was achieved by a variety of Inpari 32 (8,82 tons per hectare), followed by Inpari 33 (7,51 tons per hectare), and the lowest yield was found for Inpari 16 (6,95 tons per hectare). This shows that the use of Inpari 16, 32, and 33, can increase the percentage of rice production 6.92%, 35.62%%, and 15.54% respectively. The results showed that the three varieties inpari 16, 32, and 33 were susceptible to mild damage (≤ 11%), namely 0.56%, 0.6%, and 0.23% respectively, while Ciherang (control) 0.45%.

1 Introduction

The source of carbohydrate for Indonesian community is from Rice (Oryza sativa L.). This food is produced by around 60% of the Indonesian population who earn their living as farmers. However, rice development often experiences obstacles, including pest and disease attacks, such as the attack of rice

* Corresponding author: idab003@brin.go.id

stem borer (RSB) pests. This pest damages rice plants up to 60 percent [1] because attacks start from the seedling phase to the production phase [2]. Especially in high humidity conditions during the rainy season, the population of this pest increases significantly [3]. However, this pest can reportedly be overcome by using resistant varieties.

Several types of RSB pests found attacking rice plantations in Bali include *Scirpophaga incertulas* Walker (yellow stem borer), *Scirpophaga innotata* Walker (white stem borer), *Chilo supressalis* Walker (striped stem borer), and *Sesamia inferens* (striped stem borer) [4]. In the initial growth phase, this pest attack is still small so it is not detrimental and currently, the condition of new plant saplings continues to grow up to 30%. The condition of the plant will change as a result of the RSB attack, namely the panicle will change color to white due to empty grains [2]. Some farmers overcome this problem, among others, by using chemical pesticides [5,6], but in the long term this results in damage to the environment, biodiversity and human health. Other adverse impacts result in resistance, resurgence, or secondary pest outbreaks, killing of non-target organisms, and insecticide residues [1]. To avoid the negative impact of using insecticides in controlling RSB on natural enemies, other non-target organisms and the environment, an insecticide with the active ingredient Clorantraniliprole 0.4% G is used [7]. Apart from biotic factors, abiotic factors such as temperature, rainfall and wind speed have a negative influence on the presence of stem borer species in rice plantations, while relative humidity and duration of sunlight have a positive influence [8].

It is known that organic fertilizer can improve soil and environmental conditions and maintain the presence of natural enemies [9]. Chemical pesticides containing the active ingredients Abamectine and Spinetoram have high efficacy in controlling yellow RSB (*Scirpophaga incertulas Walker*) with the lowest percentage of attacks [10].

One of the efforts made is the use of NSV which is one of the basic technological components of the Integrated Pest Management (IPM) concept [5]. Delaying planting time can affect the degree of stem borer infection. The IPM approach combines cultivation practices, planting pest/disease resistant varieties, improving biological control, population monitoring, and the use of chemical control as a last resort, to minimize environmental impacts and ensure sustainable rice production [43]. Some NSV have high productivity and resistance to pest attacks [11; 12;13]. Therefore, the use of multiple rice NSV has been developed in Bali to minimize yield losses caused by RSB. The Ciherang variety is known to dominate the use of superior varieties in Bali, reaching more than 95% of rice production centers in Bali [13]. The aim of this research was to determine the growth performance and resistance of four NSV rice plants to RSB.

2 Materials and Methods

2.1 Research Location and Materials

Research carried out in the Subak Guama rice fields, Selanbawak Village, Marga District, Tabanan Regency covering an area of 3 hectares [14] The superior rice varieties used in this research were Inpari 16, 32, 33, and Ciherang as controls. The research was carried out from February to June 2021.

2.2. Transplanting

The age of the seeds to be planted ranges from 15 to 18 days, using a two-row planting system (2:1) *Legowo* planting system with standard planting of 25 x 12.5 x 50 cm (distance between rows is 25 cm, in a row 12.5 cm), separated by aisles/legowo measuring 50 cm so that all plants receive full sunlight and make it easier for farmers to fertilize, weed and spray insecticides, with a plant population per hole of 1 to 3 stems. All plants became edge plants. The 2:1 *legowo* planting system will produce a plant population per hectare of 213,300 bushes, and will increase the population by 33.13% compared to the tegel (25×25) cm planting pattern which is only 160,000 bushes/ha.

Urea (dose 275 kg/ha) and NPK 15 15 15 (dose 250 kg/ha) were used as fertilizer Minister of Agriculture Regulation Number 40/Permentan/OT.140/4/2007 Recommendations for Fertilizing N, P, and K in Location-Specific Rice Fields [44] each given three times, namely 1/3 dose at 7-10 days after planting (DAP), I/3 dose 20-21 DAP and 1/3 dose 30-40 DAP. Controlling pest organisms was carried out using an integrated pest control system (IPM), one of which is through the use of organic cow dung fertilizer of 2 tons/hectare which was maintained "in situ" (Cows are kept in the middle of rice fields). Harvesting was conducted when 95% of the rice plants have turned yellow.

2.3. Observation

The variables observed were plant heigh, produktive tillers, panicle length, number of fillef grains per clump, number of empty grains per clump, total number of grains per clump, weight 1000 grains, production of harvested dry grains (HDG) per hectare. Sample observed was 10 plants in the area of 400 m2 as a natural plot.

Diagonal random sampling method was used to assess the incidence and severity of rice stem at the field after 2 weeks of planting, data observation for stem borer has been investigated, then continued every 2 weeks until 10 weeks after planting. The appropriate design is a 1 factor randomized block design with 4 treatments and 6 replications. Data collected related to the percentage of RSB pest attacks every two weeks starting 2 weeks after planting (WAP), vegetative phase 2-6 WAP, *dead hearts* (DH) and generative phase 8-10 WAP, *white ear heards* (WE). Measurement of attack levels is based on the technical instructions for observing and reporting plant pests and the impacts of climate change (OPT-DPI) of the Ministry of Agriculture in 2018 [15].

$$P = \frac{n}{N} \times 100\% \text{ .... (1)}$$

Note:
P = Attack percentage
n = Number of offspring attacked
N = Total number of offspring

Table 1. Score of RSB attack level

Category	Category level of attack on plants
Mild	-when the level of attack > CT-≤11%
Currently	-when the level attack > 11% - ≤ 25%
Heavy	-when the level attack > 25% - ≤ 5%
Dead	-when the level of attack > 85%

Source: Ministry of Agriculture, (2018); CT = Control threshold

Pest attacks can be expressed quantitatively and qualitatively. Quantitative attacks are expressed in the form of percent (%) which shows the plant, plant part or group of plants attacked, while qualitative attacks are expressed in attack categories: mild, currently, heavy and dead. Analysis uses analysis of variance and continues with the least significant difference (LSD) test at the 5% level.

3. Results

3.1. Agronomic Performance

The results of field tests in this research showed that the best plant height was given by the Inpari 33 variety (Table 2). This is caused by several factors such as variety genetics, biotic and abiotic as well as cultivation management factors themselves [16;17;18;19]. In general, rice production per hectare is largely determined by cultivation such as nutritional support for non-plants by plant height. Plants with good height indicate good soil nutritional conditions [20]. Good rice cultivation management, such as providing balanced fertilizer in accordance with plant nutritional needs, has been proven to be able to increase rice production components. Soil management through the use of organic fertilizer as a cheap source of nitrogen is very important to build and maintain optimal soil physical and nutrient status which is important for plant growth [9].

Inpari 40 has been cultivated in Subak Guama, Tabanan Regency for more than five years. This variety was found more resistant to brown planthopper pests, and grows well compared to Ciherang [21]. There are also many factors that cause rice yields to decrease, including the fact that rice is weak in withstanding wind pressure because the plants are relatively tall so they fall easily. Because the rice falls, the potential for seeds to fall off or fall out of the panicles is high. In addition, tall plants have the potential to increase respiration, slower nutrient uptake and are more open to attack by plant pest organisms and disease [22, 23].

Table 2 shows that there is a significant difference between Inpari 32 and 33 varieties and the control treatment (Ciherang variety) in the number of productive tillers, while Ciherang production appears to be higher than Inpari 16. According to [24, 25] several factors that can influence the emergence of rice seedlings include plant pedigree factors, land conditions such as pH, nutrition and the presence of air, high rainfall and pest and disease attacks which directly influence the hormonal conditions of plants and the development of rice growth. In this study, it was proven by the high growth of seedlings in Inpari 32 (26.58 tillers) and Inpari 33 (29.17 tillers) per clump followed by inpari 16 (19.42 tillers) not significant different to control ciherang. The number of off spring in the control was much lower, namely 16.33 tillers. It is important to know the level of number of rice tillers can be directly able to predict the level of plant productivity [26].

Table 2. Agronomic components of several rice varieties in Subak Guama, Selanbawak village, Marga sub-district, Tabanan district

Treatment	Result Components		
	Plant hight (cm)	**Number of tillers/clump**	**Panicle length (cm)**
Inpari 16	83.75 d	19.42 b	20.15 b
Inpari 32	98.92 b	26.58 a	19.67 b
Inpari 33	109.58 a	29.17 a	27.10 a
Ciherang (Control)	91.58 c	16.33 b	24.84 a
LSD 5%	6.18	41	2.88

Note: Numbers followed by the same lowercase letter in one column indicate an insignificant difference based on the 5% LSD test (Suastika et al., 2023)

Statistical data showed that the control treatment was not significantly different from the vigor of Inpari 33 on panicle plants, while Inpari 32 and 16 were significantly different from the control and Inpari 33. Inpari 33 gave the largest value, namely 27.10 cm, followed by ciherang control (24.84 cm), Inpari 16 (20.15 cm) and the lowest Inpari 32 (19.67 cm). Factors that influence panicle length include genetic aspects of the plant, land factors such as soil fertility, soil pH, adequate nutrient intake for plants, and irrigation factors that influence plant growth [27]. Meanwhile, other opinions state that genetic factors have a very high contribution compared to the plant's environment [28, 29]. Panicle length is reported to be grouped into three groups, namely short (≤ 20 cm), medium (20-30 cm), and long (> 30 cm) [30]. Based on the definition of panicle length such as height >30 cm, medium 20-30 cm and short <20 cm, the Inpari 16, 32 and 33 varieties are included in the medium group (range 20-30 cm). According to [22] states that long panicles are better because the seed grains are low so that the potential for high yield or better productivity.

3.2. Yield Components

There are several elements put forward in this rice study consisting of aspects of rice panicles, namely the amount of grain in the clump, including empty grain and the total number of grain in the clump, the weight of 1000 grains, and the rice yield per hectare (milled dry grain) (Table 3). From this study it can be seen that the best adapted variety is Inpari 33 followed by the lower varieties Inpari 16 and 32 respectively. The results of statistical analysis on the number of grains per clump showed that the Inpari 16 (166.50 gr) and 33 (133.50 gr) varieties were not significantly different from the Ciherang variety (143.00 gr). The Inpari 32 variety had a lower grain number and was significantly different from the control Ciherang variety. If you look at the relationship between the grain and the clump, the longer the panicle, the more it can accommodate grain and vice versa [31]. In this research, this opinion is in line with the best grain number and panicle length produced by the Inpari 33 variety. Apart from that, it can also be explained that the height of grain produced by a variety is largely determined by the level of photo synthesis as well as the aspect of the variety's genetics [32].

In Table 3, it can be seen that the Inpari 32 and 33 varieties have a much higher grains weight of 1000 grains, which is very significantly different from the control (Ciherang). On the other hand, the Inpari 16 variety was not significantly different from the control. There are several factors that influence this weight, for example the use of organic and inorganic fertilizers very significantly increases the weight of grain [9]. In Table 3 it can also be seen that the three varieties, namely Inpari 16, 32 and 33, are significantly different in producing production per hectare which is apparently higher than the control (Ciherang). Meanwhile, Inpari 16 grain yield was not significantly different from the control.

Table 3 . Appearance data from the study of new varieties (Inpari 16, 32 and 33) compared with the control (Ciherang) in Subak Guama, Tabanan Regency 2021.

Treatment	Number of Filled grains/clump	Number of Empty grains/clump	Number of Total grains /clump	Weight 1000 grains (gr)	Yield (ton HDG/ha	Production Increase (%)
Inpari 16	166.50 a .	11.00 a	177.00 a	26.97 b	6.950 a	6.92
Inpari 32	101.83 b	17.67 a	122.00 a	30.02 a	8.815 b	35.62
Inpari 33	133.50 a	15.17 a	150.67 a	29.17 a	7.510 b	15.54
Ciherang (control)	143.0 a	16.25 a	159.25 a	26.57 b	6.500 a	
LSD 5%	55.11	10.28	64.81	1.08	2.32	

Note: Numbers followed by the same lowercase letter in one column indicate an insignificant difference based on the 5% LSD test.

3.3 The RSB attack occurred

In general, the level of plant damage caused by pests is directly proportional to the plant production. It has been reported that at a low attack level, there will be a relatively low decrease in production; conversely, at a higher attack level, it will cause a higher decrease in production [33]. Apart from biotic factors, stem borer populations are influenced by environmental factors, especially rice microclimate.

This microclimatic factor is related to the rice-planting system. It has been reported that the intensity of RSB damage in the jajar legowo planting system was lower than that in conventional planting systems [34]. Similarly, the study at Subak Guama, the attack of RSB did not show decreasing yield. While [30] informs the environmental conditions for growing rice plants greatly determine the level of productivity of rice yields. It was also reported that yield losses due to attacks by RSB pests at the vegetative stage were not large because the plants could still compensate by forming new shoots by up to 30% [35]. It has also been reported that condition of each variety of rice provides the capability in responses to the different environmental conditions, thus affecting production [36].

Stem borer attacks in the vegetative period (DH) when plants experience shoot death. Meanwhile, if the stem borer attacks during the generative period (ME), the panicles die causing the grains to become empty and the panicles appear white color. The same thing also happened in Subak Guama with an average RSB attack rate ≤11% compared to Ciherang (control). However, all test varieties and Ciherang (control) were suspected to be susceptible to RSB.

Percentage of RSB attacks in vegetative phase DH (6 WAP) on the Inpari 16 and 32 varieties were categorized as mild, and the Inpari 33 and Ciherang (control) varieties had no attacks on a scale of 0,58%, 0,12%, 0,71%, and 0,71% (Table 4). Meanwhile, the percentage of RSB pest attacks in the generative phase WE (8 WAP) on the varieties Inpari 16, 32, 33, and Ciherang (control) were categorized as mild. Meanwhile, the percentage of RSB attacks in generative phase WE (10 WAP) on the Inpari 16, 32, 33, and Ciherang (control) varieties were also categorized as mild on a scale of 0,56%, 0,6%, 0,23% and 0,45%. The results show that NSV Inpari 16, 32, and 33 cannot be said to be resistant because the percentage scale of attacks on the Ciherang variety (control) was categorized as mild. This shows that compared to Ciherang, Inpari 16, 32, and 33 can still be planted in Tabanan regency as a substitute for Ciherang to resist attacks by RSB pests. A previous study [20] showed that administering 100 kg of drum fertilizer per plot is the best treatment for increasing the number of tillers, number of panicles, weight of 1000 grains, and production per plot, and is the best for reducing the percentage of attacks by stem borer paddies.

Table 4. Development of the level of attack (%) by vegetative phase stem borer pests (DH) and whitear heards (WE) of inpari 16, 32 and 33 compare with control (ciherang) in Subak Guama Tabanan District 2021.

Treatment	DH 2 WAP	DH 4 WAP	WE 6 WAP	WE 8 WAP	WE 10 WAP
Inpari 16	0.71	0.71	0.58	0.56	0.56
Inpari 32	0.71	0.71	0.12	0.6	0.6
Inpari 33	0.71	0.71	0.71	0.31	0.23
Ciherang (control)	0.71	0.71	0.71	0.6	0.45

Note: WAP = week after planting, DH = dead hearts and, WE = white ear heards

RSB are very detrimental to farmers because their attacks occur so often that rice fails to bear fruit. At 7 - 11 weeks after planting (WAP), stem borers attack very intensively, but then the attacks decrease [37]. At the age of rice growth, borer attacks have begun to occur, which is known as DH, characterized by symptoms of dead plant growth points. Meanwhile, the symptoms of RSB attacks in the generative phase, called WE, show that the panicles die so that the grains become empty with a white color. After the RSB larvae enter and out from rice stem, in the next 4 days period shows the dead hearts characteristics. In the period when the RSB larvae become moths, they are able to eat 6-15 stalks of rice [2]. It is suspected that many farmers are making efforts to eradicate this pest by using chemicals. The bad impact of this step is environmental damage due to residue from these chemicals. One example is the emergence of pest resistance to insecticides, which over a certain period of time can cause an explosion of attacks. To overcome this, it has been found that the active ingredients Chlorantraniliprole

18.5 SC (150 ml/ha) and Chlorantraniliprole 0.4 GR (10 kg/ha) are able to control RSB attacks very effectively [8,15, 38, 39] and [40]. Similarly, [41] and [42] also reported that chlorantraniliprole 18.5 SC is the most widely used drug that is effective in minimizing YSB infections.

4 Discussion

In field conditions, the use of new superior varieties and insecticides in rice cultivation is considered to have greater potential for utilization compared to the use of natural enemies, because they are easier to store and transport by farmers. In this study, researchers only made visual observations about agronomic performance, yield components and the percentage of attacks by RSB pests in the vegetative phase and generative phase every 2 weeks starting 2 weeks after planting in natural rice fields measuring 400m2 and measuring productivity per plot after 95 % panicles appear physiologically mature. The research results showed that the height of the Inpari 33 variety was higher than the Inpari 32 and 16 varieties and was significantly different compared to the control (Ciherang). Rice plants that are too tall have the potential to increase respiration, slow down nutrient absorption and be more susceptible to attack by organisms and plant diseases [22, 23]. The use of superior varieties in rice cultivation such as Inpari 32 and 33 can also increase the number of tillers/clumps and can be directly used to predict plant productivity [26].

The research results also show that the use of superior varieties such as Inpari 33 and 32 can increase rice productivity per hectare. The increase in productivity of the Inpari 33 and 32 varieties was 8,815 tons of HDG/ha and 7,510 tons of HDG/ha respectively and was significantly different compared to the control (Ciherang) namely 6.50 tons of HDG/ha, and each variety could increase productivity per hectare amounted to 35.62% and 15.54% compared to the control (Ciherang).

In general, the level of plant damage caused by pests is directly proportional to the plant production. It has been reported that at a low attack level, there will be a relatively low decrease in production; conversely, at a higher attack level, it will cause a higher decrease in production [33]. Apart from biotic factors, stem borer populations are influenced by environmental factors, especially rice microclimate. This microclimatic factor is related to the rice-planting system. It has been reported that the intensity of RSB damage in the jajar legowo planting system was lower than that in conventional planting systems [34]. Similarly, the study at Subak Guama, the attack of RSB did not show decreasing yield. While [30] informs the environmental conditions for growing rice plants greatly determine the level of productivity of rice yields. It was also reported that yield losses due to attacks by RSB pests at the vegetative stage were not large because the plants could still compensate by forming new shoots by up to 30% [35]. It has also been reported that condition of each variety of rice provides the capability in responses to the different environmental conditions, thus affecting production [36].

The level of attack by pests in the RSB generative phase (WE) was higher than in the vegetative phase (DH). Previous results [45] reported that in the generative phase the population of RSB larvae was found to be higher than in the vegetative phase. It was also reported that the population of yellow rice stem borer larvae (89.0%) was found to be higher than that of the pink rice stem borer (3.0%). In general, the level of damage to rice plants due to stem borer pest attacks is directly proportional to plant production. It is reported that at low attack levels, production will decrease relatively low; conversely, a higher level of attack will cause a higher decrease in production [33]. Apart from biotic factors, rice stem borer populations are also influenced by environmental factors, especially the rice microclimate. This microclimate factor is related to the rice planting system. Apart from biotic factors, stem borer populations are influenced by environmental factors, especially rice microclimate. This microclimatic factor is related to the rice-planting system. It has been reported that the intensity of RSB damage in the jajar legowo planting system was lower than that in conventional planting systems [34]. The intensity of RSB damage in the Jajar Legowo planting system was reported to be lower than in conventional planting systems [34]. Likewise, research in Subak Guama, RSB attacks did not show a decrease in yield. Meanwhile [30] informed that the environmental conditions where rice plants grow greatly determine the level of productivity of rice yields]. Yield losses due to RSB pest attacks in the vegetative phase were also reported to be not large because the plants were still able to compensate by forming up to 30% of new shoots [35]. It is also reported that the conditions of each rice variety provide the ability to respond to different environmental conditions, thus affecting plant productivity [36].

Final effort that farmers can take to control rice stem borer pests is to use insecticides that are safe for the environment and natural enemies. One example is the impact of causing resistance, resurgence, killing non-target organisms. To overcome this, it is recommended to use insecticides containing the active ingredients Chlorantraniliprole 18.5 SC (150 ml/ha) and Chlorantraniliprole 0.4 GR (10 kg/ha) which can control RSB attacks very effectively [8,15, 38, 39, 40]. Similarly, [41, 42] also reported that chlorantraniliprole 18.5 SC is the most widely used drug and is effective in minimizing YSB infections and is safe against natural enemies.

5. Conclusion

Application of Inpari 16, 32, and 33 in this research can increase production by up to 6.9 to 30.9%. The highest production was achieved by a variety of Inoari 32 (8.82 HDG tons/ha), followed by Inpari 33 (7.51 HDG tons/ha), and the lowest production was found for Inpari 16 (6.95 HDG tons/ha). While Ciherang (control) production was 6.5 HDG tons/ha. This shows that the use of Inpari 16, 32, and 33, can increase the percentage of rice production 6.92%, 35.62%%, and 15.54% respectively. The results showed that the three varieties inpari 16, 32, and 33 were susceptible to mild damage (≤11%), namely 0.56%, 0.6%, and 0.23% respectively, while Ciherang (control) 0.45%.

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