The Potential of increasing rice production through high-yield varieties

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Abstract. High yield varieties with pests and disease resistance and environmental stress is one of the important technological components for increasing farmer productivity and income.. This research was conducted in irrigated rice fields in Kebakramat District, Karanganyar Regency at planting season (PS) II (March-July) and PS III (July-November). The purpose of this study was to determine the growth performance and productivity of high-yield varieties of rice. The completely randomized design was used with 3 treatments 5 times repeated. Code, Winongo were used and IR 64 as a comparison. Phonska 300 kg/ha and Urea 250 kg/ha were used in this study. Data of plant height, number of tillers, panicle length, and production were collected. Data plant growth and grain yield were analyzed using variance analysis. The results showed that high-yield varieties affected increasing production. The highest rice productivity obtained from the Code reached 8.44 t / ha DMG at PS 3 or 18.2% higher than the existing IR 64, while Winongo reached 8.05 t/ha DMG or 12.7% higher from IR 64. Code has the highest production, however, Winongo at PS 3 can also be used as a choice as a substitute for IR 64 besides Code in Karanganyar Regency.

1 Introduction

Rice is a staple food for Indonesian and the majority of the Indonesian population (95%) are consuming rice as a daily staple food [1]. The need for staple food (rice) is highly influenced by the factor of food availability which is closely related to the number population and consumption patterns.Therefore, the issue of rice will remain a very strategic for agricultural sector economically, socially and politically. Rice production can been hanced through increasing productivity by improving the application of technology components and packages of pre-harvest, harvest and post-harvest technologies.Rice is the main commodity in Indonesia which plays an important role in supporting food security.

The growing population in Indonesia has the potential to increase the amount of food demand, especially rice, which causes the average consumption rate of rice increase. Therefore, in order to achieve food sustainability, its need good food management system. Sustainable management of integrated rice production systems can increase awareness and understanding of the potential, flow and demand for rice needs [2]. Based on data from

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[3,4], while the planning and realization of rice in Central Java Province from 2015-2019 (tonnes) increased in 2016, on the other hand, until 2019 it continued to decline to reach 36.1%.

Table 1. Planned and Realization Rice Production in Central Java Province, 2015 – 2019 (Ton)

Year	Planned (Ton)	Realization (Ton)	Percentage (%)
2015	505,000	316,405	62.65
2016	505,000	592,738	117.37
2017	602,275	371,331	61.65
2018	442,391	254,487	57.53
2019	379,774	151,888	39.99

Source: [3,4]

In the last two decades, there has been a slump production and productivity of rice such as IR 64. Varieties that are planted continuously will change, including variety purity, decreasing resistance to certain pests and diseases, therefore other HYV (high yield variety) are needed to replace these varieties. According to Purba [5], HYV is the most effective and efficient technology in increasing productivity. The use of HYV, resistance to pests and diseases as well as environmental stress is some of the important components in increasing rice productivity. The benefits of these varieties will be enjoyed by both rice producers and rice consumers if there are sufficient quality seeds available for large-scale farmers to plant [6].In addition, [7] added that to adapt to climate change, it is necessary to explore potential climate scenarios in order to increase yields in various food-producing areas.

Karanganyar Regency has a harvest area and lowland rice production, respectively 43,366.84 ha and 367,832.68 tones with a productivity level of 6.17 t ha^{-1}[8]. The low productivity of lowland rice is partly due to the limited application of HYV and fertilizers at the farmer. The dominant rice varieties applied in the Karanganyar district are the IR 64 and Ciherang. Therefore, it is necessary to adopt new high-yielding lowland rice varieties that have high potential, are resistant to pests and diseases, have good quality grain and rice, and provide specific location fertilization recommendations.

To obtain alternative varieties to replace IR 64, it is necessary to test several varieties of lowland rice with high yield potential. Several types of lowland rice varieties that have been released by Indonesia Rice Research Institution are Conde and Winongo. The use of HYV is an opportunity to increase rice production. The approach to applying high-yielding varieties following local agroecology can effectively increase crop productivity, resistance to pests and diseases, as well as drought and flooding. The availability of HYV can also accommodate consumer tastes to get rice with various quality advantages such as tasty, fluffier, aromatic, and flavorful rice. A variety with high taste quality has a low amylose and protein content[9]. The purpose of this research was to determine the growth and yield of several lowland HYV for planting during planting season (PS) 2 and planting season 3.

2 Method

The research activity was carried out all two seasons, at PS 2 (March-July) and PS 3 (July-November) in Kebakramat subdistrict, Karanganyar Regency. The HYV used were 3 varieties Code (2 ha), Winongo (1 ha), and IR 64 (2 ha). Each variety was repeated 5 times. The introduction of technology such as the use of HYV and fertilization technology according to location-specific nutrient fertilization (PHSL) using the paddy soil test kit (PUTS). Based on the results of the soil test, the recommended fertilizers are 250 kg/ha Urea and 300 kg/ha Phonska and organic fertilizer 1 ton/ha (Table 2).

Table 2. Technology components applied with IPM approach

No.	Technology components	IPM approach
1	Tillage	Using tractor
2	Seed	High-quality seed (30 kg/ha)
3	Varieties	Code, Winongo dan IR 64,
4	Seedling	Wet
5	Age use of seedling	21 DASand use 2-3 seed/tiller
6	Planting system	20 x 20 cm
7	Organic fertilizer	Compost 1.0 t/ha
8	Anorganic fertilizer	Phonska (300 kg/ha); Urea (250 kg/ha)
9	Watering	Intermittent
10	Pest control	IPM

The research method used the OFCOR (On-farm Client-Oriented Research) approach. This method is used because research activities are on farmers' land who are partners of cooperation by taking an active role during the activity. The OFCOR method is also used by [10] in their research by actively involving farmers and field agricultural extension agents (AEA). This study used a non-factorial randomized block design. In this activity, the farmer is played as a cooperator as well as a replication.

The data collected were agronomic performance (i) number of tillers, (ii) plant height, (iii) yield; grain weight per Ha (dry unhilled grain/DUG and dry milled grain/DMG) and 3) yield components such as panicle length and weight of 1000 filled grains. To get yield productivity, it was done by using ubinan method for each variety with 5 points of ubinan. To get productivity in the form of milled dry unhulled rice (DMG), it is done by conserving it with a water content of 14 percent. To test the mean difference between rice varieties, it was analyzed using analysis of variance (ANOVA). The differences obtained were further tested using the LSD significant difference test at the 5% confidence level.

3 Result and discussion

3.1 Plant Growth Components

In Table 3, it is shown that the plant height of Code is not significantly different from Winongo but significantly different from IR64 both at PS 2 and PS 3, likewise, the number of tillers of all varieties planted at the age of 21 DAP is not significantly different either in PS- 2 or PS-3. It was different at the age of 45 DAP with a plant height range of 72.8 - 83.3 cm, between varieties, showed significant differences in both PS- 2 and PS-3, but each variety was not significantly different between PS- 2 and PS- 3. age 45 DAP,Winongo grown on PS 2 was different from that grown on PS 3 (Table 1). The number of tillers at the age of 21 DAP ranged from 9-10 tillers and at PS3 ranged from 9-10 plants. In the vegetative phase, the number of tillers is variable that can determine the yield of rice plants .According to [11], the criteria for the number of tillers are divided into 4 groups very low, low, medium, high, and very high, if each is <5; 5-9; 10-19; 20-25;> 25. The three varieties had moderate tillers. Plant height and number of tillers are among the selection criteria for rice plants, but high growth does not guarantee a high level of productivity. [12], stated that plant height is influenced by plant genetic traits, growing environmental conditions, and their interactions in the environment where it grows. The difference in genetic makeup is one of the factors that cause differences in plant growth.

Table 3. The results of observations of the components of growth of HYV rice aged 21 DAP and age 45 DAP at PS 2 and PS 3, Karanganyar Regency

Parameter	Variety	Planting Season (PS)	
		PS 2	PS 3
Plant Height (cm) 21 DAP	Code	41.68aA	41.42aA
	IR 64	35.50bA	36.04bA
	Winongo	40.19aA	40.54aA
Number of Tiller (number) 21 DAP	Code	9.60aA	10.00aA
	IR 64	9.40aA	9.20aA
	Winongo	9.80aA	9.75aA
Plant Height (cm) 45 DAP	Code	83.32aA	82.98aA
	IR 64	72.88cA	73.08cA
	Winongo	78.26bA	77.16bA
Number of Tiller (number) 45 DAP	Code	18.80aA	18.80aA
	IR 64	15.80cA	15.80cA
	Winongo	17.80abA	17.25bA

Note : The numbers followed by the same letter in columns (a,b,c) are significantly different as well as in rows(A, B, C) means thatthere is no significant difference in the LSD0.05 test

3.2 Yield Components

The results of statistical analysis showed that the different varieties had a significant effect on the number of tillers, plant height, and panicle length both in rice grown on PS 2 and PS 3 as well as between varieties on the same PS. In Table 4, it can be seen that Code has a higher number of productive tillers (19.20 - 19.52) compared to other varieties. This diversity is influenced by the genetic variation of the varieties because each of them has a unique character.Likewise, the plant height of Code varieties had the highest, reaching 109.08 cm at PS 2 and 109.18 cm at PS 3. The development of plant height to the age of the harvest stage showed variations between 90.5 to 109.9 cm.

Plant height is related to the utilization of solar radiation. [13] stated that varieties that can utilize high solar radiation for photosynthesis have a plant height of at least 100 cm and the leaves at the top of the plant remain green when filling the grain until the grain turns yellow. The variety of plant heights between varieties is caused by genetic factors and environmental factors. This is inline with the opinion of [12] which state that plant height is a genetic factor that characterizes the plant itself and is influenced by local environmental conditions.Plants that grow well are able to absorb nutrients in large quantities, so that in a growing environment with sufficient nutrient availability, it has an effect on increasing plant photosynthetic activity. Plant N uptake was positively correlated with root length, surface area, volume, and biomass so that plant growth and yield components increased [14]. According to [7], stated that the interaction between rice plants and environmental factors can affect the growth and yield of rice plants. Panicles are formed when entering the generative phase, in this phase rice requires sufficient water availability and the need for N available to plants because at this phase, plant cells are very active in dividing and the division process will be better if the supply of N is available to plants.

The length of the panicle is an important component in determining crop yields where the longer the panicle is, the more the number of grains is expected.According to[15],the length and number of panicles are important characters that directly affect the yield. Besides that, the interaction between rice plants and environmental factors can affect the growth and yield of rice plants. This is following the results of research by [16] in Malang-East Java which reported that panicle length was positively correlated with the total number of grains so that any increase in panicle length would support an increase in the number of panicles. In addition, [17] stated that cultivation system and area area also affect the number of panicles per clump

Table 4. The Average Yields of the Agronomic Component Performance of HYV Harvest at PS 2 and PS 3, Karanganyar Regency.

Parameter	Variety	Planting Season (PS)	
		PS 2	PS 3
Plant Height (cm)	Code	109.08aA	109.18aA
	IR 64	90.46cB	103.32bA
	Winongo	100.26 bB	108.92aA
Panicle length (cm)	Code	24.20aA	24.20aA
	IR 64	19.12cB	20.06cA
	Winongo	21.48bA	21.30bA
Number of Tillers (number)	Code	19.20aA	19.52aA
	IR 64	16.00cB	17.92bA
	Winongo	17.70bA	18.42abA

Note : The numbers followed by the same letter in columns (a,b,c) are significantly different as well as in rows(A, B, C) means thatthere is no significant difference in the LSD 0.05 test

3.3 Productivity Performance

For the weight component of 1000 grains, Code, Winongo, and IR 64 varieties both on PS 2 and PS 3, showed that Code had the highest weight 30.76 g on PS 2 and 31.46 g on PS 3 and the lowest is IR 64 28.93 g at PS 2 and 28.75 g at PS 3. The results of the 1000 grain weight showed that the description was higher than the 1000 grain weight of the average description [18].

Table 5. 1000 grain weight and productivity of HYV at PS 2 and PS 3, Karanganyar Regency.

Parameter	Variety	Planting Season (PS)	
		PS 2	PS 3
1000 grain weight (g)	Code	30.76aA	31.46aA
	IR 64	28.93bA	28.75bA
	Winongo	29.37bA	29.50bA
Dry-unhusked grain (DUG) (t ha $^{-1}$)	Code	6.62aB	9.12aA
	IR 64	5.84bB	7.74bA
	Winongo	5.38bB	8.57aA
Dry-milled grain (DMG) (t ha $^{-1}$)	Code	6.19aB	8.44aA
	IR 64	5.45bB	7.14bA
	Winongo	4.96bB	8.04aA

Note : The numbers followed by the same letter in columns (a,b,c) are significantly different as well as in rows(A, B, C) means thatthere is no significant difference in the LSD 0.05 test

Code has the highest yield because it has the superiority of grain weight components of 1000 grains (31.46), the number of tillers (19.52) and panicle length (24.2 cm) is higher than the other two varieties (Tables 4 and 5). The weight of 1000 grains at PS 2 Code was significantly different from IR 64 and Winongo, while IR 64 was not significantly different from Winongo, while in PS 3, Code was not significantly different from Winongo but significantly different from IR 64. The weight of 1000 gains of Winongo was also significantly different from IR 64. Yields were determined by yield components, while yield components were determined by plant genetics and environmental factors (climate, nutrients/soil, and water) [12]. Plant growth components affect plant yield components.

Based on the results of statistical analysis, it shows that the production of harvested Dry-unhulled grain (DUG) of Code is significantly different from IR 64 and Winongo while IR 64 is not significantly different from Winongo in PS 2. For DUG production on PS 3, Code is not significantly different from Winongo but Code is different from IR 64 (Table 5). Based on the DUG results obtained, Code gave the highest productivity compared to other varieties, namely at PS 2 6.62t ha^{-1} DUG and at PS 3 9.12 t ha^{-1} DUG.

The productivity of dry-milled grain (DMG) of rice obtained from 2 cultivated varieties varies in PS 2 Code (6.19 t ha^{-1}DMG) and Winongo variety (4.96 t ha^{-1}DMG), for PS 3 the production of Winongo variety is 8,04 t ha^{-1}DMG and Code had the highest production, reaching 8.44t ha^{-1}DMG, while the IR 64 had productivity on PS 2 (5.45t ha^{-1}DMG) and PS 3 reached 7.14t ha^{-1}DMG. The difference in results obtained is because each variety has different genetic, morphological, and physiological characteristics and has different yield potentials[19]. Besides, productivity is also influenced by the number of productive tillers and the weight of 1000 grains of grain [20].

According to [21, 22], there is two important factors affect plant growth (weight gain, plant height, and the number of productive tillers), namely genetic factors and environmental factors. The growth of HYV of rice that have better genetics in optimal environmental conditions can give high yields/production. Code and Winongo at PS 3 indicate that both varieties are adapting to the new location. Such conditions indicate that for PS 2 Code is adaptive, while for PS 3 besides Code, Winongo can also be used as an alternative. Plant tolerance to the environment during the growing period can affect the differences in yield for each variety. According to [23],differences in genotypes, locations, seasons and the interaction of genes and the environment affect the results

4 Conclusion

The production of the dry-milled grain of each variety was significantly different both at PS- 2 and PS- 3. Code varieties were statistically significantly different from IR 64 and Winongo while IR 64 was not significantly different from Winongo on PS-2 and PS- 3.

The highest rice productivity obtained from the Code reached 8.44t ha^{-1}DMG at PS 3 or 18.2% higher than the existing IR 64, while Winongo reached 8.05t ha^{-1} DMG or 12.7% higher from IR 64. Code has the highest and superior production compared to other varieties, however, Winongoat PS-3 can also be used as a choice as a substitute for IR 64 besides Code in KaranganyarRegency.

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