Agronomic responses of several rice varieties on ratoon salibu system

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Abstract. Salibu rice cultivation is one of the technological innovations to spur productivity or increase production. Salibu technology (modified ratoon) is a rice cultivation technology that utilizes rootstocks after harvest to produce shoots or tillers for nurturing. These shoots function as seeds in a transplanting system. Cutting treatment on the first generation of salibu crop started when the mother plant harvested at 132 days after sowing at 20 cm above the soil surface, and then re-cut seven days after harvest at 3-5 cm above the soil surface. Cutting treatment on the second generation of salibu crop started when the first generation of salibu crop harvested at 94 days. The results showed that the Batang Piama n variety has the best agronomic responses on the ratoon salibu system because the yield was 60% for the first generation of salibu and 62.5% for the second generation of salibu. Ketan Grendel variety the product was 70.5% for the first generation of salibu and 55% for the second generation of salibu.

1. Introduction
Salibu rice is a rice plant that grows again after the remaining stems of the harvest are cut or trimmed. Shoots will appear from the nodes in the soil. These shoots will issue new roots so that the nutrient supply is no longer dependent on the old stem [1]. These shoots can split or sprout like rice ordinary transplanted plants, making growth and production the same or higher than the first plant (mother plant) [2]. Salibu rice is different from ratoon rice. Ratoon is rice that grows from the remaining stems of the harvest without pruning the stems. Shoots will appear on the top of the book, and the old stems nutrient supply remains [3]. Groundwater availability strongly influences the growth of shoots after cutting, and at harvest time, the groundwater should be in a state of field capacity. Adequate fertilization is needed, especially nitrogen nutrients, to balance the need for nutrients during salibu rice tiller's growing period [4]. The element nitrogen is a significant protein synthesis component, so it is required for plants vegetative phase, especially in cell division [5].

1.1. Aim
This research aimed to determine the agronomic responses of several rice varieties on the ratoon salibu system.

1.2. Hypothesis
There are rice varieties that have the best agronomic responses to the ratoon salibu system.
2. Materials and method

2.1. Place and time of research
This research was conducted in Kuningan, West Java, Indonesia. This research was implemented from August 2019 to March 2020.

2.2. Planting materials
The materials used in this study were rice seeds of Inpari 43, Batang Piaman, Ciherang, Ketan Grendel varieties, urea, SP-36, KCl fertilizer, and mother plants planted in April 2019 and harvested in July 2019.

2.3. Tools
The tools used are analytical scales, measuring tape, tools commonly used in rice cultivation techniques in general agricultural tools, stationery, tools for observation, and documentation tools.

2.4. Experimental design
This research using a randomized block design for the experimental setup with one factor, namely rice varieties. The experiment used three replications, and each reproduction contained four rice varieties.

2.5. Procedure
The experimental procedure begins with land preparation on the mother plant, which started with two times tillage with plowing and harrowing. After that, the soil was leveled and made as bunds. Before planted, the rice seeds were sowed in the beds for 23 days. The size of the bed was 5 m x 1.5 m. Rice was planted in a row system with a spacing of 25 cm x 25 cm. Weeding and controlling pests and diseases are carried out by regularly maintaining the symptoms of attacks in the field. The mother plants were harvested when 85% of the grain color in the panicles turns yellow. Rice was harvested by cutting the stem with a height of ±20 cm from the ground. The cutting of the first and second generations salibu stem carried out for seven days after harvesting the mother plant with a cutting height of 3 to 5 cm from the soil surface. Weeding and controlling pests and diseases are carried out with standard control. The first and second generations of salibu plants were harvested when 85% of the panicles grain color turns yellow. Rice was harvested by cutting the stem with a height of ±20 cm from the ground.

2.6. Observations
- Growth responses are plant height, number of tillers hill\(^1\), flowering age, harvest age, grain filling period, grain filling rate
- Production responses are panicle length, number of panicles, number of grains hill\(^1\), number of grains panicle-1, percentage of filled grain, the weight of filled grain hill-1, weight of 1000 grains, and milled dry weight grain ha\(^1\).

2.7. Data analysis
Data analyzed using analysis of variance. Further tests were carried out with Duncan Multiple Range Test (DMRT) at the level of \(\alpha=5\%\) if the various treatment results had a significant effect. Data processing using Microsoft Excel and STAR (Statistical Tool for Agricultural Research).

3. Results and discussion

3.1. Growth responses
Table 1 shows that the mother plants plant height was significantly different between varieties and had the highest average compared to the first and second-generation salibu, which was 95.92 cm. The average size of the first-generation salibu plants decreased by 20% from the mother plant. In contrast, the second-generation salibu plants average was almost close to the mother plants height. Ketan variety had the highest plant height for the mother plant (121.29 cm), first (92.42 cm), and second (110.25 cm)
generation salibu, but the Ketan variety in the first generation salibu got a decrease from the mother plant by 23%.

Table 1. Average of plant height and number of tillers on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties | Plant height (cm) | Number of tillers | Plant height (cm) | Number of tillers | Plant height (cm) | Number of tillers |
|-----------|------------------|------------------|------------------|------------------|------------------|------------------|
|           | MP (WAP\(^a\))   | S1 (WAC\(^b\))   | S2 (WAC\(^b\))   |
| Inpari 43 | 75.63d            | 21.34a           | 57.29d            | 18.13a           | 71.13c           | 15.04a           |
| Batang Piaman | 99.17b         | 20.67a           | 87.34b            | 18.04a           | 105.79a          | 14.59a           |
| Ciherang   | 87.59c            | 17.30b           | 67.67c            | 17.92a           | 81.34b           | 13.00a           |
| Ketan      | 121.29a           | 16.63b           | 92.42a            | 16.75a           | 110.25a          | 12.38a           |
| Average    | 95.92             | 18.99            | 76.18             | 17.71            | 92.13            | 13.75            |

\(^a\)WAP = weeks after planting.
\(^b\)WAC = weeks after cutting.

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of \(\alpha = 5\%\).

It increased again in the second generation of salibu, although it was still lower than the mother plant. Likewise, other varieties experienced a decrease in plant height in the first salibu generation, then increased again in the second generation salibu. This pattern was following the research of Yamaoka \textit{et al.} [6], which showed that the height of the first generation salibu plants decreased by 26\%, then increased again by 34\% of the mother plant.

Table 1 shows that the number of tillers per hill in the mother plant had the highest average compared to the first and second-generation salibu, 18.99 tillers. The average plant height of the first generation salibu got a slight decrease from the mother plant. In contrast, the average plant height of the second generation salibu experienced a drastic reduction from the mother plant. Inpari 43 variety had the highest number of tillers for the mother plants (21.34), first (18.13), and second (15.04) generation salibu. However, the Inpari 43 variety decreased the number of tillers in the first and second generations of salibu. Likewise, with other types that got a decrease in the number of tillers for the first and second generations of salibu. This decrease was because the tillers growing from ratoon plants were generally very tall but not accompanied by productive tillers [7].

Table 2. Average of flowering age and harvesting age on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties | Flowering age (DAS\(^a\)) | Harvesting age (DAS\(^a\)) | Flowering age (DAH-MP\(^b\)) | Harvesting age (DAH-MP\(^b\)) | Flowering age (DAH-S1\(^c\)) | Harvesting age (DAH-S1\(^c\)) |
|-----------|--------------------------|-----------------------------|-------------------------------|-----------------------------|-----------------------------|-------------------------------|
|           | MP                       | S1                          | S1                            | S1                          | S1                          | S1                            |
| Inpari 43 | 92.67b                   | 132.00*                     | 75.00a                        | 94.00*                      | 61.00c                      | 104.33a                       |
| Batang Piaman | 103.00a               | 132.00*                     | 81.33a                        | 94.00*                      | 76.67a                      | 112.00a                       |
| Ciherang   | 101.00a                  | 132.00*                     | 77.00a                        | 94.00*                      | 62.67bc                     | 104.33a                       |
| Ketan      | 95.00b                   | 132.00*                     | 58.00b                        | 94.00*                      | 71.00ab                     | 112.00a                       |
| Average    | 97.92                    | 132.00                      | 72.83                         | 94.00                       | 67.84                       | 108.27                        |

\(^a\)DAS = days after sowing.
\(^b\)DAH-MP = days after harvest of the mother plant.
\(^c\)DAH-S1 = days after harvest of first-generation salibu.

* = constant harvesting age.

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of \(\alpha = 5\%\).
Table 2 shows that the second generation of salibu has a lower average of flowering age than the mother plants and the first generation salibu. Inpari 43 varieties of the mother plant and the second generation salibu had the fastest flowering period than other types. In contrast, in the first generation salibu combinations, Ketan flowering age was more rapid than different varieties. The first and second generations of salibu have a shorter flowering period than the mother plant because the ratoon flowers may appear simultaneously as the leaves [8]. Mother plants were harvested (132 DAS) and first-generation salibu (94 DAH-MP) on the same day to prevent bird pests, which could reduce yields.

In contrast, the second generation of salibu harvesting when 85% of plant panicles had turned yellow due to a reduction of bird pests population. The average harvest age for the second generation salibu was lower than the mother plants and the first generation salibu. Inpari 43 and Ciperan varieties of the second generation salibu had faster harvest age, 104.33 DAH-S1, compared to Batang Piaman and Ketan varieties, 112 DAH-S1.

Table 3. Average of grain filling period and grain filling rate on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties  | Grain filling period (days) | Grain filling rate (g days⁻¹) | Grain filling period (days) | Grain filling rate (g days⁻¹) | Grain filling period (days) | Grain filling rate (g days⁻¹) |
|------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
|            | MP                          | S1                            | S2                          |                               |                             |                               |
| Inpari 43  | 39.33a                      | 1.27a                         | 19.00b                      | 1.56a                         | 43.33a                      | 0.67b                         |
| Batang Piaman | 29.00b                     | 1.90a                         | 12.67b                      | 2.06a                         | 35.33a                      | 1.52a                         |
| Ciperan     | 31.00b                      | 1.45a                         | 17.00b                      | 1.58a                         | 41.67a                      | 0.81b                         |
| Ketan       | 37.00a                      | 1.24a                         | 36.00a                      | 1.33a                         | 41.00a                      | 0.92b                         |
| Average    | 34.08                       | 1.47                          | 21.17                       | 1.63                          | 40.33                       | 0.98                          |

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of α = 5%.

Table 3 shows that the grain filling period is the difference between the flowering age and the harvest age, while the grain filling rate is the total grain weight per hill divided by the grain-filling period. The first generation salibu had the lowest average grain filling period than the mother plants and the second generation salibu, which is 21.17 days. The Batang Piaman variety of the mother plant had the fastest grain filling rate, the first and second generation salibu, the grain filling rate. The Batang Piaman variety of the mother plant, and the first and second generations of salibu, had the highest grain filling rate. According to Bustamam [9], the higher the grain filling rate, the heavier the final weight per seed.

3.2. Production responses

Table 4. Average of panicle length and number of panicle on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties  | Panicle length (cm) | Number of panicles | Panicle length (cm) | Number of panicles | Panicle length (cm) | Number of panicles |
|------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|
|            | MP                  | S1                 | S2                  |                    |                     |                    |
| Inpari 43  | 20.38c              | 20.50a             | 16.81c              | 20.00a             | 19.07c              | 13.50b             |
| Batang Piaman | 23.26a              | 19.33a             | 20.32a              | 19.00a             | 23.03ab             | 21.67a             |
| Ciperan     | 21.83b              | 14.17a             | 18.63b              | 18.33a             | 20.85bc             | 14.00b             |
| Ketan       | 22.36ab             | 15.50a             | 20.95a              | 20.33a             | 23.85a              | 13.33b             |
| Average    | 21.96               | 17.38              | 19.18               | 19.42              | 21.70               | 15.63              |

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of α = 5%.
Table 4 shows that the length of the panicle on the mother plant had the largest average size than the first-generation salibu and was equivalent to second-generation salibu. The Batang Piaman variety of the mother plant had the highest panicle length, while the Ketan variety of the first and second generation salibu had the most increased panicle length. Inpari 43 types of the mother plant had the highest panicle length, while the Ketan variety of the first and second generation salibu had the most increased panicle length. All types of the first and second generations salibu had almost the same panicle length as the mother plant. These varieties can produce high salibu because panicle length generally correlated with the number of grains per panicle.

In contrast, the Ketan variety of the first-generation salibu had the highest number of panicles, and Batang Piaman of the second generation salibu had the highest number of panicles. Inpari 43 and Ketan varieties of the second generation of salibu had a drastic decrease in the number of panicles from their mother plants. The second-generation salibu, many tillers died.

Table 5. Average of the number of grains hill\(^1\), panicle\(^1\), and the percentage of filled grains on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties | The number of grains hill\(^1\) | The number of grains panicle\(^1\) | The percentage of filled grains (%) |
|-----------|-------------------------------|----------------------------------|-----------------------------------|
|           | MP   | S1      | S2   | MP   | S1   | S2   | MP   | S1   | S2   |
| Inpari 43 | 3183.3a | 2156.7a | 1736.5b | 157.9a | 107.0a | 125.5a | 53.8a | 72.1a | 64.6a |
| Batang Piaman | 2446.3a | 1702.5ab | 2298.2a | 125.5a | 88.5a | 104.1a | 62.4a | 79.2a | 70.2a |
| Cihерang | 2078.3a | 1413.2b | 1482.0b | 146.0a | 77.4a | 101.3a | 66.3a | 81.5a | 75.9a |
| Ketan | 1953.5a | 1899.2ab | 1452.7b | 128.2a | 94.6a | 105.7a | 64.0a | 74.2a | 68.4a |
| Average | 2415.4 | 1792.9 | 1742.3 | 139.4 | 91.9 | 109.2 | 61.6 | 76.8 | 69.8 |

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of α = 5%.

Table 5 shows that the mother plant had the highest average number of grains per hill. Mother plants produced the highest average number of grains per panicle. Inpari 43 variety made the highest number of grains per panicle in mother plant, first and second-generation salibu. The highest percentage of filled grains is found in the first generation salibu. Cihерang variety of mother plants, first and second-generation salibu, had the highest rate of filled grains. The percentage of filled grains in the first and second generation salibu was higher than the mother plants. The first and second-generation salibu could produce grain filled with salibu, equivalent to the mother plant. According to Khush (1996), three critical factors influence the grain filling process in rice, namely photosynthesize produced by plant organs that act as a source, translocation system from source to sink, and accumulation of assimilates sink.

Table 6. Average of the weight of filled grain hill\(^1\) and 1000 grains of weight on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties | Weight of filled grain hill\(^1\) (g) | 1000 grains of weight (g) | Weight of filled grain hill\(^1\) (g) | 1000 grains of weight (g) | Weight of filled grain hill\(^1\) (g) | 1000 grains of weight (g) |
|-----------|----------------------------------|--------------------------|----------------------------------|--------------------------|----------------------------------|--------------------------|
|           | MP   | S1      | S2   | MP   | S1   | S2   | MP   | S1   | S2   |
| Inpari 43 | 38.65a | 22.37d | 31.98bc | 23.07b | 23.62b | 21.73b |
| Batang Piaman | 45.10a | 28.87b | 37.50ab | 27.60ab | 45.37a | 30.47a |
| Cihерang | 37.40a | 26.37c | 30.28c | 26.13b | 29.55b | 26.87a |
| Ketan | 37.28a | 31.43a | 40.80a | 31.43a | 30.53b | 30.13a |
| Average | 39.61 | 27.26 | 35.14 | 27.06 | 32.27 | 27.30 |

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of α = 5%.
Table 6 shows that the mother plant had the highest average weight of filled grain per hill. The Batang Piaman variety of the mother plant and in the second generation salibu had the highest value of filled grain per hill, while in the first generations of Ketan had the highest weight of filled grain per hills. The second-generation Salibu had the weight of filled grain per hill, which was relatively productive even though it was smaller than the mother plants and the first generation salibu. Ketan variety had the highest weight of 1000 grains in the mother plant and first-generation salibu, while in the second generation salibu, Batang piaman had the highest 1000 grain weight. 

Table 7 shows that Inpari 43 variety of the mother plant had the highest weight of milled dry grain. In contrast, in the first and second generation salibu, the Batang Piaman variety had the highest milled dry grain weight. Salibu had a decreasing value of milled dry grain from their mother plants until 30 to 60% in all types in the first and second generations. The productivity of salibu occurred in this study was higher than the conventional ratoon, which only produces 1.42 to 3 ton ha\(^{-1}\). Inpari 43 of the first and second generation of salibu, although it has a relatively productive number, had a drastic reduction in milled dry grain weight. The number of hills decreased a lot per plot because many hills died in the first and second-generation salibu because not replanted to affect the population. Therefore, efforts are needed to maintain the population by dividing the living hills of the salibu to the location of the dead one and recording the number of living and dead hills. These results were consistent with research conducted by Nuzul et al. [12], that the yields of salibu that were not replanted decreased by 58%.

Table 7. Average of weight of milled dry grain on mother plant (MP), the first generation of salibu (S1), and second generation of salibu (S2)

| Varieties  | MP  | S1  | S2  | Weight of milled dry grain percentage S1 against MP (%) | Weight of milled dry grain percentage S2 against S1 (%) |
|------------|-----|-----|-----|--------------------------------------------------------|--------------------------------------------------------|
| Inpari 43  | 8.61a | 3.59a | 3.30b | 41.70                                                  | 38.33                                                  |
| Batang Piaman | 7.61b | 4.54a | 4.76a | 59.66                                                  | 62.55                                                  |
| Ciherang   | 7.92ab | 3.82a | 3.45b | 48.23                                                  | 43.56                                                  |
| Ketan      | 6.38c | 4.50a | 3.52b | 70.53                                                  | 55.17                                                  |
| Average    | 7.63  | 4.11 | 3.76 | 55.03                                                  | 49.90                                                  |

The numbers that follow the same letter in the same column do not differ based on DMRT post-test at the level of α=5%.

4. Conclusion
Batang Piaman variety has the best agronomic responses on the ratoon salibu system because the yield was 60% (4.54 ton ha\(^{-1}\)) for the first generation of salibu and 62.5% (4.76 ton ha\(^{-1}\)) for second generation of salibu. Ketan Grendel variety the yield was 70.5% (ton ha\(^{-1}\)) for the first generation of salibu and 55% (3.52-ton ha\(^{-1}\)) for the second generation of salibu.

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Reference
[1] Lampe K J 1988 *Rice Ratooning* (Los Banos: IRRI) p 1
[2] Krisnamurthy K 1988 *Rice Ratooning* (Los Banos: IRRI) p 3
[3] Santos A B, Fageria N K, Prabhu A S 2003 Rice ratooning management practices for higher yields *Comm. in Soil Sci. and Pla. Anal.* 34(5-6) 881-918
[4] Suparwoto and Waluyo 2017 Salibu rice cultivation increases farmers’ income *Proceedings of the
National Seminar on Location-Specific Agroinnovations for Food Security in the Era of the ASEAN Economic Community (Palembang: BPTP) p 25-34

[5] Fitri R, Erdiman, Nunung K, Yamaoka K 2019 SALIBU technology in Indonesia: an alternative for efficient use of agricultural resources to achieve sustainable food security Paddy and Water Environment 17 403-410

[6] Yamaoka K, Htay K M, Erdiman, Fitri R 2017 Increasing water productivity through applying tropical perennial rice cropping system (salibu technology) in CDZ, Myanmar 23rd International Congress on Irrigation and Drainage Mexico October 8-14th

[7] Rivaldi, Utama MZH, Marni Y 2015 Growth and yield of rice (Oryza sativa L.) salibu hybrid varieties at height and time of flooding Journal Faculty of Agriculture Taman Siswa University Padang

[8] Vergara B S 1995 A Farmer’s Primer on Growing Rice (Los Banos: IRRI) p 54

[9] Bustamam U H 2004 Rice Plant Morphology and Physiology (Jakarta: LIPI) p 109

[10] Zhao-wei J, W-Xiong L, Y-zhen L, Chuan-ying Z, Hua-an X 2003 Effects of nitrogen fertilizer rates on uptake and distribution of nitrogen in ratoon rice Fujian J. Agric. Sci. 11 14-29

[11] Ai-zhong L, Dong-sheng Z, Nai-mei T U, Wen-xin Z., Yang-xian L 2007 Relationship between distribution of photosynthesis production of flag leaf of main crop and yield of ratooning rice J. Guangdong Agric. Sci. 23(4) 27-34

[12] Nuzul V S, Indradewa D, Kastono D 2018 Effect of time and stem cutting on yield and yield components of rice (Oryza sativa L.) ratoon J. Vegetalika 7(2) 54-65