Growth and yield of various local rice varieties with system of rice intensification irrigation system

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Abstract. The aims of this research to determine the suitability of intermittent and continuous flooding irrigation techniques to reduce water requirements on local rice varieties and to study the response of various local rice varieties to the growth and yield of rice crop. The research has been conducted on the experimental field of the Faculty of Agriculture UMY. The method used the experimental method with 7 x 2 factorial design which arranged in a Completely Randomized Design with 3 replications. The first factor was rice varieties which consist of 7 varieties, i.e. Mentik wangi, Pandan wangi, Mentik susu, Rojolele gepyok, Rojolele genjah, Segoro anak, and Cirahang. The second factor was the method of irrigation consisting of 2 levels, i.e. intermittent irrigation SRI and continuous flooding. The results of the study illustrate that the treatment of varieties influences the growth and yield. Mentik susu variety have productive tiller number much than other varieties, while Mentik wangi variety have root length longer than other varieties. Tiller number, plant dry weight and grain weight shows significant interaction between varieties and irrigation. Conventional and SRI irrigation on Rojolele gepyok variety and Rojolele genjah with SRI irrigation produces grain weight more weight than other varieties.

1. Introduction
According to Statistics Indonesia [1], rice consumption in Indonesia had reached 139 kg per capita per year which considered as the highest consumption in the world. Rice production figure in 2010 had reached 66.4 million tons and it was predicted that the production could reach 67.3 million tons in 2015 [1]. As the demand for rice was getting increased from year to year, rice cultivation should be improved gradually in order to meet the need of high number of rice. However, a significant decrease on land productivity and land acreage forced the farmer to utilize any kind of possible land through intensification concept. This concept emphasized the improvement of agricultural practices through the utilization of superior varieties and high external input (such as fertilizer and pesticide) [2].

Long-term application of chemical input triggered several harmful effects towards soil fertility, human and environment [3, 4]. Moreover, decrease of soil quality due to this continuous use of chemical inputs caused the significant decline on rice production. Therefore, a new system of rice cultivation should be directed to be more environmental-friendly where all farming components were
efficiently managed. System of rice intensification (SRI) is a rice cultivation method which highlighted more balance management of plant, soil, water and nutrient [5]. This method is focused on efficient water supply for root enabling better plant growth condition, particularly in the root zone. This approach also used to anticipate an increase in water requirements for various use, including agriculture, drinking water, industry and sanitation [6].

The use of water combined with the SRI method of farming has begun in 2009 and has shown an increase in rice yield both in quantity and quality, although this cannot be applied in all paddy fields. The use of superior varieties in an area greatly determines the success factor of increasing rice production, but what happens is not all superior varieties can improve rice yield. This happens due to different environmental conditions in each place and differences in the response of rice varieties, thus affecting the growth of rice plants. The use of local varieties is one solution that can be done to increase rice production.

Local varieties have many advantages including being tolerant of the condition of marginal land, being resistant to several types of pests and diseases, requiring low inputs (fertilizers and pesticides), and easy and simple maintenance [7]. Water is one of the most important agricultural inputs. The source of surface water has been a mainstay for irrigation water supply. In general, farmers in Indonesia when conducting rice cultivation using flooded irrigation so that to irrigate the land requires a lot of water so that a lot of lands is not irrigated, thus the need for irrigation techniques that save water is one of them by the SRI method or System of Rice Intensification. One of the advantages of this method is that it saves water use in rice plantations which can also increase yield. Utilization of groundwater combined with the SRI farming method began in 2009 and has shown an increase in rice production both in quantity and quality.

According to Uphoff and Randriamiharisoa [8], implementation of SRI method in Indonesia had increased rice production about 7.4 tons/ha. Increasing rice production can be done by sharing methods with irrigation techniques and the use of local varieties in the SRI method. Rice plants are not included as water plants or plants that live in water but plants that require a lot of water so that they require proper irrigation techniques. The use of local varieties has a fast adaptation to the pattern of irrigation provided, therefore it is necessary to test irrigation techniques and local varieties with the SRI method of planting patterns, whether from the environmental aspects the varieties can grow and develop well and produce production optimally in place of research. This study was aimed to determine the effect of intermittent and inundated irrigation on the growth and yield of various local varieties of rice.

2. Materials and Methods
The study was conducted on the experimental field of the Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta. Variety of rice seeds Mentik wangi, Pandan wangi, Mentik susu, Rojolele gepyok, Rojolele genjah, Segara anak, Ciherang, manure, and polybag was used for this research.

This research method is an experimental method using polybags with 2 x 7 factorial design arranged in a Completely Randomized Design (CRD) with 14 treatment combinations and repeated three replications. The factors and treatments are: Factor 1 The type of irrigation system consists of 2 levels, i.e. continuous flooding irrigation system (Conventional) and Intermittent irrigation system (SRI). Factor 2 kinds of varieties consisting of 7 levels: Mentik wangi, Pandan wangi, Mentik susu, Rojolele gepyok, Rojolele genjah, Segara anak and Ciherang.

The soil used is Regosol type which put it into a 35 x 40 polybag of 8.5 kg then add manure as a base fertilizer of 5 kg/polybag. Transplanting time were carried out at 11 days after seedling. Planting is done by planting 1 to 2 seeds per hole with planting distance 25 cm x 25 cm by sliding in L shape in polybag.

The regulating water on intermittent irrigation in plants aged 1 - 7 days, the soil is left to dry, then after 8 days soil is irrigated for approximately 2 hours, then dried again. Days 9 to 10 and 11 are dried again. After 3 days and so on, the same treatment was carried out until the rice plants entered the
generative phase. In flooded irrigation, from the beginning of planting rice plants was flooded with 2 cm high, then at the age of 45-50. At the age above 50 day after transplanting (DAT), the rice plants are re-flooded again until a week before harvest.

Maintenance includes replanting, weeding, fertilizing and controlling pests and diseases using mechanical means. Rice is harvested when the grain of yellow rice has reached around 80% The rice is ready for harvest is by pressing the rice grain, when the granules are full filled then it is most appropriate to be harvested [9]. Parameters observed included: plant height, number of tillers, number of productive tillers, weight of dry grain/clump, the weight of 100 grains, and unfilled grain percentage. Data analysis used analysis of variance at the level of $\alpha=5\%$. If there were significantly different, then analysis used analysis Duncan's Multiple Range Test (DMRT) at the level of $\alpha=5\%$.

3. Results and Discussion

3.1. Plant growth
3.1.1. Number of tillers. The results of the analysis of variaans in the rice tillers number showed that there was a significant interaction between varieties and irrigation. There was an intercorrelation between varieties and irrigation treatments on the rice tillers number. The average tillers number was presented (Table 1).

| Treatments     | Conventional | SRI          | Average |
|----------------|--------------|--------------|---------|
| Mentik wangi   | 20.57± 4.58  | 29.00±4.36   | 24.79   |
| Pandan wangi   | 25.00± 2.00  | 26.67±9.02   | 25.84   |
| Mentik susu    | 34.00± 4.00  | 33.00±4.36   | 33.50   |
| Rojolele gepyok| 21.06±10.00  | 18.89±5.53   | 19.98   |
| Rojolele genjah| 20.67± 2.52  | 23.33±1.15   | 22.00   |
| Segara anak    | 25.00± 7.55  | 30.00±7.94   | 27.50   |
| Ciherang       | 22.61± 5.01  | 44.55±4.67   | 133.58  |
| Average        | 24.13        | 29.35        | (+)     |

The average number followed by the same letter in a row or column shows not significantly different in DMRT at $\alpha=5\%$. (+) = There is significantly interaction between varieties and irrigation treatments.

Table 1 shows that in conventional irrigation, the local rice of the Mentik susu variety showed significantly higher number of tillers than the local varieties of Rojolele gepyok, Rojolele genjah, and Ciherang. In SRI irrigation, Ciherang variety showed significantly more tillers number than other varieties. The local rice variety of Mentik susu has a significantly higher tillers number of than Rojolele gepyok variety. The difference in the number of tillers between rice varieties is influenced by differences in the characteristics according to the description of the rice varieties. The number of tillers is more influenced by genetic factors of rice varieties.

When compared to the superior varieties currently available, new types of rice have stronger stems, greener and thicker leaves, medium tillers, and panicles thicker and heavier [9]. The number of tillers is one of the growth parameters used to determine the effect of the treatment carried out in determining crop productivity [10]. The more numbers of tillers will affect the number of productive tillers that are expected to produce more grain.

The tillers number of the $3^{rd}$, $6^{th}$, $9^{th}$, and $12^{th}$ week in various varieties and irrigation treatments was presented (Figure 1 & 2). In conventional irrigation shows that at week 3, rice tiller number the varieties of Mentik susu the number of rice tillers number is relatively more than other varieties. In the
6th week, the rice varieties of Rojolele gepoyok, Pandan wangi, Mentik wangi, and Mentik susu, and Segara anak showed relatively higher tillers number than other varieties. Rice on the 9th week of rice varieties Mentik susu, Pandan wangi, Mentik wangi, Segara anak, dan Rojolele gepoyok showed a relatively higher tillers number than other varieties. In the 12th week of rice, the varieties of Mentik susu, Pandan wangi, Segara anak, Rojolele gepoyok, and Ciherang showed a relatively more tillers number than other varieties (Figure 1). This shows that these varieties have different numbers of rice tillers, so the number of tillers of 3rd, 6th, 9th, and 12th varieties are different.

![Figure 1](image-url)

**Figure 1.** The rice tillers number of various rice varieties on conventional irrigation system. Mw: Mentik wangi, Pw: Pandan wangi, Ms: Mentik susu, Rgp: Rojolele gepoyok, Rgi: Rojolele genjah, Sa: Segara anak, Ch: Ciherang. Con: Conventional. DAT: days after transplanting.

In the SRI irrigation the number of rice tillers of Mentik wangi, Pandan wangi, Mentik susu, and Rojolele gepoyok varieties showed relatively higher number of tillers than other varieties in the 3rd week. In the 6th week, the rice varieties of Rojolele gepoyok, Pandan wangi, Mentik wangi, Mentik susu, Segara anak, and Ciherang showed relatively higher number of tillers than other varieties. The 9th week of rice of the Mentik susu, Mentik wangi, Segara anak, and Pandan wangi varieties showed relatively higher number of tillers than other varieties. In the 12th week of rice, Ciherang, Pandan wangi, Mentik susu, Segara anak, and Mentik wangi varieties showed relatively higher number of tillers than other varieties (Figure 2). This shows that these varieties have different responses, so the number of tillers among rice varieties at weeks 3rd, 6th, 9th, and 12th is different. This shows the need for water when the growth of rice tillers requires the amount of water that is not too much, so that the number of tillers obtained will be more and more. When water in the area is not always flooding, more and more nutrients in the colloid are dissolved. This situation results in more nutrients being absorbed by plant roots for growth [9, 10]. The SRI technique provides an atmosphere conducive to the growth of the number of tillers, because the growth environment is not flooded during the vegetative growth phase [11, 12].
3.1.2. Productive tillers. Productive tillers are rice plants which can produce panicles. The treatment of rice varieties and irrigation had a significantly different effect on the number of productive tillers. The number of productive tillers is presented in Table 2.

The results of variations in the number of productive tillers showed not significantly interaction between varieties and irrigation treatments, meaning that the two treatments had no interrelated relationship to the number of productive tillers. The average number of productive tillers is presented in Table 2. Table 2 shows that the treatment of irrigation was not significantly different, whereas the treatment of rice varieties was significantly different.

**Table 2.** The average of productive tiller number at 12 weeks old DAT

| Treatments               | Conventional | SRI      | Average      |
|--------------------------|--------------|----------|--------------|
| Mentik wangi             | 18.00        | 21.00    | 19.50±4.42   |
| Pandan wangi             | 18.50        | 22.33    | 20.42±4.18   |
| Mentik susu              | 31.00        | 30.00    | 30.50±3.78   |
| Rojolele gepyok          | 19.03        | 13.11    | 16.07±7.03   |
| Rojolele genjah          | 15.67        | 18.67    | 17.17±3.13   |
| Segara anak              | 24.00        | 24.00    | 24.00±5.73   |
| Ciherang                 | 19.89        | 31.67    | 25.78±7.79   |

Average 20.87±6.82 p 22.97±7.04 p (-)

The average number followed by the same letter in a row or column shows not significantly different in DMRT at α = 5%. (-) = There is not significantly interaction between varieties and irrigation treatments. DAT: days after transplanting.

The intermittent irrigation treatment of SRI and conventional irrigation affected the number of productive tillers (Table 2). The local rice of the Mentik susu variety significantly produces more
productive tillers than other varieties except Ciherang variety, meaning that the number of productive tillers of the Mentik susu variety is as much as the superior rice of the Ciherang variety.

3.1.3. Plant dry weight. Measurement of plant dry weight is the best parameter used as an indicator of plant growth. Plant dry weight shows how much water and nutrients are absorbed by plants which is very dependent on the rate of photosynthesis and respiration. The higher the dry weight of the plant proves the better vegetative growth. If respiration is greater than photosynthesis, the dry weight will be smaller. Dry weight measurements were carried out at week 12. The results of variations in dry weight of rice plants showed that there was a real interaction between varieties and irrigation, meaning that there was an interrelated relationship between varieties and irrigation on dry weight of rice plants. Average dry weight of rice plants is presented in Table 3. In conventional irrigation, the dry weight of the Pandan wangi variety was 78.88 grams, significantly higher in weight than the Rojolele genjah and Ciherang varieties, respectively 40.95 grams and 27.34 grams, meaning that the vegetative growth of the Pandan wangi variety was better indicated by a higher dry weight than the Rojolele genjah and Ciherang varieties.

| Treatment        | Conventional | SRI     | Average |
|------------------|--------------|---------|---------|
| Mentik wangi     | 55.57± 8.98  | ab      | 61.31   |
| Pandan wangi     | 78.88± 7.74  | a       | 72.83   |
| Mentik susu      | 65.48±11.40  | abc     | 70.16   |
| Rojolele gepyok  | 68.99± 4.18  | ab      | 65.67   |
| Rojolele genjah  | 40.95± 8.34  | cde     | 52.97   |
| Segara anak      | 67.69±29.41  | ab      | 50.55   |
| Ciherang         | 27.34± 8.51  | e       | 39.04   |
| Average          | 57.84        | 60.02   (+) |

The average number followed by the same letter in a row or column shows not significantly different in DMRT at α = 5%. (+) = There is significantly interaction between varieties and irrigation treatments. DAT: days after transplanting.

In SRI irrigation, the dry weight of rice plants in Pandan wangi, Mentik wangi, Mentik susu, Rojolele gepyok and Rojolele genjah varieties was significantly heavier than the Segara anak variety. Between treatments 5 local rice varieties did not have significantly different plant dry weight. In the Segara anak variety, the dry weight of conventional water treatment plants was significantly heavier than the SRI treatment. The dry weight of plants in 5 local rice varieties were not significantly different. This proves that the need for water for vegetative plant growth is sufficient. Dry weight production depends on absorption, solar radiation and uptake of CO2 and water [13].

3.1.4. Root length of rice plants. Measurement of the root length of rice plants aims to determine the root growth of a plant. Root length measurement is done after harvest by measuring the tip of the root to the root base. Based on the results of the analysis of variance of the root lengths of rice plants showed that there was not significantly interaction between varieties and irrigation, meaning that there was not significantly relationship between the treatment of varieties and irrigation on the root length of rice plants. Variety treatment significantly affected the root length of the rice plants, while the irrigation treatment had not significantly effect. The average root length of a rice plant is presented in Table 4.
The local rice of the Mentik wangi variety shows longer roots than the variety of Mentik susu, Ciherang, Segara anak, Rojolele gepyok and Rojolele genjah (Table 4). Root length growth between rice varieties is not the same depending on the rice varieties used. The SRI irrigation treatment method showed that the root length growth of rice plants was not significantly different from conventional irrigation. This shows that the need for water with intermittent irrigation by SRI is sufficient for the root length growth of rice plants.

Table 4. The average root length of rice plants 12 weeks old

| Treatments       | Conventional | SRI         | Average    |
|------------------|--------------|-------------|------------|
| Mentik wangi     | 47.00±5.21   | 39.78±5.61  | 43.38±5.21 |
| Pandan wangi     | 40.00±6.36   | 35.61±6.28  | 37.80±6.36 |
| Mentik susu      | 30.64±2.84   | 35.61±2.84  | 33.12±2.84 |
| Rojolele gepyok  | 25.27±1.50   | 22.79±1.64  | 24.03±1.50 |
| Rojolele genjah  | 20.30±4.32   | 25.23±4.32  | 22.77±4.32 |
| Segara anak      | 33.33±12.48  | 32.33±12.48 | 32.83±12.48|
| Ciherang         | 34.06±4.94   | 37.61±4.94  | 35.84±4.94 |
| Average          | 32.94±10.29  | 32.71±7.67  | 32.71±7.67 |

The average number followed by the same letter in a row or column shows not significantly different in DMRT at α = 5%. (+) = There is significantly interaction between varieties and irrigation treatments.

3.2. Crop Yield

3.2.1. Weight of grain per clump. Measurement of grain weight per clump of rice plants is used as an indicator of crop yield. The weight of grain per clump of rice plants indicates how much rice yield is part of which is used by humans as a food source. The higher the grain weight per clump of rice plants, the higher the rice yield. If the weight of grain per clump is greater, the yield of rice will be higher. Grain weight measurements per clump were made after harvesting. The results of the analysis of variance in grain weight per clump of rice plants showed that there was a significantly interaction between rice varieties and irrigation treatments. Meaning that there was a mutually influential relationship between the treatment of rice varieties and the type of irrigation to the grain weight per rice plant family (Table 5). Grain weights per clump are presented in Table 5. In conventional irrigation, the grain weight per clump of rice plants Rojolele gepyok variety of 63.81 grams was significantly higher than that of other varieties. This shows that the Rojolele gepyok variety gives higher yields than other varieties indicated by the higher grain weight per clump.

Table 5. Average grain weight per clump of rice plants (g/clump) at harvest

| Treatments       | Conventional | SRI         | Average    |
|------------------|--------------|-------------|------------|
| Mentik wangi     | 25.24±4.03   | 28.55±2.76  | 26.90      |
| Pandan wangi     | 36.79±6.07   | 35.82±6.59  | 36.31      |
| Mentik susu      | 34.72±3.41   | 36.04±6.02  | 35.38      |
| Rojolele gepyok  | 63.81±1.64   | 60.91±2.19  | 62.36      |
| Rojolele genjah  | 30.14±4.98   | 55.98±12.66 | 43.06      |
| Segara anak      | 32.89±3.58   | 13.72±1.13  | 23.31      |
| Ciherang         | 33.25±7.01   | 35.91±7.98  | 34.58      |
| Average          | 36.69±7.01   | 38.13±7.67  | 37.84      |

The average number followed by the same letter in a row or column shows not significantly different in DMRT at α = 5%. (+) = There is significantly interaction between varieties and irrigation treatments.
In SRI irrigation, the grain weight per rice variety of Rojolele gepyok and Rojolele genjah varieties was 60.91 grams and 55.98 grams respectively, significantly heavier than the treatment of other varieties. This shows that the Rojolele gepyok and Rojolele genjah varieties with SRI irrigation gave higher yields than other varieties, indicated by the higher grain weight per clump. In the local rice varieties Rojolele genjah, the SRI irrigation treatment yielded grain weight per clump significantly heavier than conventional irrigation treatments. In the hybrid rice varieties of Segara anak, conventional irrigation treatment produces grain weight per clump significantly higher than SRI irrigation treatment. In other varieties, SRI intermittent irrigation and conventional irrigation treatments have the effect of producing grain weight per clump. This proves that the rice varieties of Mentik wangi, Pandan wangi, Mentik susu, Rojolele gepyok, and Ciheraang need water to produce paddy with irrigation with SRI intermittently. Rice yields depend on absorption of solar radiation and uptake of CO$_2$ and water [13] which will affect the weight of grain per clump.

4. Conclusion
The results of the study illustrate that the treatment of varieties influences the growth and the yield. Mentik susu variety have productive tiller number much than other varieties, while Mentik wangi variety have root length longer than other varieties. Irrigation treatment indicates not influence on the productive tiller number and root length of rice plants.

Tiller number, plant dry weight and grain weight shows significant interaction between varieties and irrigation. Rojolele gepyok produce grain with the same weight both of in Conventional and SRI irrigation system. Meanwhile, Rojolele genjah produce higher grain weight with SRI irrigation system.

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