Primary Macro Nutrient Content, Root Growth, and Crop Growth Analysis of Local Rice Varieties with Intermittent and Continuous Flooding Irrigation

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Abstract. An Intermittent irrigation method of rice cultivation aims to reduce water requirements. In Indonesia local rice varieties have the potential to produce high-yielding rice with intermittent irrigation method to meet food needs in Indonesia. The study about Nutrient uptake, root development, and crop growth analysis of several local rice varieties with intermittent irrigation method aims to determine the suitability of intermittent and continuous flooding irrigation techniques on local rice varieties and to study the response of various local rice varieties to Nutrient uptake, root development, and crop growth analysis. The research has been conducted on the experimental field of the Faculty of Agriculture Universitas Muhammadiyah Yogyakarta. The method used was the experimental method carried out with field research with an 4 x 2 factorial design of the treatment arranged in a Randomized Completely Block Design with 3 replications. The first factor was rice varieties which consist of 4 varieties, i.e. Rojolele, Pandanwangi, Mentik Wangi, and Ciherang. The second factor was the method of irrigation consisting of 2 kinds, i.e. intermittent irrigation and continuous flooding. Data was analysed with analysis of variance and Duncan's Multiple Range Test at α=5%. The results showed that rice varieties had different responses to macro nutrient uptake. The number of productive tillers of the Cianjur, Rojolele genjah, and Ciherang varieties is greater than the Mentikwangi variety, while the total number of tillers of the Rojolele variety is even greater than the Mentikwangi variety. SRI irrigation can increase the harvest index, whereas conventional irrigation has a higher Crop Growth Rate than SRI irrigation.

1. Introduction
A System of Rice Intensification (SRI) developed in Madagascar some 25 years ago are now using its methods to raise their rice production and also reducing their use of external inputs and production costs [1] This practice improve rice plant growth with yields up to three times more than with conventional cultivation methods, and increase crop resilience under biotic and abiotic stresses [2]. The System of Rice Intensification (SRI) reportedly enhances the yields of rice (Oryza sativa L.) through synergy among several agronomic management practices [3]. System of Rice Intensification (SRI), can reduce requirements of irrigation water, chemical fertilizer and agrochemicals while increasing paddy yields and farmer’s net incomes [4] so that intermittent irrigation is developed.
The studies on SRI method rice have been carried out including: affect the populations and diversity of soil microorganisms [2], effect year, practice and line spacing [3], the use of SRI organic fertilizers and the combination of organic and inorganic fertilizers in the Semiorganik farming system [5], SRI method rice using banana weevil Local Micro Organism/LMO [6] [7], LMO golden snails, and rabbit urine LMO [5], comparison of SRI and conventional methods [8], SRI with different genotypes [9], flooding and intermittent irrigation in 3 trials [10] [11], conventional irrigation, inundation of 35 Day After Transplanting (DAT), and flooding of 45 DAT[12]. Drying intervals of 2 days, 6 and 8 days and flooding intervals of 2 to 3 days [13], organic SRI rice cultivation systems [14], Width of beds with flooding systems in the moat [15], the yield test of 5 rice varieties [16], treatment of seed age, number of seeds per hole, and type of irrigation [17]. These studies have not yet seen any research on the different aspects of local rice varieties in Indonesia, so it is necessary to study intermittent irrigation on local superior varieties of rice.

For rice, the N, P, and K amounts absorbed during the panicle-initiation stage determine panicle primordia formation, panicle branching, and the setting of spikelets [18]. The objectives of this study are: (1) To study the response of superior local rice varieties to SRI intermittent irrigation, on primary macro nutrient uptake, (2) To study the responses of local superior rice varieties to SRI intermittent irrigation types, to root growth, shoot growth, and grain weight per clumps, and (3) Comparing responses of local superior rice varieties to SRI intermittent irrigation, on crop growth analysis.

2. Material and Method

2.1. Time and Place
The study was conducted in May 2019 to August 2019 in the Research Field of the Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta in Kasihan, Bantul Regency, Yogyakarta, with an altitude of 113 m. Laboratory analysis was conducted at the Laboratory of the Faculty of Agriculture Universitas Muhammadiyah Yogyakarta and the Faculty of Agriculture Universitas Sebelas Maret Surakarta.

2.2. Materials and Method
Rice seeds of Mentikwangi, Cianjur, Rojolele and Ciherang varieties, manure, Urea, SP-36, and KCl were used in this research. The study was conducted by field experimental method with a 4x2 strip plot design with 3 blocks arranged in a Completely Randomized Block Design. Factor I of the irrigation system i.e. intermittent irrigation SRI and conventional irrigation. Factors II of rice varieties i.e. Mentikwangi, Cianjur, Rojolele, and Ciherang.

2.3. Research Implementation
Before planting Nursery was done 12 days and tillage one week before planting. Planting was carried out with a spacing of 25 cm x 25 cm, 1-2 seeds per hole in Plot 2.25 m x 3.25 m2. Replanting was done 1 week after planting with seeds of the same age. Intermittent irrigation SRI was carried out by flooding 2-5 cm, at the beginning of planting up to 10 DAT, then dried 5-6 day, and flooded again. Continuous flooding until it enters the flowering phase. Since the phase of flower exiting up to 10 days before harvest, the land was flooded as high as about 5 cm, then 10 days before harvest when maturing until the harvest is dried. Conventional flooding irrigation, carried flooding approximately 5-10 cm continuously at all stages of growth. Urea fertilization was performed 3 times, at the time of planting, 5 WAT and just before flower primordia at a dose of 200 kg / ha. SP-36 fertilizer is given when planting at a dose of 200 kg / ha. The application of KCl fertilizer was carried out 2 times at 5 WAT and before the flower primordia with a dose of 100 kg / ha.

2.4. Observation
Analysis of plant tissue, root and shoot development, and analysis of plant growth were done. Plant tissue analysis includes: total N, total P2O5, and total K. Plant growth analysis includes: Harvest Index, Crop Growth Rate, and Net Assimilation Rate. Data were analyzed using variance with a level of $\alpha = 5\%$, and if there were real differences followed by Duncan's Multiple Range Test at $\alpha = 5\%$. 
3. Results & Discussion

3.1. Nutrient uptake

3.1.1. Nitrogen Content.
Nitrogen is a nutrient that plays a role in the vegetative growth of plants. [19] states that in tissues, nitrogen has a role in the preparation of plant organs, photosynthesis processes, constituents of chlorophyll, and other organic compounds. Total N analysis was carried out to determine the total N nutrients absorbed by plants. The results of the analysis of the total N content of rice plant tissue are presented in Figure 1.

![Fig. 1. Nitrogen Uptake in Various Rice Varieties and Irrigation](image)

Notes: MW = Mentikwangi, Ci = Cianjur, RL = Rojolele Genjah, CH = Ciherang, A1 = SRI, A2 = non SRI

Figure 1 shows that Ciherang rice varieties with conventional and intermittent irrigation had relatively higher total tissue N levels than other varieties, followed by Rojolele Varieties. N levels of rice tissue in Ciherang and Rojolele varieties with conventional irrigation are in accordance with the average nitrogen content in plant tissue, which is 2-4% dry weight [20]. Ciherang and Rojolele varieties with conventional irrigation have the ability to absorb N nutrients higher than other varieties, meaning that these varieties are more responsive in absorbing N than other varieties.

The intermittent irrigation method gives the total N of Cianjur variety rice relatively higher than conventional irrigation methods. The rice varieties of Rojolele and Ciherang are more responsive to conventional irrigation which is always flooding, the water supply is always maintained so that the transport of nitrogen nutrients to plant parts is well. During the vegetative period the flooding rice plants accelerate the movement of nitrogen in the soil and are then absorbed by the roots of the plants and transplanted into vegetative parts of the plants. The total N content of the tissue is affected by the absorption [21].

3.1.2. Phosphorus content
Phosphorus plays a role in the process of cell division, photosynthesis, respiration, and energy storage [22]. The results of the analysis of total phosphorus nutrient content of rice tissue are presented in Figure 2.
Figure 2 shows that Cianjur varieties with intermittent and conventional irrigation had relatively higher total P levels in the tissue than other varieties, followed by Mentikwangi Varieties. P content of the four varieties of rice tissue with intermittent and conventional irrigation is relatively high, above the average level of Phosphorus in plant tissue which is 0.3-0.5% dry weight [23]. Cianjur and Rojolele varieties with intermittent irrigation have the ability to absorb P nutrients higher than conventional irrigation.

The intermittent irrigation method gives the total N of Cianjur and Rojolele varieties of rice relatively higher than conventional irrigation methods, in contrast to Ciherang rice varieties. Cianjur and Rojolele rice varieties are more responsive to intermittent irrigation in dry and flooding periods, allowing increased root aeration so that the transport of phosphorus to plant parts runs well. During the vegetative period of rice plants, intermittent irrigation accelerates the movement of phosphorus in the soil and is then absorbed by the roots of the plants and transplanted into vegetative parts of the plant.

Ciherang rice varieties with conventional irrigation give P total tissue relatively higher than intermittent irrigation. Conventional irrigation methods make the soil always stagnant. During the initial flooding, the availability of P increases because P dissolves in water [24]. The P element is stable so the leaching or leaching process tends not to occur. The element P is not easily lost due to leaching or leaching but will be absorbed on the surface of the colloidal soil[25]. Phosphorus is absorbed by plant roots in the form of inorganic ions and rapidly transforms into organic phosphate compounds. P in plant tissue is mobile or easy to move.

3.1.3. Potassium Uptake
Potassium is included in elements that are mobile or easily move in the cell or plant tissue. Potassium plays a role in neutralizing cytoplasmic and chloroplast solutions to stay at pH 7-8. Under these conditions, the enzyme reaction in plants can be carried out optimally.
Based on the total K content of tissue (Figure 3) in intermittent and conventional irrigation, the Mentikwangi variety of rice gives a relatively higher total K content of plant tissue than other varieties. Conventional irrigation on varieties of Cianjur, Rojolele, and Ciherang rice showed relatively higher total K content of plant tissue than intermittent irrigation. This shows that in conventional irrigated soil, K nutrient is not easy to experience leaching even though the soil is flooded. The addition of organic fertilizer will increase soil organic matter. Organic matter can bind to K and is not leached because organic matter produces negatively charged carboxyl and phenol groups. Element K bound by organic matter is released slowly and dissolved in water that stagnates in conventional watering, then absorbed by the roots of plants [26]. The process of destruction of minerals aided by water will release elements K and other bases [27].

### 3.2. Root development

#### 3.2.1. Root length

The growth of root length was measured at week 8 and week 13. The length of rice roots of various varieties and irrigation of the 8th week is presented in Table 1. Cianjur, Mentikwangi, Rojolele, and Ciherang varieties have no significant root lengths in the 8th week, so also the length of the 8th week rice roots. Intermittent irrigation is not significantly different from conventional irrigation.

| Treatments | Root length 8 weeks (cm) | Root length 13 weeks (cm) |
|------------|--------------------------|----------------------------|
| Rojolele   | 20.60 ± 2.90 a           | 24.72 ± 4.06 a             |
| Cianjur    | 23.50 ± 8.38 a           | 26.45 ± 7.25 a             |
| Mentikwangi| 22.33 ± 3.80 a           | 25.07 ± 3.40 a             |
| Ciherang   | 18.97 ± 7.28 a           | 21.72 ± 5.02 a             |
| Conventional| 21.96 ± 4.48 p          | 30.81 ± 8.14 p             |
| SRI        | 20.74 ± 6.70 p           | 28.97 ± 2.43 q             |
| Interaction| (-)                      | (-)                        |

The average number followed by the same letter in a column shows not significantly different in DMRT at $\alpha = 5\%$. (-) = There is no significant interaction between varieties and irrigation treatments.

Cianjur, Mentikwangi, Rojolele, and Ciherang varieties had a root length of 13th week that was not significantly different. Rice root length of the 13th week with conventional irrigation was
significantly longer than intermittent irrigation. This shows that conventional irrigation is effective in increasing the length of rice roots, which is 24.77% than intermittent irrigation.

3.3. Total number of tillers and productive tillers

The average of number of tillers at the week 10th is presented in table 2. The Rojolele and Ciherang varieties have a significantly higher number of tillers of the 10th week than the Mentikwangi variety. This shows that the total number of tillers of Rojolele and Ciherang varieties was higher, each at 11.91% and 10.55% than the Mentikwangi variety. The total number of tillers in the 10th week with intermittent irrigation was not significantly different from conventional irrigation.

Table 2. Average of The Tiller Number And Productive Tillers Number Weeks 10

| Treatments   | Tiller number | Productive tillers |
|--------------|---------------|--------------------|
| Rojolele     | 27.67 ± 2.90  | 23.50 ± 4.06       |
| Cianjur      | 26.50 ± 8.38  | 23.50 ± 7.25       |
| Mentikwangi  | 24.72 ± 3.80  | 21.67 ± 3.40       |
| Ciherang     | 27.33 ± 7.28  | 23.33 ± 5.02       |
| Conventional | 26.46 ± 4.48  | 24.08 ± 8.14       |
| SRI          | 26.65 ± 6.70  | 21.92 ± 2.43       |
| Interaction  | (-)           | (-)                |

The average number followed by the same letter in a column shows not significantly different in DMRT at α = 5%. (-) = There is no significant interaction between varieties and irrigation treatments.

Distribution and average number of productive tillers at week 13 are presented in Figures 13 and 14. Cianjur, Rojolele, and Ciherang varieties have significantly more productive tillers than the Mentikwangi variety. This shows that the number of productive tillers of Cianjur, Rojolele and Ciherang varieties was higher, respectively 8.46% 8.46% and 7.69% than the Mentikwangi variety. The number of productive tillers in the 13th week with conventional irrigation was significantly more, namely 9.89 more than intermittent irrigation.

3.4. Crop Growth Analysis

3.4.1. Harvest Index

The harvest index shows the distribution of dry matter in plants which shows a balance of dry weight of economic material with a total weight of dry matter of the plant at harvest [28]. The average harvest index, Crop Growth Rate and Net Assimilation Rate are presented in Table 3. The Ciherang variety has a significantly higher crop index than the Cianjur variety. This shows that the Ciherang variety of rice harvest index is more that 64.12% higher than the Cianjur variety. The yield index with intermittent irrigation was significantly higher at 67.60% more than conventional irrigation.

Table 3. Average of The Tiller Number And Productive Tillers Number Weeks 10

| Treatments  | Harvest Index | Crop Growth Rate | Net Assimilation Rate |
|-------------|---------------|------------------|-----------------------|
| Rojolele    | 0.248 ± 2.90  | 0.001 ± 4.06     | 0.007 ± 4.06          |
| Cianjur     | 0.177 ± 8.38  | 23.50 ± 7.25     | 0.014 ± 7.25          |
| Mentikwangi | 0.222 ± 3.80  | 21.67 ± 3.40     | 0.008 ± 3.40          |
| Ciherang    | 0.299 ± 7.28  | 23.33 ± 5.02     | 0.004 ± 5.02          |
| Conventional| 0.175 ± 4.48  | 24.08 ± 8.14     | 0.009 ± 0.004         |
| SRI         | 0.293 ± 6.70  | 21.92 ± 2.43     | 0.00t ± 0.003         |
| Interaction | (-)           | (-)              | (-)                   |

The average number followed by the same letter in a column shows not significantly different in DMRT at α = 5%. (-) = There is no significant interaction between varieties and irrigation treatments.
The Ciherang variety has a significantly higher crop index than the Cianjur variety. This shows that the Ciherang variety of rice harvest index is more that 64.12% higher than the Cianjur variety. The yield index with intermittent irrigation was significantly higher at 67.60% more than conventional irrigation.

3.4.2. **Crop Growth Rate**

Crop Growth Rate (CGR) is the addition of dry weight per unit area of land occupied by plants within a certain time [28]. Based on analysis of variance shows that there is no interaction between varieties and irrigation on the growth rate of rice plants. Variety treatment has a significantly influence on the rate of plant growth, as well as irrigation treatment has a significantly effect.

The mean of plant growth rates is presented in Table 3. Cianjur varieties have significantly higher Crop Growth Rates than Rojolele and Ciherang Varieties. This shows that the Cianjur variety of rice Crop Growth Rate is higher than Rojolele and Ciherang varieties by 241.46% and 30.37% respectively. The Crop Growth Rate with conventional irrigation was significantly higher at 197.13 greater than intermittent irrigation.

3.4.3. **Net Assimilation Rate**

Net Assimilation Rate (NAR) is the ability of plants to produce dry matter per unit area of leaf per unit time [28]. NAR can describe the production of dry matter per unit area of leaves with the assumption that dry matter is composed mostly of CO2 [29]. It was further stated that NAR is the level of CO2 assimilation taken by plants reduced by the amount lost through respiration.

The mean of the Net Assimilation Rate (NAR) is presented in Table 3. The Cianjur variety has a significantly higher NAR than the Ciherang Variety. This shows that the NAR of Cianjur variety is higher than that of Ciherang which is 268.78% higher. The rate of NAR with intermittent irrigation is markedly higher, 5.29 higher than conventional irrigation.

3.5. **Dry grain Weight per clump**

The average of Dry grain Weight is presented in Table 4. The varieties of Cianjur, Mentikwangi, Ciherang, and Rojolele had the dry grain weight per clump not significantly different. This shows that the weight of dry grain weight of the four varieties is relatively the same. The weight of dry grain weight per clump with intermittent irrigation was not significantly different from conventional irrigation.

**Table 4. Average of Dry Grain Weight Per Clump**

| Treatments | Dry grain Weight per clump |
|------------|-----------------------------|
| Rojolele   | 21.74 ± 2.90 a               |
| Cianjur    | 25.79 ± 8.38 ab             |
| Mentikwangi| 24.23 ± 3.80 b              |
| Ciherang   | 22.64 ± 7.28 a              |
| Conventional| 23.57 ± 4.48 p             |
| SRI        | 23.62 ± 6.70 p              |

Interaction (-) = There is no significant interaction between varieties and irrigation treatments.

4. **Conclusion**

The results showed that rice varieties had different responses to primary macro nutrient uptake. Nitrogen and Sulfur nutrient uptake of rice Ciherang varieties with conventional irrigation is relatively higher than other varieties, while the nutrient uptake of rice of Cianjur varieties with SRI irrigation is relatively higher than other varieties. Nutrient uptake of rice Potassium Mentikwangi variety with SRI irrigation was relatively higher than other varieties, whereas nutrient uptake of rice of Rojolele varieties with SRI and non-SRI irrigation and Ciherang with conventional irrigation was relatively higher than other varieties. Irrigation systems had different responses to root development. Conventional irrigation
produces longer roots at harvest and more productive tillers than intermittent SRI irrigation. The number of productive tillers of the Cianjur, Rojolelegenjah, and Ciherang varieties is greater than the Mentikwangi variety, while the total number of tillers of the Rojolele variety is even greater than the Mentikwangi variety. SRI irrigation can increase the harvest index, whereas conventional irrigation has a higher Crop Growth Rate than SRI irrigation. Cianjur variety has higher net growth rate and assimilation rate than Rojolele and Ciherang varieties, while the Ciherang variety is higher than Cianjur variety.

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