The effect of water-saving irrigation on the growth of local rice plants

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Abstract. The decline in the function of the watershed causes the increasing scarcity of water, while the competition for water use is increasing. A conventional method of rice cultivation (continuous inundation) is very wasteful in the use of irrigation water. Water-saving irrigation by regulating the water availability in rice fields is an effort to reduce water loss due to percolation, seepage, and runoff. The study's purpose was to examine the effect of water availability in the field on the growth of local rice varieties. The study used 5 treatments of water availability in the field (GW < 50% AW, 50% AW < GW ≤ 60% AW, 60% AW< GW ≤ 70% AW, 70% AW < GW ≤ 80% AW, and saturated) with 3 replicates and the parameters observed were the height of plants and number of tillers. The results showed that the availability of water in the field did not affect the plant height but did affect the number of tillers. From the vegetative phase at the age of ±28 days after planting (DAP) to the beginning of the generative phase ±55 DAP, there was an addition of tillers. When the generative phase period from ± 55 DAP, the formation of the tillers stopped, and some of the tillers dried up or died.

1. Introduction
Climate change as the impact of environmental damage is increasing the threat of drought and flooding. There is a fluctuation in the amount of rainfall from 1% to 4% in different periods. The dry season lasts longer with decreasing rainfall. On the contrary, the rainy season lasts a short time with higher rainfall intensity. Rainfall is an important component in hydrology because it is the only source of water in a watershed. The decline in watershed function causes the scarcity of water availability, while the competition for water use is increasing. As a result, many irrigated rice fields cannot be planted due to insufficient water, especially in the downstream irrigation area.

A conventional method of rice cultivation (continuous inundation) is very wasteful in irrigation water usage. Water-saving irrigation in lowland rice is an effort to reduce water loss in rice fields to maintain or increase grain yield per unit area and volume of water. Reduction of water due to percolation, seepage, and runoff can reduce the use of irrigation water. This can be done by regulating the availability of water on the land. The results research [1] stated that the water availability at field capacity conditions on land during rice plant growth provides a higher production value for irrigation water than saturated water and 50% available water. It is in line with the opinion [2] which stated that plant growth generally would begin to be disrupted when the water content in the soil is less than 50%.
of the available water. Therefore, it could reduce production. For efficient water use, irrigation does not have to be added to meet field capacity conditions of 100% of available water, it is enough to provide about 60-80% of available water.

Research on irrigation water for efficient rice cultivation has been widely done, including alternate wetting and drying (AWD), shallow water depth with wetting and drying (SWD), and semi-dry cultivation (SDC) systems [3]. A water-saving irrigation method has been developed in Madagascar in the 1980s, which is the system of rice intensification (SRI). However, irrigation of land without inundation in rice cultivation by regulating the water availability according to soil characteristics needs to be done for water-saving irrigation. This study aims to determine the effect of water-saving irrigation on the growth of rice plants.

2. Materials and methods

2.1 Location
The research was conducted in Nagari Singakarak, X Koto Singkarak Sub District, Solok Regency, West Sumatra Province. The experiment was conducted from May 2021 to August 2021.

2.2 Trial Treatment
The study used a completely randomized design (5 treatments) with 3 replications. The implementation of water administration is shown in Figure 1. Observations were made weekly on plant growth, which was plant height and number of tillers. The treatment of water availability in the land consists of:
1. P1: GW < 50% AW: groundwater is less than 50% available water
2. P2: 50% AW < GW ≤ 60% AW: groundwater is between 50% and 60% available water
3. P3: 60% AW < GW ≤ 70% AW: groundwater is between 60% and 70% available water
4. P4: 70% AW < GW ≤ 80% AW: groundwater is between 70% and 80% available water
5. P5: Saturated.

![Figure 1. Treatment of Water Availability in the Land During Plant Growth](image-url)

Information: DAP (Days After Planting)
2.3 Data Analysis
Data analysis was carried out by analysis of single-factor ANOVA variance at the level of $\alpha = 0.05$. A P-value of less than 0.05 ($p<0.05$) was considered to have a statistically significant difference.

3. Results and discussion
3.1 Research Location Description
The ability of plants to absorb available water depends on the type of plant and the soil profile which are reached by the roots. The range of groundwater available to plants is water-bound between field capacity (pF 2.54) and permanent wilting point (pF 4.2), which varies depending on soil texture. Therefore, the finer the soil texture, the greater the range [4]. The research location has a clay texture with a percentage of 16.3% of sand, 18.58% of dust, and 65.12% of clay.

According [4], groundwater available to plants ranges from 20% to 55% for clay soils and 8% to 18% for sandy soils. The averages of soil water content for pF2.01, pF2.54, and pF4.2 were 57.56%, 49.48%, and 27.46%, respectively. The water content (% of volume) at pF2.0, pF2.54, and pF 4.2 is the basis for determining the water supply or when the water condition reaches standard according to the treatment (treatment setpoint).

3.2 Plant Growth
Plant growth was observed from day 1 to day 70. Parameters observed were plant height and the tillers number. Bujang Marantau rice is a local variety in Tanah Datar Regency, West Sumatra Province, with a Plant Variety Protection registration number 160/PVL/2014 on March 23, 2015. The description of the Bujang Marantau rice plant based on the official PVP news [5] is the cere group, age 135 to 140 days after seedling (HSS), husky shape, height 100 to 110 cm, and productive tillers 25 to 32 stems. Meanwhile, the observations on the plant height of the Bujang Marantau rice on the 70th day resulted that the plant height ranged from 95 to 100 cm. Observation data of plant height and the tillers number are presented in Figures 2 and 3.

![Figure 2. Average Plant Height from Early Phase to Generative Phase](image)

**Information:**
P1: GW $<$ 50% AW: groundwater is less than 50% available water
P2: 50% AW $<$ GW $\leq$ 60% AW: groundwater is between 50% and 60% available water
P3: 60% AW $<$ GW $\leq$ 70% AW: groundwater is between 60% and 70% available water
P4: 70% AW $<$ GW $\leq$ 80% AW: groundwater is between 70% and 80% available water
P5: Saturated.

In Figure 2, the plant height from the vegetative phase (±11-50 DAP) to the beginning of the generative phase (±51-70 DAP) continues to increase. At the end of the observation, (generative phase
at 70 DAP), the average plant heights were 100 cm (P1), 96 cm (P2), 97 cm (P3), 95 cm (P4), and 99 cm (P5). The results of statistical analysis stated that there was no difference in plant height during the growth period, with a significance value of 0.988, i.e., > 0.05, meaning that there was no effect of water availability in the land on plant height.

Figure 3 shows the number of tillers from the vegetative phase (±11-50 DAP) to the generative phase (±51-70 DAP) is fluctuating. At the end of the observation (generative phase 70 DAP), the averages number of tillers respectively were 36 stems (P1), 37 stems (P2), 46 stems (P3), 51 stems (P4), and 49 stems (P5). The results of statistical analysis stated that there was a difference in the number of rice tillers during the growth period, with a significance value of 0.047, which was <0.05. It means that there was an effect of water availability in the field on the number of rice tillers. The results of the one-way ANOVA analysis are presented in Table 1.

Table 1. Results of One Way Anova Analysis Number of Rice Tillers

| Group based on Real Level 0.05 | 1  | 2  |
|-------------------------------|----|----|
| P1                            |    |    |
| P2                            |    |    |
| P3                            |    |    |
| P4                            |    |    |
| P5                            |    |    |

Information:
P1: GW < 50% AW: groundwater is less than 50% available water
P2: 50% AW < GW ≤ 60% AW: groundwater is between 50% and 60% available water
P3: 60% AW < GW ≤ 70% AW: groundwater is between 60% and 70% available water
P4: 70% AW < GW ≤ 80% AW: groundwater is between 70% and 80% available water
P5: Saturated.
In Table 1, the number of tillers treated with water availability P1 was not significantly different from P2, but significantly different from P5, P3, and P4. The number of tillers treated with water availability P2 was not significantly different from P5, P3, and P4. The best water availability treatment was P4 with the highest average number of tillers, which is 51 stems.

The formation of tillers is influenced by genetic factors, spacing and soil fertility [6]. In this experiment, the three factors were assumed to be the same, because the experiment used seeds from the same source, the spacing was the same at the same location, and the experiment was carried out on land with adjacent beds. The treatment factor at the time of the experiment was the same, the difference was the irrigation pattern. In this case it can be concluded that the formation of tillers in rice plants is influenced by the availability of water in the soil. The optimal condition for the formation of rice tillers is the availability of water in the soil between 70% and 80% of available water. The pattern of changes in tiller formation is presented in Figure 4.

Figure 4 shows that in the vegetative phase at the age of ±28 DAP to the beginning of the generative phase ±55 DAP, the line graph of the average number of tillers always increases. This indicates the addition of tillers during the vegetative phase. However, when entering the generative phase of the age of ± 55 DAP, the line graph declines because there were several rice clumps whose tillering stopped. Some of the tillers dried up or died.

The results research [7] showed that the pattern of giving water affected the number of tillers. In the vegetative phase (±1-45 DAP), rice produced tillers and then the formation of these tillers stopped in the generative phase (±46-86 DAP). The results research [8] also showed that the cultivation method affected the maximum number of tillers of the SRI and ICM cultivation methods achieved at 55 days after planting (DAP), while conventional cultivation methods were at 35 DAP.

4. Conclusions
The results showed that the water availability in the field did not affect the plant height but affected the tillers' number. From the vegetative phase at the age of ±28 DAP to the beginning of the generative phase ±55 DAP, there was an addition of tillers. In the generative phase from the age of ± 55 DAP, the formation of the tillers stopped, and some of the unproductive tillers were eliminated or dried up.

Information:
P1: GW < 50% AW: groundwater is less than 50% available water  
P2: 50% AW < GW ≤ 60% AW: groundwater is between 50% and 60% available water  
P3: 60% AW < GW ≤ 70% AW: groundwater is between 60% and 70% available water  
P4: 70% AW < GW ≤ 80% AW: groundwater is between 70% and 80% available water  
P5: Saturated.
References

[1] Yanti, D. (2020). Model Pengelolaan Operasi Irigasi Intermittent pada Pengembangan Modernisasi [Disertasi]. Bogor (ID): IPB University. https://repository.ipb.ac.id/handle/123456789/105125

[2] Abdurachman, A., Haryati, U., & Juarsah, I. (2006). Penetapan Kadar Air Tanah dengan Metode Gravimetrik. In Sifat Fisik Tanah dan Metode Analisanya (pp. 131–142). Litbang Pertanian. http://balittanah.litbang.pertanian.go.id/ind/dokumentasi/buku/buku sifat fisik tanah/12gravimetrik.pdf

[3] Zhi, M. (2002). Water efficient irrigation and environmentally sustainable irrigated rice production in China. International Commission on Irrigation and Drainage, 1–15. http://www.zanzare-riasaie.info/wat_mao.pdf

[4] Nurhayati. (2009). Pengaruh Cekaman Air pada Dua Jenis Tanah Terhadap Pertumbuhan dan Hasil Kedelai (Glycine max (L.) Merril). J. Floratek, 4, 55–64. http://jurnal.unsyiah.ac.id/floratek/article/view/190

[5] Kementerian Pertanian Republik Indonesia. (2015). Berita Resmi PVT, Pendaftaran Varietas Lokal, No. Publikasi : 041/BR/PVL/04/2015.

[6] Efendi, E., Halimursyadah, H., & Simajuntak, H. (2012). Respon Pertumbuhan dan Produksi Plasma Nutfah Padi Lokal Aceh Terhadap Sistem Budidaya Aerob. Jurnal Agrista, 16(3), 114–121. http://jurnal.unsyiah.ac.id/agrista/article/view/655

[7] Sofiyuddin, H. A., Martief, L. M., Setiawan, B. I., & Arif, C. (2012). Evaluasi Koefisien Tanaman Padi Berdasarkan Konsumsi Air Pada Lahan Sawah. Jurnal Irigasi, 7(2), 120–131. http://jurnalirigasi pusair.pu.go.id/index.php/jurnal_irigasi/article/download/253/317

[8] Subari, Joubert, M. D., Sofiuddin, H. A., & Triyono, J. (2012). Pengaruh Perlakuan Pemberian Air Irigasi pada Budidaya Sri, PTT dan Konvensional Terhadap Produktivitas Air. Jurnal Irigasi, 7(1), 28–42. http://jurnalirigasi pusair.pu.go.id/index.php/jurnal_irigasi/article/view/99