Effect of supplementary irrigation on rice yield in dry land during rainy season

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Abstract. Climate change causes change in rainfall patterns, which will affect water availability. Water is a limiting factor for rice production on dry land. Increasing rice yields on dry land requires precise water management. This study aimed to investigate the effect of supplementary irrigation when it does not rain on rice yields in dry land during rainy season. The research was conducted on dry land in Playen, Gunung Kidul, Daerah Istimewa Yogyakarta, Indonesia during rainy season of November 2020 to February 2021. The treatments were supplementary irrigation if 1 day without rain (A1), if 2 days without rain (A2) and if 3 days without rain (A3), and they were compared to control without supplementary irrigation (A0). This research used a randomized completely block design, each treatments replicated 4 times. The results showed A1 gave the highest grain yield, namely 7.786 ton ha$^{-1}$, significant different with other treatments of A2, A3 and A0. Dry straw of A1 was 7.324 ton ha$^{-1}$, significant different with A2, A3 and A0. Carbon absorption of A1 was 6.860 ton ha$^{-1}$, consisting of carbon in grain 3.575 ton ha$^{-1}$ and straw 3.285 ton ha$^{-1}$, it was significant different with other treatments of A2, A3 and A0 (p<0.05; n=16). B/C A2 1.73 was highest from the others and its farmers have profit Rp. 19,276,360 ha$^{-1}$.

1. Introduction
Climate change is a natural phenomenon [1], occurs naturally and can be accelerated by human behavior. Climate change has an impact on the hydrological cycle [2], rainfall patterns and agriculture [3] and soil degradation potential [4]. Climate change affects agricultural production [5], especially in areas that rely on rainfall as a source of water. Information on the amount and distribution of rain are important for crop production [6].

Dry land productivity is determined by climate stability, rainfall and soil [7]. Rainfall is the main water source in dry land [8], with limited quantity and distribution [9], making it prone to drought [10]. Dry land has a low level of soil fertility [11] with rapid decomposition of organic matter resulting in low soil organic carbon [12]. Dry land is vulnerable to degradation [13].
Water limits the increase in cropping intensity on dry land [14]. Irrigation arrangements increase the guarantee of water availability [15] and the effectiveness of farming [16]. Providing water as supplementary irrigation is an alternative in limited water conditions [17], originating from deep wells, shallow wells, river or ditch dams [18]. Supplementary irrigation is an alternative to increase production from dry land [19]. Supplementary irrigation is required when at a certain time it does not rain. Supplementary irrigation as a complement to rainfall for sufficiently crop water requirements. Supplementary irrigation provides water when needed. Water utilization must also be more efficient. According to Heryani, et al [20] Specific data on water resources are needed so that water management is appropriate and sustainable. Increasing rice production on dry land can be done with the support of supplementary irrigation [19]. This study aimed to investigate the effect of supplementary irrigation when it does not rain on rice yields in dry land during rainy season.

2. Materials and method

2.1. Research location
Dry land of Logandeng Playen Gunungkidul at coordinates 7°55'59''N, 110°34'42''E, with an altitude of 211 m above sea level was the research location during the rainy season 2020-2021. The research location has 5 wet months and 6 dry months with a rainfall of 1,852 mm per year. The farmer's cropping pattern is rice-palawija-palawija/vegetables. Farmers plant rice during the first growing season relying on water from rainfall, without irrigation.

2.2. Experimental design
Irrigation as a treatment basis to support rice planting during the first growing season, as supplementary irrigation. Supplementary irrigation refers to the Oldeman classification of 200 mm monthly rainfall for the water requirements of rice plants [21], So that the rainfall of 6.33 mm per day was determined as the limit for providing supplemental irrigation. A Randomized Completely Block Design (RCBD) was used in this research with 4 treatments and 4 replications. The treatment consisted of supplementary irrigation if 1 day without rain (A1), if 2 days without rain (A2) and if 3 days without rain (A3) to compare with control without additional irrigation (A0).

2.3. Rice cultivation
Rice was planted by tillage and transplanting system. Soil tillage was done with a hand tractor. Inpari 42 varieties was planted manually at the age of 20 days after sowing, 2-3 seeds per hole. The research was supported by 100 kg of N 46% and 250 kg of NPK 15-15-15. Fertilizer was given at 5 DAS, 25 DAS and 35 DAS. Weed control at 10, 20 and 30 DAS. Supplementary irrigation comes from deep wells by pump. Rice harvest at 96 DAS.

2.4. Parameters measurement
Rainfall was observed during the rice growing season, by installing a rainfall gauge at the research site. Harvest dry grain and straw were observed at harvest. The carbon content of grain and straw was determined based on the carbon content in the tissue [22]. Economic feasibility was obtained from direct survey and farmers interview.

2.5. Statistical analysis
The F test was used to determine the significance level of the treatment and the DMRT test to determine the effect of treatment interactions at the 5% level [23]. Economic analysis was used to determine the feasibility of farming [24].

3. Results and discussion
Dry land relies on water from rainfall. Rainfall is influenced by local and global environmental conditions. Rainfall intensity and time may not be suitable for plant water needs, in terms of quantity
and time. This phenomenon causes water to become a limiting factor for the growth and production of crops on dry land, including rice. At the time of research, from transplanting to harvest, for 96 days, 1,014 mm of rain occurred, with 36 rainy days. The amount and distribution of rain were uneven during the planting period. This condition causes supplementary irrigation to be provided.

Supplementary irrigation adjusts for rainfall occurs, with a rainfall limit of 6.33 mm. Supplementary irrigation was given 20 times for A1 treatment, 12 times for A2 and 6 times for A3. Irrigation was provided with an average water level of 10 cm. Supplementary irrigation comes from a deep well water pump. The results of previous studies by Viandari and Anshori [25] showed that at the same location, the 5 cm flooding was exhausted after 8 hours and reached a depth of 20 cm after the next 16 hours. In this study, supplementary irrigation was given an average of 10 cm to support dry land rice yields.

Harvested dry grain and dry straw and carbon absorption in grain and rice straw can be seen in Table 1. The harvested dry grain of A1 was 7.786 tons ha\(^{-1}\), significantly different from all treatments A2, A3 and A0. The harvested dry grain of A1 was higher of 77.76\% than A0. A1 produced highest dry straw of 7.324 ton ha\(^{-1}\), significantly different from all treatments A2, A3 and A0. Dry straw of A1 was higher of 58.63\% than A0, without supplementary irrigation. The harvested dry grain and dry straw with supplementary irrigation was higher than control, because water is available throughout the growing and developing period of the rice. According to Tsai and Lai [26] water plays a role in the formation of tillers and panicle initiation. Water affects root formation and soil nutrient uptake [27].

![Figure 1. Daily rainfall and irrigation time for A1, A2 and A3.](attachment:image.png)

| Treatment | Dry Grain | Dry Straw | Carbon Absorption |
|-----------|-----------|-----------|-------------------|
|           | ton ha\(^{-1}\) | ton ha\(^{-1}\) | Grain | Straw |
| A0        | 4.380±0.359a | 4.617±0.184a | 2.039±0.167a | 2.071±0.083a |
| A1        | 7.786±0.368b | 7.324±0.362b | 3.575±0.169b | 3.285±0.162b |
| A2        | 7.241±0.256c | 6.451±0.531c | 3.330±0.118c | 2.893±0.238c |
| A3        | 5.624±0.243d | 5.676±0.406d | 2.597±0.112d | 2.546±0.182d |

Note: The average and standard deviations that followed by different letter in the same column show significantly different in 5% DMRT.

Supplementary irrigation increases carbon absorption in grain and rice straw. A1 absorbed the highest carbon of 3,575 ton ha\(^{-1}\) in grain and 3.285 ton ha\(^{-1}\) in straw, 75.33\% and 58.62\% higher than...
A0, significantly different from all treatments. Supplementary irrigation increases the absorption of carbon dioxide from the air, through increased photosynthesis to form plant tissue. Carbon dioxide is greenhouse gases [28], [29]. The absorption of carbon dioxide through photosynthetic reactions reduces the concentration of greenhouse gases from the air [30]. Economic analysis determines the cost and profit of farming under various treatments. A1 profit was highest of Rp. 19,566,200, greater than without irrigation of Rp. 9,305,000, an increase of 90.68%. A2 profit of Rp. 19,277,200, greater than without irrigation of Rp. 9,016,200, an increase of 87.87%. A3 profit of Rp. 14,235,800, more than without irrigation Rp. 3,905,000, an increase of 38.74%. The irrigation cost for A1 was 38.07%, A2 was 26.94% and A3 was 13.32% of the cost component. Lowest A3 irrigation cost, but low profit too (Table 2).

| Component                              | A0   | A1   | A2   | A3   |
|----------------------------------------|------|------|------|------|
| Material (seed, fertilizer, pesticide) | 2,835,000 | 2,835,000 | 2,835,000 | 2,835,000 |
| Labor                                  | 4,800,000 | 4,800,000 | 4,800,000 | 4,800,000 |
| Water for Irrigation                   | -    | 5,000,000 | 3,000,000 | 1,250,000 |
| Total cost                             | 8,135,000 | 13,135,000 | 11,135,000 | 9,385,000 |
| Receipt                                | 18,396,000 | 32,701,200 | 30,412,200 | 23,620,800 |
| Profit                                 | 10,261,000 | 19,566,200 | 19,277,200 | 14,235,800 |
| B/C                                    | 1.26 | 1.49 | 1.73 | 1.52 |

B/C shows the farmer's profit per unit cost. Positive B/C means that the farming business was feasible to develop [24], [31], the three treatments were feasible to be developed. The profit of A1 was higher than A2, but the B/C was lower. Economically, A2 was higher than A1.

4. Conclusion
Supplementary irrigation increases rice yields and absorption of the carbon dioxide greenhouse gas through photosynthetic reactions forming plant tissue on dry land in the rainy season. A1 provides the highest rice yield in the form of harvested dry grain of 7.786 ton ha⁻¹, dry straw of 7.324 ton ha⁻¹ and carbon absorption in grain of 3.575 ton ha⁻¹ and straw of 3.285 ton ha⁻¹. A1 provides the highest profit, but has lower B/C than A2. A2 was more economical than A1.

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