Assessment of irrigation water interval on maize in dryland in central sulawesi

A Irmadamayanti*, Muchtar, A N Wahyuni, I S Padang, Saidah and Syafruddin

Balai Pengkajian Teknologi Pertanian Sulawesi Tengah, Jl. Poros Palu-Kulawi Km 17 Desa Maku Kecamatan Dolo Kabupaten Sigi Provinsi Sulawesi Tengah

*Email: andirma.damayanti@gmail.com

Abstract. Dryland agriculture has many problems, one of which is the limited level of water availability. The water supply interval is able to use water efficiently with the maximum possible yield potential. This study aims to determine the time of giving water that can give optimum results in maize cultivation in dry climates. The research was conducted at the Sidondo III Agricultural Technology Research and Assessment Installation, Sigi Biromaru District, Sigi Regency, Central Sulawesi. The activity was carried out from March to July 2019. The method used was Randomized Block Design using Bima 15 Variety with four water treatment intervals (Control, 8 days, 14 days and 18 days) and each was repeated 3 (three) times. Interval treatment of giving water every 8 days gave better growth and yield compared to other water treatment intervals, namely each 114.67 cm plant height, 10.40 strands number of leaves, 1.51 cm stem diameter, 16.70 cm cob length, 4.36 cm cob diameter, 38 seeds each row, 171.33 grams of 5 cob weight sample, 26.86 grams weight of jenggel and 6.63 tons / ha yield.

1. Introduction
One of the essential food commodities in Indonesia is corn. In addition to be used as a food source, corn is also used as feed and industrial raw materials. This resulted in domestic demand for corn to be increased each year. The increasing demand for corn must be balanced with high productivity, otherwise Indonesia must provide it by importing large quantities [1]. One of the efforts to increase productivity to support the maize agribusiness development program is the provision of sufficient water for plant growth [2]. However, this has encountered problems in the field because almost 79% of the crop area in Indonesia is located on dryland, and the remaining 11% and 10% are on irrigated rice fields and rainfed lowland [3]. The main obstacle in maize cultivation in dry climate dryland is water shortage. Therefore, the planting time must pay attention to rainfall and its distribution. Water functions to dissolve nutrients and help metabolic processes in corn so that the supply must be sufficient to prevent growth disorders [4]. In the plant life process, water greatly affects both directly and indirectly because almost all processes in plant development are influenced by the function of water, including: as a solvent, as a medium for transporting nutrients, as a hydrogen source, regulate soil temperature and aeration, also maintain cell turgidity [5]. Besides water also serves as a medium to help the absorption of nutrients by the roots and distribute it to all organs of plants [6]. On dryland, the imbalance between water resources and water demand becomes a major problem in the dry season. Therefore, saving water during the dry season on dryland is an important thing to do. Water is an important factor to support plant growth, if
water is not available for plants, plant growth will be inhibited [7]. Water functions as a constituent of the plant body, solvents and biochemical reaction media, transport medium compounds, provide turgor for cells, raw material for photosynthesis and keep plant temperatures constant. Provision of water under the optimum conditions for plant growth will result in plants being stunted (plants becoming stunted) or blocked from entering the next vegetative phase. According to Blair et al. [8], a low groundwater content can result in low concentrations of nutrients present in the soil. The low concentration of nutrients presents in the soil solution, the need for plant nutrients is not fulfilled and will result in nutrient competition between plants. On the other hand, the excessive water, will cause the stems of plants will rot. Plant water supply itself is the amount of water used to fulfilled plant evapotranspiration so that it can grow normally [9]. Water supply is said to be economical if there is no difference in the amount of water supplied by plant water with a large amount. Irrigation systems in turn can reduce seepage and evaporation, other benefits of these conditions can improve the physical and chemical properties of soil [10]. Provision of different water will lead to different plant responses. This study aimed to determine the time of watering that can give optimum results in the cultivation of maize in dry climate.

2. Materials and Methods

The research was conducted on March to July 2019. The research location was at the Sidondo Agricultural Technology Research and Assessment Installation (IP2TP), Sidondo III Village, Sigi Biromaru District, Sigi Regency, with an average air temperature ranging between 22°C-33°C and altitude ±80 m asl, climate type E 2 with rainfall less than 800 mm/year with entisol soil type. The materials used in this study were Bima 15 maize seeds, pesticides, fungicides, herbicides, UREA fertilizers, NPK fertilizers and other materials. The tools used in this study were hoe, tape measure, raffia rope, analytic weights, PVC pipe, water pump, and other stationery. The study was conducted by using a non-factorial randomized block design (RBD). The treatment given was watering interval calculated based on the consideration of the availability and need of water which is still sufficient to meet the needs of the plants. The treatments were as follows: Control (without watering from rainwater), watering once in 8 days, watering once in 14 days, and watering once in 18 days, by watering of 5000 liters/irrigation period. Each treatment was repeated 3 (three) times, so that there were 12 experimental plots using Bima 15 variety of maize as an indicator of the crop. The components of the observations were made on plant height (cm), cob height (cm), cob length (cm), cob diameter (cm), number of rows per cob, weight of 1,000 seeds (g) and production (t/ha). The observational data obtained were analyzed by using analysis of variance (F test) at the 5% level. If there is a significant difference, it will be tested further by using HSD 5%.

3. Result and Discussion

The treatment of water supply interval in maize has a significant effect on plant height and the number of leaves, but did not differ significantly on stem diameter based on the analysis of variance results. The treatment of watering intervals every 8 days resulted in a higher average height of plants (table 1) which is 114.67 cm, and it’s significantly different from the control, but not significantly different from the average height of plants at the treatment of watering interval every 14 days and 18 days. Provision of water gives a direct response to the plant because the water has a very important role in the growth both increasing the high and the levels of water at the bottom of the plant, where water affects the average plant height increase as a reflection of plant growth. Increasing plant height occurs through the extension of the segments due to the enlargement of cells or increasing plant age. This condition is consistent with the statement Suhartono et al. [11] which states that water is a major component in plant life. The plant's fresh weight contains 70-90% of water. Water is a good medium for the course of biochemical reactions. In the plant body, water can get into the plant tissue directly through the diffusion process. This process is influenced by many factors, such as 1) the differences in water concentration and 2) the presence of environmental factors that play a role in the water balance process in the soil, plants, and air. Height of plants that were given water at a faster interval (8 Days), is higher when compared with other treatments. This result showed that the water supply can provide water for plants in optimal conditions. This
condition is in line with Haryadi [12] that giving water intervals under optimal conditions allows certain hormones to work actively in the cell wall to stretch. In the parameter number of leaves, the treatment interval of giving water every 8 days produces an average number of leaves that is significantly different from the treatment interval of other watering as many as 10.40 strands. The control treatment showed the lowest number of leaves (8.93 strands). Providing proper water during vegetative periods could increase the number of leaves, indicating the sufficient level of water is available for plants growth. Sulistyono et al. [13] stated that the number of leaves related to the number of sources that formed to increase plant photosynthetic potential. Plant growth, especially the number of leaves is sensitive to water deficits because it can stop cell division and result in smaller plant leaves. While the stem diameter, although not significantly different, the treatment interval of giving water every 8 days resulted in an average value of a larger stem diameter of 1.51cm when compared to the control of 1.39cm. Plant yields are related to plant growth characters such as plant height, number of leaves, and others. Optimal growth in the vegetative phase will support the generative growth phase so that it will produce high yield. The average measurements result of plant height, leaves number and stem diameter of each treatment are presented in table 1.

| Treatments                        | Plant Height (cm) | Number of leaves (strands) | Stem Diameter (cm) |
|-----------------------------------|-------------------|---------------------------|--------------------|
| Control                           | 85.60 b           | 8.93 c                    | 1.39 a             |
| watering interval every 8 days    | 114.67 a          | 10.40 a                   | 1.51 a             |
| watering interval every 14 days   | 108.53 a          | 9.87 b                    | 1.40 a             |
| watering interval every 18 days   | 105.13 a          | 9.87 b                    | 1.49 a             |
| HSD 5 %                           | 33.74             | 0.05                      | 0.01               |

The number followed by the same letter in the same column is not significantly different according to HSD test at 5%.

The results of analysis of variance (table 2) showed that the treatments gave a significant effect on the parameters of cob length, cob diameter and number of rows / cob. Plants that experience lack of water have a smaller size compared to plants that grow normally [14]. All treatment of watering intervals in this study resulted longer cobs than control treatment (table 2). However there are no significantly different of cobs length between different watering interval treatments that have been tested in this study. The treatment of giving water every 8 and 14 days produced cobs that has significantly different diameter from control and the longest interval days of watering (18 days). Whereas in the parameter number of rows / cob, all treatments produced higher number of cob each rows than control (table 2). Plants aged between 33-50 days after germination, grow quickly and the accumulation of dry matter increases rapidly as well. The need for nutrients and water is relatively very high to support the rate of plant growth. Plants are very sensitive to drought stress and nutrient deficiencies. In this phase, drought and nutrient deficiencies greatly affect the growth and development of cobs, and will even reduce the number of seeds in one cobs due to shrinking cobs, which consequently decreases yield [15]. The difference size of cobs in accordance with Salisbury and Ross [16] which states that the lack of water causes a very significant decrease in yield and even causes death in plants.
Table 2. The average of cob length, cob diameter, and number of rows/cobs of each treatment.

| Treatments                  | Cob Length (cm) | Cob Diameter (cm) | Number of rows/cobs |
|-----------------------------|-----------------|-------------------|---------------------|
| Control                     | 11.26           | 3.49              | 12.13               |
| watering interval every 8 days | 16.70          | 4.36              | 13.73               |
| watering interval every 14 days | 15.51          | 4.27              | 13.87               |
| watering interval every 18 days | 15.52          | 4.05              | 14.13               |
| HSD 5 %                     | 0.57            | 0.01              | 0.6                 |

The number followed by the same letter in the same column is not significantly different according to HSD test at 5%.

The results of the analysis of variance (table 3) showed the interval of giving water has a significant effect on the observation variable of the number of seeds each row, where the control treatment shows the lowest value, namely 27.60 the number of seeds each row, while the highest value is in the treatment interval of giving water for 8 days, namely 38 number of seeds each row, but not significantly different from the treatment interval giving water for 14 days and 18 days. This shows that the role of water in the plant growth process is very necessary. Water, as a means of transport for nutrients from the soil to plants, is needed in plant metabolic processes such as photosynthesis, plant transpiration, and solvent of many organic matters for plants. The role of water in the photosynthesis process is one of the basic ingredients to produce optimal output, mainly in the form of carbohydrates, proteins, and fats in plants. One of the representations of the optimal photosynthesis output can be seen in the component of the number of seeds in each row. The interval of giving water to the observation variable sample weight of 5 cobs and jenggel weight also showed a significant effect where it was seen that the control treatment showed the lowest value, namely 71.60 grams, while the highest value was seen in the 8-day water supply interval, namely 171.33 grams which was significantly different from the interval for giving water was 14 days but not significantly different from the interval for giving water for 18 days. This is following Kartasapoetra [17] which states that water is the largest part of the network formation of all living things. Between 40% - 60% of the fresh weight of the tree is composed of water. Therefore, the more water contains in the plant, the greater the weight of the plant. Alahdadi et al. [18] suggests that shortages of water supply either temporarily or permanently affect morphology and physiology and even biochemical processes in plants can be disrupted. Meanwhile, according to Koesriharti et al. [19], each type of plant has different water requirements for each growth phase, more water needs are needed in the generative phase than in the vegetative phase. The control treatment usage is the provision of water by utilizing natural water sources in the form of rain which occurs during the growth process without the addition of other water. Corn plants are very sensitive to drought stress because they greatly affect the growth and development of cobs. If water needs are not met, plant growth will be hampered, because water functions to dissolve nutrients and help metabolic processes in corn plants [4].

Table 3. The average of number of seeds/rows, weight of cob, and maize stover in each treatment.

| Treatments                  | Number of Seeds each Row | Weight of 5 Cobs Sample (gram) | Maize Stover |
|-----------------------------|--------------------------|--------------------------------|--------------|
| Control                     | 27.60                    | 71.60                          | 10.13        |
| watering interval every 8 days | 38.00                    | 171.33                         | 26.86        |
| watering interval every 14 days | 36.87                    | 144.47                         | 21.13        |
| watering interval every 18 days | 35.93                    | 130.73                         | 20.40        |
| HSD 5 %                     | 4.61                     | 26.31                          | 5.12         |

The number followed by the same letter in the same column is not significantly different according to HSD test at 5%.
The water interval treatment significantly affected the weight of 100 seeds and crop yields. Farooq et al. [20] states that drought stress can cause a decrease in the number of leaves, leaf area, specific leaf area, dry weight, number of tillers, plant height, and also transpiration. The treatment of watering intervals every 8 days produced an average weight of 100 seeds heavier which weighed 30.33 grams (table 4), significantly different from the control and watering interval of 18 days, but not significantly different from the average weight of 100 seeds at the interval of water treatment every 14 days. When plants wilt due to lack of water, plants cannot carry out physiological functions such as slow cell development and photosynthesis inhibition. Prolonged water shortages can cause crop death [21]. Inhibition of photosynthesis causes inhibition of carbohydrate formation so that the formation of seed weight is low when the plant is in a state of water shortage. In the yield parameters, the treatment of watering interval every 8 days produces a higher average yield of 6.63 tons/ha and not significantly different from the treatment of watering interval every 14 days, but significantly different from the control and watering interval every 18 days treatment. Water is an important component for the process of various physiological activities such as nutrient uptake, photosynthesis, and biochemical reactions, so that a decrease in water absorption results in growth retardation and decreased yield. Water is a very important physical component and is needed in large quantities for plant growth and development. Water also has a function as a plant temperature stabilizer [7]. Provision of water with the right time and the right quantity can affect the growth and yield of plants. The function of water in plants are to determine the rate of photosynthesis, as a universal solvent in the process of plant growth and development, to determine the process of transportation of nutrients available in the soil, and circulate the results of photosynthesis to all parts of the plants [22]. Water is one of the most important needs in the cultivation of crop production. Water demand and water use efficiency are simple ways to find out whether crop yields are affected by water supply. Dryland crops produce lower yields when drought stress occurs [24]. Plants grown on dry land have a higher yield decline during drought [23].

### Table 4. The average weight of 100 seeds and productivity in each treatment.

| Treatments                        | Weight of 100 Seeds (gram) | Productivity (ton ha⁻¹) |
|-----------------------------------|-----------------------------|-------------------------|
| Control                           | 17.00                       | 2.40                    |
| watering interval every 8 days    | 30.33                       | 6.63                    |
| watering interval every 14 days   | 27.33                       | 6.43                    |
| watering interval every 18 days   | 23.00                       | 3.90                    |
| HSD 5%                            | 6.11                        | 0.45                    |

The number followed by the same letter in the same column is not significantly different according to HSD test at 5%.

### 4. Conclusion

Water interval treatment in every 8 days, 14 days and 18 days gave significant effect to variable observation of plant height, number of leaves, cob length, cob diameter, number of rows each cob, number of seeds each row, 5 cobs weight sample and jenggel but no significant effect to variable observation of the observed maize stem diameter. Water interval treatment in every 8 days gave better growth and yields compared to other water treatment intervals, 114.67cm of plant height, 10.40 strands number of leaves, 1.51cm stem diameter, 16.70cm cob length, 4.36cm cob diameter, 38 seeds number of seeds each row, 171.33 grams of 5 cobs weight sample and 26.86 grams jenggel weight and this result was significantly different from the control treatment. Lack of water in the generative phase until harvest affects plant growth and yield.
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