Eco. Env. & Cons. 27 (3) : 2021; pp. (1102-1107)
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ISSN 0971–765X

Drip irrigation system for strawberry plants (Fragaria Sp) : case study in Pandanrejo Village, Bumiaji Sub-district, Batu City, Indonesia

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(Received 22 October, 2020; Accepted 12 January, 2021)

ABSTRACT

Strawberry plants can usually live in the highlands, while in land that is not in the highlands strawberries can live only during the rainy season. Strawberries can be categorized as fruits with high economic value. The high economic value found in strawberries is not accompanied by a high quantity of production. Strawberry plants are included in plants that can not stand the drought and therefore it is necessary to provide water regularly, especially during the dry season. One area that has been known to have a fairly large area of strawberry plantations is the city of Batu, East Java Province. Inappropriate irrigation is the main cause of the low productivity of strawberry plants, this can be seen from the strawberry plants that rot easily caused by excess water, because the provision of water through traditional irrigation, farmers provide water without any quantities that are in accordance with the needs of strawberry plants. Drip irrigation is chosen for strawberry plants so that the use of water for irrigation is more efficient and can improve the quality of the strawberries produced. The research method uses factorial randomized block design (RBD) which is arranged in a systematic and useful way to solve the problems examined in the research to be conducted. The results showed the results of the performance evaluation, drip irrigation design included in both categories with EU values of 84.98%, Ea 76.47%, CU 98.57% and SU 88.52%. The operational time of drip irrigation depends on crop water requirements and Kc value of strawberry plants. The operational time for drip irrigation tends to be longer when the plants are at the stage of growth and mid-season. When giving the best water for strawberry plants is done once every day to avoid drought in plants and have good strawberry crop production

Key words : *Drip irrigation, Strawberry plant, Water provision time*

Introduction

Strawberry plants can usually live in the highlands, while on land that is not in the highlands, strawberries can live only during the rainy season. Strawberries can be categorized as fruits with high economic value. The high economic value found in strawberries is not accompanied by a high production quantity. Strawberry plants are included in plants that are not drought tolerant, therefore it is necessary to

1. Lecture, 2. Student, 3. Student

provide water regularly, especially during the dry season. The water is given from the pre-planting stage so that at the time of planting the land to be planted with strawberries is moist.

The medium used for strawberry fruit plants is soil mixed with sand and clay so that the strawberry plants are obtained in optimal conditions. Sand has loose pores so it can absorb water and air circulation can occur properly. Sand contains a small amount of nutrients, therefore a clay mixture with a finer soil is used. Clay has properties that are difficult to absorb water and poor air circulation, but contains high nutrients.

The definition of irrigation is the use of water to meet the nutritional needs of the plants themselves. Irrigation itself is divided into various forms including surface irrigation, swamp irrigation, underground water irrigation, pump irrigation and pond irrigation. Everything is functioned to support the agricultural system. Some of the benefits of irrigation for agriculture are supplying water for agricultural land, ensuring water availability during the dry season, improving water flow to agricultural land and to wetting the soil. The irrigation system that allows to regulate the amount of water needed by plants is a drip irrigation system so that the level of water use efficiency can be increased. Drip irrigation is a method of giving water to agricultural land or plants directly to plant roots or to the soil surface through continuous and slow droplets. The operation of drip irrigation is done manually by opening the water source faucet so that water can pass through the pipeline and eventually will be flowed to the plants. When watering using drip irrigation is not done continuously throughout the day, but looking at the condition of the soil around the plants, if the soil looks dry then drip irrigation can be used until the soil becomes moist again.

The method of providing irrigation that is not right is the main cause of the low productivity of strawberry plants, this can be seen from strawberry plants that are easy to rot caused by excess water, because the provision of water through traditional irrigation farmers provide water without a dose that is in accordance with the needs of strawberry plants. Drip irrigation is chosen for strawberry plants so that water use for irrigation is more efficient and can improve the quality of the strawberries produced.

Strawberry production in the Batu area is influenced by the way the strawberry farmers are given water, this is because the amount of water needed by strawberry plants can affect the quality of the strawberries produced. If water is given in excessive amounts, the strawberry plant will rot easily. Therefore, an effective irrigation design is needed in order to increase crop yields.

Research Methods

Research Sites

The research was conducted on Mr. Kholik's strawberry farm in Torongrejo Village, Junrejo District, Batu City, East Java. The research was conducted in September - December 2019. The location of the research was precisely at coordinates 7o52'12,0 "LS and 112o32'39,3" East Longitude.

Stages of Research

The stages of research carried out in this study began in stages, starting with identifying the problem until it was finally at the decision-making stage**.**

Problem Identification and Literature Study.

Before the research is carried out, what needs to be done is to identify the problem and conduct a literature study to be able to study the existing problems. The topic studied was the problem of operating drip irrigation on strawberry plants. Determination of research locations and study of relevant literature from related sources can facilitate the research process carried out.

Land preparation

The strawberry plants used for this research are on Pak Kholik's land in Pandanrejo Village, Junrejo District, Batu City.

Data Collection

There are two data used in the research, namely secondary data and primary data. The secondary data needed are climate data and rainfall data. The primary data required is the volume of collected water, water discharge, soil physical data, plant age and number of plants.

Soil Analysis

Soil analysis aims to describe the characteristics of the soil in the research location including texture, porosity, moisture content, field capacity and permanent wilting point.

Determination of Strawberry Plant Water Needs

Analysis of the water needs of strawberry plants in this study was carried out using the Cropwat 8.0 method by entering climate data, rainfall data, crop crop data, and soil physical data. The need for crop water that has been treated automatically on Cropwat 8.0 also determines the operating time of drip irrigation.

Drip Irrigation Preparation and Installation

Drip irrigation installation is carried out by installing tools in the form of designs on the land in accordance with the needs of plant water.

Irrigation System Design and Treatment given a.

Factor I : The number of plants consists of two levels,namely: JI = 3 plants in one polybag J2 = 4 plants in one polybag
b. Factor II: Time of giving water to plants, consisting of four levels, namely:

The design method used in this experiment was a randomized block design (RBD), which was arranged in factorial 3 times, consisting of two factors:

W1 = once a day W2 = once every 2 days W3 = once every 3 days W4 = 4 days

The poly bag used is 30 cm in diameter x 30 cm high. The soil used is land taken in the research garden mixed with compost from the Faculty of Agriculture, Universitas Brawijaya. The ratio of soil: fertilizer: husk is 60%: 30%: 10%. The following is a layout design for a calibrated irrigation system that will be applied in the research field.

Testing of Emitter Output Discharge

The emitter output discharge was measured once a week for five minutes with a pressure of 1.5 bar. The emitter output discharge is used to determine the coefficient of uniformity, uniformity of water output and efficiency of water storage in drip irrigation systems.

Data Processing

The research method used was a factorial randomized block design (RBD) arranged systematically. Compiled with two factors, namely the number of plants and the time of giving water to the plants according to the Complete Randomized Design table where the experiment was carried out three times so that there were 24 experimental plots.

Observation of Results

Based on the randomized block design (RBD) experiment, vegetative observations were made on strawberry plants. The parameters observed were the number of flowers and the number of ovules. The data obtained will be analyzed using ANOVA (Analysis of Varience) tables assisted by Microsoft Excel with a significant level of 5%. The ANOVA statistical test aims to determine the magnitude of the effect with different treatments and also perform the F test and BNT test with a level of 5%.

Determination of Drip Irrigation Operational Time

Determination of operational time can be determined by the following equation:

$$\text{Operational Time} = \frac{ETc}{EDR} \quad (1)$$

$$\text{EDR} = \frac{q}{sxl} \quad (2)$$

Where :

ETc = Plant evapotranspiration (mm / day)
EDR = Emitter drop rate (mm / hour)
q = Discharge emitter (m^3/hr)
s = Distance between emitter holes (m)
l = Emitter lateral distance (m)

Results and Discussion

Most of the land in Torongrejo Village is paddy land, 64% and dry land 36%. Most of the land in Torongrejo Village is allocated for agricultural activities. Most of the farmers in Torongrejo Village use their land for various kinds of vegetables because they produce a lot in a shorter time than other crops. In addition, there are also food crops such as rice and corn, but not as much as vegetables.

Cropwat Data Processing 8.0

Analysis of Potential Evapotranspiration

The climatic data required to determine potential evapotranspiration include minimum temperature, maximum temperature, average humidity, wind speed and duration of sun exposure. The climate data used is from 2010 to 2019. The amount of ground surface radiation energy and the potential evapotranspiration value from the Cropwat 8.0 analysis can be seen in Table 1.

Table 1. Results of Calculation of Potential Radiation and Evapotranspiration (ETo)

Month	Radiation ($MJ/m^2/day$)	ETo (mm/day)
January	15.1	3.37
February	15.7	3.38
March	16.7	3.57
April	17.2	3.75
May	16.6	3.67
June	16.3	3.51
July	16.5	3.59
August	18.8	4.05
September	20.4	4.67
October	20.6	4.79
November	18.2	4.06
December	15.6	3.39
Average	17.3	3.82

Effective Rainfall

The data used is the average result of rainfall data from 2010 to 2019. The effective rainfall calculation with the help of the Cropwat 8.0 program uses the USDA SCS method that has been provided in the program. The calculation of effective rainfall with this method in the Cropwat program is automatically interpolated into daily, decade and monthly so that it can facilitate the determination process. The results of the calculation of effective rainfall can be seen in Table 1.

Plant Characteristics Data

The data needed in the characteristics of this plant is the value of the crop coefficient (Kc). Kc data in Cropwat 8.0 is available in the FAO (Food and Agricultural Organization) database. Determination of plant characteristics is divided into four stages, namely the initial period (initial), the growth period (development), the mid-season (mid-season) and the end of the season (late-season). The FAO database in Cropwat 8.0 has not provided a Kc value for strawberries, so this study used the Kc value for melon plants assuming they are both horticultural crops and both have a planting period of 120 days.

Table 2. Effective Rainfall

Month	Rainfall (mm)	Effective Rain (mm)
January	301.8	155.2
February	309.6	156
March	265.9	151.6
April	201.6	136.6
May	131	103.5
June	46.2	42.8
July	35.8	33.7
August	26.4	25.3
September	30.5	29
October	74.3	65.5
November	256.7	150.7
December	294.6	154.5
Average	1974.4	1204.3

Soil Characteristics Data

The soil medium used for strawberry plants is dusty loam soil. The porosity of the land is 59.43%. The soil composition consists of 25% sand, 55% dust and 20% clay. The soil medium used has a soil permeability of 0.569 cm / second. The amount of soil permeability is influenced by the pore size of the soil.

Strawberry Plant Water Needs (CWR)

The need for irrigation water is influenced by several factors, such as water loss during evapotranspiration and water loss during water supply itself. In the calculation of plant water needs and irrigation water needs, this is expressed in decades. A decade has 10 daily intervals. The drip irrigation carried out in this study only adds to the need for plant water to meet water availability in plants. In addition, specifically for this study, the results of plant evapotranspiration (ETc) calculations were used to determine the operating time of drip irrigation on strawberry plants.

Plant water requirements depend on the growth phase, Kc value, and potential evapotranspiration. Based on the table, it can be seen that the highest evapotranspiration (ETc) value was in October in the third decade, amounting to 47.6 mm / decade. Meanwhile, the lowest was in September of the first decade, namely 22.3 mm / decade. The highest need for irrigation water was in October in the third decade, namely 17.9 mm / decade. Meanwhile, the lowest was in November in the first decade, namely 0.2 mm / decade.

Irrigation Scheduling in Strawberry Plants

The irrigation scheduling stage includes two criteria, namely the time of water distribution and the amount of water provided through irrigation. Cropwat automatically shows the time of administration and the amount of water that must be given based on the data that has been inputted in the previous stage. The data in question are climate data, rain data, soil data, crop data and data from the

analysis of crop water needs that have been carried out by the previous Cropwat 8.0 program. The criteria for a good irrigation scheduling is based on the conditions of water availability in the soil so that the irrigation system can be used efficiently. Soil must be irrigated immediately before it is at the point of permanent wilting.

Irrigation is carried out at the initial, growth and final stages. At the initial stage, it was carried out on the first and sixteenth day with clean irrigation of 33 mm and 39.9 mm. The growth stage was carried out on the fortieth day with 61.4 mm of clean irrigation. The total water requirement that has been given during irrigation is called Gross Irrigation where this irrigation takes into account the water lost. Loss of irrigation water can be caused by surface runoff and percolation into the soil that is not covered by roots. The actual need for irrigation water (net irrigation) is the total need for irrigation water to replace water lost as a result of actual evapotranspiration.

Drip Irrigation Operational Time on Strawberry Plants

This operating time is obtained from the results for the plant water requirements of the emitter rate. The plant water requirement is the ETc value that has been obtained from the results of the crop evapotranspiration count using the Cropwat 8.0 program. In this research, irrigation is provided to replace water lost as a result of plant evapotranspiration so that water will remain available in the soil for use by plants. The operating time of drip irrigation for strawberry plants can be seen in Table 3.

Table 3. Drip Irrigation Operating Hours

Days to-	Plant Water Requirements (mm/decade)	EDR (mm/hour)	Operational Time Every Day (minute)
1-10	22.3	25	5.34
11-20	23.4	25	5.64
21-30	24.6	25	5.88
31-40	31	25	7.44
41-50	38.3	25	9.18
51-60	47.6	25	11.4
61-70	43.5	25	10.44
71-80	41.1	25	9.84
81-90	38.8	25	9.3
91-100	36.5	25	8.76
101-110	30.8	25	7.38
111-120	23.1	25	5.52

Evaluation of Drip Irrigation Performance in Strawberry Plants

Drip irrigation performance evaluation includes distribution efficiency, usage efficiency (Ea), emission uniformity (EU), uniformity coefficient (CU) and statistical uniformity (SU). The data required is the volume of water collected from the emitter for five minutes with a pressure of 1.5 bar. Data was collected once a week for a month, namely at the first week, second week, third week and fourth week. Based on these results, it can be seen that the criteria class for the level of good droplet uniformity in the irrigation system used on strawberry plants can be obtained. The evaluation results can be seen in Table 4.

Table 4. Drip Irrigation Performance Evaluation

Week	EU (%)	Ea (%)	CU (%)	SU (%)
1	84.18	75.76	98.54	88.27
2	85.03	76.52	98.58	88.53
3	89.25	80.32	98.86	90.9
4	81.44	73.3	98.3	86.4
Average	84.98	76.47	98.57	88.52

California Strawberry Production Results

1. The Results of The Number of Flowers Observation of the results of the number of flowers was carried out on strawberry plants that were treated with watering time using drip irrigation and the number of plants carried out for one month. The ANOVA test results have shown the effect of the treatment used, so further tests are needed to determine which treatment is the best. The test performed was the LSD test (List Square Design) at 5% level. The LSD test was carried out to determine which combination of treatments could produce the best yield on strawberry plants. The best treatment combination that affects the growth of the number of flowers on strawberry plants is J1W1, which is the number of three plants with the time of giving water once a day. LSD test results can be seen in Table 5.

Fruit Results

Observation of the results of the number of ovules was carried out on strawberry plants that were treated with watering time using drip irrigation and the number of plants carried out for one month. ANOVA test results have shown the effect of the treatment used, so further tests are needed to deter-

Table 5. Test Results LSD of Flowers

Treatment	Average	Notation BNT0.05
J1W4	2.3	a
J2W4	2.3	a
J2W2	3	ab
J2W3	3.3	ab
J1W3	4.3	bc
J2W1	4.7	bcd
J1W2	5.7	cd
J1W1	6.3	d

Keterangan : BNT 5% = 1.97

mine which treatment is the best. The test is the LSD test (List Square Design) at 5% level. The LSD test was conducted to determine which combination of treatments could produce the best yields on strawberry plants. The best treatment combination that affects the growth of the number of flowers on strawberry plants is J1W1, which is the number of three plants with the time of giving water once a day. LSD test results can be seen in Table 6.

Table 6. Test Results LSD of Fruits

Treatment	Average	Notation BNT 0.05
J2W4	1	a
J2W3	1,67	a
J1W4	2,3	ab
J1W3	3,77	b
J1W2	4,67	bc
J2W2	5	bcd
J2W1	6	cd
J1W1	6,67	d

CONCLUSION

The results of the research that has been carried out regarding Water Supply Scheduling Planning Using Drip Irrigation for California Strawberry Plants (Fragaria sp), the following conclusions are obtained:

1. Based on the results of analysis using Cropwat 8.0, the operational time of drip irrigation in the initial stage is an average of 5.49 minutes per day, in the growth stage the average operational time is 7.5 minutes per day, the mid-season stage is the average operational time 10.25 minutes per day and in the final stages of the season an average of 7.22 minutes per day.
2. Water for strawberry plants is done once a day in the morning so that water availability can be guaranteed so that it will not damage the plants and have good productivity.

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