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# DESIGN AND CONSTRUCTION OF SPRINKLER IRRIGATION FOR STABILISING APPLE CROP IN DRY SEASON

# Bambang Suharto<sup>\*</sup>, Liliya Dewi Susanawati

Agriculture Engineering, Faculty of Agriculture Technology, University of Brawijaya, Malang

# ABSTRACT

The aim of this research was to increase the efficiency and effectiveness of water use by introducing technology innovation of sprinkler irrigation in dry season. It was intended to prevent the apple production which would decrease in water lack condition. Research was included: (1) laboratory research was conducted for designing sprinkler irrigation and its calibration, (2) field research was intended for studying the optimal of delivered time and riser pipe height of water application. This research used the randomized block design arranged in factorial by 3 replications. The first factor was water delivered time and the second one was riser pipe height. Result was used to give consideration for using sprinkler irrigation for increasing apple production. **Key words**: riser pipe height, water delivered time, sprinkler irrigation.

# **INTRODUCTION**

Droughts influenced economic and social damage worldwide. Their irregular occurance and frequent had been a reason for the construction of water resources infrastructure [1]. Therefore, it intended to increase the reliability of water supply in drought area. The understanding of drought duration, recurrence, and severity was of importance water supply. It was due to droughts exacerbate the scarcity of natural water resources.

Fresh water availability varied largely in time and space, and there were limited [2]. Many people still lacked reliable access to adequate some of fresh water and sufficient quality for domestic, recreation, irrigation, industry, and many purposes of other productions. Their access was constrained by the temporal variability and natural spatial of runoff and rainfall because of the climate change impacts. It was assumed that runoff and rainfall would be accelerated because of a simple increase in temperature would increase evaporation and enable the atmosphere to transport higher amounts of water vapor [3]

Apple plantation could be high producted by the end of rainy season, because there was sufficient water in the soil. Therefore, apple production was relative low in the dry season. Beside it, apple production was not as well as if it got enough water. Sprinkler irrigation had not been carried out in the farmers scale, where as in one side, this irrigation system incited drainage system and in the other side it was as water supply method and it was effectively used as manuring method, pest irradication, and plant parasites [3].

Apple farmers in Batu always had difficulty in water problem, which was only depended on rainfall. The amount of rainfall was not always the same for each year. Therefore, the low amount of groundwater in dry season would cause the decreasing quantity and quality of fruits, and it impacted the decreasing of apple production, it reached 30-45% (it was reported in statistical data of 2004). Based on this reality as above, it was needed introduction and new technology innovation of sprinkler irrigation system so that the water use could be efficient and effective; and the production was so stabil in dry season as well as in rainy season.

## **MATERIALS AND METHODS**

The research used the randomized block design arranged in factorial by 3 replications. The first factor was water delivered time (T) which is consisted of four levels: 1 week, 2 weeks, 3

weeks, and 4 weeks, by water given equal on evapotranspiration (ET). The second factor is the riser height I, which is consisted of 3 levels: 50 cm, 100 cm, and 150 cm from the ground. The observation included: climate data, soil physical data, the number of flower, the total of fruit per flower, production per tree, and production per hectare. The experiment consisted of two steps of research as follow:

1. Laboratory experiment:

Based on the design of sprinkler irrigation system, it was observed for: a). Average sprinkler discharge and head; b) Average sub-main discharge of the experiment result and head loss.

2. Field experiment:

Field experiment intended to observe the interaction between effect of riser pipe height and the time interval of water delivered. It was observed too for unrippen and ripe fruit, fruit yield per-tree, and production per-hectare.

## **RESULTS AND DISCUSSIONS**

## Laboratory experiment

Before applying in the field, sprinkler irrigation for apple plantation was trialed in the laboratory and the results were as follows:

1. Outflow

The highest of average sprinkler outflow was occured at the combination of P3R3 (the pressure of 30 Psi and riser pipe height of 150 cm), it was 164.600 liter/hour, but the lowest occured at the combination of P1R1 (the pressure of 20 Psi and the riser pipe height of 50 cm), it was 127.600 liter/hour. This condition was presented as in Figure 1 below.



Figure 1 The influence of pressure and riser height to outflow

The addition of pressure with the same riser pipe height was produced the difference sprinkler outflow. The addition of pressure which was given to the same riser pipe height would cause bigger outflow. It was shown at the combination of P1R1 (the pressure of 20 Psi with the riser pipe height of 50 cm), P2R1 (the pressure of 25 Psi with the riser pipe of 50 cm), and P3RI (the pressure of 30 Psi with riser pipe height of 50 cm), which the outflow was higher than 127.600 liter/hour, 128.600 liter/hour, and 162.600 liter/hour. This result was shown too at the combination of treatment with riser pipe height factor of 100 cm dan 150 cm.

The result above showed that operating pressure was very influenced to the average outflow of sprinkler. Less pressure caused outflow of sprinkler would become little. It was suitable with Michael [5] which said that the outflow of sprinkler was compared straightly with pressure, so that the pressure increasing of sprinkler would increase the outflow of sprinkler.

- 2. Homogeneity coefficient (CU)
  - Homogeneity coefficient was needed to know variation of outflow which was produced along the riser pipe. Based on the analysis of pressure treatment (P) and riser pipe height (R) due to homogeneity coefficient (CU), it showed the same result for all kind of combinations. It was occured too for the interaction among the influence of treatment. The detail of these results were described as in Figure 2 below.



Figure 2 Influence of pressure and riser pipe height to homogeneity Coefficient (%)

Figure 2 showed that homogeneity coefficient had the same trend at all of the treatments. The range was between 85 to 96% and the average was 92.632%. The highest homogeneity coefficient was 95.642%. It was produced at the combination of P2R1 (the pressure was 25 Psi with riser pipe height of 50 cm). The combination of P1R3 (the pressure was 20 Psi with riser pipe height of 150 cm) could still be accepted because according to Cristiansen and Davis in [5], the normal value of homogeneity coefficient was 89% and according to Mc Cullogh [6] was 89%, and Dabbous [6] was 85%.

The influence of pressure to homogeineity coefficient showed that higher pressure would produce higher homogeineity coefficient. This condition was presented as in Figure 3 below. Low pressure would produce low outflow. According to Merriem *et al.* [7], inaverage water delivered would increase deviation value so that homogeneity coefficient would be small. Small homogeneity coefficient indicated that the sprinkler irrigation was not too good in delivery of average water irrigation so that the plantations would receive not the same amount of water.



Figure 3 The influence of pressure to homogeneity coefficient (%)

## Field research

- 1. The influence of riser pipe height and time of water delivery to plantation yield
  - a. The influence of riser pipe height and time of water delivery to apple yield

The influence of riser pipe height and time of water delivery was significant at level  $\alpha$  of 0.05%. This condition was for kind of treatment as well as for each factor. The influence for fruit indicated that the highest product was 257.667 fruits and the lowest was 105.66 fruits. Figure 4 and 5 was described these conditions.



Figure 4 The Influence of riser pipe height and time of water delivery to the amount of apple fruit

Production of fruit was correlated to production of ovary. Supply energy was very important. There was enough energy for each treatment in this research Supply energy as described above, produced the different amount of fruit. Water delivery during 3 or 4 weeks could not be maximized used for plantation, because critical period of apple plantation was during generative period. In this phase if apple plantation could not get enough water, it became devoliage and the production was not maximal.



Figure 5 The influence of riser pipe height and time of water delivery to the amount of fruits

b. The influence of riser pipe height and time of water delivery to apple yields (kg/ha)

The result of variate analysis at level  $\alpha$  of 0.05 for the production in kg/ha showed that it was the same as the production of kg/tree which the whole factors showed the same significant influence to the production. Figure 6 and 7 showed that the highest production was 55,623 kg and the lowest was 19,024.20 kg. Therefore, it was concluded that comparing to conventional system, the production could be increased 3 times by regulating riser pipe height and time of water delivery.



Figure 6 The influence of riser pipe height and time of water delivery to the average of apple production

If water in the soil was so enough to supply water requirement, the plantation would produce maximal yield. Climate factor which influenced plantation growth and production was included of temperature and radiation during growth period. These all conditions were caused by water lack and it would decrease plantation yield. The influence of riser pipe height and time of water delivery was described as in Figure 7.



Figure 7 The influence of riser pipe height and time of water delivery to the average of total apple (kg/ha)

#### **Financial analysis**

Based on the analysis as above, application of sprinkler irrigation system at the apple plantation gave more profits and it was presented as in Table 1 below.

Table 1 Sensitivity analysis of finance due to application of sprinkler irrigation system at apple plantation per-ha

No.	Sensitivity parameter	Value
1.	Payback period	2 years and 6 months
2.	Net Present Value (I = 11 %)	Rp. 134,551,638,-
3.	Internal Rate of Return (IRR)	45,5 %
4.	Profitability index	1,68

Table 1 showed that payback period of capital was 2 years and 6 months, and the value of NPV was Rp. 134, 551,638.-; IRR was 45.5% and Profitability Index was 1.68. This result recommended that application of sprinkler irrigation system was very available.

# CONCLUSION

Based on the analysis as above, it was concluded that:

Laboratory research: The highest of sprinkler average discharge was 164,600 liter/hour. It was produced by combination of P3R3 (the pressure was 30 Psi with riser pipe height of 150 cm). The lowest was 127,600 liter/hour. It was produced by combination of P1R1 (the pressure was 20 Psi with riser pipe height of 50 cm). The influence of pressure and riser pipe height to the performance of low angle challenger micro sprinkler at sprinkler irrigation showed the different result. The highest pressure was 25 Psi with riser pipe height of 50 cm). The value of CU (homogeneity coefficient), DU (Distribution Uniformity), and PELQ (Potential Application Efficiency of Low Quarter) was 95.642%, 71.456%, and 87.212%

Field research: The highest result of T1R3 (time delivered of water was 1 week with riser pipe height of 150 cm) treatment was 55,623 kg/ha and the lowest was 19,300.33 kg/ha. Optimal production was produced at riser pipe height of 150 cm and time delivery of 1 week. Effective riser pipe height for apple plantation at sprinkler irrigation was 150 cm over soil surface. The using of sprinkler irrigation could increase apple plantation for almost 3 times compared with conventional method. Investation cost for system application of sprinkle irrigation was Rp. 80.000.000.-/ha. Payback period was 2.5 years; NPV at the interest of 11% after 10 years was Rp. 134,551,638.-; IRR was 45.5%; and Profitability Index was 1.68.

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