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Effects of transmission pipe slope on PVC pipe drip irrigation flow

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Abstract. Agricultural activities on sloping land need to be supported by an adequate irrigation system such as efficient drip irrigation. This study aims to determine the impact of the slope of the drip irrigation transmission pipe on the uniformity coefficient and volume of irrigation flow. The study used a PVC drip irrigation network. The drip hole spacing was 60 cm with a diameter of 0.5 mm and a transmission network pipe using Ø1/2-inch PVC and irrigation water source from a 200-litre capacity of the tower 3.3 m high. The slope (α) of the test transmission pipes 10°, 20°, 30° and 40° and variations of the water height in the tank of 20 cm, 30cm, and 40cm, with 1, 3 and 5 minutes of dripping time. Data analyzed on uniformity coefficient (Cu), the relationship between the slope of the transmission pipe and the distributions irrigation. The test results show that $\alpha=10^\circ$ - 20° and head 30 cm - 40cm have the best performance with droplet uniformity above 80%. Variations in the slope of the transmission pipe and the distribution of drip irrigation flow have a polynomial regression relationship with an average R-value of 0.6– 0.99.

1. Introduction

Utilizing flat or sloping land conditions is very important for the agriculture and irrigation development of dry land because it will reduce the cost of farming. Utilize land with sloping conditions and without reforms of formation into flat land is expected to facilitate agricultural activities on dry land. Therefore, the exploitation of sloping dry land needs to be supported by an efficient irrigation system such as a drip system. The commonly field constraints are rarely found in ideal conditions, where the potential availability of land have supported by the availability of adequate water sources for farming. In coping with the limitation of water resources, it is necessary to encourage the efficient use of the limited water. So that agricultural activities can be carried out and provide benefits. The utilization of solar energy as a substitute for electricity in deep groundwater pumps with PVC drip irrigation has had applied in the NTB province, namely in the dry land of Pringabaya, and the results of the average drip irrigation uniformity are 72% [1]. The research land is a hillside that is processed into flat plots so that tests on dry land with sloping conditions need to be carried out as a comparison later.

Drip irrigation applications have used many fabricated drip pipes produced by factories on flat plots of land for tomato farming of 2.5 acres, showing that the average irrigation uniformity (CU) is above 80%. The average discharge used for each irrigation is 0.14 litres/second, with the average volume of water used is 359.5 litres [2]. So that further studies need for the development of existing land uses and without having to go through excessive land management.



The influence of variations in the transmission pipe slope on its uniformity has also been carried out by the previous researchers, on perforated irrigation systems. And the results show that the uniformity achieved is getting smaller if the slope of the transmission pipe is getting bigger. The minimum uniformity (CU) value is 85%, and the highest CU value is 91% [3]. Based on the test results, if a drip irrigation system has slope variation, it may show a different phenomenon and benefit of using drip irrigation for agriculture on sloping land.

Research on the effect of variations in the slope of the transmission pipe on the output of drip line drip irrigation shows that the greater the slope of the transmission pipe, the greater the discharge used. The maximum uniformity of the previous study obtained 94% and 92% at a pipe slope of 10° at a transmission pipe slope of 10° and 40° , respectively [4].

Testing the effect of variations in the distance between the lateral drip pipe on irrigation uniformity has been carried out with a duration of 5 minutes, showing the uniformity coefficient obtained is 94%–100% and is included in the good performance category. The highest CU obtained at a lateral pipe distance of 0.3 m at $Q_p=0.46$ l/s, which is 97%, while at a distance between lateral pipes 1 m at $Q_p=0.30$ l/s, the CU is 94.6% [5]. Good uniformity of drip irrigation is one of the critical factors that need to be met by a drip irrigation system, and therefore it is the aim of this study.

By using several variations of slopes and variations in the depth of certain tower water levels, it is hoped that there will be a description of the use of dripline drip irrigation on sloping land. For this reason, this study aims to determine the effect of variations in the slope of the transmission pipe on the uniformity of irrigation and distribution of drip irrigation and to find the relationship between variations in the slope of the transmission pipe and the volume distribution of drip irrigation type dripline.

2. Method

This research is experimental in the Laboratory of Hydraulics and Coastal Engineering, Engineering Faculty, University of Mataram. The research activity was conducted in three stages as follows: a literature study, preparation of materials and tools, and design the irrigation network systems and water sources and testing. The testing activities can be described as follows.

2.1. Preparation stage

Collection of literature and references that form the basis of theory, preparation of tools in the form of pipe drills, water tanks. The frame of the water reservoir made of bamboo has a height of 3.3 m and the capacity of the water reservoir is 200 litres. The preparation of 4 PVC pipes that were used as materials for drip irrigation transmission networks. The distance of the dripper and diameter is about 60 cm and 0.5 mm, respectively. The distribution channel was made by a PVC pipe of 1.27 cm in diameter (1/2 inch) and a transmission pipe length of 3.35 m. The variations of the transmission pipe slope were about 10° , 20° , 30° and 40° and variations in the height and depth of the reservoir water level consist of 10 cm, 20 cm and 30 cm. The top view and side view of the drip irrigation network with water reservoirs can be seen in Figure 1 and Figure 2.

2.2. Test stage

This test begins with a preparatory test, namely the flow test of variations in the depth of the reservoir water and testing for variations in slope. After the test is complete and ready, then proceed with further tests for data collection. The test is carried out on variations in the slope of the transmission pipe first, then the selection of variations in the depth of the reservoir water is 20 cm, 30 cm, and 40 cm. By this step, the dripping uniformity data is taken three times for all transmission pipes for each test variation. Each data collected is then tabulated and prepared for further analysis. Testing and retrieval of test results data then were carried out for all variations tested.

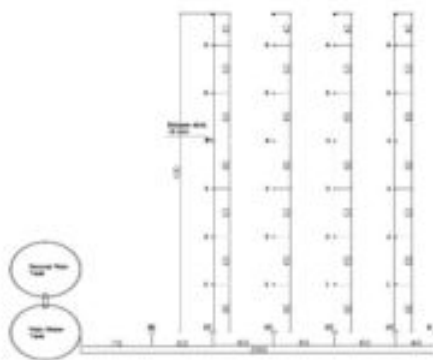


Figure 1 Site plan of drip irrigation network

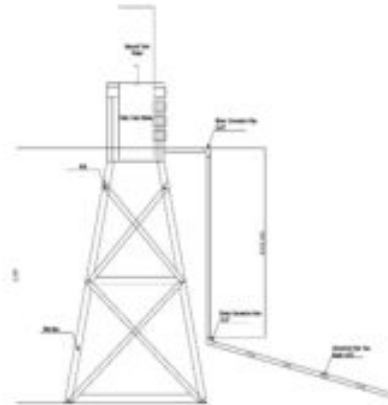


Figure 2 Side view of drip line drip irrigation network

2.3. Data analysis stage

Data analysis was carried out on the irrigation uniformity value using the Christiansen formulation [5], analysis of the distribution of irrigation water for each drip pipe and analysis of the relationship between irrigation uniformity and the slope of the transmission pipe. The drop uniformity then classified using ASEA criteria as presented in Table 1 [7].

Table 1 CU criteria for drip irrigation system according to ASEA

Criteria	Statistical Uniformity (SU)	Coefficient of Uniformity (CU)
Very good	95%–100%	94%–100%
Good	85%–90%	81%–87%
Pretty good	75%–80%	68%–75%
Bad	65%–70%	56%–62%
Not feasible	<60%	<50%

3. Results and discussion

3.1. Effect of variation of transmission pipe slope (α) onto the distribution of drip irrigation volume (v_i)

The relationship between the volume of water released by the whole nozzle is essential to be measured because it indicates the performance of the drip irrigation system. Therefore, it is necessary to know the effect of slope of the transmission pipe variations as a representation of the slope of the land that distributes irrigation water. The regression line is then modified to see the relationship between the two variables above to meet the results of this study can be more widely applied. The founding of the analyses was carried out the relationship between slope and irrigation volume distribution (v_i) in dripper pipes 1 to

4 by a polynomial relationship.

3.1.1. Effect of variation of transmission pipe slope (α) on drip pipe 1.

The results of data analysis on the distribution of drip pipe 1 in the form of a polynomial regression graph that produces an R-value above 0.5, namely the variation of the reservoir water depth of 30 cm and 40 cm, are shown in Figures 3 to 4. In the variation of reservoir water depth h_2 30 cm with a head of 283 cm, with R 0.727, while in the variation of reservoir water depth h_3 40 cm with a head of 293 cm, the obtained R 0.997.

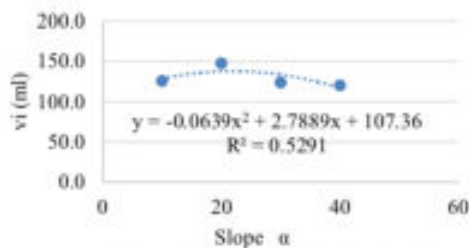


Figure 3 Relationship v_i and α at h_2 .

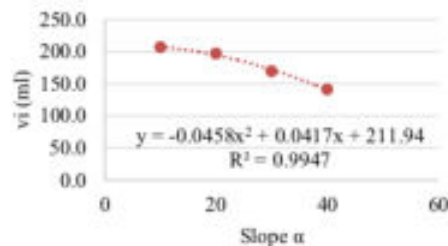


Figure 4 Relationship v_i and α at h_3 .

Hence, the variation of slope (α) and volume of irrigation produces a very high polynomial regression correlation coefficient, where the increase or decrease in irrigation volume related to the increasing and decreasing in the slope of the transmission pipe follows the polynomial curve. With the increasing value of the pipe slope, the irrigation volume tends to decrease in drip pipe 1, which is closer to the water source.

3.1.2. Effect of variation of transmission pipe slope (α) on drip pipe 2. The test results of the influence of variations of transmission pipe slope on drip pipe 2 had figured out in the graphs in Figure 5 and Figure 6. The value of the determinant R of R^2 the regression relationship between slope and irrigation volume shows a polynomial regression relationship. The magnitude of the determinant value and the correlation of the two parameters derives a conclusion.

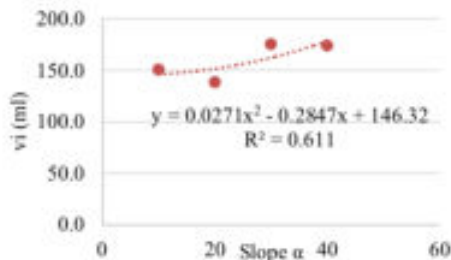


Figure 5 Relationship v_i and α at h_2 .

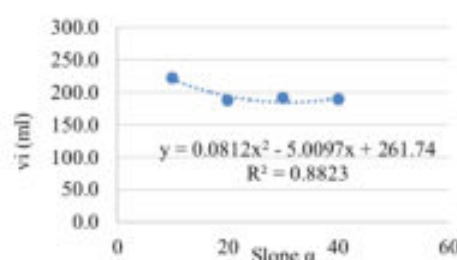


Figure 6 Relationship v_i and α at h_3 .

The relationship of the angle of the transmission pipe to the volume of irrigation water (v_i) produced shows a polynomial regression relationship, with an R-value greater than 0.5 obtained at a reservoir water depth of h_2 and h_3 . The polynomial regression graphs obtained in Figure 5 and Figure 6 have a value of R 0.781, respectively, at the reservoir water depth h_2 and h_3 , the value of R 0.939. So, based on the value of

the determinant and its correlation coefficient, the polynomial regression relationship between slope variation and irrigation volume has a strong relationship. The higher the slope of the transmission pipe, the larger the irrigation volume.

3.1.3. Effect of variation of transmission pipe slope (α) on drip pipe 3. Based on the results of the analysis produced in graphical form, it has known that all graphs show the tendency of the relationship between the volume of drip irrigation to the slope of the transmission pipe in a polynomial relationship. The polynomial regression relationship with the resulting graph has shown in Figures 7 to 8 and explained as follows.

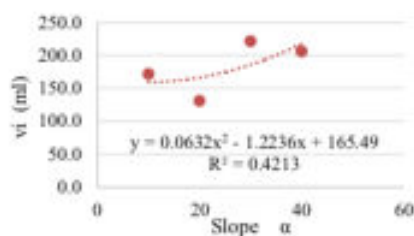


Figure 7 Relationship v_i and α at h_1

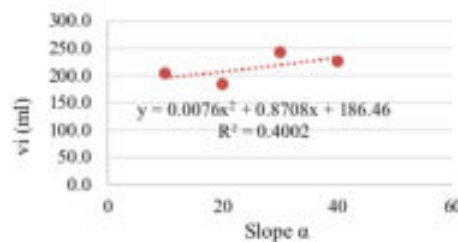


Figure 8 Relationship v_i and α at h_2

The reservoir water depth h_1 has a head height of 273 cm, produces $R = 0.649$. At the variations in reservoir water depth h_2 , has a head height of 283 cm gives $R = 0.632$, while at a head variation of the reservoir water depth h_3 of 293 cm obtain $R = 0.706$. So, the variations of pipe slope and the average irrigation volume (v_i) show a strong relationship in polynomial regression. The graph of the parameter relationship has figured out in Figure 9, where there is a decrease in the average irrigation volume (v_i) with the increase in the angle of inclination of the transmission pipe.

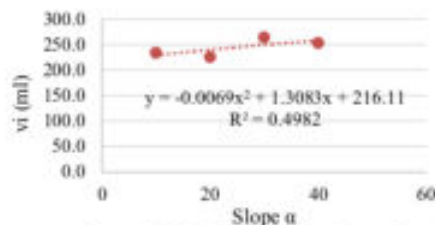


Figure 9 Relationship v_i and α at h_3

3.1.4. The effect of variations in the slope of the transmission pipe (α) on the drip pipe 4. Based on the analysis results in graphical form, it has known that the relationship between irrigation volume and the slope of the transmission pipe has a polynomial regression relationship based on the determinant values of R^2 presented in Figures 10 to 12.

At a water depth variation h_1 of 20 cm and the head height of 273 cm, obtained $R = 0.828$. At a head height of 283 cm (water depth variation h_2 30 cm) obtained $R = 0.979$ and at a head 293 cm (variations in water depth h_3 40 cm) obtained $R = 0.998$. So, the variation of the slope and the resulting irrigation volume has a very high correlation number of a polynomial regression.

Based on the results of the graph analysis of the polynomial relationship between the average volume of drip irrigation and the variation of the slope of the transmission pipe, the overall graph test results show that the greater the angle of inclination of the transmission pipe, the greater the volume of drip irrigation water produced on average.

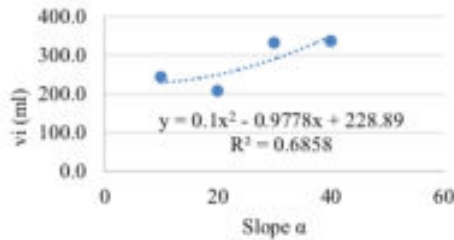


Figure 10 Relationship v_i and α at h_2

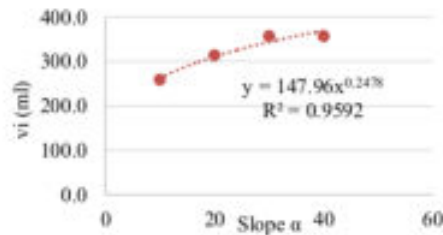


Figure 11 Relationship v_i and α at h_2

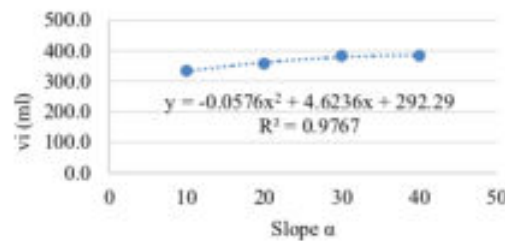


Figure 12 Relationship v_i and α at h_3

3.2. Uniformity of drip irrigation to the slope of the transmission pipe

3.2.1. *Uniformity of drip irrigation at 10° transmission pipe slope.* The results of the drip irrigation uniformity in using a 10° pipe slope and a head height of 273 cm, 283 cm, and 293 cm and three variations of test time, namely 1 minute, 3 minutes and 5 minutes, can be seen in Table 2. At a low head on h_1 , the results of CU values are low, under 80% on average. The higher the water level heads, the better the CU. The highest irrigation uniformity obtained at 10° slope pipe, namely at the highest head height of 293 cm with a value above 82%, and according to ASEA, is classified as a good performance [7].

Table 2 Average uniformity of drip irrigation at 10°

Time (minutes)	Average Cu value (%)		
	$h_1=273$ cm	$h_2=283$ cm	$h_3=293$ cm
1	70,11	73,86	82,02
3	71,02	78,87	85,92
5	83,37	87,0	89,43

However, for each measurement duration, the results of the uniformity value are higher when the head is higher. Compared to the CU values achieved by the perforated irrigation system, the results of this drip

study obtained a higher value. The perforated irrigation system has a CU value range of 85% to 91% [3]. In addition, the uniformity of drip irrigation is obtained higher with increasing head height in the reservoir.

3.2.2. Uniformity of drip irrigation on 20° transmission pipe. With variations in the slope of the transmission pipe 20° and variations in water depth h_1 to h_3 , the head height is obtaining in Table 3. With a head height of 273 cm to 293 cm, the CU value is increasing. The average value of CU is above 82%. So, the increase in the slope of the transmission pipe had greatly affected the uniformity of the drip irrigation pipe of the PVC drip line system.

Table 3 Average uniformity of drip irrigation at 20°

Time (minutes)	Average CU value (%)		
	$h_4=223$ cm	$h_5=233$ cm	$h_6=243$ cm
1	70,91	81,02	82,84
3	78,46	79,85	91,49
5	82,60	88,34	90,90

Based on the results of this test, it is still possible to obtain a higher uniformity above 80% than flat land conditions, which is only 72% of the test results [1]. So, this system has a very potential development in the future as a sloping land irrigation system. According to the ASEA criteria [7], the uniformity obtained in this study indicated a good performance with the average of CU values is more than 85%. Therefore, it is possible to increase the value of irrigation uniformity to be close to the uniformity of the fabricated drip pipes [2].

3.2.3. Uniformity of drip irrigation at a transmission pipe slope of 30°.

The results of the uniformity analysis on the variation of the transmission pipe slope of 30°, head height 173cm, and the water depth of the reservoir is 20 cm above the outlet shown in Table 4 below. Dealing with the test results at a 30° slope on a sloping transmission network also shows good uniformity result values is above 80%, that it is better than if compared to a flat land condition, which is only 72% of the test results [1]. So it is possible to produce a higher uniformity value such as a fabricated drip pipe with the CU average value above 80% [2]. So, this system has the potential to be further developed.

Table 4 Average uniformity of drip irrigation at 30° slope

Time (minutes)	Average Cu value (%)		
	$h_7=173$ cm	$h_8=183$ cm	$h_9=193$ cm
1	77,42	77,09	80,10
3	82,71	84,86	88,16
5	88,45	85,40	90,14

The uniformity (CU) of drip irrigation has an average result above 82% for variations in water depth h_2 above the outlet and head height 183 cm, while variations in water depth h_3 with a head of 193 cm gave an average CU value above 85%. Based on the result, the uniformity value obtained from the study was classified good category according to ASEA [7].

3.2.4. Uniformity of drip irrigation on the slope of the transmission pipe 40°. The results of the analysis of the uniformity of drip irrigation on the variation of the 40° transmission pipe slope obtained a head height of 118cm at a variation of the reservoir water depth of 20 cm above the outlet with the uniformity of drip irrigation obtained an average of 80% and above. For more details, see Table 5. In variations in the depth

of the reservoir water h_2 and h_3 with a head height of 128 cm and 138 cm, the average uniformity value of drip irrigation obtained was about 82% and above, and the CU value was good according to ASEA [7]. So based on the results of the uniformity data analysis that has been carried out, in general, the uniformity of the uniformity value obtained decreases with the increasing slope of the transmission pipe.

Table 5 Average uniformity of drip irrigation at 40°

Time (minutes)	Average Cu value (%)		
	$h_{10}=118$ cm	$h_{11}=128$ cm	$h_{12}=138$ cm
1	68,50	75,97	75,82
3	83,55	84,65	85,06
5	85,16	87,29	88,76

4. Conclusion

1. The test results show that at the slope of the transmission pipe 10° and 20°, and variations in the depth of the reservoir water $h_2=30$ cm and $h_2=40$ cm, the average drip irrigation uniformity is above 80%, that classified as good.
2. The relationship between the slope of the transmission pipe and the flow distribution of drip irrigation generally shows a strong relationship in polynomial regression, where the average R-value is 0.6 to 0.99.

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