Technological Innovation Drip Irrigation for Dry Land Chile Farming in Rural Salut, Kayangan Sub-District, North Lombok Regency, West Nusa Tenggara, Indonesia

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1. INTRODUCTION

1.1. Research Background

Various studies have been and are being carried out in North Lombok Regency (NLR) by researchers in the Research and Development Agency, lecturers at universities, and students on dry land management as a strategy to strengthen food security and food sovereignty. However, very few studies have specifically analyzed the development of gravity control system drip irrigation as a climate change adaptation strategy that supports food security. There is relatively little available irrigation water during the dry season and the cost of irrigation for vegetable farming with pump well water is relatively expensive (IDR 40,000 - IDR 50,000 - per hour), and a lot of water is absorbed along the canals, so that the water that reaches the plants is not up to 75%. The need for water for irrigation of...
vegetable and seasonal fruit crops is more or less the same as the need for irrigation water during the rainy season. Dryland farmers only cultivate vegetables during the rainy season, while farmers’ main concern is farming on dry land. To overcome the need for water in times of water shortages is to use drip irrigation. In drip irrigation, irrigation can be adjusted to the water needs of each type of plant, which varies depending on the growth phase and type of plant. In farming in yards, the need for water is very important, considering that water is one of the determining factors for plant growth. With drip irrigation, water can be used more efficiently, and farmers can grow crops anytime.

The production of horticultural crops (vegetables and seasonal fruit) has the potential to wastewater. The main characteristics of horticultural crops require sufficient but not excessive water, requiring farmers to provide water with frequent frequency and in amounts that often exceed the needs of the plants. So, it is common for us to see farmers watering their plants every morning and evening, especially during the dry season.

The development of horticultural farming based on seasonal vegetables and fruit on dry land in Rural Salut, Kayangan District, North Lombok, has made a significant (positive) contribution to strengthening the economic empowerment of farmer households [1,2]. The magnitude of this contribution is indicated by the large farm income per farmer household in each production process. Production activities can be carried out by each farmer twice to 3 (three) times a year because it is supported by the availability of water from boreholes, water pumps and agricultural machinery facilities such as hand tractors assisted by the local government [2].

The profit of seasonal vegetable and fruit farming can increase if the share of irrigation costs is saved (efficient) because the proportion of irrigation costs is the largest in the cost structure of horticultural farming based on seasonal vegetables and fruits [2]. The large proportion of irrigation costs in vegetable farming in the dry land of North Lombok is due to the manual irrigation system from drilled wells to the planting area for IDR. 40,000 to IDR 50,000 per hour. In addition, manual surface irrigation systems in the dry season tend to be wasteful of water because it is estimated that the water reaching the farming area does not reach 75% because most of the water is absorbed along the canals.

In the dry season, very little water is available, while the need for water is more or less the same as the water requirement in the rainy season for irrigation of seasonal vegetable and fruit crops. Meeting the need for water during hard water times (dry) can be overcome by using drip irrigation. In drip irrigation, irrigation can be adjusted according to the water needs of each type of plant, which varies depending on the growth phase and type of plant. Meeting the water needs in seasonal vegetable and fruit farming on dry land is very important because water is one of the main inputs and becomes a determining factor for plant growth. Water can be used more efficiently by applying a drip irrigation technology.

Management of water resources and proper utilization are the most important factors in determining the success of farming in terms of quality and quantity in increasing crop production. Water content in the soil is one of the important things in crop production. The success of the planting system will be achieved if the amount and time of water administration are regulated. Excess and lack of water will also inhibit growth and affect crop production. Water is needed for plant growth as a medium for transporting nutrients from the soil to all parts of the plant. In general, irrigation management aims to maximize crop production in terms of efficiency, operating costs, and operational ease. Therefore, drip irrigation is an option for irrigation water, but its efficiency must be proven through intensive and in-depth research. Drip irrigation systems can be used for almost all types of plants, such as vegetables, fruits, vines, and other plants with high economic value.

One of the drip irrigation systems that has not been widely tried and researched is the gravity drip irrigation system, which has not been well developed, and there has not been much research related to the gravity drip irrigation system. Even this is only done with an infusion tube, as done by Ref. [3].

Related to increasing the ability of farmers to cultivate profitable seasonal vegetables and fruits on dry land, this is greatly supported by irrigation factors and agricultural machinery such as tillage tools because the cost of cultivating land is relatively high. Therefore, irrigation facilities require the government’s attention to implement its policies in empowering farmers. Researchers should carry out their roles and functions in improving and increasing farmers’ ability in aspects of Better Farming, and the agricultural extension officer should support and provide information to farmers so that Better Farming is perfect. Vegetable farming in Kayangan District has also been carried out in several villages, such as in Amor-Amor and Gumantar Rural areas, because the development of horticultural agriculture based on dry land vegetables aims to support the tourism industry in North Lombok. Therefore, information and scientific findings are needed through research on the Development of Drip Irrigation technology with a Gravity Control System in Dry Land Seasonal Vegetable Farming in the Rural Salut area, Kayangan District, North Lombok Regency. The research results are expected to be considered in developing horticultural agribusiness to strengthen the economy of farmer households and support aspects of food security [4]. The research question should be whether innovative drip irrigation technology can save water use and how much it can be cost-efficient, profitable, and financially and economically feasible.

It was a short- to medium-term action research method that started at the beginning of the dry season. The research approach applied is participatory action research, namely action research by applying a rural community participatory approach.

1.2. Research Objective
This research aims to analyze and find savings in irrigation water use, cost efficiency, and profitability of drip irrigation technology for dryland chilli farming.

2. MATERIALS AND METHODS

2.1. Method and Approach
The research was conducted on farmers’ land belonging to the Pade Girang Farmers Group in rural Salut. There is a Borehole

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TM 151, and the farmers always continuously farm vegetables with surface irrigation. The research was a short to medium term Action Research study (Short to medium Action Research), which begins in early May 2021 and March 2022 (every entering the dry season). Therefore, the Participatory Action Research method was the research method applied is, namely Action Research by applying a rural community participatory approach. The reason for choosing the Participatory Action Research method is because this method is considered to have several advantages in the process of introducing an innovation that has not been widely disseminated in a group of people. This method has several advantages [5, 6], including the fact that action research is based on objective and actual direct observation results, it is relatively flexible in conducting treatment models that will be tried out, and it works with on-the-spot experimentation.

This activity was divided into 3 stages, namely the initial stage (preparation), the implementation stage, and the final stage, all carried out for approximately 8 months. The implementation stage of this activity is divided into several stages, namely: (1) The design of tools/materials (assembly) begins with the preparation and measurement of planting media (making planting beds). (2) Preparation of tools and materials followed by designing and drawing a sketch of the Control System flow of the control circuit used in the installation of the device; (3) setting the drip irrigation network installation, (4) testing the emitter; (5) test the performance of drip irrigation networks on plants; (6) Observation, data processing.

The design of a drip irrigation system utilizes gravity pressure to drain water from the reservoir to the plants. The reservoir's main pipe (Brand of PIPAKU) measures 1.5 Inc., and the lateral pipe used in the drip irrigation system is 0.5 inches in size and consists of two lines in one planting bed. With a length of 25 meters each, each side is paired with a dropper (emitter) according to the spacing of the chili plants.

The design of the Drip Irrigation System includes testing the dropper (emitter). The emitter used in the drip irrigation system design is a regulating stick emitter. The emitter used in the design of this drip irrigation system is a regulating stick emitter. Some of the parameters used in testing the characteristics of the dropper are the dropper discharge, operating pressure (head), the relationship between the dropper discharge and the operating head which is known as the emission component, the coefficient of variation of the dropper, the diameter of the dropper and the wet volume of soil.

2.2. The formula of Dropper Discharge (Q) is [7]

\[ Q = \frac{V}{t} \quad . . . . . (1) \]

\( Q \) = Dropper discharge (l/hour)
\( t \) = time (hours)
\( V \) = Volume (liters)

2.3. Dropper coefficient of variation (CV)

The dropper coefficient of variation (CV) [7] is a static parameter with which values are compared standard deviation of the dropper with the average dropper discharge, from a number of dropper samples tested with the same operating head.

\[ CV = \frac{S}{Q_{\text{avs}}} \quad . . . . (2) \]

CV = Coefficient of variation
\( Q_{\text{avs}} \) = average debit (Liter per hour)
\( S \) = Standard Deviation

2.4. Data analysis method

This quantitative data was gathered from the experimental research. This research focuses on profit analysis, economic efficiency, and profit and loss analysis [8,9]. The data analysis technique used in this study are as follows:

\[ \pi = TR - TC \]

Description
\( TR \) = Py. Y and TC = FC + VC

Where:
\[ \pi = Py. Y - (FC + VC) \]
\( \pi \) = Income (profit)
\( Py \) = Commodity Price of shallots
\( Y \) = Profit
\( FC \) = Fixed Costs (fixed costs)
\( VC \) = variable cost
\( TR \) = Total Revenue (total revenue)
\( TC \) = Total cost (total cost)

3. RESULT AND DISCUSSION

3.1. Drip Irrigation System Performance

This drip irrigation system utilizes gravity pressure and water pressure from a water reservoir as a 3,300-liter Volume Reservoir as a water source (reservoir). The water is channeled to the plants. The main, manifold, and lateral pipes used in the drip irrigation system have the size of the reservoir, which is a 1.5-inch pipe (Brand PIPAKU) that branches to a Parallon
consisting of two lanes of lateral pipes on a raised bed with a length of 30 meters. In each 0.5 Inc pipe that is installed laterally, a dropper (emitter) is installed. The dropper (emitter) used is a regulating stick emitter installed on the right and left lateral sides connected to a 5mm adapter and nipple with a distance of 40 cm (according to the spacing of cayenne pepper). In contrast, the distance between the pipes on the right and left sides is 60 cm (according to the bed size) as shown in the picture.

### Table 1. Specifications for the Components of the Drip Irrigation System.

<table>
<thead>
<tr>
<th>No</th>
<th>The component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main pipe</td>
<td>PVC (PIPAKU) diameter 1,5 -inches with a length of 20 mch</td>
</tr>
<tr>
<td>2</td>
<td>Manifold pipe</td>
<td>PVC diameter ½ inch the length 40 m (10 sticks)</td>
</tr>
<tr>
<td>3</td>
<td>Pipa lateral (on the raised bed)</td>
<td>PPC diameter 0.5-inch length 840 m (210 sticks)</td>
</tr>
<tr>
<td>4</td>
<td>Supporting components</td>
<td>Stop Faucets, Valves, Water Faucets, Knee and T Connectors</td>
</tr>
<tr>
<td>5</td>
<td>The source of irrigation water</td>
<td>Drill Well TM 151 depth of 110 meter110 m,</td>
</tr>
<tr>
<td>6</td>
<td>Reservoir</td>
<td>Tank volume of 3,200 L, filled with a water pump machine Tandon volume 3.200 L, filled with a water pump machine</td>
</tr>
<tr>
<td>7</td>
<td>The name of the Water Pump Machine</td>
<td>TM 151</td>
</tr>
</tbody>
</table>

Drip irrigation is carried out on dry land rice fields where the average water content is unknown because laboratory analysis has not been conducted. Therefore, for the sake of analyzing the physical properties of soil as a planting medium based on drip irrigation, the role of soil experts must carry out laboratory tests on soil moisture content, texture, and structure. Data on the physical properties of dry land soils such as soil water content are needed to analyze the physical properties of the soil.

### Table 2. Calculate plant water needs and operational time of irrigation.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Plant Coefficient</th>
<th>Plant water need</th>
<th>ETc Operational time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative growth</td>
<td>0.65</td>
<td>4.33</td>
<td>0.75</td>
</tr>
<tr>
<td>Water stress for flower induction</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flower development</td>
<td>0.78</td>
<td>5.5</td>
<td>0.92</td>
</tr>
<tr>
<td>Fruits formulation</td>
<td>0.55</td>
<td>3.7</td>
<td>0.64</td>
</tr>
<tr>
<td>Young fruit growth</td>
<td>0.63</td>
<td>4.34</td>
<td>0.73</td>
</tr>
<tr>
<td>Fruit growth</td>
<td>0.80</td>
<td>6.15</td>
<td>1.05</td>
</tr>
<tr>
<td>Fruit ripening</td>
<td>0.76</td>
<td>5.4</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Observations were made at the age of 8 days after planting, which was marked by the condition of the soil dried up because planting was carried out at the beginning of the dry season. So, irrigation water was only sourced from drilled wells, which were stored in reservoirs of 3200 volume. By the time the plants were 8 days old, the plant roots had started to develop fully. Absorb nutrients from the soil. The parameters measured were the growth of the number of leaves and the volume of irrigation water given at each irrigation. The dropper used illustrates that the lower the CV value produced, the better the performance of the dropper type. The EU value of 65.50% is categorized as low because there is head loss in the system due to the use of drip irrigation system components.

From the observations that have been made, the average discharge of droplets using gravity pressure is 0.78 L/hour, while the average discharge of droplets using pump pressure is 1.25 L/hour. Calculating the uniformity of dropper discharge for irrigation using gravity pressure obtained a CV value of 0.27 and an EU value of 65.39%. The CV value indicates that the dropper-type constant is used. The lower the CV value generated, the better the performance of the dropper type.

The results of drip irrigation dropper count that uses gravity are calculated with

\[ Q = \frac{v}{t \tan \theta} \]
\[ CV = \frac{x - \bar{x}}{\bar{x}} \]

obtained a CV of 0.30 which indicates that the dropper type constant used illustrates that the lower the CV value produced, the better the dropper type performance. The EU value of 65.50% is categorized as low because there is a head loss in the system due to the use of drip irrigation system components that are not appropriate.

The amount of water cayenne pepper plants need during evapotranspiration depends on weather conditions and crop efficiency. Observations showed that the average minimum and maximum temperature conditions around cayenne pepper (Rural Salut) were between 24°C – 30°C. This temperature is very suitable for growing cayenne pepper plants because the ideal temperature for chilli seed germination is 25-30°C. Cayenne pepper can adapt to temperatures of 24°C – 27°C with humidity that is not too high. The growth of hybrid chilli plants requires a temperature of 24°C-28°C. Temperatures that are too low will inhibit plant growth. In addition, the growth and development of flowers and fruit is less than perfect.

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Air humidity is the relative ratio between air and water vapor in an area. The higher the water vapor content, the higher the air humidity. In chili planting, environmental humidity becomes more important to note because it is related to the development of disturbing microorganisms. The relative humidity needed for the growth of chili plants is around 80% \( \text{10} \). The results of the study illustrated that the application of drip irrigation water in the vegetative phase for the highest plant height parameters on average was at the age of 10 days given about 50% water, at the age of 20 days it was given 60% and at the age of 30 - 40 days it was given 75%, the primordia phase (40 -50 days) providing water that can produce an average maximum number of flowers is giving water 80% of the plant's water needs in the fertilization phase (45, 55 days) providing water that can produce an average maximum number of ovaries is 85%. At 55, the provision of water, which produces an average maximum interest, is 85%. In the chili fruit ripening phase at 70 days, the amount of water that can produce the maximum fruit weight is 85% of the plant's water requirement.

Water use efficiency is the ratio of the average water supply to the average water use for each phase. The efficiency of water use with drip irrigation is at the age of plants 0-10 days = 50%, 10-20 days = 60%, 30-40 days = 75%. The percentage of water supply with the drip irrigation system illustrates that the provision of irrigation water for cayenne pepper plants does not have to be 100% full of the plant's needs, but depends on the plant growth phase (vegetative phase and generative phase) and when the rainy season starts.

**Figure 1.** Installing plastic mulch on the planting medium before setting the paralon drip irrigation pipes.

**Figure 2.** Initial setting of drip irrigation on the raised
The results of the study illustrate that the actual amount of irrigation water needed in the application of drip irrigation systems in chili farming during vegetative growth to generative growth is 57,600 litres for an area of 1,000M² at the cost of IDR 440,000 (diesel fuel). This amount was obtained from the suction from the Bore Well, which was then accommodated in a 3,300-liters volume tank as a reservoir. After six months, drip irrigation was not operated because the rainy season has arrived. At the same time, the volume of water for manual irrigation (surface flow), namely by channeling water from bore wells to the on-farming area through simple irrigation canals, is 150,000 liters per 1,000 M² for IDR 900, 000 (for 9 hours of irrigation for IDR 50,000 per hour). This proves that innovative drip irrigation systems could save water use and casual labor costs.

![Figure 3. Cayenne pepper plants with drip irrigation aged 2 weeks and three weeks](image)

![Figure 4. Performance of cayenne chilli plants with drip irrigation during generative growth](image)

<table>
<thead>
<tr>
<th>No</th>
<th>Observation items</th>
<th>Surface irrigation</th>
<th>Drip irrigation Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land Area</td>
<td>1,000M² (Control)</td>
<td>1,000M²</td>
</tr>
<tr>
<td>2</td>
<td>Water irrigation need</td>
<td>150,000 Liter/ 6 months</td>
<td>57,600 Liter/6 months</td>
</tr>
<tr>
<td>3</td>
<td>Total irrigation costs</td>
<td>IDR 900,000, -</td>
<td>IDR 440,000, -</td>
</tr>
<tr>
<td>4</td>
<td>Variable costs</td>
<td>IDR 650,000, -</td>
<td>IDR 650,000, -</td>
</tr>
<tr>
<td>5</td>
<td>Total Cost (4 +5)</td>
<td>IDR 1,550,000</td>
<td>IDR 1,090,000</td>
</tr>
<tr>
<td>6</td>
<td>Total Revenue</td>
<td>IDR 6,730,000, -</td>
<td>IDR 9,050,000, -</td>
</tr>
<tr>
<td>7</td>
<td>Profits</td>
<td>IDR 5,180,000, -</td>
<td>IDR 7,960,000, -</td>
</tr>
<tr>
<td>8</td>
<td>Casual labor</td>
<td>5 Persons</td>
<td>1 Person</td>
</tr>
</tbody>
</table>

R/C 4.34 8.30

Profit margin (%) = (Profit / Total Profit) x 100%

The study shows that the actual amount of irrigation water needed in the application of drip irrigation systems in chili farming during vegetative growth to generative growth is 57,600 litres for an area of 1,000M² at the cost of IDR 440,000 (diesel fuel). This amount was obtained from the suction from the Bore Well, which was then accommodated in a 3,300-liters volume tank as a reservoir. After six months, drip irrigation was not operated because the rainy season has arrived. At the same time, the volume of water for manual irrigation (surface flow), namely by channeling water from bore wells to the on-farming area through simple irrigation canals, is 150,000 liters per 1,000 M² for IDR 900, 000 (for 9 hours of irrigation for IDR 50,000 per hour). This proves that innovative drip irrigation systems could save water use and casual labor costs.
The main advantage and benefit of innovative drip irrigation on dry land is that farmers can grow vegetables outside the season and are not dependent on the rainy season. Chili harvest was carried out 11 times, and revenue was calculated for each harvest. Harvesting is done every week. Chili sales are done by weighing—total revenue of IDR 9,050,000. - was obtained from selling 526 kilograms of cayenne pepper. The average income per harvest was IDR 456,000.00, and the total profit was IDR 7,960,000. during one growing season for about 11 months. It was greater than the profits of surface irrigation (IDR 5,180,000). Chili farming without drip irrigation with an area of 1,000M² produces 168 kg of fresh chilis with an average yield of 3.75 kilograms per plant. The average selling price of chilis was IDR 30,000. Per kilogram (the price rank IDR 20,000) to IDR 120,000. The farmers usually get pick season and high chilis prices from January to April yearly. Total Revenue earned in one growing season was IDR 6,730,000, and the profit was IDR 5,180,000. The greater profits of chili farming by drip irrigation technology indicated that the innovative drip irrigation technology is more profitable than the surface irrigation system.

4. CONCLUSION

Developing innovative drip irrigation technology for fresh vegetable-based horticulture, such as cayenne pepper and seasonal dry fruits, proves efficient and water-saving. This technology reduces production costs, increasing total revenue and profits for farmers. The implementation of innovative drip irrigation in horticultural farming of seasonal vegetables and fruits demonstrates significant potential for enhancing household food security by boosting production and lowering farming costs, particularly those associated with irrigation and casual labor. This technology is especially beneficial for large-scale economic commodity farming, enabling farmers to grow fresh vegetables outside the traditional rainy season. Drip irrigation technology significantly reduces water usage, costs, and casual labor. For example, chili cultivation using drip irrigation requires approximately 57,600 liters of water over six months per 1,000 square meters, costing IDR 440,000 for diesel fuel. In contrast, the manual surface flow method consumes 150,000 liters per 1,000 square meters, costing IDR 900,000. This demonstrates that drip irrigation is financially viable and more profitable than surface irrigation, as evidenced by the lower production costs and higher farming income and profits. Calculations indicate that chili farming with drip irrigation yields a financial turnover of IDR 9,050,000 per 1,000 square meters, compared to IDR 6,730,000 per 1,000 square meters with surface irrigation.

To enhance dryland productivity, the development of innovative drip irrigation in seasonal vegetable and fruit farming should involve four key stakeholders: (1) Universities, as carriers of agricultural cultivation technology; (2) Government, as policymakers, facility providers, and supporters of agricultural facilities for farmers; (3) Agricultural Extension services, as transmitters of agricultural technology information; and (4) Entrepreneurs, as collectors and sellers of fresh vegetable and fruit commodities. Implementing innovative drip irrigation is crucial for accelerating the economic recovery of farmers post the 2018 earthquake and the COVID-19 pandemic. Feasibility analysis indicates that adopting a drip irrigation system is technically viable, financially feasible, and economically profitable, making it a promising alternative to enhance the productivity of dryland farming.

REFERENCES


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