Engineering and Technology Journal e-ISSN: 2456-3358
Volume 11 Issue 06 June-2026, Page No.- 10748-10754
DOI: 10.47191/etj/v11i06.49, I.F. – 8.595

Performance of Piping Hose Use in Drip Irrigation for Golden Melon Plants in Gumantar Village, North Lombok Regency, Indonesia

Muh Bagus Budianto[1], IDG Jaya Negara[2], Meta Gautami Putri[3]
[1,2,3]Civil Engineering Department, Faculty Of Engineering, University Of Mataram, Majapahit Street No. 62 Mataram, West Nusa Tenggara Province, Indonesia

ABSTRACT: Gumantar Village is a village in North Lombok Regency that has a fairly extensive dry land area of 2.996 ha. Most dry land utilization relies solely on rainwater, resulting in low productivity. One effort that can increase productivity is the development of horticultural crops with drip irrigation. This study aims to analyze water requirements, distribution uniformity, and irrigation scheduling in a drip irrigation system with piping hoses for golden melon cultivation. The results show that plant water requirements vary at each growth phase. In the initial phase (July–August), water requirements are relatively low at 649 liters/day (0.19 liters/sec/ha). In the vegetative phase (August–September), water requirements increase to 1,880 liters/day (0.54 liters/sec/ha). The highest demand occurred during the fruit enlargement phase (September–October) at 2,514 liters/day (0.73 liters/sec/ha), then decreased slightly to 2,017 liters/day (0.58 liters/sec/ha) during the fruit ripening phase (October). The uniformity coefficient (CU) value ranged from 91.59% to 97.23%, which according to ASAE standards is classified as very good. Irrigation scheduling was adjusted to the number of laterals and the daily water needs of the plants, with operational times of 55.62 minutes/day in the early phase, 161.19 minutes/day in the vegetative phase, 215.51 minutes/day in the middle phase, and decreasing to 172.87 minutes/day in the ripening phase. Overall, the piping hose type drip irrigation system proved effective and efficient in meeting the water needs of golden melon plants in dry land conditions.

KEYWORD: Growth Phase, Water Requirement, Uniformity Coefficient, Irrigation Scheduling.

INTRODUCTION

North Lombok Regency contributes the largest proportion of dryland to total agricultural land, reaching 47,653 hectares, or approximately 75.7% (Jayaputra et al., 2021). Gumantar Village, located in Kayangan District, has hilly topography with 2,966 hectares of potential dryland, making it the largest source of dryland in Kayangan District (Sumiadi et al., 2021). Dryland typically relies solely on rainwater or limited irrigation systems for soil moisture (Balitbang Pertanian, 2015). Dry land is an expanse of land that is not flooded for a long period of time, such as one year. (Dewi, 2022).

Irrigation is the process of extracting water from a water source to meet the water needs of plants (PP Irigasi No. 20, 2006). Irrigation includes facilities and infrastructure for distributing water and removing excess water (Renaldi, 2021). One irrigation method is drip irrigation, which directly irrigates plant roots (Kurniasih, 2022). According (Udiana, 2014) drip irrigation is a method of delivering air directly to the root zone of plants using pipes. Drip irrigation, which delivers water in small, slow volumes, is intended to prevent percolation and runoff (Adhiguna, 2018).

Limited water availability, particularly due to the village's location in the highlands, is a major obstacle to horticultural crop development. One solution that can be implemented is drip irrigation based on a groundwater pump with a piping system. This system efficiently delivers water directly to plant roots, reduces losses due to evaporation and runoff, and maintains water availability according to plant needs.

RESEARCH METHOD

Data Collection

The data used in this study was collected through direct observation or field testing, as well as from relevant agencies. The data required for this study includes the following:

1. Climatology Data
2. Plant Data
3. Water Volume Data

Data Analysis

1. Water Requirements Analysis

Irrigation water requirements analysis can be calculated using (KP Irrigation, 2006):

- Water Requirements Analysis
- Hydrological Analysis. This analysis determines:
  - a. Average rainfall
  - b. Effective rainfall
- Potential evapotranspiration (ETo)
- Crop coefficient (Kc) for golden melon
- Consumptive use (ETc) for golden melon plants
- Irrigation water requirements

2. Drip Uniformity Analysis

This analysis calculates drip irrigation uniformity based on the uniformity coefficient (Cu) calculated by Christiansen formula (Saidah, 2016).

3. Irrigation Water Delivery Pattern Analysis

Planning the irrigation water delivery pattern is based on the following results:

- Water Requirements
- Emitter drip rate
- Water distribution operating time
- Irrigation discharge

Drip Irrigation Network Scheme

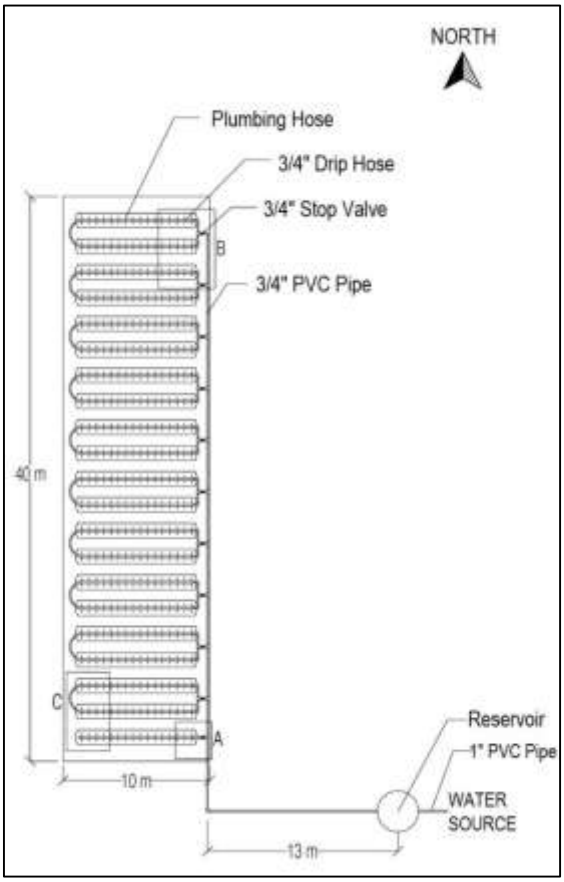

Figure 1. Drip irrigation system network diagram

RESULT AND DISCUSSION

Water Availability

The water source comes from a drilled well constructed by the government as part of the groundwater irrigation network program. The well's technical data is as follows:

Well Name : SPB 200
Fiscal Year : 1995-1996
: Amor Amar Hamlet, Gumantar Village, Kayangan District
Rig Type : Tone 750
Depth : 120 m

The water from the well is pumped into a reservoir with a capacity of 1.100 liters to irrigate 4 ares of land. Water availability is the volume of water per unit of time. In this study, the time used was 75 minutes for the entire area used. The irrigation process was carried out in rotation, divided into 5 blocks, so that each block received water for 15 minutes. This research was conducted on a 10 m x 40 m dry plot of land, using a deep groundwater well as a water source. Water from the well was channeled into a drip irrigation pipe network using a pump, which was then collected in an 1,100-liter water tank 5 meters above ground level. The pipes used to transport water from the water tank to the plants were 1-inch PVC main pipe, 3/4-inch PVC sub-main pipe, and 3/4-inch drip hose as the lateral pipes. There were 11 sub-main pipes, while the lateral pipes were divided into 21 sections, each channeling water to 21 1 m x 8 m soil beds. Each bed was planted with 32 golden melon plants and irrigated using 672 emitters, consisting of piping hoses.

Field tests yielded a water source discharge of 14,67 liters/minute.

Irrigation Water Requirements

Irrigation water requirements are defined as the volume of water required to support plant growth during the growing season, taking into account the contribution of effective rainfall adjusted for the efficiency of the irrigation system used. Generally, water requirements analysis for drip irrigation systems is used to determine the water requirements of plants. In this study, golden melon plants were used. Irrigation water requirements are calculated through hydrological analysis, evapotranspiration analysis, and plant water requirements analysis.

Effective Rainfall

Effective rainfall is the rainfall that falls in an area and can be absorbed by plants to support their growth and to cover water losses resulting from plant evapotranspiration, percolation, and other factors. The amount of rainfall that can be utilized by plants depends on the type of plant. The results of the monthly rainfall analysis with a 50% probability and effective rainfall are shown in Figure 2.

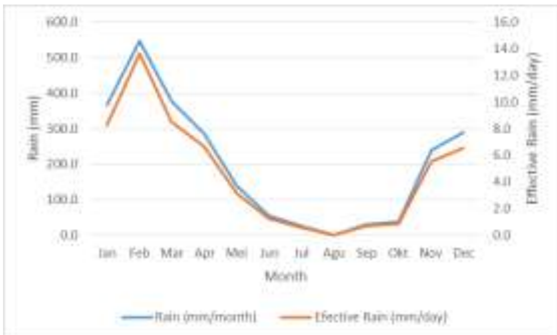

Figure 2. Effective Rain

Effective rainfall (Reff) for golden melon plants is calculated by multiplying the 50% Reff value (R50) by 70% and then divided by the length of the observation period. Rainfall data at a 50% probability shows that the period from January to April has a high rainfall intensity, the values are respectively 366.20 mm/month (8,269 mm/day), 546.11 mm/month (13,653 mm/day), 376.75 mm/month (8,507 mm/day), and 284.85 mm/month (6,647 mm/day). From June to August, rainfall decreases sharply to 54.70 mm/month (1,276 mm/day), 26.40 mm/month (0.596 mm/day), and 1.95

mm/month (0.044 mm/day) which indicates the dry period. Then it increased again from September to December with a value of 30.12 mm/month (0.703 mm/day), 38.95 mm/month (0.880 mm/day), 238.55 mm/month (5,566 mm/day), and 289.25 mm/month (6,531 mm/day). This data shows that during the rainy season most of the water needs can be met from rainfall, while in the dry season additional water supplies are needed either in the form of irrigation or the use of groundwater reserves to maintain water availability according to plant water needs.

Evapotranspiration

Evapotranspiration analysis was calculated using the FAO Modified Penman Method, which considers variables such as air temperature, duration of sunshine, relative humidity, and wind speed. The climatological data used was from the Sopak Climatological Station with an observation period of 10 years, from 2015 to 2024. The results of the evapotranspiration analysis are presented in Figure 3.

Figure 3. Evapotranspiration

Based on Figure 3, it can be seen that the results of evapotranspiration analysis for one year show clear variations between wet and dry periods, with an annual total of 2017.80 mm, a monthly average of 168.15 mm. These values were obtained from calculations using climatological data that had been corrected to match field conditions. At the beginning of the year, the ETo value was quite high, namely in January at 184.70 mm/month, slightly decreasing in February to 169.50 mm/month, and remaining relatively high in March at 167.60 mm/month. Entering April, the value dropped to 142.02 mm/month and in May to 141.57 mm/month, indicating a decline in the rate of evapotranspiration, with the lowest value occurring in June at 129.67 mm/month. After this low period, ETo began to increase in July to 135.84 mm/month and rose sharply again in August to 166.62 mm/month. Evapotranspiration peaked in September at 199.15 mm/month and reached its highest value in October at 221.37 mm/month, reflecting dry conditions with maximum evaporation. Furthermore, the ETo value decreased slightly but remained high in November at 186.89 mm/month and in December at 183.21 mm/month, indicating the beginning of the transition to the rainy season. Overall, these calculations indicate that the dry season, particularly from August to October, is the period with the highest water demand, while June is the month with the lowest water demand, thus requiring more optimal water management.

Crop Coefficient

The age and type of plant influence the crop coefficient value. The crop coefficient (Kc) is used to determine the amount of air consumed by the plant during its growth period. The Kc value for melon plants in this study was 0.45 in the early phase, then increased to 0.75 in the development phase and 1.00 in the middle phase, then decreased to 0.75 in the late phase (Allen, 1998).

Consumptive Use

he value of crop evapotranspiration (ETc) to determine the consumptive use of water in crops is calculated according to Doorenbos and Pruitt (Achmad, 2011). The study, the consumptive water requirements for golden melon crops planted from July to September are as follows:

Table 1. Analysis of crop evapotranspiration (ETc) for golden melon crops

Month	Plant growth phase	Average Kc	Eto mm/day	Etc mm/day
July	Early	0.45	4.38	1.97
August	Development	0.75	5.37	4.03
Agt-Sep	Middle	1.00	5.37	5.37
September	Maturation	0.75	6.64	4.98

Based on the calculations in Table 1, the crop evapotranspiration (ETc) values for the consumptive use of golden melon crops during the growth phase from July to September are shown. In the early phase in July, with a crop coefficient (Kc) of 0.45, the ETc value was 1.97 mm/day, indicating that the crop's water requirements were still low. During the development phase in August, the Kc value increased to 0.75 and the ETc value was 4.03 mm/day, indicating an increase in water requirements in line with plant growth. The middle phase from August to September had the highest Kc value of 1.00 with an ETc value of 5.37 mm/day, due to the plants being at their peak growth. Entering the ripening phase at the end of September, the Kc value dropped back to 0.75 with an ETc value of 4.98 mm/day, which may be due to the plants entering the final stage of fruit ripening.

Irrigation water requirements

Irrigation water requirements refer to the volume of water needed to meet evaporation, water loss, and crop water needs, taking into account the amount of water provided by rainfall and groundwater contributions. In this study, calculations were made on a monthly basis.

Table 2. Irrigation water requirements for golden melon crops

Month	Plant growth phase	NFR lt/sec/ha	IR lt/sec/ha	Q m3/day
July	Early	0.16	0.19	0.65
August	Development	0.46	0.54	1.88
Agt-Sep	Middle	0.62	0.73	2.51
September	Maturation	0.50	0.58	2.02

Table 2 above shows that the irrigation water requirements for golden melon plants vary according to the plant growth phase from July to September. In the early phase in July with a crop coefficient (Kc) of 0.45, the irrigation water requirement was the lowest at 649 liters/day (0.188 liters/dt/ha), due to the crop evapotranspiration (ETc) requirement of only 1.97 mm/day. Entering the development phase in August with a Kc value of 0.75, irrigation water requirements increase to 1880 liters/day (0.544 liters/dt/ha) along with an increase in ETc to 4.03 mm/day. In the mid-phase from August to September, irrigation water requirements peaked with a Kc value of 1.00 and ETc of 5.37 mm/day, requiring 2514 liters/day (0.727 liters/dt/ha) of irrigation water, indicating the period with the highest water requirements during the planting period. Furthermore, in the ripening phase at the end of September, the Kc value decreased again to 0.75 with an ETc of 4.98 mm/day, so that the irrigation water requirement for plants decreased to 2017 liters/day (0.584 liters/dt/ha). This was because watering needed to be reduced to improve fruit quality and sugar content. Overall, this pattern shows that the highest water requirement for melons occurs during the middle phase, namely the fruit formation phase, while the lowest water requirement is during the early growth phase. Therefore, irrigation water management needs to be adjusted to optimize water use efficiency.

Uniformity of Droplets

This analysis aims to evaluate the uniformity of water distribution in a pipe-based irrigation system with 21 laterals. The testing focused on the performance of the lateral pipe system when operated alternately through 2 to 3 variations in the number of stop valves located in the irrigation block. These variations are intended to obtain an overview of the level of water distribution uniformity in each lateral and to determine the most efficient and uniform opening pattern. Operating all 21 laterals simultaneously was not used as a test method because in this condition, one of the laterals, specifically the one located furthest from the reservoir in Block 1, only released a small amount of water, and some emitters did not distribute water at all. This indicates a decrease in pressure and an imbalance in distribution due to the excessive opening of laterals at the same time.

The test was conducted by measuring the volume of water coming out of the emitter. The volume of droplets was measured for 3 minutes on each emitter used as a sample. After obtaining the average volume of droplets from the uniformity test results, the next step was to analyze the level of uniformity of droplets in the drip irrigation system. The average volume was calculated by dividing the total volume of droplets by the number of emitters observed. Next, the value $(y_i-\bar{y})^2$ was determined, which is the difference between the drip volume of each emitter and the average volume, which was then squared and summed to calculate the standard deviation value. After the standard deviation was obtained, the drip uniformity level was determined by calculating the uniformity coefficient (CU) using the Christiansen (1942) method.

Tabel 3 Unifomity test

Block	Average	D	CU (%)	Uniformity Category
1	110.08	9.26	91.59	Very Good
2	138.25	8.8	93.64	Very Good
3	168.92	7.12	95.78	Very Good
4	195.75	5.62	97.13	Very Good
5	158.44	4.38	97.23	Very Good

Based on these calculations, the drip irrigation system using piping hoses showed variations in water distribution among the emitters. From the volume of droplets produced, the uniformity of droplets in the lateral pipes in Block 1 reached 91.59%, Block 2 93.64%, Block 3 95.78%, Block 4 97.13%, and Block 5 97.23%. Based on the ASAE criteria for drip irrigation system uniformity, each lateral pipe in the tested blocks had a drop uniformity coefficient (CU) value above 90%, which is classified as excellent. Thus, all tested blocks showed a very high level of uniformity in discharge distribution. These results indicate that the drip irrigation system used is capable of distributing water uniformly to each emitter, thereby ensuring that the water requirements of the plants are met evenly.

Irrigation Water Distribution Pattern

Based on the predetermined water supply network scheme, water availability, and plant water requirements that have been analyzed, the next step is to calculate the emitter drip rate (EDR), operational time, and irrigation discharge used to determine the irrigation water supply pattern and schedule.

Table 4. EDR, Operational Time and Irrigation Discharge

Month	Plant growth phase	EDR (mm/hour)	Operating time (minutes/day)	Irrigation discharge (lt/minute)
July	Early	1.75	55.62	11.67
August	Development	1.75	161.19	11.67

Agt-Sep	Middle	1.75	215.51	11.67
September	Maturation	1.75	172.87	11.67

Emitter drop rate (EDR) refers to the volume of water discharged by each emitter in a drip irrigation system within a certain period of time. The analysis results show that the emitter drop rate (EDR) for golden melon plants is 1.75 mm/hour. The operational time of drip irrigation shows significant variations in each phase of plant growth. In the early phase in July, the operating time was 55.62 minutes/day, then increased sharply in the development phase in August to 161.19 minutes/day. In the middle phase from August to September, the longest operating time was 215.51 minutes/day, before finally decreasing to 172.87 minutes/day. Although water requirements and operating time varied in each phase, the irrigation discharge used in this system was set at a constant 11.67 liters/minute, so that water distribution remained even and uniformity of water supply could be maintained throughout the irrigation block.

Watering Patterns

The water distribution pattern in the hose piping drip irrigation system is determined based on the number of stopcocks per block and the daily water requirements of golden melon plants. Irrigation is carried out in turns, with each irrigation block operated by opening two stopcocks, where each stopcock irrigates two beds, so that one block can irrigate four to five beds. Of the total five irrigation blocks, four blocks irrigate four beds each, while the fifth block uses three stopcocks to cover five beds. Irrigation is carried out alternately, starting from Block 1, which is furthest from the water source, then continuing to Block 2 to Block 5 by only opening the stopcocks in the irrigation block being reviewed, while the stopcocks in other irrigation blocks are closed. This pattern is designed to adjust water distribution to the available reservoir capacity, so that irrigation can be more efficient and even.

Table 5. Pattern of operating time allocation

Month	Plant growth phase	Water requirement (lt/day)	Reservoir Filling	Operational Duration (minute)	
				Block 1-4	Block 5
July	Early	649	1	7	10
August	Development	1880	2	25	40
Agt-Sept	Middle	2514	3	35	55
Sept.	Maturation	2017	2	30	45

In the initial phase in July, it can be filled with one cycle of filling a 1100-liter reservoir, so that all beds can be irrigated, with an operational time of 7 minutes per session for Blocks 1-4 and 10 minutes per session for Block 5. Irrigation in this phase is still minimal to avoid excessive moisture in the soil, which can cause root rot in plants that do not yet have perfect root systems. Furthermore, in the development phase in August, two water tank filling cycles are needed to irrigate all beds, with the operational time increasing to 25 minutes per session for Blocks 1-4 and 40 minutes per session for Block 5. This is because the plants are entering an intensive vegetative growth stage and therefore require more water. In the mid-phase from August to September, three reservoir filling cycles are required to irrigate all beds, with an operational time of 45 minutes per session for Blocks 1–4 and 55 minutes per session for Block 5. This is the longest time during the crop period, as the plants require a larger volume of water to support their water needs in the process of fruit formation and enlargement. Finally, in the ripening phase in September, two reservoir filling cycles are required to meet the water needs of all beds, with an operational time for Blocks 1–4 of 30 minutes per session and for Block 5 of 45 minutes per session. Thus, it can be concluded that as the water requirements increase in each growth phase of golden melon, the number of reservoir filling cycles and the operational duration of drip irrigation also increase. However, irrigation in the field can be adjusted if it rains and the soil is still considered moist to meet the plants' needs optimally.

Water Supply Schedule

The irrigation schedule is prepared based on the calculation of crop water requirements at each growth stage, taking into account reservoir capacity, system discharge, and irrigation block distribution adjusted to facilitate implementation in the field. The operational time is calculated by referring to the proportion of water requirements to irrigation discharge, resulting in an efficient and measurable watering duration. Details of the irrigation schedule for each growth phase of golden melon are presented in the following table..

Table 6. Duration and schedule of irrigation water supply

Plant growth phase	Water requirement (lt/day)	Block	Duration (munite)	Schedule
Early	649	Reservoir Filling		05:30 - 05.37
		1	7	06:00 - 06:07

Plant growth phase	**Water requirement (lt/day)**	**Block**	**Duration (munite)**	**Schedule**
		2	7	06:07 - 06:14
		3	7	06:14 - 06:21
		4	7	06:21 - 06:28
		5	10	06:28 - 06:38
Development	1880	Reservoir Filling		05:30 - 05:37
		1	25	06:00 - 06:25
		2	25	06:25 - 06:50
		Reservoir Filling		16:30 - 16:37
		3	25	17:00 - 17:25
		4	25	17:25 - 17:50
		5	40	17:50 - 18:30
Middle	2514	Reservoir Filling		05:30 - 05:37
		1	35	06:00 - 06:35
		2	35	06:35 - 07:10
		Reservoir Filling		07:30 - 07:37
		3	35	08:00 - 08:35
		Reservoir Filling		16:30 - 16:37
		4	35	17:00 - 17:35
		5	55	17:35 - 18:30
Maturation	2017	Reservoir Filling		05:30 - 05:37
		1	30	06:00 - 06:30
		2	30	06:30 - 07:00
		Reservoir Filling		16:30 - 16:37
		3	30	17:00 - 17:30
		4	30	17:30 - 18:00
		5	45	18:00 - 18:45

Plant Development and Growth

Plant growth and development are important indicators for assessing the success of cultivation. Each phase of plant growth has its own characteristics that can be observed visually, from the early stages to the ripening phase. Planting began on July 17 and continued until harvest on September 19. For more details, the results of plant growth observations at each phase are presented in the following figure.

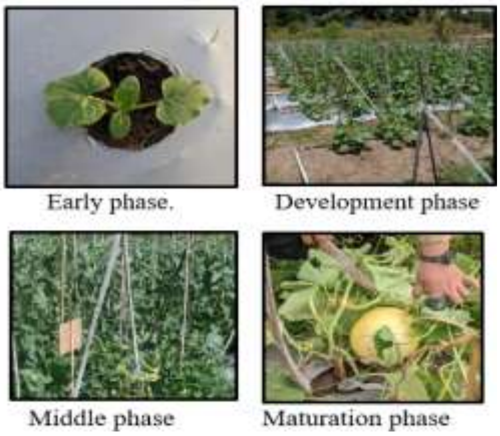

Figure 4. Observation of the development and growth of golden melon plants

CONCLUSIONS

Based on the results of the analysis and discussion that has been carried out, the following conclusions can be drawn:

1. The water requirement of golden melon plants increases from 0.188 liters/second/ha in the early phase to 0.544 liters/second/ha in the development phase, and reaches a peak of 0.727 liters/second/ha in the middle phase, then decreases to 0.584 liters/second/ha in the ripening phase to maintain the quality and sugar content of the fruit.
2. The droplet uniformity coefficient (CU) values in Blocks 1 – 5 were 91.59%, 93.64%, 95.78%, 97.13%, and 97.23%, respectively. Based on the ASAE criteria, all CU values >90% are in the very good category, indicating even water distribution at each emitter.
3. The water supply pattern in the drip irrigation system is adjusted to the water needs of each growth phase. In the initial phase (649 liters/day) one cycle is carried out for 7 minutes for Blocks 1-4 and 10 minutes for Block 5, the development phase (1880 liters/day) two cycles of 25 minutes and 40 minutes, the middle phase (2514 liters/day) three cycles of 35 minutes and 55 minutes, while the maturation phase (2017 liters/day) two cycles of 30 minutes and 45 minutes. In general, the higher the water needs, the longer the duration and number of

watering cycles, but still adjusted to rainfall conditions and soil moisture. This drip irrigation system has proven to be efficient and suitable for dry land conditions in Gumantar Village because it is able to maintain soil moisture evenly with economical and measured water use.

REFERENCES

1. Achmad, M. (2011). Hidrologi Teknik. Universitas Hasanuddin.
2. Adhiguna, R. T., & Rejo, A. (2018). Teknologi Irigasi Tetes Dalam Mengoptimalkan Efisiensi Penggunaan Air Di Lahan Pertanian. Prosiding Seminar Nasional Hari Air Dunia 2018, Palembang, 20 Maret 2018, 107. e-ISSN: 2621-7449.
3. Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements (FAO Irrigation and Drainage Paper No. 56). Rome: FAO.
4. Balitbang Pertanian. 2015. Sumberdaya Lahan Pertanian Indonesia. Luas Penyebaran, dan Potensi Ketersediaan. IAARD Press. 100 Hlm.
5. Dewi, Diana Puspita. 2022. Pengaruh Pemberian Air Irigasi Tetes Sistem Bertingkat terhadap Perubahan Lengas Tanah. Tugas Akhir. Jurusan Teknik Sipil, Fakultas Teknik, Universitas Mataram.
6. Jayaputra, J., Nurrachman, N., & Santoso, B. B. (2021). Peningkatan Pendapatan Petani Melalui Diversifikasi dan Intensifikasi Tanaman Hortikultura di Lahan Kering Desa Gumantar Kabupaten Lombok Utara. Jurnal Gema Ngabdi, 3(1), 29-39.
7. Kurniasih, Q. E. (2022). Uji Unjuk Kerja Sistem Irigasi Tetes pada Tanaman Melon (Cucumis melo L.). Politeknik Enjiniring Pertanian Indonesia.
8. Peraturan Pemerintah Republik Indonesia Nomor 20 Tahun 2006 Tentang Irigasi. Kementerian Sekretaris Negara Republik Indonesia
9. Renaldi, R. (2021). Study Prencanaan Jaringan Irigasi Tetes Untuk Tanaman Cabai di Tanah Kering. Institut Teknologi Padang.
10. Saidah, H., & Wirahman, L. (2016). Optimasi Parameter Desain Irigasi Tetes Sederhana Type Dripline Optimizing Of Simple Dripline Pipe Design Parameter. Spektrum Sipil, 3(1), 92–98.
11. Sumiadi, dkk. (2021). Teknik Pengairan Kenalkan Irigasi Tetes untuk Pertanian Lahan Kering di Lombok Utara. Fakultas Teknik, Universitas Brawijaya.
12. Udiana, I. M., Bunganaen, W., & Padja, R. A. P. (2014). Perencanaan Sistem Irigasi Tetes (Drip Irrigation) di Desa Besmarak Kabupaten Kupang. Jurnal Teknik Sipil, 3(1), 63-74.