Performance analysis of drip and sprinkler irrigation on pineapple cultivation

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Abstract. Irrigation is one of important process in pineapple planting, it caused pineapple needs one in its cultivation which means it will face two kind of season (dry and rainy season) in Indonesia. So that, irrigation process is a routine which is done by PT. Great Giant Food (GGF), East Lampung to keep their pineapple’s growth in optimum condition. PT. GGF choose two types of irrigation system, there are sprinkler and drip irrigation, but they do not have enough research to know the efficiency of their irrigation systems. Because of that reason, this research is aimed to know the efficiency of irrigation system in pineapple cultivation of PT. GGF. Researchers used random sampling to collect the data, then they counted the value of CU and DU of irrigation system. This research showed that the value of CU and SU are 73.03% and 52.84% respectively. That number of CU and SU showed that drip irrigation of pineapple cultivation in PT. GGF is good enough, but the drip irrigation is needed to be developed because the number of SU is really high which indicated that the emitter debit of drip irrigation has a low homogeneity.

1. Introduction
Pineapple is one of most consumed fruit in this world, it is third most consumed fruit in this world after bananas and oranges [1]. Its sweetness and flavourists taste become the most reason why people choose pineapple [2]. Pineapple could be consumed as a fresh fruit or after processed as juice or cocktail to make it become tastier [3].

In Indonesia, pineapple production is growing rapidly start from 2010 – 2014 (14.02% per year in average) which 33.64% of pineapple production in Indonesia is produced from PT. Great Giant Food (GGF) [4]. Good management of pineapple cultivation is the key of PT. GGF to produce a good pineapple [5].

Irrigation become one of the most important treatment in pineapple cultivation [5], even though its needs of water could be fulfilled by rainfall water because pineapple could be cultivated in dry land or field [6]. Irrigation become important because it would keep pineapple in its optimum condition to grow when it faced lack of water in dry season [7].

Irrigation system which is used by PT. GGF is Sprinkler Irrigation and Drip Irrigation, but PT. GGF has lack of research about the efficiency of that irrigation systems. So that, this research is aimed to find the efficiency of it.
2. Materials And methods
This research is done on June 25 until July 25 2018 at Plantation Group IV (PG IV), Labuhan Ratu, PT. Great Giant Foods (GGF), East Lampung which has red podzolic with sandy clay soil. The analysis is done by technical analysis for each type of irrigation systems (sprinkler and drip irrigation).

2.1. Sprinkler irrigation
Some tools which is used to collect the data are:
1. Gun sprayer (irrigation tools) as the representative of sprinkler irrigation system
2. Plastic glass (d=10 cm) to collect the water
3. 1.25 m of PVC pipe which is used to support the plastic glass
4. Measuring glass to measure the volume of collected water
5. Measuring tape to measure the distance of each glass
6. Saw to cut the PVC pipe
Field observation is done first to choose the right location based on field condition, after that researcher determined the large of field block which would be observed is 3,122 m², then random sampling is done to choose 25 spots (with 1.5 m distance of each spot) as sample which represents the condition of the field block. Collected data is the volume of water which is contained by each glass when Gun Sprayer sprays the water in pineapple plantation (length of irrigation is 200m and the speed of roll pipe is 30m/hour).

The parameters which is used in this research to do the technical analysis are:
1. Coefficient of Uniformity
2. Distribution of Uniformity
3. Actual capacity
4. Efficiency
5. Water thickness
The formula which is used to count that parameters is:[2]

\[ CU = \left(1 - \frac{\sum |z-m|}{\sum z}\right) \times 100\% \]
\[ DU = \left(\frac{\text{AvgLowQuart}}{\text{Avg}}\right) \times 100\% \]
\[ KA = \left(\frac{LK \times KG}{10000}\right) \]
\[ Ed = (1-y/d) \times 100\% \]
\[ d = \left(\frac{V}{A}\right) \]

Where :
CU = Coefficient of Uniformity (%)
z = water volume (ml)
m = mean of water volume (ml)
DU = Distribution of Uniformity (%)
AvgLowQuart = mean of meddle quartile (ml/mm)
Avg = Average (ml/mm)
KA = actual capacity (Ha/jam)
LK = Actual working width (m)
KG = PE pipe roll velocity (m/jam)
Ed = Efficiency (%)
y = average of deviation (mm)
d = water depth Average.

2.2. Drip irrigation
The list of authors The tools which is used to collect the data are:
1. Drip irrigation machine
2. Plastic glass (d=10 cm) to collect the water
3. Measuring glass to measure the volume of collected water

Similar with data collection in sprinkler irrigation, field observation should be done first, then decided the large of field block (1,475 m²), after that researcher did random sampling to choose 25 spots of dripped water from emitter for each lateral pipe. The length of lateral pipe is 50 m and the dripped water from emitter should be came from same water pipe. Collected data is the water volume which is contained by glass after five minutes.

The formula that used to count is: [8]

\[ Ed = 100(1-y/d) \]
\[ EDR = q/(s \times l) \]
\[ SU = (1-CV) \times 100\% \]
\[ CU = 100 \left\{ 1 - \frac{\sum (x_i - x)}{\sum x} \right\} \]

With:
- Ed = efficiency (%)
- y = deviation of water depth (cm)
- d = mean of water depth (cm)
- EDR = Debit (mm/jam)
- s = distance of emitter (m)
- q = debit emitter (m³/jam)

3. Result and Discussion

In here have two result for drip irrigation and sprinkler irrigation. Table 1 and table 3 shows the water distribution of drip and sprinkler irrigation. While table 2 and table 4 shows how the data analysis. Analysis doing to know how performance and efficiency of drip and sprinkler irrigation.

3.1. Springkler irrigation

Table 1 shows that the water distribution is yet equally distributed to each pineapple area. It could be happened because each pineapple plant has a huge canopy which make the pineapple plantation is too rapid to distribute the water.

| Number | Volume (ml) | Number | Volume (ml) |
|--------|-------------|--------|-------------|
| 1      | 35          | 14     | 90          |
| 2      | 50          | 15     | 100         |
| 3      | 50          | 16     | 100         |
| 4      | 50          | 17     | 100         |
| 5      | 50          | 18     | 100         |
| 6      | 70          | 19     | 100         |
| 7      | 75          | 20     | 100         |
| 8      | 75          | 21     | 100         |
| 9      | 75          | 22     | 165         |
| 10     | 80          | 23     | 165         |
| 11     | 85          | 24     | 165         |
| 12     | 85          | 25     | 200         |
| 13     | 90          |        |             |
Table 2 Result of data analysis

| No | Volume (ml) | No | Volume (ml) | $|z-m|$ | $|z-m|$ |
|----|-------------|----|-------------|--------|--------|
| 1  | 35          | 14 | 90          | 59.3   | 9.3    |
| 2  | 50          | 15 | 100         | 44.3   | 4.3    |
| 3  | 50          | 16 | 100         | 44.3   | 4.3    |
| 4  | 50          | 17 | 100         | 44.3   | 5.7    |
| 5  | 50          | 18 | 100         | 44.3   | 5.7    |
| 6  | 70          | 19 | 100         | 21.8   | 5.7    |
| 7  | 75          | 20 | 100         | 19.3   | 5.7    |
| 8  | 75          | 21 | 100         | 19.3   | 5.7    |
| 9  | 75          | 22 | 165         | 19.3   | 5.7    |
| 10 | 80          | 23 | 165         | 14.3   | 5.7    |
| 11 | 85          | 24 | 165         | 9.3    | 70.7   |
| 12 | 85          | 25 | 200         | 9.3    | 70.7   |
| 13 | 90          |    |             | 4.3    |        |
| Av  | 94.3        |    |             | 70.7   |        |
| Total | 2357.5   |    |             | 105.7  |        |
| Avg Low Quarter | 28.62   |    |             |        |        |

- Coefficient of uniformity (CU)
  \[
  \text{CU} = \left(1 - \frac{\sum |z-m|}{\sum z}\right) \times 100\%
  \]
  \[
  \text{CU} = \left(1 - \frac{744.016}{2357.5}\right) \times 100\%
  \]
  \[
  \text{CU} = 68.44\%
  \]

- Distribution of Uniformity (DU)
  \[
  \text{DU} = \left(\frac{\text{Avg Low Quarter}}{\text{Avg}}\right) \times 100\%
  \]
  \[
  \text{DU} = \left(\frac{49.3}{94.3}\right) \times 100\%
  \]
  \[
  \text{DU} = 54.35\%
  \]

- Actual Capacity (KA)
  \[
  \text{KA} = \left(\frac{L \times K}{10000}\right)
  \]
  \[
  \text{KA} = \left(\frac{35.6 \times 30}{10000}\right)
  \]
  \[
  \text{KA} = 0.108 \text{ ha/ hours}
  \]

- Water thickness (d)
  \[
  d = \left(\frac{V}{A}\right)
  \]
  \[
  d = \left(\frac{2357500}{70650}\right)
  \]
  \[
  d = 33.37 \text{ mm}
  \]

- Efficiency (Ed)
  \[
  \text{Ed} = (1 - \frac{y}{d}) \times 100\%
  \]
  \[
  \text{Ed} = (1 - 14.00/33.37) \times 100\%
  \]
  \[
  \text{Ed} = 58.05\%
  \]

- Water volume needed for once irrigation
  \[
  V = Q \times t
  \]
  \[
  V = 56.4 \text{ m}^3/\text{hours} \times 6.67 \text{ hours}
  \]
  \[
  V = 376,188 \text{ m}^3
  \]

The analysis above shows that the number of CU is 68.44% which means the sprinkle irrigation system of PT. Great Giant Foods (GGF) is good enough, because the range number of CU is 68% - 100% [5]. Besides, the number of DU is 53.35% which is in the lowest quartal of the range number of DU. It could be happened because the water which is given to the pineapple is too much, so that the pineapple got stressed caused too much water. The last is the number of efficiency (58.05%) which shows that the efficiency of the gun sprayer is still good, because the average of big gun sprayer type is 55% - 65% [9].

3.2. Drip irrigation

Table 3 Distribution water volume of drip irrigation

| Number | Water volume (ml) | Number | Water volume (ml) |
|--------|------------------|--------|------------------|
| 1      | 50               | 15     | 150              |

Table 4 Results of data analysis

| Number | Water volume (ml) | Xi-X (ml) | Water high (cm) | H-Hi (Xi-X^2) | Number | Water volume (ml) | Xi-X (ml) | Water high (cm) | H-Hi (Xi-X^2) |
|--------|------------------|----------|----------------|---------------|--------|------------------|----------|----------------|---------------|
| 1      | 50               | 95       | 1.77           | 3.36          | 15     | 150              | 5        | 5.31           | 0.18          |
| 2      | 75               | 70       | 2.65           | 2.48          | 16     | 150              | 5        | 5.31           | 0.18          |
| 3      | 75               | 70       | 2.65           | 2.48          | 17     | 150              | 5        | 5.31           | 0.18          |
| 4      | 100              | 45       | 3.54           | 1.59          | 18     | 165              | 20       | 5.84           | 0.71          |
| 5      | 100              | 45       | 3.54           | 1.59          | 19     | 165              | 20       | 5.84           | 0.71          |
| 6      | 100              | 45       | 3.54           | 1.59          | 20     | 165              | 20       | 5.84           | 0.71          |
| 7      | 100              | 45       | 3.54           | 1.59          | 21     | 175              | 30       | 6.19           | 1.06          |
| 8      | 115              | 30       | 4.07           | 1.06          | 22     | 200              | 55       | 7.08           | 1.95          |
| 9      | 125              | 20       | 4.42           | 0.71          | 23     | 200              | 55       | 7.08           | 1.95          |
| 10     | 140              | 5        | 4.95           | 0.18          | 24     | 225              | 80       | 7.96           | 2.83          |
| 11     | 150              | 5        | 5.31           | 0.18          | 25     | 300              | 155      | 10.62          | 5.48          |
| 12     | 150              | 5        | 5.31           | 0.18          | Average | 145          | 37.6     | 5.13           | 1.33          |
| 13     | 150              | 5        | 5.31           | 0.18          | Total   | 3625          | 977.6    | 34.59          | 6700          |
| 14     | 150              | 5        | 5.31           | 0.18          |         |                |          |                |               |

- Coefficient Uniformity
  
  $CU = 100 \left\{ 1 - \frac{\sum \frac{x_i - \bar{x}}{\bar{x}t}}{\sum x_i^2} \right\}$

  $CU = 100 \left\{ 1 - \frac{977.6}{3625} \right\}$

  $CU = 73.032\%$

- Efficiency (ed)
  
  $Ed = 100 \left( 1 - \frac{y}{d} \right)$

  $Ed = 100 \left( 1 - \frac{1.331}{5,131} \right)$

  $Ed = 74.069\%$

- Statistical Uniformity (SU)

  $SU = (1-CV) \times 100\%$

  $SU = (1-0.3643) \times 100\%$

  $SU = 52.84\%$

- Water needed for once irrigation
  
  $V = Q \times t$

  $V = 5 \text{ m}^3 \times 5 \text{ hours}$

  $V = 25 \text{ m}^3$
CU number of drip irrigation in PT. GGF which is showed by the analysis above is 73.02% which shows that the drip irrigation machine is in quite good condition (based on Table 5.5). Besides, the number of SU is 52.84% which means the value of dripped water from each emitter is not equally. Then, the efficiency number of drip irrigation is 74.069% [10].

Table 5 Standart uniformity [5]

| Parameters   | Coefficient Uniformity (CU) (%) | Statistical Uniformity (SU) (%) |
|--------------|---------------------------------|---------------------------------|
| Very good    | 94-100                          | 95-100                          |
| Good         | 81-87                           | 85-90                           |
| Enough       | 68-75                           | 75-80                           |
| Poor         | 56-62                           | 65-70                           |
| Not feasible | <50                             | <60                             |

Besides analyze the number of CU, DU, SU, and the efficiency of sprinkler and drip irrigation, this research also counted the needs of water for each type of irrigation systems. Sprinkler irrigation system needs 0.1205 m³ of water for each 1m² of pineapple plantation, while drip irrigation needs 0.017 m³ of water for each 1m² of pineapple plantation. Based on that, sprinkler irrigation needs more water than drip irrigation, but drip irrigation is more difficult to be implemented even it need less water (1). The other problem of irrigation system in PT. GGF is the number of waters which is given to the pineapple is based on objective perspective without counting the right amount of pineapple needs of water.

Therefore, PT. GGF needs to pay more attention in its irrigation system, so that it can give water to the pineapple based on its requirement of water. It is very important to make sure the pineapple get the right amount of water, because it gives a huge effect in pineapple growth [3]. Pineapple also could become dwarf or get rotten root when its needs of water is not met properly [11].

4. Conclusion
PT. Great Giant Foods uses two types irrigation system, there are sprinkler and drip irrigation. The result shows that the number of CU, DU, and efficiency of sprinkler irrigaton are 64.44%, 53.35%, and 58.08%, respectively. It also shows that the sprinkler irrigation system is in quite good condition. The result shows that the number of CU, DU, and efficiency of drip irrigaton are 73.032%, 53.84%, 74.069%, respectively. It also shows that the condition of drip irrigation of PT. GGF is needed to be developed, because it is not good enough.

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References
[1] Baruwa O I 2013 Profitability and constraints of pineapple production in Osun State J. Hortic. Res. 6 59–64
[2] Arya C K, Purohit R C, Dashora L K, P K S and M K 2017 Performance Evaluation of Drip Irrigation Systems. International Journal of Current Microbiology and Applied Sciences Int. J. Curr. Microbiol. Appl. Sci. 6 2287–2292
[3] Hossain, Farid, Shaheen Akhtar A M A 2015 Nutritional Value And Medicinal Benefits Of
Pineapple *Int. J. Nutr. Food Sci.* **4** 84–88

[4] Candra, Hendrik, Sugeng T, Kadir M Z and A T 2015 Design and test performance system automatic control on drip irrigation using microcontroller arduino mega *Agric. Engeneering J.* **4** 235–244

[5] A S 2018 Smart Drip Irrigation System *Int. J. Trend Sci. Res. Dev* **2** 1560–1565

[6] Franata, Rendy A A T 2014 Perubahan Kadar Air Tanah Dengan Menggunakan [ Design Of Automatic Drip Irrigation Based On Change Of Soil Water Content Using Arduino Nano Microcontroller] *Agric. Engeneering J.* **4** 19–26

[7] A T, Ewemoje, Lateef, S A and S O A 2008 Performance Evaluation of Drip Irrigation System Using Sweet Corn *J. Appl. Sci. Eng. Technol.* **6** 16–21

[8] S H, M Al-Mhmddy, S E H A-D 2018 Performance Evaluation Of Drip Irrigation System According To The Suggested Standards *Iraqi J. Agric. Sci.* **49** 0111–0011

[9] Oteng-Darko P, Annan-Afful E, Ofori E and S K A 2014 Performance assessment, monitoring and evaluation of a portable sprinkler irrigation system at CSIR-Crops Research Institute *Int. J. Innov. Appl. Stud.* **8** 891–897

[10] PK Jamrey RKM and G N 2018 Performance evaluation of drip irrigation systems *Pharma Innov. J.* **7** 346–348

[11] Zhu, Xingye, Prince Chikangaise, Weidong Shi, Wen-Hua Chen S Y, 2018 Review of intelligent sprinkler irrigation technologies for remote autonomous system *Int J Agric Biol Eng* **11** 23–30