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The Study of Placement Pattern Micro Sprinkler Depends on Hanging Micro Sprinkler Irrigation Against the Value of Irrigation Efficiency

Bambang Aris Sistanto

[#] *Directorat of Agricultural Technical Industrial Management, Agricultural Industrial Technology Faculty, Padjadjaran University*
Jl. Raya Bandung-Sumedang KM 21. Jatinangor 45363, Sumedang Regency. West Java, Indonesia.
E-mail: aris_marhadi2000@yahoo.com

***Abstract*— Micro-sprinkler Irrigation which emitter are laid in hanging position was one's alternative on water given technology to getting high and uniform irrigation efficiencies. Sprinkler irrigation efficiency determined by the value of a Coefficient of Uniformity (CU) and value of Distribution Uniformity (DU). This research purpose is seeking to locate and test placement pattern and the distance spaces between sprinkler to obtain a better value of irrigation efficiency on each type of micro sprinkler. This research was carried out in September-October 2012, which are located in the greenhouse of Faculty of Agriculture, Padjadjaran University. The method of performed on this research is descriptive analysis, with a two pattern of the placement that are tested which is a square in a serial manner and square in parallel, with three spaces between the tested sprinklers i.e. 55%, 60% and 65% of the wetting diameter on three kinds of micro sprinkler in three repetitions. This research concluded that the best distance spaces between the sprinkler on hanging position the type of microspin ie equal to 4,8 meters (60 %), on the type of modular the best sprinkler distance spaced amounting to 5,2 meters (65 %) and a square parallel pattern was the best sprinkler placement pattern on both of this type . Whereas on the type of spray jet the best sprinkler spaces are 1,65 meters (55%) and a pattern of a square series is the best pattern on the type of this . the value of a coefficient of uniformity (CU) and distribution uniformity (DU) there are most properly on the type of microspin with the result of the value of CU amounting to 91,43 % , and the results value of DU by 86,52 % .**

***Keywords*— Micro sprinkler irrigation; Irrigation efficiency; Sprinkler placement pattern; distance spaces**

I. INTRODUCTION

Irrigation is the provision and regulation of water to support agriculture, which includes the type of surface irrigation, sub-surface irrigation, irrigation pumps, and irrigation ponds [7]**.** Irrigation is done to increase the availability of water in the soil, especially in the root zone of plants are usually sourced from nature, such as rain, dew, rivers and groundwater. Irrigation is needed in areas where the only natural source of water in crop production to meet the needs of the growing season just one time, or in some years and not in the year onwards [5].

With regard to the relatively limited amount of water, while the availability of water is often not sufficient to meet the needs of water users as demand continues to increase, so naturally there will be competition from each sector of water use such as drinking water, agricultural, domestic, and industrial at each region at any time. In anticipation of the competition in the distribution and allocation of water between sectors, the efficient use of water is absolutely necessary. The one solution for the problem above, is by the application of pressurized irrigation system. Although initially require relatively high investment, but with the calculation and determination of accurate design, operation and maintenance must be precise, the use of water for agriculture can be enhanced competitiveness of the sector competitors.

Application of this pressurized irrigation is sprinkler irrigation system and trickle irrigation systems, is both an alternative technology in the delivery of the water needs of plants with irrigation efficiency approximately 85% higher than surface irrigation. Sprinkler irrigation consists of pipeline from the water source to the land where the water is delivered under pressure from the pump before it is released to the plant through the sprinkler nozzle. Basically, this system simulates rain water applied by sprayer, so the system is also known by the sprayer upright irrigation system [11].

In addition to spinkler irrigation system applied in the open land areas (outdoor), the system is also applied to irrigation in greenhouse wich the area is enclosed (indoor). Spinkler irrigation system in greenhouse irrigation is basically the same as the spinkler is in the open land, but the wetting and coverage area of irrigated areas in greenhouse

have limited coverage compare with in open areas, due to water loss in the absence of the wind aspect. The difference is quite obvious at spinkler irrigation in greenhouses are placed depending on the position of the sprinkler nozzle face to the ground, in addition for the irrigation system in greenhouse usually has multiple functions in addition to distributing the water is needed for plant growth, as well as to distribute liquid fertilizer or liquid substances to protect plants from pests, diseases, and maintain the environmental conditions in the greenhouse when the temperature is too hot [10]. Types of spinkler irrigation system on greenhouse which is underfoliage full-circle fans, overhead fans, variable-height fans, fans peripherals, boom sprinklers, and nozzle lines. sprinkler irrigation system efficiency determined on two components: (a) uniformity, and (b) the distribution of water. To obtain a high value of irrigation efficiency, one of the efforts that can be done is to adjust the placement and layout of sprinkler so the spread and distribution of water falling into the root zone of plants can be uniform. Water distribution uniformity values expressed by a parameter called the coefficient of uniformity, CU. The coefficient of uniformity is influenced by the relationship between the size of the nozzle, the pressure, the distance between the sprinkler, and wind speed [14]. Sprinkler irrigation system is stated as have a high efficiency irrigation if the value of the coefficient of uniformity (CU) over greater than 85% [6].

According [8] there are three types of sprinkler placement : putting sprinklers in circular, triangular and rectangular. The most common way of laying used are rectangular and triangular. To obtain a uniform distribution of water flow between the emitter sprinkler spacing both in the lateral and inter-sprinkler can be in the range of 60-80% of the wetting area [10]. To obtain a high efficiency irrigation on sprinkler irrigation systems, especially in the micro irrigation system hanging in certain high, it is necessary to do intensive research to setup the placement of sprinklers, position, spacing between emitters, high emitters from the ground/plants, and pressure in order to obtain a high uniformity patterns and loss due to evaporation at the nozzle becomes smaller.

II. Objective and Aims

The purpose of this study was to determine the pattern of placement and micro sprinkler spacing appropriate to obtain high uniformity of water distribution and irrigation efficiency, and get the pattern placement and micro sprinkler spacing between the most appropriate.

III. Pressurized Irrigation System

Irrigation base on [1] declare as the water application artificial in the plant area, to control the distribution, to drain the excess water to the natural or man-made channel after the water use in optimal purpose. Irrigation system in agricultural area should be serve the water in exact volume, time and place to fullfil the requirement and schedule of irrigation land [5] The other role of water in agriculture, water as a cooling agent for soil dan plantation, protect the plantation from frezzing, to slow-down the fruit and fertilizer solute agent.

Pressurized irrigation as the one of an alternative technology applicative, which from teoritical point of view have irrigation high efficiency compare with surface irrigation. Because of this, pressurize irrigation more suitable if the application in the dry area, who needs irrigation technology in saving way. Pressurized irrigation system ussualy have one or more horizontal and vertical pump generate by machine or electricity motor. Horizontal centrifugal pump use for surface water or water source, vertical centrifugal pump rather rare for use because the the difficulty in maintenance and size of pipe inlet from the water sources should be more long, thus the initial cost were most expensive compare horizontal centrifugal pump.

The types of pressurized irrigation system, such as sprinkler irrigation and trickle irrigation system. Sprinkler irrigation system distributed the water from reservoir through spinning or static emitter, the water spray like droplet water from rainfall. Trickle irrigation system in the base concept was similar like sprinkler irrigation system, the different the water came out from the emitter as a drip, not as water spray. Spinkler irrigation known as overhead irrigation because the water applied from the top of the plantation, spray like rainfall. According statement from [5] sprinkler irrigation system flow the water from the water source support with pressure from the water pump average at 70 - 700 kPa (10 - 100 psi), this pressure can distribute the water from the nozzle (small orifice hole) as water droplet water rainfall.

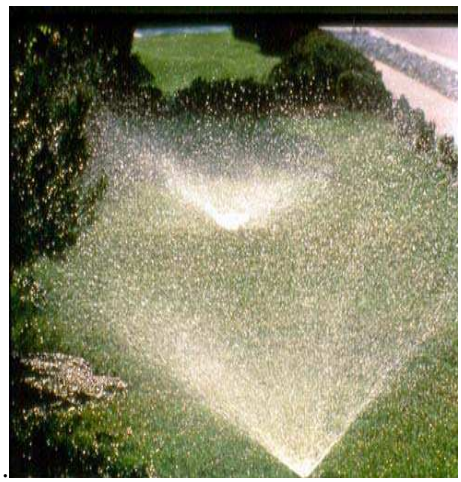

Fig.1 Sprinkler Irrigation Fixed Head type for Small Field
Source : [13]

Pipe Network equipment of sprinkler irrigation consist of several part :

- Supply line, from the water source.
- Mainline, as a main pipe network connecting to water pump.
- Valve line, as pipe to place the water valve.
- Manifold, connecting the pipe with another pipe.
- Lateral, as a pipe network, for placing the *sprinkler*.

A. Uniformity Coeficient

Coeficient uniformity define as a parameter namely as CU. This parameter depent on relation between pressure, nozzle size, sprinkler spacing and wind condition. Base on [3],

coefficient uniformity can be calculate using formula (1). Value CU round 85% can be use for sprinkler irrigation.

$$CU = 100 \times \left(1{,}0 - \frac{\sum|z-m|}{mn}\right) \quad (1)$$

Where :

m : Avarage Valueof Observation (mm)
n : Total of Observation
z : Value of each observation (mm).
X (| z-m |) : Absolut Deviation

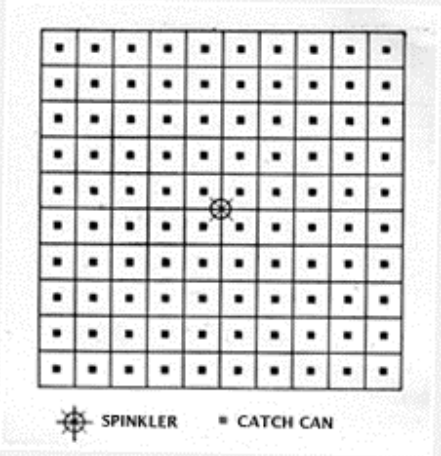

Fig. 2 Layout of Emitter Sprinkler & Can Container for CU Trail
Source : [2]

B. *Distribution Uniformity*

Distribution Uniformity determine as value of sparding water from the sprinkler in the surface soil, base on [6] can be calculate using the formula (2) as below :

$$DU = \frac{\text{rata-rata } \frac{1}{4} \text{ nilai terkering air yang diterima}}{\text{rata-rata kedalaman air diterima}} \times 100 \quad (2)$$

Value of DU around 75 % to up, its enough and good for using irrigation sprinkler [4]. Relationship between two formula above can be combine as formula (3) and (4) :

$$CU = 100 - 0.63(100 - DU) \quad (3)$$

and

$$DU = 100 - 1.59(100 - CU) \quad (4)$$

Source : [2]

IV. Material and Methods

This research was carried out in September-October 2012, which are located in the greenhouse of Faculty of Agriculture, Padjadjaran University. The method of performed on this research is descriptive analysis , with a two pattern of the placement that are tested which is a square in a serial manner and square in parallel, with three spaces between the tested sprinklers i.e. 55%, 60% and 65% of the wetting diameter on three kinds of micro sprinkler in three repetitions.

The matrial use for the research, consist of :

1. Water Pump (125 watt), as a sources for pressure;
2. Well as a water sources (intake source);
3. Plastic tube as a main line (Ø 1”), as a intake water to the pump.
4. Plastic tube as a lateral line (Ø ½”) connecting the main line to the lateral line.
5. Micro sprinkler, consist of three type : microspin, modular, spray jet
6. Plastic Can, to cath the water from the micro sprinkler:
7. Stopwatch and hand anemometer, to measure temperature and wind speed.

Distance Spacing Arragement

A. *Spacing between sprinkler*

Arrangement distance spacing between *sprinkler* determain base on type of *sprinkler* and weeting diameter of *sprinkler, the value around* 65 % - 30 % distance spacing [2]. Therefore in the research distance spacing will overcome to test : 55 %, 60 %, dan 65 % from wetting diameter, at Table 1. bellow :

TABLE I
Sprinkler Distance Spacing Base on Placing Pattern

Placing Pattern Series & Parallel Rectangle			
Micro-sprinkler	Distance Spacing (m unit)		
	55 %	60 %	65 %
Microspin	4,40 × 4,40	4,8 × 4,8	5,20 × 5,20
Modular	4,40 × 4,40	4,8 × 4,8	5,20 × 5,20
Spray Jet	1,65 × 1,65	1,8 ×1,8	1,95 ×1,95

Source : Preliminary Observation.

The whole pattern of this placement sprinkler has a sprinkler distance height from the soil surface approximately 2,5 m tall.

B. *Catch-Can Spacing*

The distance between the catch-can that is 50 cm. Catch-can be placed around the sprinkler wetting diameter.

V. Results and Discussion

A. *Sprinkler Irrigation Efficiency Analysis*

The efficiency of an irrigation system, is a priority that must be met to obtain the same results in every area. There are several factors that needed to meet the irrigation efficiency as: excellent planning, installation of systems and supporting good equipment, system maintenance tools to a high standard, and the good management and control of scheduled [4].

Some situations that affect the uniformity of the irrigation system. These situations include: the amount of water supplied exceeds the crop water requirements, lack of uniformity of water applied, water presispitasi outpouring rate higher than the soil infiltration rate, operating in very windy conditions, runoff water, excess water flow due to wrong placement of sprinklers or spray emitters.

Irrigation efficiency in sprinkler irrigation systems, determined by the value of the Coefficient of Uniformity (CU) and Distribution Uniformity (DU) of the entire

sprinkler irrigation system applied. Value of the coefficient of uniformity and uniformity of the distribution, is one way to perform an evaluation of the design of the irrigation system, if the value of the water distribution uniformity and distribution is high then the irrigation system can be state to be proper irrigation system.

B. Uniformity Coefficient, CU

According to [6], if the value of the coefficient uniformity (CU) by 85% or more, it can be said that the efficiency of sprinkler irrigation applied is quite high (relatively good uniformity of water flow). The table below shows the results of the measurement of the coefficient uniformity on the three types of micro sprinkler, namely: microspin, modular, spray jets are tested on two patterns of placement and spacing between the three micro sprinkler.

TABLE II
MEASUREMENT RESULTS OF UNIFORMITY COEFFICIENT (CU).

Type	Position	Distance Spacing	Average (%)
Microspin	Rectangle Series	55% × 8 m	90,28
		60% × 8 m	88,28
		65% × 3 m	91,43
	Rectangle Parallel	55% × 8 m	86,72
		60% × 8 m	87,24
		65% × 3 m	84,14
Modular	Rectangle Series	55% × 8 m	90,55
		60% × 8 m	89,37
		65% × 3 m	88,64
	Rectangle Parallel	55% × 8 m	82,69
		60% × 8 m	84,33
		65% × 3 m	91,41
Spray Jet	Rectangle Series	55% × 8 m	86,08
		60% × 8 m	82,34
		65% × 3 m	84,03
	Rectangle Parallel	55% × 8 m	79,21
		60% × 8 m	78,72
		65% × 3 m	81,72

From table 2, above, the coefficient of uniformity of the test results on microspin and modular showed good uniformity coefficient. It looks different on the results in the spray jet-can. Uniformity coefficient values result in this type of micro sprinkler almost entirely below the minimum standard. In type microspin, the most well spacing is at 65% on the placement pattern of square series with CU value of 91,42%.

The value of CU on the modular type, spacing which produces the highest value CU on the micro sprinkler this type is 65%, with a value of CU 91.41% at the placement pattern of parallel square. While on the type of spray jets CU highest value of 86.08% is obtained at 55% spacing in a square pattern placement series.

C. Distribution Uniformity, DU

Distribution uniformity (DU) values generated by a sprinkler irrigation system by 75% is the minimum acceptable value as the limit value of good efficiency [4]. The results of the measurement for the distribution uniformity of the three types of micro sprinklers in the test, can be seen in the Table 3. below:

TABLE III
MEASUREMENT RESULTS OF DISTRIBUTION UNIFORMITY (DU)

Type	Potition	Distance Spacing	Average (%)
Microspin	Rectangle Series	55% × 8 m	86,32
		60% × 8 m	82,15
		65% × 3 m	86,52
	Rectangle Parallel	55% × 8 m	80,24
		60% × 8 m	82,53
		65% × 3 m	78,42
Modular	Rectangle Series	55% × 8 m	85,38
		60% × 8 m	84,31
		65% × 3 m	83,81
	Rectangle Parallel	55% × 8 m	73,40
		60% × 8 m	74,01
		65% × 3 m	86,06
Spray Jet	Rectangle Series	55% × 8 m	78,17
		60% × 8 m	72,76
		65% × 3 m	72,33
	Rectangle Parallel	55% × 8 m	67,72
		60% × 8 m	70,22
		65% × 3 m	74,52

In table 3, the results show the value of uniformity of distribution of (DU) on the type of sprinkler spray jets is almost entirely DU has a value below 75%, except at 55% spacing in a square pattern that produces series DU value of 78,17%. If the value of DU under 75% then the distribution of water droplets on sprinkler distribution not acceptable.

However, according to [9], the value of the distribution uniformity (DU) which can not be accepted at all of a measurement system sprayer is less than 62%. Because the value of 62% is the limit value of the smallest and most poorly spread distribution of a sprinkler irrigation operating system.

DU highest value with a value of 86,52% on micro-type spin spaces are at a distance of placement of 65% on a square pattern series, and the modular type DU value of 86.06% contained at a spacing of 65% on the placement pattern of parallel square represents the value DU best on this type. While on the type of spray jets DU value of 78,17% at 55% spacing in a square pattern placement DU series is the best value among all the spacing and pattern placement are tested on this type.

D. Comparative Analysis of Spray Wetting Area

The area of water that is poured out by the outpouring of micro sprinkler emitters are influenced by the size of the emitter hole and the pressure that comes out at the time of

the operation, but when the wind speed also affect the operation of the micro sprinkler spray wetting area [10].

Figure 3. below shows the comparison between the micro area outpouring microspin sprinkler on the type and placement of the modular micro sprinkler emitters that hang above shows a greater spray wetting area with a diameter of 8 meters wetting area when compared to micro sprinkler emitters location of the position that placed on the soil surface only in diameter of 6 meters wetting area.

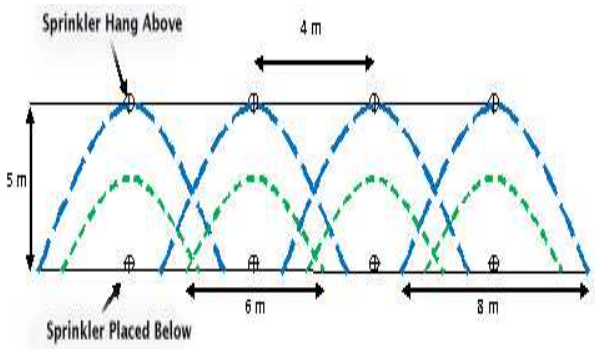

Fig. 3 Comparison Spray Wetting Area on Microspin and Modular Type

While in Figure 4. below illustrates the similarity of the type spray wetting area jet with a diameter of 3 meters in the positioning of the micro sprinkler emitters suspended by the location of the position of the micro sprinkler emitters placed on the soil surface.

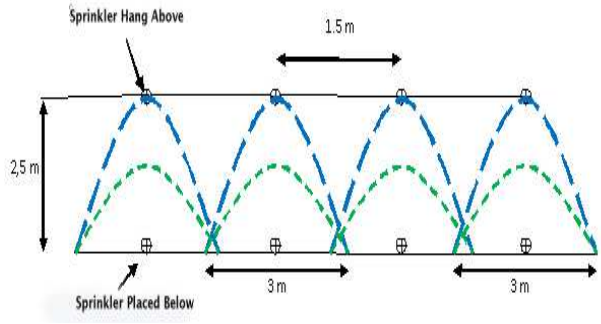

Fig. 4 Comparison of Spray Wetting Area at Jet Spray Type

The area of the spray wetting area of the placement position micro sprinkler emitters hang above shows the larger size of the area due to the emitter placement position facing downward force of gravity with altitude following the pre-arranged in such that, so the water flow incurred greater coverage of the area when compared with the position placement micro sprinkler emitters are placed at ground level. Due to the position opposite to the direction of gravity, then the coverage area of spray wetting area of water affected by the force of gravity so that the coverage area is smaller.

The following are the results of comparative results of the spray wetting area of the area's most well spacing in the three tested, namely 55%, 60%, and 65% of each of the three types of micro sprinkler with the position of the emitter placement hang above a rectangle pattern in two series and parallel to the results of all three types of wetting the area with emitter placement position at ground level (below).

TABLE IV
COMPARISON OF SPRAY WETTING AREA IN MICROSPIN TYPE AT RECTANGLE PARALLEL PATTERN.

Microspin at Hang Above		Microspin at Below	
Spray Water Distance (m)	Volume Average (ml)	Spray Water Distance (m)	Volume Average (ml)
0	0	0	0
1	13,7	1	8
2	26,7	2	17
3	20,0	3	23
4	37,0	4	17
5	20,0	5	8
6	26,7	6	0
7	13,7		
8	0		

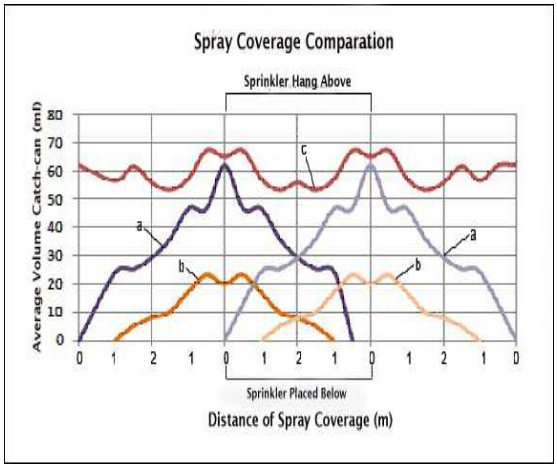

Fig. 5 Comparison of Spray Wetting Area of Microspin type on Two Position of Emitter Distance Layout with Spacing 60%.

Specification:
- a: The sprinkler spray wetting area in a position hang above.
- b: The sprinkler spray wetting area in a position placed below.
- c: Overlapping area of two sprinkler spray wetting area.

The best spray wetting area microspin between the two patterns of placement of the rectangle and series pattern,with three types of spacing between emitters in the lateral and inter micro sprinkler layout, there is a square on the pattern placement parallel with a spacing of 60%. The average volume of catch-can in the pattern placement and spacing is 37 ml of spray wetting area. On the use of this type of micro sprinkler with emitter placement position on the surface of the soil, average water of catch-can is 23 ml.

In Figure 5 above shows the difference in color on the size of the sprinkler spray wetting area contained in the area of points (a) and points (b). The color difference shows the location and spray wetting area of the comparation of two sprinklers. The area of the spray wetting area that has a darker color like purple for example in figure 5 is the area of the water flow in the shed by the first sprinkler, while the area of the outpouring of color have younger example like the color purple is the area of the water flow in a sprinkler sprayed by both .

The spray wetting area of the modular type with the best area indicated by a rectangle pattern parallel placement within a space 65%. With an average of 50,7 ml of water catch. while the position of the emitter placement on the soil

surface (below), the average volume is 23 ml of water catch. Table 5. below shows the comparative results of the spray wetting area in between the micro sprinkler type modular placement positions above and below.

TABLE V
COMPARISON OF SPRAY WETTING AREA OF MODULAR TYPE IN RECTANGLE PARALLEL PATTERN .

Modular placed Above		Modular placed Below	
Water Spray Distance (m)	Average Volume (ml)	Water Spray Distance (m)	Average Volume (ml)
0	0	0	0
1	15,7	1	8
2	28,3	2	17
3	38,0	3	23
4	50,7	4	17
5	38,0	5	8
6	28,3	6	0
7	15,7		
8	0		

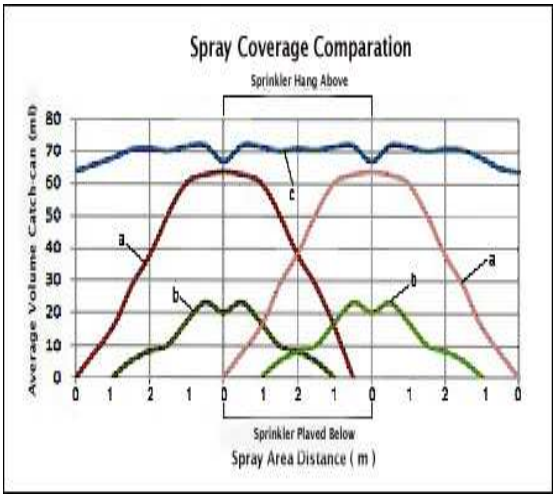

Fig. 6 Comparison of Spray Wetted Area on Modular Type at Two Position Distance Emitter Layout with Spacing 65%.

Specification:
a: The sprinkler spray wetting area in a position hang above.
b: The sprinkler spray wetting area in a position placed below.
c: Overlapping area of two sprinkler spray wetting area.

TABLE VI
COMPARISON OF SPRAY WETTED AREA IN SPRAY JET TYPE AT RECTANGLE SERIES PATTERN.

Modular placed Above		Modular placed Below	
Water Spray Distance (m)	Average Volume (ml)	Water Spray Distance (m)	Average Volume (ml)
0	0	0	0
1	54,0	1	26
2	74,0	2	40
3	92,3	3	58
4	74,0	4	40
5	54,0	5	26
6	0	6	0

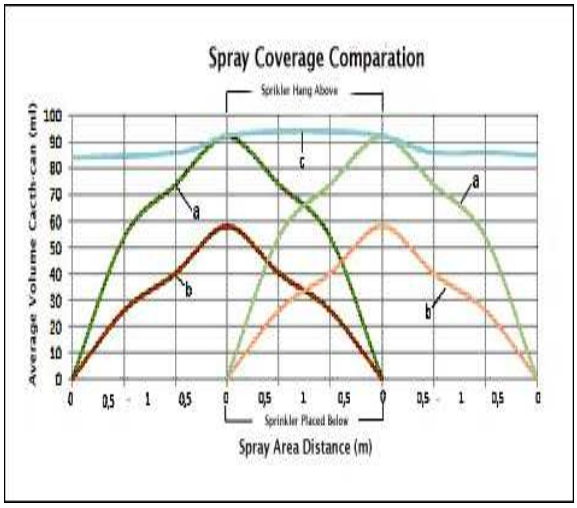

Fig. 7 Comparison of Spray Wetting Area of Spray Jet Type on Two Position Distance Emitter Layout with Space 55%.

Specification:
a: The sprinkler spray wetting area in a position hang above.
b: The sprinkler spray wetting area in a position placed below.
c: Overlapping area of two sprinkler spray wetting area.

Placement pattern of parallel rectangle earlier in the micro sprinkler operation such as modular and microspin type the spray wetting area produce a fairly good area when compared with the results in the spray wetting area of the rectangle placement series pattern, it looks different when the operation of the type of spray jets that produce the spray wetting area most good, on a square of the series placement pattern with 55% spacing.

The average volume water catch of spray wetting area the most high, produced by micro spray jet type sprinkler with a value of 92,3 ml, that the microspin type produces an small average volume of the water catch of the three types were tested, the state was due to differences in the size of the nozzle emitters, difference at pressure operation, and the size of the water droplets in the sprayed, as well as wind speed conditions at the time of the operation. Water droplets shed by microspin produce larger droplets of spray jets so that the distribution of water on microspin types tend to be less uniform and throw water droplets are less consistent because only one emitter hole, so throw water droplets are less smooth and evenly distributed as in the modular type or spray jet.

From the all description of the results of comparative spray wetting area as mentioned above, shows the overlapping area of the two micro sprinkler outpouring shown through the line of intersection in the area of the outpouring of points (a) it is still not good due to the distance between the emitter micro sprinkler that is still too tight. so that the overlapping area becomes too wet. Therefore, proposed an alternative placement of the distance between the emitter so that the wider area of overlap is not too wet.

VI. CONCLUSIONS

Based on the results and discussion of this study it can be concluded that: The most best spacing on each micro sprinkler types : for the microspin type is 60% or equal to 4, 8 meters, modular type is 65% or equal to 5,2 meters, and the spray jet is 55% or equal to 1,65 meters. The best

placement pattern on each of types for micro sprinkler such as microspin and modular type is a rectangle parallel pattern, and for the type jet spray is a rectangle series pattern. The coefficient of uniformity (CU), the highest value is 91,43% in micro sprinkler microspin with a spacing of 5,2 meters between the emitter and the distribution uniformity (DU) highest is 86,52% on the spacing between emitters equal to 5, 2 meters in micro sprinkler for microspin type. Both of these values obtained in a rectangle series placement pattern. Based on the results of comparative analiisis water flow area of the two micro sprinkler, sprinkler spacing settings can still be maximized distance to see the profile of water flow within jets overlapping area is not ignoring the drink with the wind conditions at the time of the operation.

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