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GROWTH AND YIELD OF WATERMELON (*Citrullus vulgaris*) IN SUBSURFACE FERTIGATION USING CLAY POT ON ALFISOL AND ENTISOL

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ABSTRACT

This study aims to identify the effect of spacing from subsurface irrigation sources and soil type on the growth and yield of watermelon plants. The research was carried out in the experimental field in Sukosari Village, Karanganyar Regency, with sub-irrigation using clay pots. The experiment used a nesting design with 2 types of soil, namely Alfisol (T1) and Entisol (T2), and the spacing of 4 plants from clay pots was 5 cm (J1), 10 cm (J2), 15 cm (J3), and 20 cm. cm (J4). The research data were analyzed by ANOVA, and if it had a significant effect, then Duncan's test was continued, at a 95% confidence level. The results showed that the treatment of jatropha affected the growth and yield of watermelon plants. Planting distance of 5 cm caused plant height, fruit weight, shoot fresh weight, and shoot dry weight to be higher than other treatments. The type of soil that produced the best watermelon plants was Entisol soil were plant height, shoot fresh weight, and shoot dry height were higher than in Alfisol soil, but for fruit weights the two were not much different.
Keyword: *Subsurface fertigation, clay pot, growth and yield, watermelon.*

INTRODUCTION

Watermelon is a fruit well-tasted by many people and has a relatively high economic value so many farmers cultivate watermelons (Mujaju & Nybom, 2011). Watermelon has a relatively short planting life and are suitable for planting in the lowland (Sumartono et al., 2017). Watermelon requires full of sunlight during their growing period and very low rain intensity because if the humidity is too high it can cause plant-destroying fungi. Watermelons are usually planted during the dry season, so they require irrigation that doesn't rely on rainwater (Handayani et al., 2016). The research that has been done by (Haryati, 2014) about watermelon is using a subsurface irrigation system using pipes and the result of this research can increase watermelon productivity.

The availability of water even though in small quantities must be considered and its continuity maintained (Benti & Achalu Chimdi, 2019), so that an irrigation system needs to be carried out, and one of the appropriate irrigation systems to use is subsurface irrigation (Sadewa et al., 2016). Sub-irrigation system is one way of providing irrigation water that can be applied profitably (Yuswari, 2016), because the sub-irrigation system utilizes the power of capillaries (Septiana, 2014; Rinasari et al., 2016) to absorb water from underground to the root zone. Agricultural drought impact mitigation by encouraging farmers to adopt appropriate agricultural technologies, drought-tolerant crop varieties and small-scale irrigation (Adunya &

Benti, 2020) to improve agricultural productivity (Weldearegay et al., 2021).

One of the sub-irrigation technologies that have been developed is by using clay pot as a medium for storing plat irrigation water to save water and save watering power (Tesfaye et al., 2011). A sub-irrigation systems using clay pots has been developed by many researchers (Mohammed, 2018) including clay pot irrigation on Melons in India (Mondal, 1974), irrigation in Pakistan (Soomoro, 2020), clay pot irrigation for dry land horticultural crops in Indonesia (Setiawan et al. 1998; Saleh and Setiawan, 2002; Setiawan, 2000), clay pot irrigation for coffee plants on dry land (I Wayan Pariante, 2019), and clay pot irrigation efficiency for maize crops (Retiana Anggraini Putri, 2018). A sub-irrigation system is more suitable to be applied to areas with moderate to coarse soil texture so there are no frequent blockages in the hole where water flows out (Haryati, 2014). Therefore, this study uses Entisol soil which has a sandy texture and Alfisol soil which has a sandy clay texture. Entisol soil with a dominant sand fraction composition makes this soil naturally has a low binding ability (Siburian et al. 2016), while Alfisol soil is dominant with clay and dense structure so that it has strong binding characteristics (Suntoro et al. 2016).

Based on the description above, the author are interested in conducting research by implementing a clay pot sub-fertigation system for watermelon plants with 2 types of soil and 4 plant distance from the clay pot. The main objective of this study was to identify the effect of plant distance with a clay pot on the growth and yield of watermelon, to evaluate the effect of soil type on the growth and yield of watermelon, and determine whether there is an interaction between the plant distance with a clay pot and the soil type on the growth and yield of watermelon.

MATERIAL AND METHOD

The research was conducted at the experimental field, Sukosari Village, Karanganyar Regency, from July until December 2019. Soil analysis was conducted at the Soil Science Laboratory. The material used includes watermelon seed, clay pot, NPK fertilizer by dose 16:16:16, manure, and materials used for laboratory analysis. The tools used include hoes, roller meters, stationary, trowel, label, plastic bag, and measuring cups.

The experiment used nested design with 2 type of soil i.e Alfisol (code T1), and Entisol (code T2), and 4 plant distance from the clay pot i.e 5 cm (code J1), 10 cm (code J2), 15 cm (code J3), and 20 cm (code J4). There are 8 types of treatment with 4 replication in this experiment and resulting 32 experimental pots. Data analysis was performed with analysis of variance (ANOVA) at 95% confidence level, if it is resulting in a significant value in the treatment, so its continue with the Duncan Multiple's Range Test (DMRT) on 95% confidence level.

The experimental field was made with size of 5 x 5 meters. Then made 4 mounds with size 0.7 x 5 meters and the distance between the mounds is 0.7 meters. Four clay pot was buried on each mound with a distance of 0.8 meters between the clay pot and each clay pot is planted with 4 watermelon seed (Figure 1) with a distance between the plant and the clay pot at 5 centimeters (J1), 10 centimeters (J2), 15 centimeters (J3), and 20 centimeters (J4). The irrigation water source for agriculture must comply with irrigation water quality standards so that is suitable as irrigation water for plants (Widodo et al., 2019). Irrigation is provided by filling the clay pot with a capacity of 7 liters, then the water will seep out through the pores of the clay pot and moisture the surrounding soil. Clay pot filling is done every 2 days. Fertilization with organic fertilizers is carried out during soil processing, while chemical fertilization using NPK fertilizers is carried out at 10 days after planting, 1 month after planting, and 2 months

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after planting by adding it to each clay pot. During the growth, weeds removal is carried out.

Figure 1. Placing barrels for crop irrigation

The parameters observed include material characteristics; pH (pH meter method), C-Organic (Spectrophotometer method), Total-N (Kjeldahl method), C/N Ratio, and plant characteristics soil moisture, irrigation volume and for plant parameters were watermelon growth (plant height), fruit weight, plant fresh weight, and plant dry weight.

RESULT AND DISCUSSION

Material Characteristics

Laboratory analysis before the research began was carried out to determine the characteristics of the materials used in this study such as clay pots, organic fertilizers, and inorganic fertilizers as well as soil samples. The initial characteristics of the clay pot, soil, and fertilizers used in this study which are presented in Table 1. The initial soil characteristics used for this study had very low levels of Organic Carbon (C-Organic) and total N value both in Entisols and Alfisols soil. In line with the results of research by Nusantara et al., (2014) Alfisol soil have very low Organic C-content and low total-N. The value total-N is low in Entisol and very low in Alfisol. Therefore, the addition of organic fertilizers was carried out on both types of soil which were expected to increase the soil organic C content (Syukur and Indah, 2006) and sufficient plant growth (Mulyanto et al., 2015). The addition of organic fertilizer can also prevent the loss of nutrients due to evaporation and carried by percolation water (Pranata, 2010). Besides that, appropriate fertilizers can also improve the soil structure to become crumbling (Hastuti et al., 2018). The content of the C-organic, N-total, and C/N ratio supports the soil decomposition process (Mujiyo et al., 2021).

Table 1. Characteristics of Clay Pot, Soil, and Fertilizer

No	Materials	Variable	Result
1	Clay Pot	Soil Moisture (%)	7.07
		Organic C (%)	0.007
		Texture	Silty clay
		- Silt (%)	62.00
		- Clay (%)	33.14
		- Sand (%)	4.86
2	Alfisol Soil	pH	6.13
		Organic C (%)	0.46
		N-Total (%)	0.07
		C/N Ratio	6.57
3	Entisol Soil	pH	6.7
		Organic C (%)	0.95
		N-Total (%)	0.18

No	Materials	Variable	Result
		C/N Ratio	5.28
4	Organic Fertilizer	pH	6.35
		Organic C (%)	22.70
		N-Total (%)	2.8
		C/N Ratio	8.1
5	Inorganic Fertilizer	N-Total (%)	16
		P_2O_2 (ppm)	16
		K_2O (ppm)	16

Remark *) : Based on the Soil Research Institute (2009)

Soil Parameters

Based on ANOVA (95%) presented in Table 2, most of the treatments had no significant effect on soil observation parameters. The parameter that is strongly influenced by the treatment is the soil moisture parameter. The shorter distance of plant causes high soil moisture, because sunlight does not directly hit the soil surface among the plant due to the cover (canopy) of the plant leaves, and it makes the soil contains much more moisture (humidity increases by lower temperatures) (Hayata & Selly Febrina, 2019). The distance of planting by placing different water sources makes the amount of water absorbed by the soil in the planting hole also varies. This is related to the evaporation of water due to temperature and weather (climate). At the time of irradiation by the sun, the temperature will increase in line with the irradiation and cause evapotranspiration in the soil and plants so that the availability of groundwater is reduced and limited for plants (Sasaqi et al., 2019).

Table 2. Results of analysis of variance on soil parameters

Treatment	Sig.				
	Soil Moisture	Water Volume	pH	C-Organic	N-total
Soil Types	0.24^{ns}	0.55^{ns}	0.71^{ns}	0.79^{ns}	0.59^{ns}
Plant Distance	0.01^{**}	0.268^{ns}	0.15^{ns}	0.68^{ns}	0.62^{ns}

Remark : *) (significant); ns) (not significant)

The average results presented in Table 3 show that the highest soil moisture value is found at the shortest distance from the barrel. The farther the distance from the water source (barrel), the lower the value of soil moisture. The water that seeps out of the barrel is not absorbed according to the volume that comes out over long distances. Rahmawati (2015) stated that plants planted at a distance of more than 15 cm from water sources will lack water and cannot reach moisture levels at the wilting point condition.

Table 3. Monthly average soil moisture

Treatment		Soil Moisture (%)			
		Agustus	September	Oktober	During the plant period
Alfisol	J1	13.72c	14.35d	15.52b	15.2d
	J2	12.40b	14.03d	14.71ab	14.67bcd
	J3	13.79c	13.27d	14.06ab	13.83ab
	J4	11.87b	11.91c	14.51ab	14.11bc
Entisol	J1	10.16a	11.13bc	13.55ab	14.84cd

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J2	9.39a	9.27a	13.85ab	14.12bc
J3	9.21a	10.40b	13.97ab	13.8ab
J4	9.04a	11.13bc	13.23a	13.12a

Explanation: The mean in the same column followed by the same letter shows no significant difference in the DMRT level of 5%

Based on the results of the observations presented in the Table 3, the soil moisture in the J1treatments of both Alfisols and Entisols were the highest. At Alfisols the J1 treatment shows an effect that is not significantly different from the J2 treatment with a value of 14.67 during the period of the plant. The treatment J1 has different soil moisture with the treatment J3 and J4 with the respective values of 13.83% and 14.11%. Likewise, the Entisol soil treatment J1 had no significant difference from treatment J2, with a value of 14.12%, but had a significant effect on treatment J3 and J4 with values of 13.8% and 13.12% respectively.

The highest soil moisture was found in the treatment of plant distance with J1 treatment on both Alfisol and Entisol soils, about 15.20% and 14.84%, respectively. The J1 treatment is the shortest distance to the barrel which is the source of plant irrigation. The farther the plant is from the barrel, the lower the humidity of the soil because water seeping out of the barrel cannot reach that distance. In general, it can be seen that the moisture value of the Alfisols soil is higher than the Entisol soil. However, the difference in value is not too high, with less than 1% value. Alfisol and Entisol soils have the ability that is not much different in binding water based on their characteristics. The C-organic content of Entisol soil was higher than that of Alfisols soil in this study, 0.95% and 0.46%, respectively (Table 1). In line with the research results of (Ramli et al., 2016) which states that Entisols soil has a high organic matter content so that it helps the soil in its water-binding function and creates a high water field capacity that can even reach 6 times compared to other soils. Likewise, on Alfisol soils with natural characteristics of soil that has a high clay composition on the surface and tillage layer so that the water holding capacity is also very good (Wijanarko et al., 2016; Pathak et al. 2013; Safitri et al., 2018).

Table 4. The volume of water that seeps out of the clay pot during the planting period

Treatment		Volume of water seeping out (Liter)			
		Month 1	Month 2	Month 3	Total
Alfisol	5 cm	57.85bc	62.92a	59.333ab	174.43ab
	10 cm	53.12abc	55.18a	48.71ab	157.02ab
	15 cm	47.61ab	53.74a	44.41a	145.77ab
	20 cm	38.28a	57.68a	40.87a	136.84a
Entisol	5 cm	69.45c	67.09a	66.16b	202.71b
	10 cm	50.59ab	53.54a	42.98a	147.11ab
	15 cm	68.97c	60.74a	59.33ab	189.05ab
	20 cm	40.51bc	61.67a	52.51ab	174.70ab

Explanation: The mean in the same column followed by the same letter shows no significant difference in the DMRT level of 5%

Table 4 presented the average value of the volume of water lost during the planting period. It can be seen that the highest volume of water lost during the planting period is in the treatment J1 on Entisol soil, about 202.71b and the lowest is in J4 treatment in Alfisols that's about 136.84a. Table 4 can be seen that there is no significant difference in both soil types of treatment. There is no significant difference between these treatments because in this study uses a clay pot of the same raw material and composition. However, in Entisols, the total volume of water lost during the planting period is higher than in Alfisols. This is because the soil moisture content in the Entisol soil is lower than the Alfisol soil, which means that the soil conditions around the clay pot on the Entisol soil are drier, so that the rate of water seepage from the clay pot on the Entisol soil is higher than the Alfisols soil.

Plant Parameters

The results of ANOVA (95%) on plant parameters showed that the treatment of soil types showed a significant effect on all plant parameters, except that the fruit weight parameter has no different effect. All plant parameters have no shown significant effects on distance treatment, except for fruit weight parameters which had a significant effect. Entisols and Alfisols soils had different C-organic and N-Total contents, where the C-organic and N-total content in Entisols soils tended to be higher than in Alfisols soils (Table 1). Total N in the soil plays an important role in the supply of nitrogen (N) nutrients to plants and the uptake of plant N supports the formation of plant parts during growth (Firmansyah & Sumarni, 2013), so that plant growth in Entisol soils has a higher average higher than those planted on Alfisols soil, with an average plant height of 156.29 cm and 83.01 cm, respectively. The content of N which is mobile and leaching makes the N that is absorbed by plants is not optimal and results in the yield of plants being also not optimal.

Table 5. Results of analysis of variance on plant parameters

Treatment	Sig			
	Plant Height	Fruit Weight	Plant Fresh Weight	Plant Dry Weight
Soil Type	0.000**	0.995ns	0.000**	0.000**
Plant Distance	0.587ns	0.023**	0.822ns	0.701ns

Remark: ** (very significant); * (significant); ns (not significant)

Tabel 6. Result of Duncan Multiple's Range Test (DMRT) on plant parameters

Treatment		Plant Height (cm)	Fruit Weight (kg)	Plant Fresh Weight (gram)	Plant Dry Weight (gram)
Alfisol	5 cm	111.12abc	4.03b	214a	87abc
	10 cm	87.88ab	3.00ab	141a	71.75ab
	15 cm	80.38a	2.01a	135.5a	59.5ab
	20 cm	52.66a	1.72a	70.5a	39.5a
Entisol	5 cm	184.06d	4.04b	797.75ab	181c
	10 cm	153.62bcd	3.00ab	573ab	178.5c
	15 cm	151.69bcd	2.11ab	558ab	146.5bc
	20 cm	135.81cd	1.62a	474ab	123abc

Explanation: The mean in the same column followed by the same letter shows no significant difference in the DMRT level of 5%

The results of watermelon plant height as presented in Tabel 6. showed that the highest plant length in Alfisol soil was found at J1 treatment, about 184.06 cm. The treatment had no

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significant with the J2, J3, or J4 treatment. Likewise, in Entisol soil the highest plant height was found in the treatment at a distance of 5 cm from the clay pot (J1), about 111.12 cm. The J1 treatment also had no significant with other treatments (in 10 cm distance treatment, 15 cm distance, and 20 cm distance).

Plant fresh weight states the weight of fresh plants where the plant weight is included in the weight of the water content, and conversely, the dry weight states the dry weight of the plant without water content. The yield of fresh weight of plants determines the quality of growth and yield of plant production per clump or per plant at harvest (Kusdiana et al., 2016). The average weight of watermelon in this study is in the range of 2 kg to 4 kg, less than watermelon's weight in general. This is because the water needs of the plants are not fulfilled due to the existence of four watermelon plants from the same irrigation source. So that there is competition between plant roots to meet the water needs of the plants which in turn have an effect on the process of forming watermelons. Apart from the limited need for water, the relatively small fruit weight can also occur due to not thinning the fruit which can reduce competition between fruits for obtaining photoshoots from these plants.

Based on the results of the further analysis as presented in Table 6 showed that the fresh weight of watermelon plants on the highest Alfisols was found in the J1 treatment with a value of 215 grams, but between the treatments, the distance of 5 cm (J1), a distance of 10 cm (J2), a distance of 15 cm (J3) and a distance of 20 cm (J4) had no significant difference between the four treatments. Likewise, in Entisol soil, the highest plant fresh weight was found at J1 treatment, about 797.75 grams. Meanwhile, the distance of 5 cm (J1), 10 cm (J2), 15 cm (J3) and 20 cm (J4) was not significantly different between the four treatments.

In general, plant fresh weight on Alfisol is lower than on Entisol. Plant fresh weight is influenced by plant height because the plant's fresh weight consists of all plant parts (Wijiyanti et al, 2019). So that the higher the watermelon plant, the greater the wet weight of the plant. As has been explained from Table 6, the length of the plant in Entisol soil is higher than the length of the plant in Alfisol which is influenced by the water requirements of the plant. The farther the plant's are, the lower the plant fresh weight. This is because the soil moisture is getting smaller that which affects the growth of the watermelon plant.

Based on the results of further Duncan tests, the plant dry weight of watermelon plants is presented in Table 6. shows that the highest plant dry weight is found in the J1 treatment, both in the soil of Alfisol and Entisol respectively with values of 87 gram and 181 gram. The treatment showed that had no significant difference with the J2, J3, and J4 treatments. The lowest plant dry weight was found in the J4 treatment both in Alfisol and Entisol soils. The J4 treatment has the lowest weight because the moisture of the soil at that distance is relatively low which causes the plants to lack water so that their growth is not optimal. This is in accordance with the statement from Pramanasari (2013) which states that the lower moisture content causes a decrease in plant dry weight at harvest.

The largest fruit weight is in the J1 treatment both in Alfisols and Entisol soils. The highest average fruit weight was 4.03 kg on the Alfisols soil, while on the Entisol soil it was 4.04 kg, the difference was 0.01 kg with the highest fruit weight on the Alfisols soil. In the treated Alfisol soil, the distance of 5 cm and the distance of 10 cm had no a significant difference between the two but showed a significant difference with the treatment at a distance of 15 cm and 20 cm. Whereas in the Entisol soil treatment, the distance of 5 cm had no significant difference with the treatment with a distance of 10 cm and a distance of 15 cm, but showed a significant difference with the treatment with a distance of 20 cm. Fruit weight is influenced by the availability of water and soil nutrient content which is transformed by the plant during the plant growth period. The results of the study (Tejero et al., 2010) fruit production with water deficit conditions had a smaller fruit weight compared to regular watering conditions according to plant water needs.

CONCLUSION

The distance from the placement of the clay pot to the watermelon plant has a significant effect on the growth and yield of the watermelon fruit. The best growth and yield of watermelon plants is in the treatment of plant distance with a 5 cm distance clay pot and the growth and yield of watermelon on Entisol soil are better than on Alfisols soil.

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