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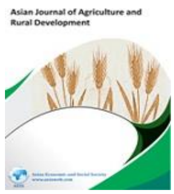

GROWTH AND YIELD OF CAULIFLOWER (*BRASSICA OLERACEA*. L.) AS AN EFFECT OF WATER SUPPLY AND THE DOSAGES OF RICE STRAW MULCH

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ABSTRACT

Limited available water, especially in dry land, causes decreasing production of vegetable plants. Cauliflower originates from subtropical regions which require water. Mulching can manage water to a limited extent. An experiment was carried out in the lowlands to find out whether cauliflower cultivar Orient hybrid could grow in an environment with water available under optimal conditions combined with the use of rice straw mulch. The experimental results show that the Orient hybrid of cauliflower is a lowland plant that can provide the same (marketable curd) yield even with the water conditions below the field capacity (75% FC). The use of rice straw mulch doses of 5-10 t ha^{-1} can help maintain water available for plants. The Orient cultivar hybrid is a lowland cauliflower sufficiently tolerant to lack of water.

Contribution/ Originality
This study informs that the use of mulch 5 -10 t/ha can maintain the availability of water for plants even though the water conditions are below the field capacity, and can gave passably growth and yield of cauliflower. Cultivar Orient hybrids can be planted in dry land of the low land.

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1. INTRODUCTION

Cabbage (*Brassica oleracea* L. Var *botrytis* sub var. *Cauliflora* DC) is one of the commercial vegetables produced in Indonesia. The plant belongs to the cabbage family of Brassicaceae. Ministry of Agriculture of the Republic of Indonesia has developed highland vegetable species to be planted in five lowland West Java districts combined with other food crops (Ministry of Agriculture, 2012) because the lowlands of West Java have high potential to be developed and planted with vegetables from the highlands such as cabbage, cauliflower, and caysim. The success of the vegetable cultivation development program in the lowlands can be demonstrated by an increasing production of cauliflower from 2010 to 2012, namely 101,205 tons in 2010, 113,491 tons in 2011, and 135,837 tons in 2012 (Central Bureau Statistics, 2013).

As cauliflower originates from the subtropical region, it is more suitable to be planted in low-temperature highlands in Indonesia, but there are now seeds of cauliflower cultivars that tolerate high temperatures. One of them is cauliflower F_1 cultivar Orient hybrid. Although this cauliflower is profitable and lowland cultivars have been available, the cultivating vegetables, especially hybrids in the lowlands, have various problems. The problems in the lowlands are limited water, types and fertility of soil, low air humidity, high temperatures, and frequent attacks by pests and diseases (Kasiran, 2006).

Based on the four problems of the limited water in vegetable crops, cauliflower is the main problem. Cauliflower includes inflorescent-producing vegetable crops which require a lot of water. Water deficiency stresses plants, impoverishes them in enzymes, and reduces growth speed. Water is a major component of photosynthesis. Lack of water causes turgidity of stomata guard cells to decrease, stomata to close, CO_2 absorption to reduce, and photosynthesis to decrease. Water plays a role in the translocation of photosynthesis. That inhibits plant growth. Water influences the work of enzymes in metabolic processes because water acts as a temperature stabilizer in plants. Therefore the availability of water will affect metabolic processes in plants and decrease growth and productivity (Fitriana *et al*., 2009).

Water shortages are often caused by climatic conditions and weather characteristics. In the tropics, especially during the dry season, evaporation is so high that water shortages are frequent (Blaha *et al.*, 2003 cited in Koudela *et al*., 2011). Lack of water can stress plants which results in stress on physiological processes and other functionalities. The first response to lack of water is closing the stomata which will inhibit photosynthesis so that the flow of carbon dioxide decreases, which triggers respiration (Zlatev and Lidon, 2012). In a drought the plant will reduce the use of carbohydrates to maintain its metabolic process. This will decrease the carbon content so that plant growth is hampered and can even cause death (Liu *et al*., 2013).

Efforts to reduce water evaporation can be done by using mulch. One agricultural waste in lowland rice fields is rice straw. Besides being able to reduce production costs the use of rice straw as mulch is expected to be able to restore organic matter into the soil, decrease soil temperature, conserve moisture in the soil, and act as nutrient (Wireko-Manu and Amamoo, 2017). Hence it can improve growth and yield of vegetable, mainly in the lowlands. This study aims to determine the water requirements and the effect of using mulch on the growth and yield of cauliflower in the lowlands.

2. MATERIALS AND METHODS

The experiment was conducted in the Puseurjaya Village in the East Telukjambe District of the Karawang region of the West Java Province located at the altitude of ±17m above sea level. The soil used was Inceptisol with a clay texture and the pH of 4.75. The experimental design used was a randomized block design (RBD) with a factorial pattern. The first factor was the supply of water (A) consisting of three levels; a_1 = 100% (field capacity), a_2 = 75% FC, and a_3 = 50% FC. The second factor was the dosage of rice straw mulch (M) which consists of three levels: m_0 = without mulch, m_1 = rice straw mulch 5 t ha^{-1} and m_2 = rice straw mulch 10 t ha^{-1}. Each treatment was repeated three times.

Water supply for the first 7 days was the same for all treatments in the conditions of field capacity. Water was supplied every day from the time the plants were 8 days old until harvest. The addition of the supply of water lost was calculated by the Gravimetric Water Content method. Dried straw mulch cut into ± 10cm was introduced simultaneously with the start of the supply of water, 8 days after planting. Inorganic fertilizer dosages were used on recommendations of Maynard and Hocmuth (Susila, 2006).

Measurement of growth components included plant height, number of leaves, and stem diameter, Leaf Area Index (LAI), and Net Assimilation Rate (NAR) were measured every 7 days. Observation of yield components included the diameter of the cauliflower curd, curd height, shoot weight, and marketable yield of cauliflower plants. Data from growth response variables using regression analysis followed by parallelity and confusion tests (Draper and Smith, 1981 cited in Ariyanto *et al*. (2013). Plant height, the number of leaves, curd diameter, curd height, shoot weight, and the weight of marketable yield per plant were analyzed using variance analysis and continued with Duncan's Multiple Range Test (DMRT) at 5% significant level (Steel and Torrie, 1989).

3. RESULTS

3.1. Plant height

The results of the analysis showed that there was an interaction effect between the supply of water and the dosage of straw mulch on the plant height at 28 and 35 days only. Table 1 show that at 21 and 42 days after planting the highest cauliflower plant height was achieved with the supply of water in a field capacity condition (100%). The same table shows that at 21 and 42 days the height of the cauliflower plants that had mulch is higher than the height of the plants that did not have mulch. At 42 days a 10 t ha^{-1} rice straw mulch can increase plant height compared to no mulch.

Table 1: Cauliflower plant height (cm) at the age of 7, 14, 21, and 42 DAP affected by water supply and rice straw mulch

Treatment	Mean of Plant Height (cm)			
	7 DAP	14 DAP	21 DAP	42 DAP
Water Supply (A)				
a_1= 100% (FC)	17.50 a	25.11 a	36.89 b	52.67 c
a_2=75% FC	17.33 a	24.95 a	35.56 a	49.72 b
a_3=50% FC	17.89 a	25.28 a	34.61 a	44.50 a
Rice Straw Mulch (M)				
m_0= 0 t ha^{-1}	17.83 a	25.17 a	34.28 a	47.50 a
m_1= 5 t ha^{-1}	17.39 a	25.17 a	36.33 b	49.00 ab
m_2= 10 t ha^{-1}	17.50 a	25.00 a	36.44 b	50.39 b

Note: The average number of treatments followed by the same letter in the column direction is not significantly different according to DMRT at the 5% level

Table 2: Height of cauliflower plants (cm) at 28 and 35 DAP affected by water supply and rice straw mulch

Plant age	Mulch	Water Supply			Mean
		a_1 (FC)	a_2 (75%FC)	a_3 (50% FC)	
28 DAP	m_0 (0 t ha^{-1})	43.33 a C	39.17 a B	34.00 a A	38.83

	m_1 (5 t ha^{-1})	44.17 A	a	43.83 A	b	41.33 A	b	43.11
	m_2 (10 t ha^{-1})	43.67 A	a	43.33 A	b	42.67 A	b	43.22
	Mean :	43.72		42.11		39.33		41.72
35 DAP	m_0 (0 t ha^{-1})	48.83 C	a	44.67 B	a	36.00 A	a	43.17
	m_1 (5 t ha^{-1})	49.00 B	a	50.00 B	b	42.17 A	b	47.06
	m_2 (10 t ha^{-1})	52.00 B	a	48.67 AB	b	45.50 A	b	48.72
	Mean :	49.94		47.78		41.22		46.31

Note: The average treatment number is indicated by the same (lowercase) letter in each column and each line (uppercase) and they are not significantly different at the 5% real level based on Duncan's Multiple Range Test

Table 2 shows that when plants are 28 and 35 days old in sufficient water conditions (field capacity) rice straw mulching does not affect their height. But at the water supply of 75% and 50% FC rice straw mulch can increase plant height. On the other hand supply of 75% and 50% FC decreases the plant height for each dosage of rice straw mulch only if mulch is not applied. At 35 days the dosage of 5 t ha^{-1} and 10 t ha^{-1} of rice straw mulch with the reduction of water supply affects plant height.

3.2. Number of leaves

The interaction between water supply and dosages of rice straw mulch has no effect on the number of leaves per plant and stem diameter. The supply of water significantly affects the number of leaves per plant at 42 days. The number of leaves was the highest at medium field capacity. The dosage of rice straw mulch only affects the number of leaves per plant at 42 days. 5 t ha^{-1} and 10 t ha^{-1} of straw mulch yielded a higher number of leaves (Table 3).

Table 3: Number of leaves per cauliflower plant (strands) at 7, 14, 21, 28, 35, and 42 DAP affected by water supply and rice straw mulch

Treatments	Number of Leaves per Plant											
	7 DAP		14 DAP		21 DAP		28 DAP		35 DAP		42 DAP	
Water supply (A)												
a_1= 100% (FC)	6.11	a	8.59	a	12.33	a	15.56	a	18.67	b	23.44	c
a_2=75% FC	6.00	a	8.48	a	12.12	a	15.22	a	18.00	b	21.67	b
a_3=50% FC	6.11	a	8.44	a	12.00	a	14.56	a	16.56	a	18.89	a
Mulch (M)												
m_0 = 0 t ha^{-1}	6.22	a	8.80	a	12.12	a	14.78	a	17.78	a	20.56	a
m_1 = 5 t ha^{-1}	6.11	a	8.35	a	12.22	a	15.22	a	17.67	a	21.78	b
m_2 = 10 t ha^{-1}	5.89	a	8.36	a	12.11	a	15.33	a	17.78	a	21.67	b

Notes: The average treatment number is indicated by the same (lowercase) letter in each column and each line (uppercase) is not significantly different at the 5% real level based on Duncan's Multiple Range Test

3.3. Stem diameter

The supply of water has an effect on the stem diameter from the age of 21 DAP to harvest. From 28 to 42 days the 50% and 75% water supply results in a shorter stem diameter compared to 100% water supply. Measures of rice straw mulch affect the stem diameter from 35 days until harvest. The application of 5 t ha^{-1} and 10 t ha^{-1} of rice straw mulch resulted in a longer diameter of the cauliflower plant stems compared to that without mulch at 35 and 42 days after planting (Table 4).

Table 4: Stem diameter of cauliflower (mm) at age 7, 14, 21, 28, 35, and 42 days as affected by water supply and rice straw mulch

Treatments	Stem diameter (mm)											
	7 DAP		14 DAP		21 DAP		28 DAP		35 DAP		42 DAP	
Water supply (A)												
a_1= Field Capacity	4.10	a	5.62	a	7.69	b	9.40	c	11.12	c	12.63	c
a_2=75% FC	3.88	a	5.42	a	7.38	b	8.80	b	10.03	b	11.26	b
a_3=50% FC	3.93	a	5.24	a	7.01	a	8.22	a	9.00	a	9.68	a
Rice Straw Mulch(M)												
m_0= 0 t ha^{-1}	4.06	a	5.70	a	7.21	a	8.59	a	9.67	a	10.77	a
m_1= 5 t ha^{-1}	4.01	a	5.44	a	7.37	a	8.92	a	10.27	b	11.31	b
m_2= 10 t ha^{-1}	3.84	a	5.14	a	7.50	a	8.91	a	10.22	b	11.49	b

Note: The average treatment number is indicated by the same (lowercase) letter in each column and each line (uppercase) and they are not significantly different at the 5% real level based on Duncan's Multiple Range Test

3.4. Leaf area index

Plant response measured on Leaf Area Index (LAI) of the cauliflower plants to the water supply at each dosage of rice straw mulch is shown in Figure 1. Without mulch, the cauliflower plants are in a different state of field capacity with a growth rate of 75% and 50% of water supply, whereas in the supply of 5 tons of mulch per hectare and 10 tons per hectare LAI at the water level the field capacity is equal to 75% but faster the LAI growth compared to 50% water supply.

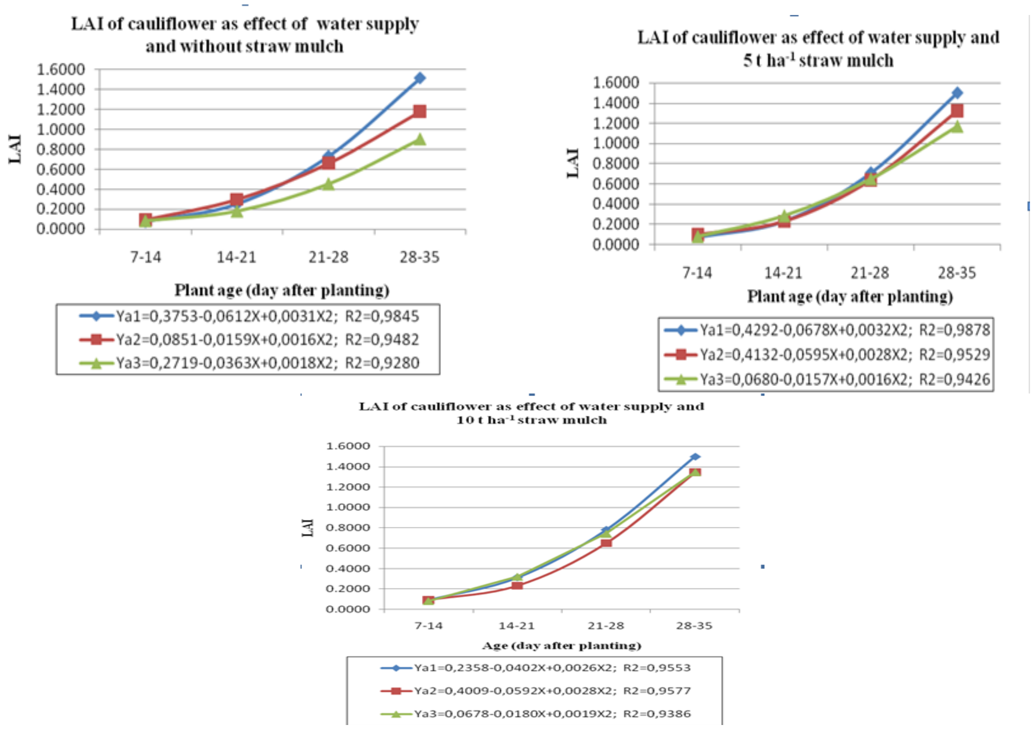

Figure 1: Grafts of leaf area index of cauliflower

3.5. Net assimilation rate (NAR)

In the absence of mulch by supply 100% water (FC) the net assimilation rate is higher than the supply of water 75%% and 50% FC. The optimum NAR reaches at the age of 14-21 days after which it decreases at different speeds. In the applicationof 5 t ha^{-1} rice straw mulch, plants in the supply of 100% water (FC) have the same pattern with 50% FC, whereas with

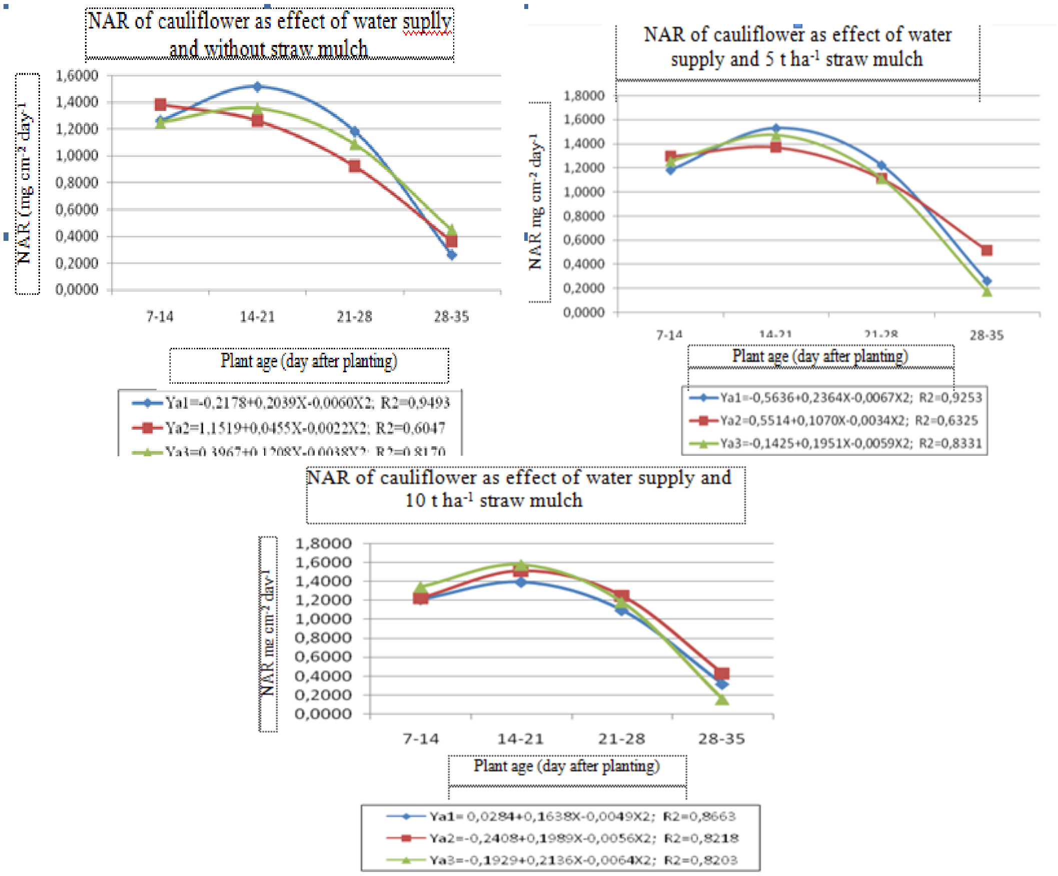

Figure 2: **Net assimilation rate of cauliflower affected with water supply and rice straw mulch**

75% water supply the pattern is different but higher NAR is in field capacity water supply . At the dosage of straw mulch 10 t ha^{-1} of cauliflower plants in the field capacity the pattern is different from the supply of 50% FC water but the same as the supply of 75% water, NAR is optimal at supply water 50% FC or 75% FC higher than supply water at field capacity (Figure 2).

3.6. Curd diameter, curd height and shoot weight of cauliflower

The results of the variance analysis showed that there was no interaction effect between the level of water supply and the dosage of mulch on the curd diameter, the curd height and shoot weight of the cauliflower with the results of the analysis of main effect shown in Table 5.

In Table 5 it can be seen that in the water supply of 50% FC and 75% FC the size of the diameter, height cauliflower mass and fresh weight of shoot are smaller than that of the field capacity water supply. While supply rice straw mulch at a rate of 10 t ha^{-1} can increase the size of the diameter and height of cauliflower mass, and also fresh weight of the cauliflower shoot.

Table 5: Curd diameter, curd height and shoot weight of cauliflower affected with water supply and rice straw mulch

Treatment	Curd Diameter (cm)		Curd Height (cm)		Shoot Weight per Plant (g)	
Water supply :						
a_1=100% (FC)	12.54	c	7.92	c	757.16	c
a_2= 75% FC	11.16	b	6.96	b	577.71	b
a_3= 50% FC	7.56	a	5.34	a	361.87	a
Rice straw mulch:						
m_0= 0 t ha^{-1}	9.47	a	6.17	a	550.83	a
m_1= 5 t ha^{-1}	9.78	a	6.57	a	553.99	a
m_2= 10 t ha^{-1}	12.01	b	7.49	b	591.92	b

Note: The average number of treatments followed by the same letter in the direction of the to DMRT column is not significant according at the 5% level

3.7. Weight of marketable yield per plant

Weight of marketable yield is affected by water supply and application of rice straw mulch. In conditions without mulch, water supply 50% FC and 75% FC even lowering the weight of marketable yield per plant. In the delivery of 5 and 10 t ha^{-1} dosages of rice straw mulch, 75% FC of the water supply does not reduce the weight of marketable yield of cauliflower, while the water supply of 50% FC reduced the yield of the cauliflower marketable (Table 6).

Table 6: Weight of marketable yield per plant (g) affected with water supply and rice straw mulch

Rice Straw Mulch	Water Supply						
	a_1 (100%)		a_2 (75%)		a_3 (50%)		Mean
m_0 (0 t ha^{-1})	257.40	a	179.39	a	94.85	a	177.21
	C		B		A		
m_1 (5 t ha^{-1})	297.57	ab	222.95	b	112.43	ab	210.98
	B		B		A		
m_2 (10 t ha^{-1})	319.79	b	278.80	c	140.13	b	246.24
	B		B		A		
Mean	291.59		227.05		115.80		211.48

Note : The average number of treatments that are marked with the same letters in each column (lowercase letters) and each row (uppercase letters) are not significantly different at the 5% real level based on Duncan's Multiple Range Test

In the case of field capacity, supply mulch as much as 5 t ha^{-1} and 10 t ha^{-1} does not significantly improve the yield. At the level of 75% FC of rice straw mulch as much as 5 t ha^{-1} and 10 t ha^{-1} increases the weight of marketable yield, whereas in the water supply of 50% FC only the rice straw mulch is 10 t ha^{-1} which can increase marketable yield of cauliflower weight.

3.8. Weight of edible curd

The results of the analysis show that there is an effect of the interaction between the supply of water and the dosage of rice straw mulch on the weight of *edible* curd per plant. Results of the analysis of simple effects presented in Table 7**.** When there is no mulching, water supply of 50% FC and 75% FC may reduce the weight of edible curd per plant. Whereas in the case of being applied mulch with a dosage of 5 or 10 t ha^{-1} the water supply of 75% FC does not reduce the weight of the edible curd only water supply 50% FC which reduces the weight of edible curd per plant.

In a field capacity, only 10 t ha^{-1} of mulch is applied which significantly increases the yield. While at the level of water supply of 75% FC of rice straw mulch as much as 5 t ha^{-1} and 10 t ha^{-1} increases the weight of edible curd per plant. In water supply 50% FC, application of rice straw mulch cannot increase the weight of edible curd.

Table 7: Weight of cauliflower consumable (g) affected with water supply and rice straw mulch

Rice Straw Mulch	Water Supply (%)						
	a_1 (100%=FC)		a_2 (75% FC)		a_3 (50% FC)		Mean
m_0 (0 tha^{-1})	184.21	a	118.59	a	58.93	a	120.57
	C		B		A		
m_1 (5 tha^{-1})	218.39	a	161.32	b	63.96	a	147.89
	B		B		A		
m_2 (10 tha^{-1})	257.57	b	221.07	c	98.34	a	192.33
	B		B		A		
Mean	220.06		166.99		73.74		153.60

Note: The average number of treatments that are marked with the same letters in each column (lowercase letters) and each row (uppercase letters) are not significantly different at the 5% significant level based on Duncan's Multiple Range Test

4. DISCUSSION

Cauliflower plants require a high amount of water for survival. Although the Orient cultivar can adapt to the lowlands in both the rainy and dry seasons, this plant requires adequate air humidity and soil moisture. Cauliflower plants are usually planted on soil with sufficient irrigation with adequate drainage (Rukmana, 1994). Based on this the use of rice straw mulch is an alternative technology that can reduce evaporation and maintain soil moisture.

The response of cauliflower plants to the supply of water and rice straw mulch was seen in the high components of plants starting at 21 DAP. This indicates that up to 14 days the supply of 50% water without mulch still meets the water needs of the cauliflower plant. At 28 and 35 days the supply of water and dosage of rice straw mulch affect the height of the plants due to the period of 21, 28, and 35 DAP. The highest dosage of 5 t ha^{-1} of rice straw mulch obtained 100% water (FC), while at 10 t ha^{-1} of mulch the three levels of water supply had almost the same maximum. Lack of water in cauliflower plants that were applied new rice straw mulch had an effect on the plant height at 35 days because the older the plant, the higher the demand for water.

The response of each component of growth in the supply of water varies. On the number of leaves the effect of supplying water began to appear at 35 days. This caused a difference in the leaf area index. Generally the leaf area index of cabbage plants on water supply is 50% lower than the leaf area index at the two other levels of water supply.

At the beginning of the growth the net assimilation rate is still low because the plants are small. As they grow, the leaves function in photosynthesis, causing an increase in the net assimilation rate. Many older leaves are shed, so the net assimilation rate decreases even though the leaf area index increases, because many leaves are shed. The aging of leaves causes low rates of net assimilation due to reduced photosynthetic rates while respiration continues (Gardner *et al*., 1991). Older leaves may burden the physiological process of estate crops (Subandi *et al*., 2017).

Groundwater benefits plants as a fertilizer, soil temperature stabilizer, solvent, and a trigger for unavailable nutrient supply chemical reactions becomes available, as solvents carry nutrient ions from the rhizosphere into the roots and leaves, and as a means of transportation and distribution of nutrients from leaves to all parts of the plant. Sufficient water will increase absorption of nutrients (Hanafiah, 2007; Subandi *et al*., 2018).

More than 50% at FC of the water supply are used in the generative phase (35 DAP until harvest). Lack of water in this phase causes a decrease in yield components and low yields. At seedling black locus, watering 30-40% of field capacity and longer watering intervals lower photosynthesis and transpiration rate, stomatal conductance, and growth of a plant (Anggraeni *et al*., 2015). Rice straw mulch plays a role in reducing evaporation, thereby helping plants absorb nutrients which can increase their growth and yield.

The supply of straw mulch can maintain soil moisture 50% higher than without mulch. Maintenance of soil moisture will create a microclimate conducive to plant growth and soil organisms. Increased activity of soil organisms will increase soil capacity to hold water and nutrients to plants. This causes the cauliflower plants which receive 100% water with 10 t ha^{-1} of rice straw mulch to obtain the highest yield (Kumar and Lal, 2012).

The inflorescence time of cauliflower plants is influenced by the supply of water and the amount of rice straw mulch. Cauliflower buds are formed after plants reach a carbon/protein balance. This is related to the ability of plants to assimilate, accumulate food, and the allocation or distribution of assimilation results because carbon is mostly derived from mobilization of food reserves and the result of photosynthesis. Owing to the fact that water plays a role in photosynthesis and the distribution of assimilation results, the higher the availability of water, the faster the harvest. Therefore the fastest harvest time in this experiment was achieved by cauliflower plants which were treated with 100% water (FC) combined with a dosage of 10 t ha^{-1} of rice straw mulch. This is in line with the heaviest cauliflower weight without leaves obtained from plants with 100% water supply plus 10 t ha^{-1} of rice straw mulch while the lightest weight is obtained from cabbage cauliflower plants with 50% water supply without mulch (Elisa, 2004).

Each component of the highest yield is achieved by the level of water supply field capacity. Growth components and high yield components in conditions of field capacity indicated that this growth requires water available for optimal performance. Availability of water is needed to adapt and be used for plant growth and increasing leaf area (Doorenbos and Kassam, 1979). Water deficits only affect gas exchange capacity and photosynthetic efficiency in the short term, while in the long term they result in decreased efficiency of dry matter formation (Munchow *et al*., 1986 cited in Agung and Rahayu, 2004). Lack of water results in reduced photosynthesis because dehydration of protoplasm will reduce photosynthetic capacity (Thomas and Lasminingsih, 1994 cited in Agung and Rahayu, 2004). Sufficient water will support an increase in leaf area related to the level of crop production (Gardner *et al*., 1991). Low amount of water will cause limited root development. That will disrupt nutrient absorption. Lack of water will cause nitrogen nutrient uptake to be inefficient and reduce the growth and yield of soybean crops (Agung and Rahayu, 2004). Soil environment lacking water in the first stages of growth may cause a retarded plantlet (Subandi and Dikayani, 2018).

5. CONCLUSION

Cauliflower plants require high amounts of water. Although the Orient cultivar can adjust to both the rainy and dry seasons in the lowlands, plant growth will decrease without rice straw mulch at water supply lower than 75% FC, but will be good with 5 or 10 t ha^{-1} of rice straw mulch at the water supply of 75% FC. The worst result was observed at the water supply of 50% FC. Each component of the highest yield is achieved by the level of water supply at field capacity. Growth components and high yield in conditions of field capacity indicated that this growth requires water available for optimal performance, and straw mulch applied at 5-10 t ha^{-1} can be a means of preserving water in the soil.

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References

Agung, T. D. H., & Rahayu, A. Y. (2004). Analysis of N uptake efficiency, growth, and results of several new superior soybean cultivars with drought and biofertilizer stresses. *Agrosains, 6*(2), 70-74.

Anggraeni, N., Faridah, E., & Sapto, I. (2015). Effect of drought stress on physiological behavior and growth of black locust seedlings (Robinia pseudoacacia). *Journal of Forestry Science, 9*(1), 40-56. doi.org/10.3724/sp.j.1148.2011.00139.

Ariyanto, D., Mitakda, M. B., & Wardhani, N. W. S. (2013). *Group linear regression study*. Department of Mathematics, FMIPA, Brawijaya University, Malang, Indonesia. Statistik.studentjournal.ub.ac.id/index.php/.../61/63.

Central Bureau of Statistics (2013). *Domestic vegetable production in 1997–2012*. Available at http://www.bps.go.id/tab_sub/view.php?kat=3&tabel=1&daftar=1&id_subyek=55&notab=70.

Doorenbos, J., & Kassam, A. H. (1979). *Yield response to water*. FAO Irrigation and Drainage Paper 33. 257. FAO, Rome.

Elisa, (2004). *Inflorescen*. Retrieved from http://www.elisa.ugm.ac.id. on 28 June 2014.

Fitriana, J., Pukan, K. K., & Herlina, L. (2009). Aktivitas enzim nitrat reduktase kedelai kultivar Burangrang akibat variasi kadar air tanah pada awal pengisian polong. *Biosainfifika, 1*(1), 1-8. DOI:10.15294/biosaintifika.v1i1.36.

Gardner, F. P., Pearce, B., & Mitchell, R. L. (1991). *Cultivation physiology*. Translation. UI Press, Jakarta.

Hanafiah, K. A. (2007). *Basics of soil science*. PT Raja Grafindo Persada, Jakarta.

Kasiran (2006). Ro drip drip irrigation technology for vegetable crops in lowland dry land. *Journal of Science and Technology Indonesia, 8*(1), 26-30.

Koudela, M., Hnilička, F., Svozilová, L., & Martinková, J. (2011). Cauliflower qualities of the hydrophilic agent. *Horticulture Science (Prague), 38*, 81-85. doi.org/10.17221/149/2010-hortsci.

Kumar, S. D., & Lal, B. R. (2012). The effect of mulching on crop production under rain condition: a review. *International Journal Research Chemical Environment, 2*(2), 8-20.

Liu, X., Fan, Y., Long, J., Kjelgren, R., Gong, C., & Zhao, J. (2013). Effect of water and nitrogen availability on photosynthesis and water use efficiency of Robinia pseudoacacia seedlings. *Journal of Environmental Science, 25*(3), 585-595.

Ministry of Agriculture (2012). *Develops lowland vegetables*. West Java. http://www.florabiz.net/news/kemtan-perkembangan-tanaman-sayuran-dataran-rendah.html.

Rukmana, R. (1994). *Cultivation of cauliflower and broccoli.* Kanisius Publisher, Yogya-karta.

Steel, R. G. D., & Torrie, J. H. (1989). *Statistics principles and procedures*. A biometric approach. translation. PT. Gramedia. Jakarta.

Subandi, M., & Dikayani, F. E. (2018). Production of reserpine of Rauwolfia serpentina (L) kurz ex benth through in vitro culture enriched with plant growth regulators of NAA and kinetin. *International Journal of Engineering & Technology, 7*(2,29), 274-278.

Subandi, M., Eri, M., & Ari, S. (2018). The crossing effect of dragon fruit plant caltivars (Hylocereus Sp.) on yield. *International Journal of Engineering & Technology, 7*(2,29), 762-765.

Subandi, M., Setiati, Y., & Mutmainah, N. H. (2017). Suitability of *Corcyra cephalonica* eggs parasitized with Trichogramma japonicum as intermediate host against sugarcane borer chilo auricilius. *Bulgarian Journal of Agricultural Science*, *23*(5), 779-786.

Susila, A. D. (2006). *Guide to vegetable plant cultivation.* Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Indonesia.

Wireko-Manu, F. D., & Amamoo, C. (2017). Comparative studies on proximate and some mineral composition of selected local rice varieties and imported rice brands in Ghana. *Agriculture and Food Sciences Research*, 4(1), 1-7.

Zlatev, Z., & Fernando, C. L. (2012). An overview on drought induced changes in plant growth, water relation and photosynthesis. *Emirates Journal of Food Agriculture*, *24*(1), 57-72. doi.org/10.9755/ejfa.v24i1.10599.