Micro Climate Behavior on Cauliflower Plant Canopy in Intercropping System with Sweet Corn in Central Kalimantan

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Abstract- This study aims to observe and examine the micro climate behaviour on intercropping pattern of cauliflower with sweet corn in Central Kalimantan, which performed in May to September 2016, in Kalampangan, Palangka Raya, Province of Central Kalimantan. This research applied split plot design, consisted of main plot, i.e. planting period of sweet corn consisted of 3 levels, W_1 = 4 weeks prior to planting of cauliflower, W_2 = 2 weeks prior to planting of cauliflower and W_3 = at the same time planting with cauliflower ; as subplot was planting spacing in row of sweet corn consisted of 3 levels : J_1 = 60 cm, J_2 = 30 cm and J_3 = 20 cm. Data analysis used diversity analysis, if there was significat effect between treatments, further continued to Least Significance Different (LSD) test 5% and regression analysis. The result showed that setting of planting sweet corn 2 weeks before planting cauliflower and planting spacing in a 60 cm sweet corn sequence can modify the microclimate above the canopy of cauliflower plants, which is able to reduce the intensity of radiation and air temperature and increase air humidity above the cauliflower canopy making it suitable for the growth and yield of cauliflower at high temperature in Central Kalimantan.

Index Terms- Air temperature, air humidity, radiation intensity, intercropping, cauliflower.

I. INTRODUCTION

Central Kalimantan lies in the position of 0° 45 'north latitude -3° 30' south latitude and 110° 45 - 115° 51 east longitude. Central Kalimantan is one of the provinces passed by the equator. Altitude of Central Kalimantan on swamp areas was around 0 to 50 metres above the sea level and hills was around 50-100 metres above the sea level, and is dominated by peatlands. Data for 2016, the Central Kalimantan region gets an average solar radiation of 55.79%. The temperature is quite hot, which can reach maximally 35.06°C at noon while the average temperature is 27.4^0C with rainfall 289.36 mm^3 and rainy day 201.60 days [1].

During the growth stage, plants are affected by environmental factors with unavoidable risks. which includes sudden temperature increases, changes in CO_2 content, and rainwater supply, rising atmospheric temperatures will cause the loss of soil moisture and will increase the need for plants for water [2]. The cultivation of cauliflower crops has already been applied in tropical lowland, but inhibited by many obstacles. The main obstacle of cauliflower cultivation in tropical lowland is insupportable environmental factors, such as insuitable agroclimat to its growth. High temperature and radiation intensity are inhibition factors of vegetable production with moderate climate in tropical area [3]. Cauliflower also requires more specific environmental conditions than other cabbage types [4]. Microclimate elements such as air temperature, solar radiation, and moisture support and play an important role in influencing soil conditions as well as crop production [5]. In order for cauliflower plants are cultivated in the tropical lowland producing high quality and size flower, therefore micro climate modification is needed, especially during transition phase from vegetative phase to generative phase [6].

Planting of cauliflower with intercropping pattern is a way to modify micro climate in simple and cheap way. Air temperature of canopy in intercropping pattern was lower than the monoculture. Higher transpiration increases relative humidity and the energy penetrating the canopy was used to photosynthesize and production process [7]. Therefore, by intercropping system of cauliflower and sweet corn, perhaps it will set appropriate micro climate condition for cauliflower crops planted in tropical lowland at high air temperature. This research aims to observe and examine the micro climate behaviour on the canopy of cauliflower crops in intercropping pattern with sweet corn in Central Kalimantan.

II. RESEARCH METHODOLOGY

1. Location, time, materials and research equipment

This study was performed in peatland of Kalampangan Village, Palangka Raya City of Central Kalimantan Province, Indonesian Country. This location was 35 metres above the sea level with average temperature of 27^0C – 32^0C. Materials used in this study were sweet corn seeds of Bonanza variety, cauliflower seeds of PM 126 variety, chiken manure and anorganic fertilizer (Urea, SP-36, and KCl), and burnt ash. Tools used in this study were thermohygrometer, solar meter, analytic scales, digital camera, meter scale, ruler, scissor, hand sprayer, knifes, buckets, LAM, oven paper envelopes.

2. Experimental design

This study applied split plot design, consisted of main plot, i.e. planting period of sweet corn and subplot i.e. planting spacing of sweet corn and repeated 3 times. Main plot was planting period of sweet corn, consisted of 3 levels, W_1 = 4 weeks prior to planting of cauliflower, W_2 = 2 weeks prior to planting of cauliflower and W_3 = at the same time planting with cauliflower. Sub plot was planting spacing in row of sweet corn consisted of 3 levels : J_1 = 60 cm, J_2 = 30 cm and J_3 = 20 cm. Monoculture of cauliflower was used as comparison indicator of rate micro climate change around the cauliflower in intercropping pattern.

3. Conducting field research

Cauliflowers were planted with spacing of 60 cm x 60 cm in trial plot of 3.0 x 5.4 metres, meanwhile sweet corns were planted with spacing between row of 120 cm and spacing in a row based on each treatments. Cauliflower crops were fertilized with anorganic fertilizer (Urea 200 kg.ha^{-1}, SP-36 250 kg.ha^{-1} and KCl 150 kg.ha^{-1}) and manure 10 t.ha^{-1}, also burnt ash 10 t.ha^{-1}. Fertilizer SP-36 and KCl were applied in 7 days after planting, while the urea fertilizer was applied twice in 7 and 21 days after planting, half of dose for each treatments. Application of urea fertilizer and burnt ash was performed 2 weeks prior to planting. Sweet corn crops were fertilized by urea 200 kg.ha^{-1}, 100 kg.ha^{-1} SP-36 and 100 kg.ha^{-1} KCl. While for SP-36 and KCl fertilizer were applied at once in 7 days after observation, whereas urea fertilizer was applied in 7, 28, and 49 days after planting, 1/3 of dose for each treatments.

4. Microclimate observation

Observation of micro climate was performed in 14, 21, 28, 35, 42, and 49 days after observation (DAO). Observations of temperature and humidity are carried out on the canopy of cauliflower plants at 07.00 - 07.30; 12.00 - 12.30 and 16.00 - 16.30, while for solar radiation observation only done at 12.00 - 12.30 [8].

III. RESULT AND DISCUSSION

1. Influence of Planting Period and Spacing on Intercropping System to Changes in Micro Climate Behavior

Cultivation of cauliflower in Central Kalimantan requires crop management techniques in accordance with environmental conditions. This is because the Central Kalimantan has a high temperature and light intensity making it less suitable for cultivation of cauliflower. The success or failure of cauliflower production is heavily dependent on climate, controlling temperature and this relationship is very intensive and complex [9].

The result showed no visible change of micro climate behaviour occurred in 14 DAO, the new changes occurred next to 21 DAO (Table 1). It was because in the beginning of growth, sweet corn crops were short and had less leaves, so their effect on cauliflower crops was not significant yet. There was no interaction between planting period and crop spacing in row of sweet corns to all observations of micro climate behaviour. Treatment at planting periods and planting spacing in row of sweet corn crops separately affected micro climate behaviour above the canopy of cauliflower crops. It showed both treatments were independent to affect micro climate components, but each treatments independently affected the micro climate components significantly, whether the temperature, humidity, or radiation intensity.

Table 1. Temperature (^{0}C) above the canopy of cauliflower crops caused by setting of planting periods and planting spacing in row of sweet corn crops in intercropping system of cauliflower and sweet corn.

Treatments	Temperature (%) Days after Observation (DAO)					
	14	21	28	35	42	49
Planting period of SC (W)						
W_1 (4 weeks prior to CF)	26,9	26,2 a	25,9 a	25,5 a	24,4 a	24,1 a
W_2 (2 weeks prior to CF)	27,8	27,1 ab	26,5 ab	25,9 b	25,3 b	24,7 b
W_3 (along wiith CF)	28,1	27,6 b	27,4 b	26,5 c	26,3 c	25,1 b

LSD 5%	ns	1,1	1,0	0,42	0,9	0,5
Planting spacing of SC (J)						
J_1 (60 cm)	28,2	27,5 b	27,0 b	26,8 c	26,2 c	25,2 c
J_2 (30 cm)	27,3	26,9 ab	26,6 ab	25,9 b	25,4 b	24,6 b
J_3 (20 cm)	27,3	26,5 a	26,2 a	25,2 a	24,5 a	24,1 a
LSD 5%	ns	0,7	0,5	0,7	0,5	0,4
Monoculture of CF	28.50	28.16	28.50	28.70	29.28	28.60

Annotation : Amounts in same columns and accompanied with similar alphabets showed non significant on LSD test 5%)
ns = non significant, SC = sweet corn, CF = cauliflower

Table 1 shows that the arrangement when planting sweet corn affects the temperature on the canopy of the cauliflower plant 21 DAO, whereas the slower the cultivation of sweet corn increases the temperature above the cauliflower canopy. Explains that the temperature drop is correlated with reduced solar radiation received by the plant canopy [6]. At 35 - 49 DAO showed, sweet corn planting 4 weeks before cauliflower planting (W_1) causes the lowest temperature above the canopy between other treatments. While for sweet corn planting together with cauliflower (W_3) causes the air temperature above the canopy cauliflower plants to be higher though not different from the planting period 2 weeks before planting cauliflower (W_2).

In 35 to 49 DAO, planting of sweet corn with spacing between crops in row of 60 cm (J_1) resulted highest temperature above the of cauliflower crops, otherwise spacing between crops in row of 20 cm showd lowest temperature among the other planting spacing treatments. As wide the spacing between crops in row of sweet corn yielded higher temperature above the canopy of cauliflower crops. This was caused by the sunlight penetrating onto the canopy of cauliflower was not blocked by leaves of sweet corn crops.

Table 2. Air humidity above the canopy of cauliflower crops (%) caused by setting of planting period and planting spacing of sweet corn in intercropping system between cauliflower and sweet corn

Treatments	Humidity (%) Days after observation (DAO)					
	14	21	28	35	42	49
Planting period of SC (W)						
W_1 (4 weeks prior to CF)	78,0	82,3 b	83,4 c	84,7 c	85,3 b	86,1 b
W_2 (2 weeks prior to CF)	79,5	80,0 ab	80,5 b	82,4 b	82,6 b	84,3 b
W_3 (along wiith CF)	78,2	78,1 a	78,8 a	79,7 a	80,8 a	81,2 a
LSD 5%	ns	3,1	1,6	1,5	2,3	2,3
Planting spacing of SC (J)						
J_1 (60 cm)	78,3	78,2 a	79,0 a	80,9 a	81,5 a	81,6 a
J_2 (30 cm)	79,2	79,9 a	81,0 a	82,3 ab	82,6 a	83,9 b
J_3 (20 cm)	80,1	82,2 b	82,7 b	83,6 b	84,5 b	86,0 b
LSD 5%	ns	2,0	2,7	1,8	1,7	2,2
Monoculture of CF	77.96	77.30	76.00	74.25	75.50	76.80

Annotation : Amounts in same columns and accompanied with similar alphabets showed non significant on LSD test 5%.
ns = non significant, SC = sweet corn, CF = cauliflower

Setting of planting period and planting spacing in row of sweet corn separately affected air humidity above the canopy of cauliflower crops in 21 to 49 DAO. Planting of sweet corn 4 weeks prior to planting of cauliflower (W_1) had higher air humidity above the canopy of cauliflower crops, although insignificantly different with planting of sweet corn 2 weeks prior to planting of cauliflower (W_2). In 28 and 35 DAO, planting of sweet corn 4 weeks prior to planting of cauliflower (W_1) produced highest air humidity above the canopy of cauliflower crops. The lowest humidity was obtained in planting period of cauliflower at the same time when planting with sweet corn (W_3).

In intercropping pattern of sweet corn with cauliflower, wide spacing between row of sweet corn can lower air humidity above the canopy of cauliflower crops than tighter spacing. Table 2, reduced spacing between crops in row of sweet corn crops from 60 cm into 20 cm further increased air humidity above the canopy of cauliflower crops. Planting of sweet corn in spacing in row of 20 cm (tight) would block penetrating sunlight onto the canopy of cauliflower crops due to leaves of sweet corn crops whose long and plenty enaugh to enchanced highly air humidity above the canopy of cauliflower. Shelter played a role to reduce lighting intensity and high temperature, also increase the air humidity [10].

Table 3. Radiation intensity (cal.cm^{-2}.second^{-1}) above the canopy of cauliflower caused by setting of planting period and planting spacing of sweet corn in intercropping system between cauliflower and sweet corn

Treatments	Radiation intensity (cal.cm^{-2}.second^{-1}) Days after observation (DAO)					
	14	21	28	35	42	49
Planting period of SC (W)						
W_1 (4 weeks prior to CF)	1.082	992 a	862 a	861 a	805 a	786 a
W_2 (2 weeks prior to CF)	1.115	1.050 b	1.016 b	921 ab	853 ab	816 ab
W_3 (along wiith CF)	1.126	1.098 c	1.077 b	985 b	922 b	839 b
LSD 5%	ns	43	97	75	71	36
Planting spacing of SC (J)						
J_1 (60 cm)	1.129	1.140 c	1.057 b	989 b	926 b	836 b
J_2 (30 cm)	1.105	1.035 b	1.000 b	922 ab	851 a	812 a
J_3 (20 cm)	1.088	965 a	898 a	856 a	804 a	792 a
LSD 5%	ns	39	93	77	50	23
Monoculture of CF	1,185	1,183	1,193	1,201	1,202	1,243

Annotation : Amounts in same columns and accompanied with similar alphabets showed non significant on LSD test 5%. ns = non significant, SC = sweet corn, CF = cauliflower

Among the various factors of resource competition, the light factor is one of the factors that determine success in the intercropping system [11]. Setting of planting period of sweet corn in intercropping pattern with cauliflower affected the changes of radiation intensity above the canopy of cauliflower crops. Spacing between crops in row of sweet corn affected the radiation intensity penetrating the canopy of cauliflower crops. Table 3 showed that in 21 to 28 DAO, planting of sweet corn 4 weeks prior to planting of cauliflower (W_1) caused lowestrate of light intensity above the canopy of cauliflower crops than other planting periods. Planting of sweet corn with range between crops of 50 cm caused greater radiation intensity penetrating the canopy of cauliflower than planting spacing of 20 and 30 cm. Wide planting spacing caused sunlight freely penetrating the canopy of cauliflower, so otherwise. Higher rate of shelter was obtained in spacing between row of sweet corn 20 and 30 cm. This was compatible with observation of 21 and 28 DAO, setting of planting spacing between sweet corn of 20 cm (J_3) caused lowest radiation intensity above the canopy of cauliflower crops. Light factor might had positive or negative impact to crops growth. Less shelter might reduce the radiation intensity, therefore might accelerate flowering on cauliflower positively [12]. Plant density of 75 cm × 20 cm had the highest light interception compared to the density 60 cm × 20 cm and 75 cm × 40 cm. Dry matter production increased with light interception and was highest at 105 DAP when light interception was between 55% and 60% for all Arachis varieties [13].

The earlier cultivation of sweet corn from cultivation of cauliflower, the less radiation intensity that reaches above the cauliflower canopy. In 35 to 49 DAO, planting of cauliflower 4 weeks after planting of sweet corn caused lower radiation intensity above the canopy of cauliflower, although insignificantly different with planting of sweet corn 2 weeks prior to planting of cauliflower.

2. Relationship Between Three Micro Climate Factors to Plant Growth of Cauliflower in Intercropping and Monoculture System

To produce a microclimate in accordance with the growth stage of cauliflower, it is necessary to adjust the planting time and distance in the line of sweet corn plants on the intercropping system. [14} The intercropping system can improve the interception of light, reduce evaporation and improve soil moisture. Intercropping cultivation between high and low habits can reduce the intensity of light and air temperature, and increase relative humidity [7]. In Figures 1, 2, 3 and 4 it is known that the intensity of radiation and air temperature above the cauliflower canopy at monoculture planting is higher than the intercropping system. High temperatures and high light intensity especially in the flowering initiation phase will inhibit the formation of flowers as it enters the transition phase from vegetative to flowering, flower cauliflower plants require low temperatures to induce flowers [15]. The intercropping system produces lower light intensity and temperature than cauliflower monoculture.

When planting sweet corn has a real effect on micro-climate change in canopy cauliflower plant. Figures 1 and 2 explain that each treatment when cultivating sweet corn in the intercropping system has different effects on changes in temperature and light intensity. At the planting of sweet corn 4 weeks before planting cauliflower (W_1), indicated that along with increasing of plant age hence intensity of sunlight entering into canopy cauliflower become decreased (Y = 1159.75 – 8.32x, R^2 = 0.74) so the temperature above canopy cauliflower plants also lower (Y = 28.04 – 0.081x, R^2 = 0.76). In the treatment of sweet corn planting together with cauliflower (W_3) indicated that, with increasing age of the plant, the intensity of sunlight reaching the canopy of the cauliflower plant is still quite high (Y = 1272.17 – 8.39x, R^2 = 0.79) which causes the temperature above the canopy of the cauliflower plant to be high (Y = 29.31 - 0.079x, R^2 = 0.71) to enter the flower initiation phase. It shows that the micro climate change around the cauliflower plant is influenced by the time of planting sweet corn as a shade plant. The canopy architecture of sweet corn played critical role in how much solar radiation might be intersepted via planting other crops in intercropping pattern. The high level of shade and the low intensity of radiation cause the air humidity above the cauliflower canopy to be higher [16].

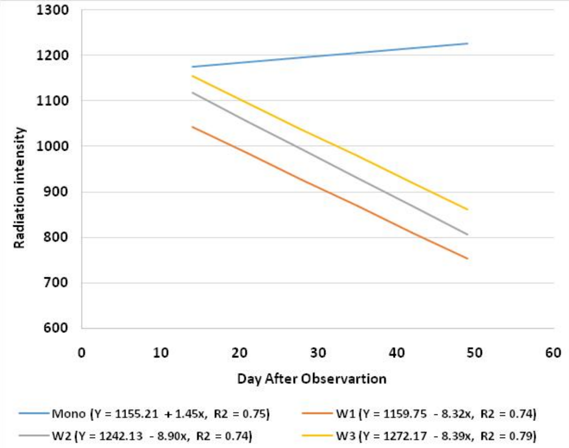

Figure 1. Radiation intensity above the canopy of cauliflower plants during the growth of cauliflower plants due to difference of planting time of sweet corn on intercropping system and monoculture.

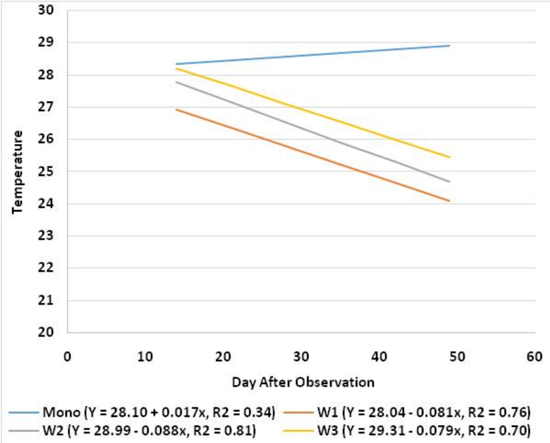

Figure 2. Temperatures above the canopy of cauliflower plants during the growth of cauliflower plants due to difference planting time of sweet corn on intercropping system and monoculture.

Sweet corn planting 2 weeks before planting cauliflower produces suitable micro climatic changes for lowland cauliflower cultivation with intensity and high temperature. Figure 1 shows that sweet corn planting 2 weeks before cauliflower (W_2) decreases radiation intensity (Y = 1242.13 - 8.90x, R^2 = 0.74), and as the age of the plant increases, the light intensity reaches the canopy of the plant cauliflower so as to produce an appropriate temperature to stimulate flower initiation in the cauliflower plant. Figure 2 shows a decrease in temperature above the canopy of the cauliflower plant as the age of the plant increases on the intercropping system (Y = 28.99 – 0.09x, R^2 = 0.81). In cauliflower monoculture showed a slight increase in the observation of radiation intensity and air temperature in accordance with increasing plant life.

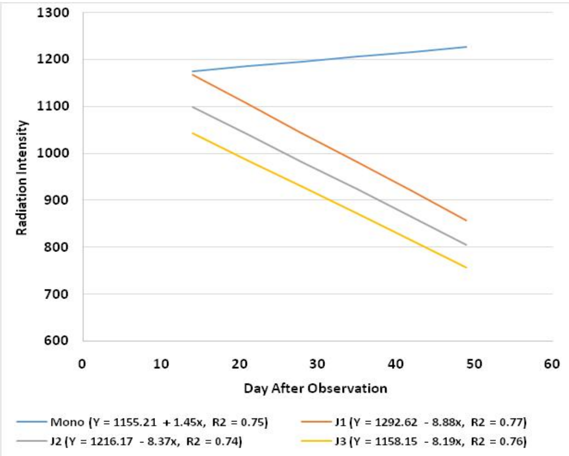

Figure 3. Radiation intensity above the canopy of cauliflower plants during the growth of cauliflower plants due to various spacing of sweet corn on intercropping system and monoculture.

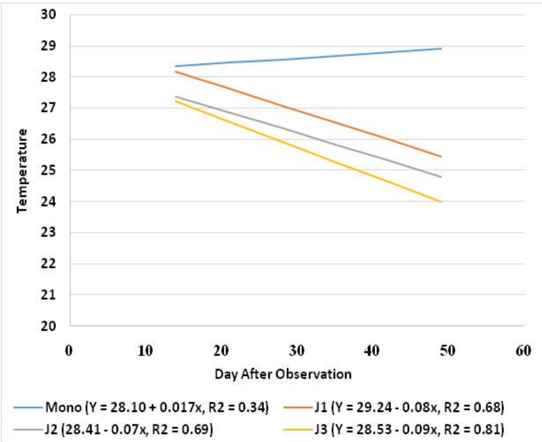

Figure 4. Temperatures above the canopy of cauliflower plants during the growth of cauliflower plants due to various spacing of sweet corn on intercropping system and monoculture.

In Figures 3 and 4 it is seen that the more tightly spaced on the sweet corn sequence can decrease the intensity of light and air temperature above the canopy of the cauliflower plants in the intercropping system. Based on the results of linear regression analysis it is known that with increasing age of plants, will decrease the intensity of light and temperature more quickly, this occurs in J_3 when sweet corn is planted with spacing 20 cm (Y = 1158.15 – 8.19x, R^2 = 0.76 and Y = 28.53 - 0.09x, R^2 = 0.81). While the decrease in light intensity and the slower temperature occurs when sweet corn is planted with a spacing of 60 cm (J_1) on the intercropping system. In cauliflower monoculture showed a slight increase in the observation of radiation intensity and air temperature in accordance with increasing plant life (Y = 1155.21 + 1.45x, R^2 = 0.75 and Y = 28.10 + 0.017x, R^2 = 0.34). To produce good quality flowers, it is important to note when the transition from the growth phase to the flowering phase, ie cauliflower plants require low air temperature. This occurs because the induction of flowering is caused by light, temperature, water availability, nutrients or chemicals such as hormones and growth regulators [10]. It is therefore very important to regulate the temperature and intensity of radiation.

Sweet corn planting with a distance in the 60 cm line (J_1) produces a microclimate condition that is more suited to the growth of the cauliflower plant. This can be seen in Figure 3 (Y = 1292.62 - 8.88x, R^2 = 0.77), so that in the vegetative phase, cauliflower plants get enough sunlight to process photosynthesis. While at the time the cauliflower plant enters the initiation phase of the flower, it is sufficient to obtain shade from sweet corn so that the air temperature in the canopy of the cauliflower plant becomes lower (Figure 4). The cauliflower crop is very sensitive to climate variability, to enter the initiation phase of the flower requires a lower temperature than the vegetative phase [17].

The fulfillment of light and temperature requirements in accordance with the growth stage of cauliflower plants will increase the success of cauliflower planting in hot temperature areas. Explaining the condition of temperature, availability of water and sunlight during vegetative growth, especially when entering the flowering initiation phase significantly affect the cauliflower plants. Suitable environmental conditions will produce mass of flowers with good quality [18]. Setting the distance in a solid sweet corn line that is 20 cm makes some sweet corn leaves cover each other so that it can reduce the intensity of light that reaches the canopy of cauliflower plants. In Figure 3 it is known that as the plant age increases, the amount of sunlight entering the canopy of the cauliflower plant becomes less (Y = 1158.15 – 8.19x, R^2 = 0.76). The decrease in radiation intensity reaching the canopy of the cauliflower plant will cause a decrease in air temperature Intensity and low temperature will inhibit the growth and yield of cauliflower plants. The heat resistant cauliflower varieties have decreased yield if on entering the period of initiation the flower mass has too low a temperature [15].

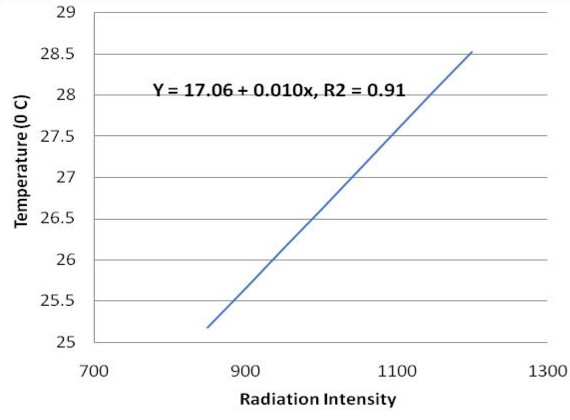

Figure 5. Graph of the relationship between air temperature and radiation intensity

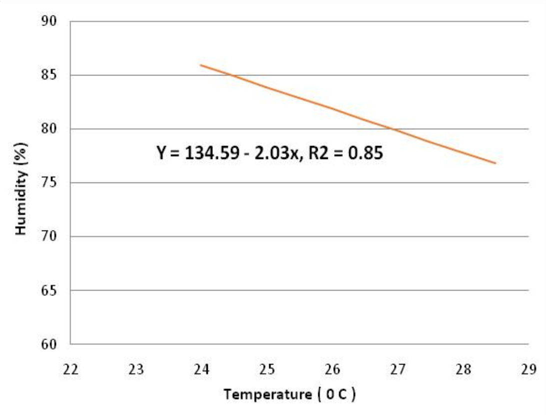

Figure 6. Graph of the relationship between air temperature and air humidity

Changes in the intensity of light, temperature and humidity above the canopy of cauliflower plants are affected by the time of planting and the distance in the line of sweet corn plants. The rate of temperature change is closely related to radiation intensity above the cauliflower canopy. Figure 5 generally shows a linear relationship, ie an increase in radiation intensity followed by a rise in temperature. The results of linear regression analysis showed that the intensity of radiation affects the temperature above the cauliflower canopy of 91% (R^2 = 0.91), which means that 90% temperature rise is affected by radiation intensity and 10% is influenced by other factors.

The decrease in air temperature directly affects the air humidity of the cauliflower canopy. The result of linear regression analysis in Figure 6 shows that the temperature has an effect of 85% (R^2 = 0.85) to the air humidity. Temperature and humidity have the opposite relationship, ie the higher the air temperature on the canopy of cauliflower plants will cause low humidity, and vice versa. The relationship between relative humidity (RH) and dew point temperature (Td) is exponential up to 50% RH, above which the relationship is linear. From the pooled data of the five sites. All the relationships between RH and Td were exponential with significant coefficients of determination (R^2) [19]. Air temperature is closely related to air humidity and greatly affects the growth and flower production of cauliflower plants. Relatively high humidity will help the growth and development of the mass of flowers. At high humidity will result in a larger mass size and more dense so that the mass weight of the interest becomes larger.

IV. CONCLUSION

1. The intensity of radiation and air temperature above the cauliflower canopy at monoculture planting is higher than the intercropping system.
2. Arrangements when planting and spacing of sweet corn affect the micro climate behavior on the canopy of cauliflower plants.
3. The microclimate change corresponding to the growth stage of the cauliflower plant was obtained at arrangement when planting sweet corn 2 weeks before planting cauliflower and planting distance in sweet corn line 60 cm, which is able to reduce the intensity of radiation and high temperature so that suitable for cultivation of cauliflower at the intensity and high temperature.

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