THE CLIMATIC SPACE FOR GROWTH OF ENDEMIC ORCHIDS (*Phalaenopsis amabilis* (L.) BLUME FORMA PELAIHARI

Gusti Rusmayadi[1], Rodinah[1] and Heri Sujadmiko[2]

[1] Faculty of Agriculture Lambung Mangkurat University
Jl. Jend. A. Yani Km.36 PO Box 1028 Banjarbaru 70714
[2] Faculty of Biology Gadjah Mada University
Jl. Flora Bulaksumur Yogyakarta
e-mail: gustirusmayadi@yahoo.co.id

ABSTRACT

Comfort environment condition will influence on orchid flowering, and the using of comfort index as indicator for determination climatic space is suitable or not for orchids. The greenhouse covered with insect proof net is designed from the viewpoint of physically controlling the environment of production. Phalaenopsis amabilis *(L.) Blume Forma Pelaihari each ten is placed inside greenhouse on Mango and Coffee media to observation it's growth. The roof and wall of greenhouse was placed net with radiation penetration about 25%. Air temperature and relative humidity is measured by a thermo-hygrometer recorder typeTR-72S. Solar radiation is measured by point solar-meter recorded. Media temperature is measured by soil thermometer Weeksler type. The net radiation for the Mango medium is Rn = -539 Wm^{-2}. The net radiation for the Coffee medium is Rn = -541 Wm^{-2}. It indicate that Coffee media has low temperature rather than Mango media. After 6 month in greenhouse, orchid that was placed on mango media can make stalk of flower. I's mean the climatic space is suitable for orchid to growth.*

Key words: Greenhouse, Mango and Coffee Media, Net Radiant, Temperature air humidity.

ABSTRAK

Kondisi lingkungan yang nyaman akan berpengaruh terhadap pembungaan anggrek, dan indeks kenyamanan sering digunakan untuk menentukan ruang iklim yang sesuai untuk anggrek. Rumah kaca yang ditutupi dengan screen net di rancang sebagai faktor fisik dalam mengendalikan lingkungan. *Phalaenopsis amabilis* (L.) Blume Forma Pelaihari diletakan pada media tumbuh dari batang Mangga dan Kopi untuk diteliti pertumbuhannya. Atap dan dinding rumah kaca ditutupi dengan net yang bisa ditembus radiasi matahari sebesar 25%. Suhu dan kelembapan udara diukur dengan termohigrograp tipe TR-72S. Radiasi matahari diukur dengan solarimeter titik berperekam. Suhu media tumbuh diukur dengan thermometer tanah tipe Weeksler. Radiasi bersih media batang Mangga dan Kopi adalah Rn=-539 Wm^{-2} dan -541 Wm^{-2}. Hal mengidentifikasikan bahwa media batang Kopi mempunyai suhu yang lebih rendah dibandingkan dengan media batang Mangga. Setelah 6 bulan, anggrek yang ditempat pada media batang Mangga dapat membentuk tangkai bunga. Ini bermakna ruang iklim yang dibuat sesuai untuk pertumbuhan anggrek.

Kata Kunci: Rumah kaca, batang Mangga dan Kopi, Radiasi bersih, Suhu dan Kelembapan udara

INTRODUCTION

There are 41 kinds of orchids in South Kalimantan, and 11 kinds of those present at Kentawan Mountain, in Meratus Mountains area, and were identified by (BKSDA) of South Kalimantan (Sumedi & Noor, 1998). Rodinah *et al*. (2000) reported, there are 27 kinds of orchid at Natural Preserve of Kentawan mountain.

The natural orchid that present at Meratus Mountains in example is moon orchids "mountains Meratus" *Phalaenopsis amabilis* (L.) Blume Forma Pelaihari. *Phalaenopsis amabilis* have high economic value because it is one of orchid kinds that much be desired by people for collection and cross pollination with the other orchids. So, sustainable development of orchid can be hold.

Climate is one of environment variable that very significant to growth and development of orchids. If water can be withhold for a period during the plants natural habitat, dry period this will often stimulate flowering of such plants.

The early research showed that regency potential to orchid development can be made based on air temperature and relative humidity data. Generally, the analysis showed that Pelaihari's orchid was suitable with space climatic.

The early analysis comfort index showed that length of blossom (LB), sum of flower (JB) and sum of fruit (SF) optimal is 1.5, 4.9 and 0.8 respectively. The use comfort index, air temperature and relative humidity can determined the other suitable site for development. The suitable region for optimal LB, JB and SF are the region that has average temperature between 27.5–27.9 and average relative humidity between 77.5– 85.9% (Rusmayadi *et al*., 2010).

Area of South Kalimantan is 3,753,052 ha.

ISSN 0854-2333

Almost half of this area about 1,800,000 ha is coal mining. Then, about 1,864,511 ha is forest and this forest will be decrease because of almost part of forest will be breakdown into coal mining exploitation, forest authority management (HPH), industrial plant forest (HTI) and oil palm land conversion (Forest Service Government, 2011). It is mean natural habitat of orchids will be threatening. Therefore, the research about application comfort index to artificial environment must be done as anticipation step.

Because of comfort environment condition will influence on orchid flowering, the using of comfort index as indicator for determination climatic space is suitable or not for orchids need to study. In this research, comfort index is used to create suitable climatic space for orchid with to make greenhouse covered insect proof net.

The greenhouse covered with insect proof net is designed from the viewpoint of physically controlling the environment of production. The whole the greenhouse according Obu & Maki (2005) is covered with insect proof net and modification it has three effects that are expected. The first, the natural wind can penetrate into the greenhouse. Second, the high temperature inside the greenhouse during summer can be prevented. The third, the damaged by noxious insects can be eliminated.

MATERIALS AND METHODS

Site plan and Material

This research will be conducted on green-house that located in Banjarbaru. The structure of the practical greenhouse affects the meteorology. In this research, in order to investigate not only orchid growth and development but also meteorological inside greenhouse insect proof net. Simple-type greenhouse with 3.0 m length and width of 4.0 meter, and height of, 2.0 meter and 1.0 mesh of insect proof net will be made according Obu & Maki (2005) (Figure 1). *Phalaenopsis amabilis* (L.) Blume Forma Pelaihari about twentieth is placed inside greenhouse on each Mango and Coffee media to observation. The roof and wall of greenhouse was placed net with radiation penetration about 25%.

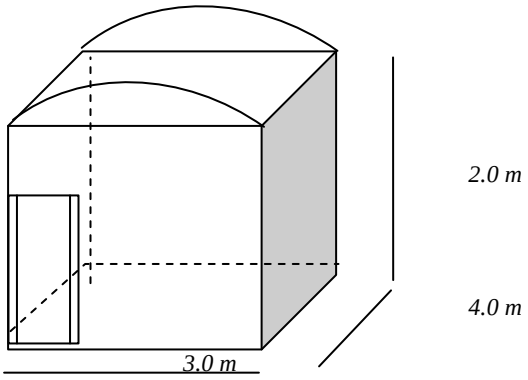

Figure 1. Greenhouse covered insect proof net tunnel type to make climate space.

Method

Data is collected with measure orchid growth and development and meteorological characteristic of greenhouse covered with insect proof net. The growth and development of orchid are emerge of root, emerge of shoot, emerge of flower (in time unit) and length of shoot, length of root, (the new root and shot are measured in length (cm) unit) and sum of root, leave (quantities unit)

At the center of the greenhouse, 2.0 m away from the corner and 1.2 m from the surface of the floor, meteorological instrument are installed and weather measured, that are: air temperature in ^{0}C unit, relative humidity in %, solar radiation in Wm^{-2} unit and media temperature in ^{0}C unit.

Beside that the outer greenhouse also was installed meteorological instrument to daily measure: air temperature in ^{0}C unit, relative humidity in %, and solar radiation in Wm^{-2} unit.

Air temperature and relative humidity is measured by a thermo-hygrometer recorder typeTR-72S. Solar radiation is measured by point solar-meter recorded. Media temperature is measured by soil thermometer Weeksler type.

Radiation Analysis

The energy emitted by non-blackbodies or gray bodies is given by

$$\emptyset = \in \sigma T^4 \qquad (1)$$

where ε is the emissivity of the surface. For a blackbody, ε = 1. Most natural surfaces have long wave emissivities between 0.90 and 0.98. σ = Stefan-Boltzmann constant (5.67 x 10^{-8} Wm^{-2}K^{-4}) and T = Temperature (K).

The total irradiance on a horizontal surface (roof), St (which is used to compute the reflected short-wave flux), is the sum of direct irradiance o a horizontal surface (Sb) and the diffuse sky irradiance:

$$S_t = S_b + S_d \qquad (2)$$

The direct irradiance for a roof is

$$S_b = S_p \cos\theta \qquad (3)$$

where θ is zenith angle between the light beam and a normal to the surface. Sp is a function of the distance traveled by the solar beam through the atmosphere, the transmissivity of the atmosphere, and the incident flux density. A simple expression combining these factors is

$$S_p = a^m S_{p0} \qquad (4)$$

where S_{p0} is the extraterrestrial flux density normal to the solar beam (1360 Wm^{-2}), a is an atmospheric coefficient, and m the optical air mass number, the

ratio of slant-path length thorough the atmosphere to zenith path length. For elevation angles greater than 10 degree, refraction effect in the atmosphere are negligible, and m is given by

$$\boldsymbol{m} = \frac{\left({}^{P}/_{P_0}\right)}{cos\theta} \qquad (5)$$

The ratio P/P_0 is atmosphere pressure at the observation site divided by sea level atmosphere pressure, and corrects for altitude effects.

The transmission coefficient varies from around 0.9 for a very clear atmosphere, to around 0.6 for hazy or smoggy atmosphere. A typical value for clear days would be around 0.84.

A rough estimate of S_d, List (1971) suggests using half difference between the irradiance on a horizontal surface below and above the atmosphere. Thus,

$$S_d = 0.5\, S_{p0}(1 - a^m) \cos\theta \qquad (6)$$

One each of the streams of radiant energy to or from an orchid can be estimated or measured, the next step is to determine the radiant energy budget for orchid. The ne radiation for a surface is the algebraic sum of all incoming and outgoing streams of radiation. Thus net radiant flux density (per unit projected area) for a small, flat object suspended horizontally above the ground is

$$R_n = 2\, L_{oe} - a_s S_t(1 + \alpha) - a_L(L_{iu} + L_{id}) \qquad (7)$$

where L_{oe} is the long-wave emittance for each side of the object, L_{iu} and L_{id} are the long-wave irradiances for the up- and down-facing surface, and a_s and a_L are short- and long-wave absorptivities. Fluxes are taken as positivie in the direction away from the heat exchange surface.

RESULTS

The Climatic Space

Climatic space was made with 4 x 3 x 2 m^3 dimension (Figure 2). The roof of greenhouse was replaced net with 25% penetration radiation. The dimension is appropriate to available area. The greenhouse is lied to enough solar radiation since at 07.30 in the morning until 17.30 in the afternoon.

Figure 1. Green-house covered with insect net

Media of orchids

It is two medias, that are coffee and mango stem. Every media has 50 cm length with diameter about 5 – 6 cm. There are 5 coffees and 5 mangos stem. The media has been hanged on greenhouse. Every medium was put down two orchids, so there were 20 orchids (Figure 2.). Every orchid that place on media has 3 leaves to get uniformity.

Meteorological instrument

There are two meteorological instruments. Every instrument was put in and also out green-house. Every instrument is measure air temperature, air humidity and solar radiation Figure 3..

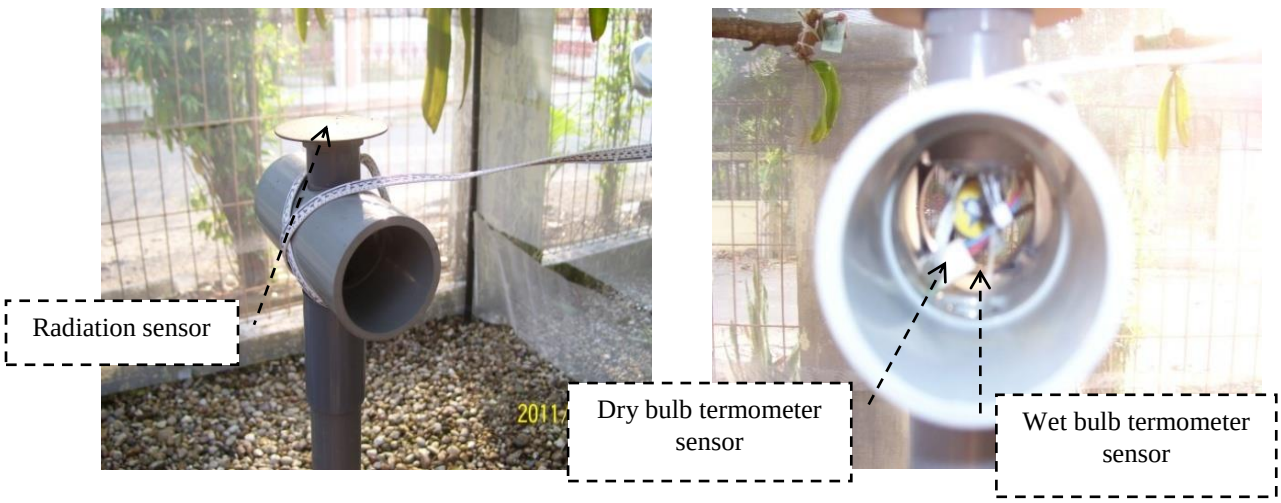

Figure 2. Meteorological instrument in green-house

ISSN 0854-2333

Radiation, Temperature and Relative Humidity

Daily radiation in green house is always smallest than outer. It's difference about 19%. Radiation was measured every day. Radiation has contribution to greenhouse environment.

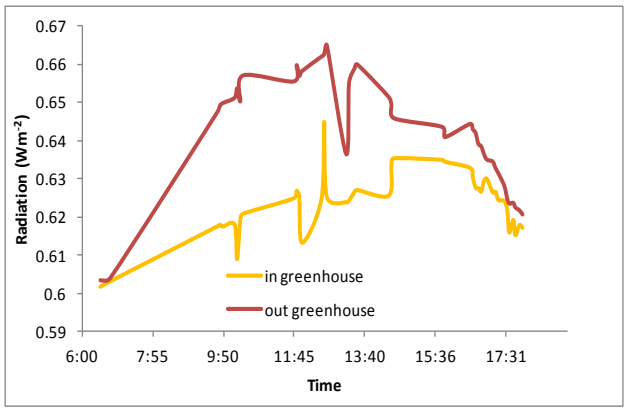

Figure 3. Radiation fluctuation in and out greenhouse.

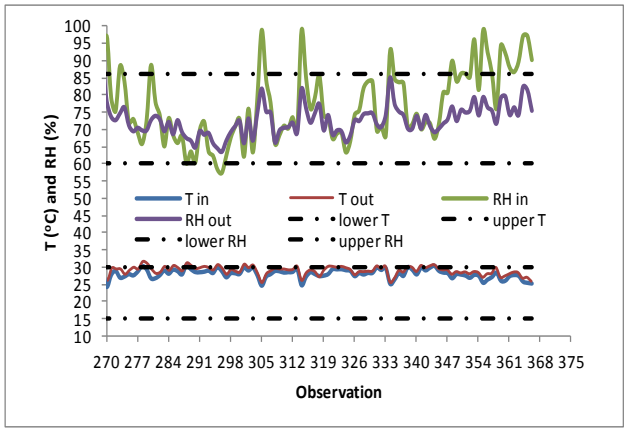

Figure 4. Temperature and Relative Humidity in and out Greenhouse

Relative humidity as long as experiment is suitable for orchid. For some days, relative humidity is upper head from orchid level. While, air temperature is correct for orchid. Two climatic that air temperature and relative humidity will be used to make climatic space. Organism reaction to air temperature was affected by conduction rate, convection, radiation and evaporative cooling on surface. The climatic space in a climatic diagram is effort to get the objective sense temperature index based on air temperature and wet factor (Griffith, 1966), absorbed radiation, wind and air temperature (Porter & Gates, 1969) and terms related to the organism.

Radiant Energy Budgets

Two type radiant energy exchange between organism and their surroundings. For the first, detailed observation of radiant flux densities to and from an organism. The second type is an effort to model the behavior of part an ecosystem. The radiant energy emitted by a unit of greenhouse can be calculated from the Stephan-Boltzmann law. After that, radiant energy from roof, wall, and floor to orchid can be estimated or measured based on object surface temperature. Fluctuation temperature in green house can be sawn in Figure 8. The next step is to determine the radiant energy budget for orchid with measure on each media.

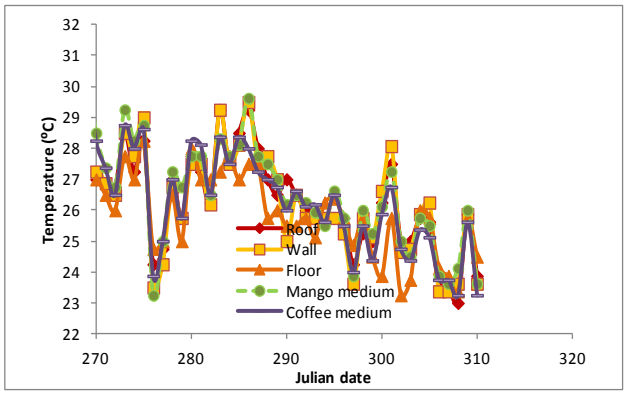

Figure 5. Temperature all in greenhouse

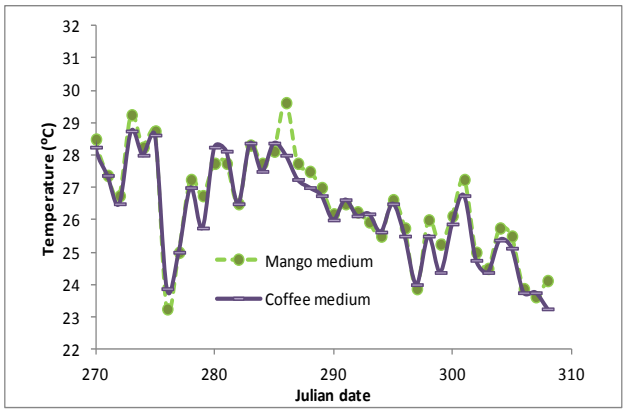

Figure 6. Temperature media.

To determine the radiant energy budget we assume orchid leaf suspended horizontally above a floor surface. Short-wave absorptivity for the leaf is 0.4 and long-wave absorptivity and emissivity are 0.95. Albedo for the floor is 0.24 and emissivity are 0.95. Mango media temperature and coffee are 26.7 and 26.5, respectively. Floor temperature is 26ºC. Air temperature is 28.0ºC. The average zenith angle of the sun is 100 degrees. This gives a sea level air mass of 1.05 (Equation 5) and assuming an atmosphere transmission coefficient of 0.84, a value of S_p of 1132 Wm^{-2} (Equation 4). The direct irradiance on a horizontal surface is S_b = 977 Wm^{-2} (Equation 3). For an atmosphere transmission coefficient 0.84, the diffuse is 8% of S_{po} (Equation 6), so S_d = 98 Wm^{-2}. The total short-wave irradiance on a horizontal surface is therefore St = 977 + 98 = 1075 Wm^{-2} (Equation 2). The long-wave irradiances

and emittances are found from Equations 1 and 7. They are L_{oe} = 0.95 x 458 = 435 Wm^{-2} for Mango's media and L_{oe} = 0.95 x 457 = 434 Wm^{-2} for Coffee medium. L_{id} from floor = 0.97 x 454 = 440 Wm^{-2}. L_{iu} from air = 0.85 x 466 = 396 Wm^{-2}. The net radiation for the Mango medium is Rn = 2 x 435 – 0.4 x 1075 x 1.24 – 0.95 x (396 – 440) = -539 Wm^{-2}. The net radiation for the Coffee medium is Rn = 2 x 435 – 0.4 x 1075 x 1.24 – 0.95 x (434 – 440) = -541 Wm^{-2}. The negative sign means that the net flux is directed toward the medium.

Orchid's Growth

Every week, sum of root, length of root, sum of leaf, length and widest of leave were measured (Figure 8. And Figure 9.). The analysis shows that orchid growth is almost the same. Orchid leaf growth on Mango media is better than orchid on Coffee media.

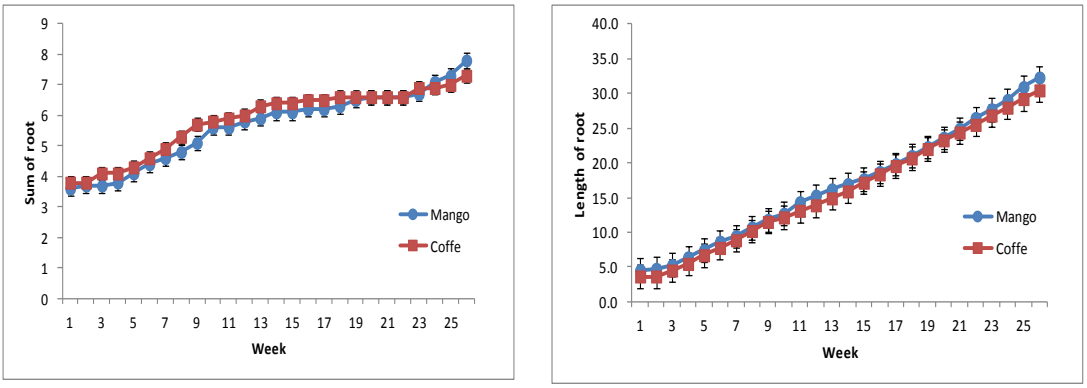

Figure 7. Root growth. Sum of root is left and length of root is right. (Vertical lines are double times standard error)

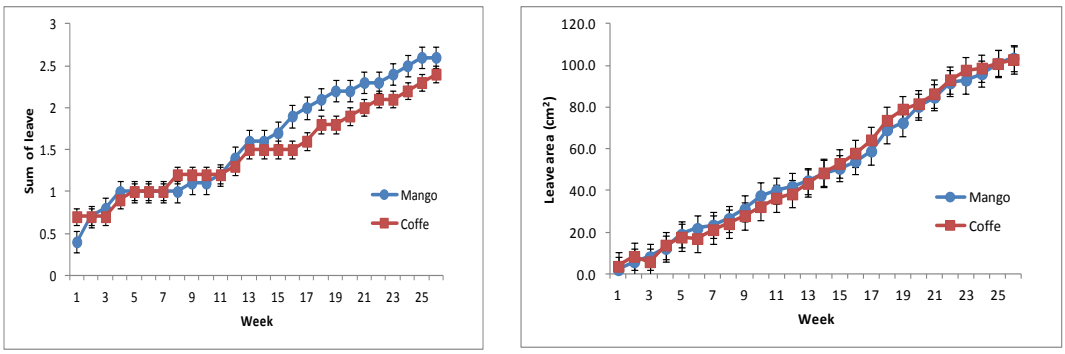

Figure 8. Leaf growth. Sum of leaf is left and leaf area is right. (Vertical lines are double times standard error)

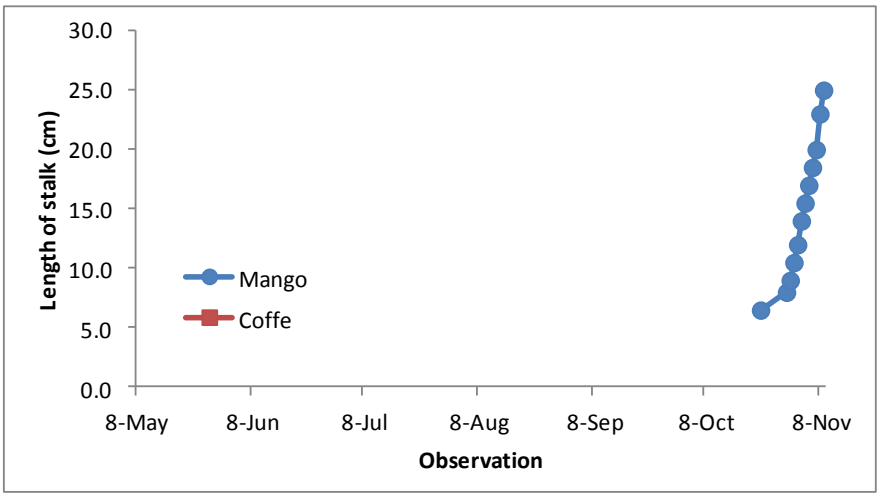

Figure 9. Stalk of orchid

ISSN 0854-2333

Development phase was observed every day. The new root was reformed every 36 days. Mango has about 7.8 roots and coffee has about 7.3 roots. Growth rate root length of Mango and Coffee media are about 1.3 cm ($y = -0.0773x^2 + 4.031x - 50.76$) and 1.1 cm ($y = -0.0051x^2 + 0.2205x - 1.0678$) per weeks, respectively. Notation x is media temperature in ºC.

The new leave was reformed about 61 days. Orchid on Mango and Coffee media have 2.6 and 2.4 leaves. Growth rate leaf area of Mango and Coffee rate are about 5.7 mm and 5.6 mm per days, respectively. Mango leaf area is 103.5 cm^2, while Coffee leaf area is 102.8 cm^2.

Orchids that replaced on Mango media can make reform a stem, while the other is not yet. The new stem or stalk was appeared after 147 day after orchid placed. Until now length of stalk reached 23 cm with rate about 1.4 cm per days and have 3 nodes.

DISCUSSION

Climate-graph showed that growth and development orchid in greenhouse to suitable to growth and development orchid like in naturally habitat. Relative humidity in greenhouse on July (dry season) is down to close by 60%. After 6 month in greenhouse, orchid that was placed on mango media can make stem of flower. The early research founded that the suitable region for optimal long of blossom (LB) and sum of blossom (JB) and sum of fruit (SF) are the region that has average temperature between 27.5 – 27.9 and average relative humidity between 77.5 – 85.9%. According Blanchard & Runkle (2006) the inhibition of flowering when the day temperature was 29 ºC and the night temperature was 17 ºC or 23 ºC suggests that a warm day temperature inhibits flower initiation in Phalaenopsis.

Although climate space is the same to orchid to growth and development (Figure 11.), but media temperature is different (Figure 7.). A small different in fact can make orchid on Mango media faster reform stem of flower. In the frame is comfort condition. The outside comfort frame condition will be very hot, very cold, very wet, and very dry.

Average temperature on Mango and Coffee media are 26.6ºC and 26.4ºC, respectively. Coffee media temperature that low may be cause of has been stable bark, crack and thin slot, hard periderm and not sap. The structure maybe can intercept water and water vapor more than Mango bark, so the Coffee media has low temperature. Net Radiation has been sign negative means that the net flux is directed toward the media. Coffee media need radiant energy to get it capacity than Mango media.

The high media temperature determined root capacity to get water. Water absorption can increase if root zone temperature is high. So, orchid that replaced on Mango medium not only have root length most long but also can make stem of flower.

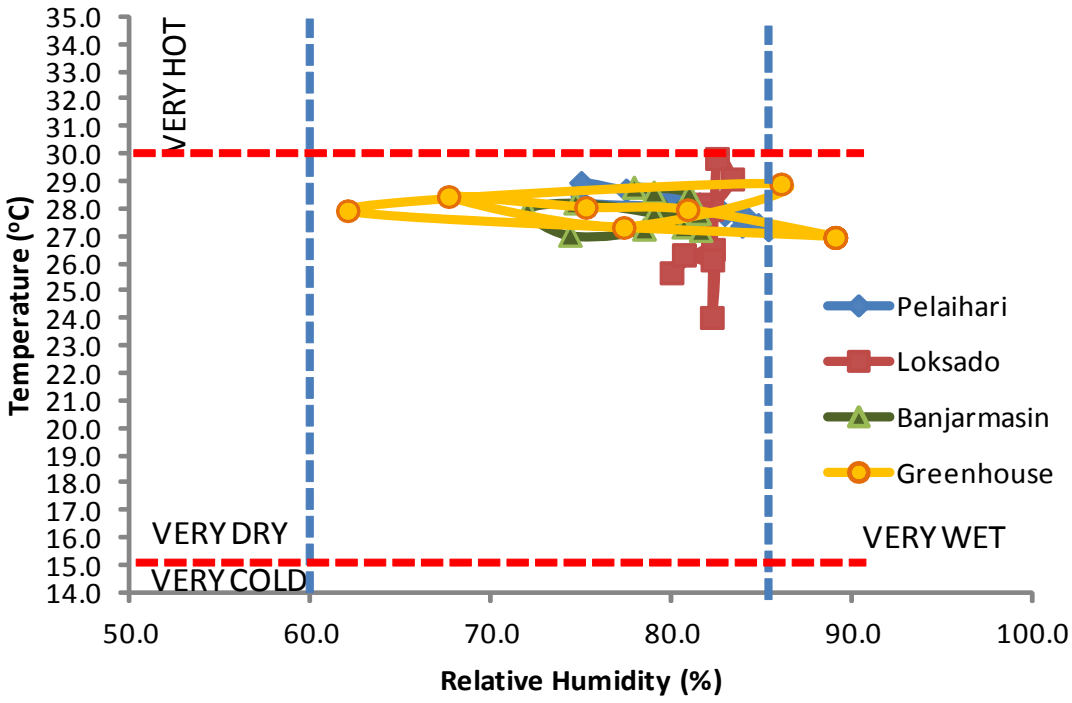

Figure 10. Climate space (Relative humidity and Air temperature).

CONCLUSION

Conclusion this research that the climatic space is suitable for orchid to growth and development. The others are to reform stem of flower not only climatic space and media type but also media temperature important too.

ACKNOWLEDGEMENT

We thank to I-MHERE UGM in 2011 that was supported by funds provided.

REFERENCES

Blanchard, M G and Runkle, E S. 2006. Temperature during the day, but not during the night, controls flowering of Phalaenopsis orchids. *J of Exp Botany*, 57(15):4043–4049.

Forest Service Government, 2011. Luas Hutan KalSel. Banjarmasin Post. Hal 3.

Griffiths, J F. 1966. Applied Climatology. Oxford University Press. New York.

List, R J 1971. Smithsonian Meteorological Tables, 6th Ed. Washington, D C: Smithsonian Institution Press.

Mader. 2006. Wind Speed and Solar Radiation Adjustments for the Temperature-Humidity Index. U.S. Department Of Energy, Great Plains Regional Center of the National Institute For Global Environmental Change (NIGEC) Under Cooperative Agreement.

Obu, M and Maki, T. 2005. Meteorological Characteristic of Greenhouses Covered with Insect Proof Net. J. Agric. Meteorol. 60 (5):693-696.

Porter, W P and Gates, D M. 1969. Thermodinamyc equilibrium of animal with environment. Ecol. Monogr. 39:245-270.

Rodinah. 2000. Koleksi dan Karakteristik Anggrek Langka Kalimantan Selatan. Fakultas Pertanian – Pemprov, Kalimantan Selatan. Banjarbaru.

Rusmayadi, G, Rodinah, Sumardi, I, and Sujadmiko, H. 2010. The Use of Comfort Index for Assessing the Suitability of Endemic Orchids (*Phalaenopsis amabilis* (L.) Blume Forma Pelaihari) in South Kalimantan. Final Research Report. I-MHERE UGM.

ISSN 0854-2333