Growth and yield of hydroponic watermelon with straw compost substrate and giberelaline (GA3) application

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Abstract. Watermelon plant in Indonesia are generally grown on paddy fields at an altitude of 0-500 m above sea level (asl) as intercrops between paddy planting seasons. The difficulties of watermelon cultivation are to achieve uniform and steady fruits quality (sweetness and weight). Implementation of hydroponics watermelon technology is an effort to increase production and productivity without disrupting rice production as a food crop. The objectives of this study were to examine the effects of straw compost substrate and giberelaline application to watermelon growth and yield. The research was conducted in Cilamaya Kulon of Karawang district (35 m asl) in October 2015 until January 2016. The research method used was experimental research using factorial randomized block design of 2 factors. The first factor was the ratio of planting medium consisted of 3 levels of treatment ie the ratio of straw compost with sand (1: 3, 1: 1 and 3: 1) and the second factor was the concentration of giberelaline (GA3) consisting of 4 levels of giberelaline concentration (0 ppm; 50 ppm; 150 ppm and 250 ppm). The results showed that giberelaline and straw compost ratio with sand did not occur interaction but influenced independently giving the composition of planting medium (1: 1) to plant height, fruit weight and fruit sweetness. Giberelaline concentration 50 ppm independently affects the number of leaf. The optimum growth and yield of watermelon were obtain if straw compost application equal to 50%(v/v).

1. Introduction
Watermelon plants in Indonesia are generally cultivated on paddy field as crop rotation (paddy-watermelon-paddy) [1]. The development of watermelon plants as perquisite for paddy farmers. The watermelon farmer encounter challenge of fluctuation productivity, uniformity and steady fruit quality [2]. The efforts to increase watermelon production intensively as the main crops in paddy fields have an impact on the disruption of rice production. The implemetation of hydroponics technology to cultivate watermelon is an effort to increase productivity and harvest quality without disrupting paddy production.

Hydroponic system generally is divided into two system, respectively substrate and water culture. Hydroponic substrates are commonly used for fruit-vegetables, herbs and fruit plants whereas water culture commonly used in leafy vegetable [3]. Previous research about cultivating melon on the nutrient film technique system or water culture system [4] yield fruit have lower sucrose content than soil planted melons.

Utilization of paddy straw as compost or organic fertilizer rarely applied by paddy farmer, commonly farmers burn paddy straw [5]. Whereas paddy straw has a high nutrient content [6] Si (4-7


\%), K (1.2 – 1.7\%), N (0.5-0.8 \%) P (0.07-0.12 \%) dan S (0.05-0.1\%). Utilization of paddy straw compost as a planting medium have many benefits such as, enhance plant nutrient and keep plant roots moisture [7]. Optimum growth and yield of watermelon sufficient plant nutrient and fulfill root zone aeration. If the plant substrate is too saturated may invite various types of plant diseases, other than that too saturated media can reduce fruit sweetness. The combination of composition sand and paddy straw compost is expected to provide aeration and nutrients for the plant growth. The application of gibberelin at generative phase is expected to improve the quality of watermelon fruit size, seedless and uniform [8].

2. Methods
This research has been conducted from October 2015 to January 2016 in Cilamaya Kulon, Karawang district (±35 m above sea level). Materials and tools used during this research respectively: watermelon cultivar Nina, AB Mix Fertilizer, GA3 powder, sand, straw compost, polybag, EC meter, pH meter, Thermohygrometer, refractometer.

The experimental design was used factorial randomized block design with two-factor (M: composition of sand-growing media with straw compost; G: gibberelline concentration). The first factor of planting medium M (comparison of straw compost: sand) consists of three levels (m1: (1: 3), m2: (2: 2); m3: (3: 1) v/v. The second factor of gibberelline concentration G consist of four levels (g0: without gibberellin g1: 50 ppm; g2: 150 ppm; g3: 250 ppm) each treatment combination was repeated three (3) times.

The parameters used to measure the optimum combination of treatment on growth and watermelon yields are: plant height (cm), number of leaf, fruit sweetness (ºbrix) and fruit weight (kg). Data observation then analized use variance analysis (F test) at 5\% error level. If the F test results is significant, the next step is post test using Duncan's multiple-range test at significant level 5\%. The secondary observations during the research are temperature and humidity measurement.

The research implementation divided into several stages, respectively: nursery stage use tray seedlings (containing the media of manure and soil (1:1) v/v in order to obtain uniform seeds of watermelon plants before it is planted to polybag, cropping, nutrient making, fertilization as well as watering with volume of vegetative phase application 200 ml (EC= 2 mS cm⁻¹) twice daily in generative phase water volume 300 ml (EC= 2.5 mS cm⁻¹) three times daily application. Combination EC value on vegetative phase and generative result optimum growth and yield of chili [9]. Gibbereline (GA3) application by spraying accordance level concentration on the female flowers and the last step harvest watermelon.

3. Result and discussion
Temperature and humidity measurements showed average daily temperature 29.98\ºC and average humidity 71.4\% (Figure 1). The micro climate of research site has generally fulfill the requirements of growing watermelon plants. Optimum growth of watermelon plants was achieved at 25-30\ºC with humidity less than 80\% [10]. Daily temperature average in tropical region is relatively constant throughout the year [11].
3.1. *Plant height*

Plants height were commonly used as a growth parameter. Plants that acquire light, water and nutrients will show optimum high growth but otherwise insufficient sunlight will show symptoms of excessive height (etiolation), insufficient of water and nutrition show dwarf symptom [12].

**Table 1.** Effect of substrate composition and gibbereline concentration to plant height

| Treatment | Plant Height\(^{(\dagger)}\) 28 DAP\(^{(\ddagger)}\) | Plant Height\(^{(\dagger)}\) 90 DAP |
|-----------|----------------|-------------------|
| Substrate | --- | --- |
| m\(_1\)   | 115,78a | 405,92a |
| m\(_2\)   | 121,46b | 470,44b |
| m\(_3\)   | 126,01b | 583,23c |
| Gibbereline| --- | --- |
| g\(_0\)   | 121,88a | 490,12a |
| g\(_1\)   | 120,30a | 528,24a |
| g\(_2\)   | 117,27a | 450,44a |
| g\(_3\)   | 124,89a | 477,31a |

Remarks:\(^{(\dagger)}\) The number followed by the same letter (lower case) indicate significant difference based on post hoc test Duncan Multiple Range test \(\alpha=5\%\).

The application composition plant substrate with concentration gibbereline showed no interaction in increasing plant height (Table 1). The availability of additional nutrients from straw compost (m\(_3\)) composition straw compost: sand (3: 1) more dominant in affect plant height. K element content in the paddy straw highest after Si content. The results of this research confirm previous research that enhancement of K fertilizer in watermelon plants are increase growth and yield quality [13]. Enhance compost to the hydroponic plant substrate improve water holding capacity [14]. The role of Si straw compost increase plants tolerance to abiotic stress such as relative humidity fluctuations occurring during growth period [15].

3.2. *Leaf number*

The number of leaf is another leaf parameter observed in addition leaf area [12]. Generally, plants with sufficient nutrients respond to increase leaf number than plants with insufficient nutrition (Table 2).
Application nutrient is not only success factor in hydroponic cultivation, appropriate nutrient composition increase plant growth [16].

| Treatment | Number of Leaves$^*$ |
|-----------|----------------------|
| Substrate | 28 DAP$^{	ext{**}}$ | 90 DAP$^{	ext{**}}$ |
| $m_1$     | 17,33a               | 115,67a               |
| $m_2$     | 21,00b               | 125,00a               |
| $m_3$     | 22,33b               | 118,00a               |
| Gibbereline |              |                      |
| $g_0$     | 19,22a               | 103,22a               |
| $g_1$     | 20,67a               | 126,44b               |
| $g_2$     | 20,89a               | 125,67b               |
| $g_3$     | 20,11a               | 122,89b               |

Remarks: $^*$ The number followed by the same letter (lower case) indicate significant difference based on post hoc test Duncan Multiple Range test $\alpha=5\%$.

**Table 2.** Effect of substrate composition and gibbereline concentration to leaf number.

Gibbereline application in generative phase has an effect on increasing the number of leaf at each level treatment dose compared to without gibbereline application. Gibberelline concentration more than 50 ppm in this research showed a decrease in the number of leaves. The results of this study records the previous studies [17] that application of gibberellin 50 and 100 ppm have an effect on increasing number of tomato leaf. The best concentration of gibberelline to increase growth was 50 ppm.

### 3.3. Fruit weight

Gibbereline application on fertilization stage and composition straw compost-sand substrate did not show interaction between these factors to improve fruit weight (Table 3). Optimum fruit weight based on Nina cultivar description between 8-10 kg. Factor composition of planting substrate independently affected the fruit weight increase. Comparison of straw and sand composition (2: 2) and (3: 1) significantly improved fruit weight. The enhance nutrient availability of straw compost and aerated planting media resulting from the addition of sand creates a microenvironment that supports plant growth. Even though yield of watermelon lower than the expected target.

In this research, gibberelline application did not affect fruit weight increase. The results of this research is different from the previous research [19] gibberelline application 60 ppm yield 4.39 kg fruit weight and 240 ppm yield 3.2 kg weight. Gibberellin application by spraying on female flowers are thought to be less effective than the female flower method immerse for five (5) seconds into gibbereline solution.

| Treatment | Fruit weight (kg) |
|-----------|-------------------|
| Substrate |                   |
| $m_1$     | 1,18a             |
| $m_2$     | 1,52b             |
| $m_3$     | 1,46b             |
| Gibbereline |               |
| $g_0$     | 1,32a             |
| $g_1$     | 1,34a             |
| $g_2$     | 1,45a             |
| $g_3$     | 1,44a             |

Remarks: $^*$ The number followed by the same letter (lower case) indicate significant difference based on post hoc test Duncan Multiple Range test $\alpha=5\%$.
3.4. Fruit sweetness
Gibberellin application and composition straw compost-sand showed no interaction to fruit sweetness (Table 4). The substrate composition factor showed an independently effect on fruit sweetness. The optimum fruit sweetness obtain from watermelons grown on a medium of straw-sand compost (1: 3) and (2: 2). The fruit sweetness is not only influenced by the availability of nutrients but the excessive water content in the media affects the sweetness of the fruit. This evident in the treatment of m3 (3: 1) where the availability of nutrients from straw compost is higher but the ability of media water holding capacity was high.

The element content of K on paddy straw provide plants in the process of photosynthesis [20], potassium plays an important role in the transportation of carbohydrates and the formation of amino acids, sugar content, potassium elements that can adequately improve the quality of watermelon, especially fruit sweetness [13][21]. In addition to the K content in straw, it is known that straw contains a high Si element of 4-7%. The Si element affects the assimilation of N and K, enhance Si element to hydroponic fruit plant increase fruit sweetness and quality of watermelon [22]. The availability of Si is abundant in soil but on the hydroponic system nutrient of Si content is rarely applicable in hydroponic nutrient formulations [16]. The findings of this research provide appropriate nutrition, especially the enhance of Si increase the fruit sweetness.

| Treatment | Fruit Sweetness (°brix) |
|-----------|-------------------------|
| Substrate |                         |
| m1        | 10.80b                  |
| m2        | 10.93b                  |
| m3        | 9.88a                   |
| Gibbereline |                    |
| g0        | 10.53a                  |
| g1        | 10.44a                  |
| g2        | 10.53a                  |
| g3        | 10.64a                  |

Remarks: *) The number followed by the same letter (lower case) indicate significant difference based on post hoc test Duncan Multiple Range test α=5%.

4. Conclusions
There was no interaction between gibberelline application and straw compost ratio with sand. The composition of planting medium (1:1) independently affected plant height, fruit weight and fruit sweetness. Gibberelline application of 50 ppm independently affected the number of leaves.

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